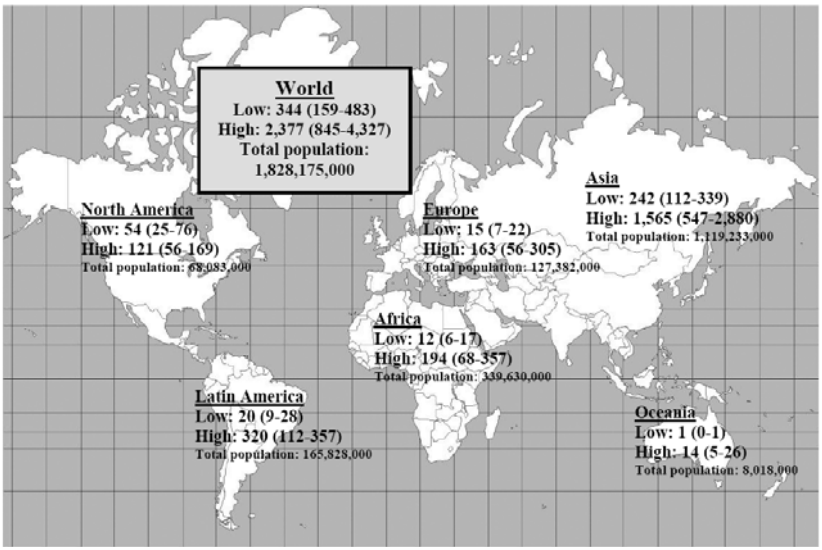

Figure A.3. Estimated number and range of world-wide and regional cases of childhood leukaemia among children under 14 years of age that are possibly attributable to EMF arithmetic mean exposure > 0.3 μT (and the corresponding derived confidence interval). Regional range is based on the lowest level and highest exposure levels from the countries in a given region. Where there was no information from any countries in the region, the lowest and highest exposure levels overall were used.

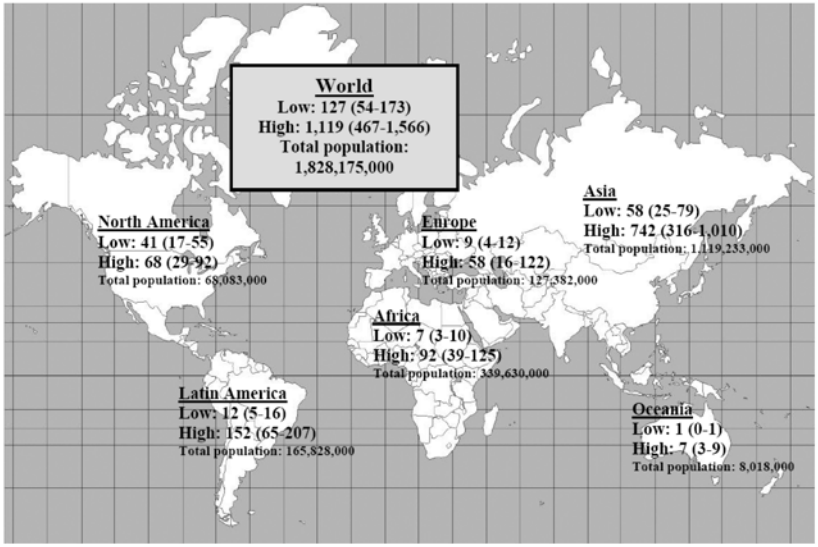

Figure A.4. Estimated number and range of world-wide and regional cases of childhood leukaemia among children under 14 years of age that are possibly attributable to EMF geometric mean exposure ≥ 0.4 μT (and the corresponding derived confidence interval). Regional range is based on the lowest level and highest exposure levels from the countries in a given region. Where there was no information from any countries in the region, the lowest and highest exposure levels overall were used.

Table A.1. Exposure distribution of the arithmetic mean based on exposure of cases in a case-control study or all respondents in an exposure survey

Country	Study	Study type	Measurement	Magnetic field category (μT)				N
				0.1	> 0.1–≤ 0.2	> 0.2–≤ 0.3	> 0.3	
Belgium	Decat, Van den Heuvel & Mulpas, 2005	Exposure survey	24-hr personal	81.9%	11.5%	1.6%	5.1%	251
Canada	McBride et al., 1999 [a]	Case-control	48-hr personal	58.59%	25.93%	10.77%	4.71%	297
Germany	Michaelis et al., 1998 [a]	Case-control	24-hr bedroom	85.23%	9.66%	1.70%	3.41%	176
	Brix et al., 2001	Exposure survey	24-hr personal	73.6%	17.8%	4.1%	4.5%	1952
	Schüz et al., 2001 [b]	Case-control	24-hr bedroom	91.83%	6.42%	0.97%	0.78%	514
Japan	Kabuto et al., 2006 [b]	Case-control	7-day home	88.46%	5.77%	3.85%	1.92%	312
Korea	Yang, Ju & Myung, 2004	Exposure survey	24-hr personal	64.0%	24.2%	4.0%	7.8%	409
UK	UKCCSI, 1999 [b]	Case-control	48-hr home	92.73%	5.31%	1.49%	0.47%	1073
USA	London et al., 1991 [a]	Case-control	24-hr bedroom	67.90%	18.52%	3.09%	10.49%	162
	Linet et al., 1997 [a]	Case-control	24-hr bedroom	63.17%	23.82%	6.43%	6.58%	638
	Zaffanella & Kalton, 1998	Exposure survey	24-hr personal	64.2%	21.1%	7.8%	6.6%	995
	Zaffanella, 1993	Exposure survey	24-hr home	72.3%	17.5%	5.6%	4.6%	987

[a] Based on the distribution for pooled analysis reported by Greenland et al., 2000 .

[b] Exposure categories: < 0.1, 0.1–< 0.2, 0.2–≤ 0.4, ≥ 0.4 μT.

Table A.2. Exposure distribution of the geometric mean based on exposure of cases in a case-control study or all respondents in an exposure survey

Country	Study	Study type	Measurement	Magnetic field category (μT)				N
				< 0.1	0.1–< 0.2	0.2–< 0.4	≥ 0.4	
Belgium	Decat, Van den Heuvel & Mulpas, 2005	Exposure survey	24-hr personal	91.9%	4.1%	2.8%	1.2%	251
Canada	McBride et al., 1999 [a]	Case-control	48-hr personal	63.97%	20.59%	10.66%	4.78%	272
Germany	Michaelis et al., 1998 [a]	Case-control	24-hr bedroom	89.14%	6.86%	2.86%	1.14%	175
UK	UKCCSI, 1999 [a]	Case-control	48-hr home	94.87%	3.54%	1.21%	0.37%	1073
USA	Zaffanella & Kalton, 1998	Exposure survey	24-hr personal	72.6%	17.6%	7.5%	2.3%	995
	Linet et al., 1997 [a]	Case-control	24-hr bedroom	70.25%	18.66%	8.24%	2.86%	595

[a] Based on the distribution for pooled analysis reported by Ahlbom et al., (2000).

Table A.3. Point, low and high estimates of the proportion (AF) and number (AN) of cases in the USA for the hypothetical scenario of 50% reduction in exposure

	Exposures above:		
Arithmetic mean	**0.1 μT**	**0.2 μT**	**0.3 μT**
Proportion of all cases attributable to exposure (AF):			
Current exposure distribution[a]	5.41% (-3.78%, 16.48%)	5.18% (-0.05%, 11.96%)	4.73% (1.65%, 8.73%)
Hypothetical distribution[b]: all exposures decreased by 50%	1.27% (-2.02%, 5.29%)	1.16% (-0.21%, 3.02%)	1.01% (0.34%, 1.93%)
Number of cases attributable to exposure (AN):			
Current exposure distribution	138 (-97, 421)	133 (-1, 306)	121 (42, 223)
Hypothetical distribution: all exposures reduced by 50%	32 (-52, 135)	30 (-5, 77)	26 (9, 49)
Number of cases averted due to exposure reduction	105 (-45, 286)	103 (4, 228)	95 (33, 174)
Geometric mean	**0.1 μT**	**0.2 μT**	**0.4 μT**
Proportion of all cases attributable to exposure (AF):			
Current exposure distribution[a]	3.95% (-2.83%, 12.30%)	2.46% (-0.71%, 6.77%)	1.67% (0.46%, 3.49%)
Hypothetical distribution[b]: all exposures decreased by 50%	0.94% (-0.99%, 3.32%)	0.37% (-0.20%, 1.17%)	0.20% (0.05%, 0.42%)
Number of cases attributable to exposure (AN):			
Current exposure distribution	101 (-72, 315)	63 (-18, 173)	43 (12, 89)
Hypothetical distribution: all exposures decreased by 50%	24 (-25, 85)	10 (-5, 30)	5 (1, 6)
Number of cases averted due to exposure reduction	77 (-47, 230)	53 (-13, 143)	38 (10, 83)

[a] Calculated log-normal distribution based on Zaffanella & Kalton, 1998.

[b] Calculated log-normal distribution based on Zaffanella & Kalton, 1998, with all exposures reduced by 50%

To estimate the impact of a hypothetical scenario where the population's exposure distribution is reduced by 50%, a new exposure distribution was calculated to reflect this change. Calculating the exposure distribution shift requires knowing the mean and standard deviation of the distribution; this information was available for only one of the distributions, the USA EMF Rapid Survey, 1998 (Zaffanella & Kalton, 1998). Hence, AF and AN estimates for exposures greater than 0.1 μT, 0.2 μT, 0.3 μT or 0.4 μT were calculated for the arithmetic mean and geometric mean exposure distributions, before and after making the 50% exposure reduction in the USA (see Table A.3). The difference in the AN reflects the number of cases that would be averted due to the exposure reduction of 50%.

The conventional calculations of AF do not reflect any source of uncertainty other than random error, and informal judgments regarding the effect of possible biases. To provide additional input to policy analysis also formal Bayesian analyses are provided of the impact of high residential magnetic-field exposure (as measured by AF), accounting for uncertainties about study biases as well as uncertainties about exposure distribution. These Bayesian analyses support the idea that the public-health impact of residential fields is likely to be limited, but both no impact and a large impact remain possibilities in light of the available data (Greenland & Kheifets, 2006). The difference between the two analyses varies in both directions, but on the whole the Bayesian results make the conventional results look overoptimistic and overconfident (Table A.4).

Table A.4. Conventional estimates (with 95% confidence limits) and Bayesian (posterior) percentiles for percentage of leukaemia case load attributable to exposure > 0.3 μT versus < 0.3 μT (AF%) in 15 case-control studies of magnetic fields and childhood leukaemia and in four populations with surveys of fields [a]

Reference	Country	Population AF% (95% limits)	
		Conventional	Posterior
Case-control:			
Coghill, Steward & Philips, 1996	England	0.5 (0.2, 0.7)	0.7 (-0.4, 18)
Dockerty et al., 1998	N.Z.	0.9 (0.5, 1.3)	0.9 (-0.5, 20)
Feychting & Ahlbom, 1993	Sweden	3.1 (1.4, 5.2)	8.6 (0.6, 44)
Kabuto et al., 2006	Japan	1.5 (0.7, 2.3)	3.2 (-1.0, 24)
Linet et al., 1997	U.S.	2.9 (1.4, 4.2)	3.5 (-1.1, 20)
London et al., 1991	U.S.	4.5 (2.2, 6.5)	4.9 (-1.2, 27)
McBride et al., 1999	Canada	2.1 (1.0, 3.1)	3.1 (-0.9, 23)
Michaelis et al., 1998	Germany	1.2 (0.6, 1.8)	1.0 (-0.5, 21)
Olsen, Nielsen & Schulgen, 1993	Denmark	0.1 (0.1, 0.2)	0.6 (0.0, 17)
Savitz et al., 1988	U.S.	2.1 (1.0, 3.5)	4.7 (-1.0, 34)
Schüz et al., 2001	Germany [b]	0.3 (0.1, 0.5)	0.7 (-0.4, 17)

Table A.4. Continued

Reference	Country	Population AF% (95% limits)	
		Conventional	Posterior
Case-control:			
Tomenius, 1986	Sweden	0.9 (0.4, 1.4)	0.7 (-0.5, 18)
Tynes & Haldorsen, 1997	Norway	1.0 (0.4, 1.6)	0.6 (0.0, 15)
UKCCSI, 1999	UK [b]	0.2 (0.1, 0.3)	0.6 (-0.4, 16)
Verkasalo et al., 1993	Finland	1.1 (0.5, 1.9)	0.8 (0.0, 20)
Surveys:			
Brix et al., 2001	Germany	3.1 (1.3, 5.5)	3.8 (0.0, 36) [c]
Decat, Van den Heuvel & Mulpas, 2005	Belgium	3.0 (1.1, 6.5)	3.8 (0.0, 36) [c]
Yang, Ju & Myung, 2004	Korea	5.2 (2.2, 9.6)	5.6 (-0.1, 44) [d]
Zaffanella, 1993	U.S.	3.2 (1.3, 5.9)	3.9 (0.0, 36) [c]
Zaffanella & Kalton, 1998	U.S.	4.4 (1.9, 8.0)	4.5 (-0.1, 38) [c]

[a] Adopted from Greenland & Kheifets, 2006.

[b] AF for > 4 μT vs. $\leq$ 2 μT, excluding 2-4 μT.

[c] Adjusted using the odds-ratio model for North America (direct measurement, high prevalence) and the summary field-leukaemia odds ratio of 2.9 (CI: 0.99–8.6).

[d] Adjusted using the odds-ratio model for Kabuto (direct measurement, high prevalence).

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15 GLOSSARY

AC
Alternating current. An electrical current whose magnitude and direction vary cyclically, as opposed to direct current, whose direction remains constant.

Action potential (nerve impulse or "spike")
A sudden brief reversal of the local membrane electrical potential that occurs once a threshold depolarisation has been exceeded and which quickly propagates down a nerve axon conveying "digitally" encoded information.

Acute effect
Effect of short duration and occurring rapidly (usually in the first 24 h or up to 14 d) following a single dose or short exposure to a substance or radiation.

Adverse health effect
A biological effect which has a detrimental effect on mental, physical and/or general well being of exposed people, either in the short term or long term.

Antibody
A class of proteins produced by (B) lymphocytes that recognises and binds to a specific antigen, thereby aiding its elimination, or elimination of the agent, such as a bacterium, expressing it.

Antigen
Any substance, usually (but not always) foreign, that provokes an antigen-specific immune response, such as antibody-binding.

Apoptosis
A specific form of cell death during which cells degrade their own DNA. Apoptosis can occur normally during organ formation, or as a result of DNA or cellular damage.

Autonomic nervous system
A part of the peripheral nervous system that regulates the visceral or "housekeeping" functions of the body, such as heart-rate and blood pressure. It's cell bodies lie either in the central nervous system, or in ganglia in other parts of the body.

Background levels
The amounts of EMF found (that are not due to an obviously specific source) in a typical environment of an industrialized society.

Basic restrictions
Restrictions on exposure to time-varying electric, magnetic, and electromagnetic fields that are based directly on established health effects. Depending upon the frequency of the field, the physical quantities used to specify these restrictions are induced electric field (E), current density (J), specific energy absorption rate (SAR), and power density (S). Only power density in air, outside the body, can be readily measured in exposed individuals.

Bias
A systematic tendency to error as a consequence of the design or conduct of a study.

Biological effect
A measurable change in a biological system in response (for example) to an electromagnetic field.

Biophysical mechanisms
Physical and/or chemical interactions of electric and magnetic fields with biological systems.

Blind study
A study in which the subject or, in the case of studies using animals, tissues or cell cultures, the experimenter, is unaware of whether exposure is to the agent under test or to a neutral or comparison agent until completion of the experiment, in order to avoid unconscious subjective bias affecting the study outcome.

Blood-brain barrier
A physiological "barrier" comprising endothelial and epithelial cells that regulates the composition of cerebrospinal fluid of the central nervous system.

Calcium efflux
The release of calcium ions from a sample into a surrounding solution.

Cancer
An uncontrolled and abnormal proliferation of cells that causes disease.

Carcinogen
An agent that can induce cancer.

Carcinoma
A tumour arising from epithelial tissue (e.g. glands; breast; skin; linings of the urogenital, intestinal and respiratory systems).

Case-control study
An investigation into the extent to which a group of persons with a specific disease (the cases) and comparable persons who do not have the disease (the controls) differ with respect to exposure to putative risk factors.

Causal relationship
A causal relationship occurs between two agents when one causes the other. For example, researchers are studying whether there is a causal relationship between EMF and cancer, meaning that they are studying to see if EMF causes, or affects the progress of, cancer.

Cell signalling (pathways)
A sequence of intracellular changes linking a "signalling event", such as activation of membrane-bound ion channels or ligand-receptors, and a "response", such as a change in gene expression, for example, leading to increased proliferation.

Central nervous system (CNS)
Usually taken to mean the cells, such as neurons and glial cells, of the brain and spinal cord. It also includes the retina, which is formed as an outgrowth of the forebrain.

Chromosome
A single molecule of DNA, comprising a large number of genes and other DNA, together with associated protein molecules that condense during cell division to form a deeply staining, rod-shaped body.

Chronic effect
Consequence which develops slowly and has a long-lasting course (often but not always irreversible).

Circulary polarized
If the electric field is viewed as a point in space, the locus of the end point of the vector will rotate and trace out an ellipse, once each cycle.

Cognition
Information processing by the brain, including processes such as attention, perception, learning, reasoning, comprehending and memory.

Cohort study
An investigation involving the identification of a group of individuals (the cohort) about whom certain exposure information is collected, and the ascertainment of occurrence of diseases at later times. For each individual, information on prior exposure can be related to subsequent disease experience. Cohort studies may be conducted prospectively or retrospectively.

Combined analysis
Analysis of data pertaining to the same topic that have been collected in several different studies. Usually based on individual level data from each of the available studies, rather than on the published findings (see Meta analysis).

Comet assay
A single cell electrophoresis assay in which DNA is caused to migrate away from the nucleus by an applied electric field. The extent of migration gives a measure of DNA damage.

Conductance
The reciprocal of resistance. Symbol: G. Unit: siemens (S).

Conductivity, electrical
The scalar or vector quantity which, when multiplied by the electric field strength, yields the conduction current density; it is the reciprocal of resistivity. Expressed in siemens per meter ($S\ m^{-1}$).

Confidence interval (CI)
An interval calculated from data when making inferences about an unknown parameter. In hypothetical repetitions of the study, the interval will include the parameter in question on a specified percentage of occasions (e.g. 90% for a 90% confidence interval).

Confounding
Spurious findings due to the effect of a variable that is correlated with both the exposure and disease under study.

Contact current
Current flowing between an energized, isolated, conductive (metal) object and ground through an electrical circuit representing the equivalent impedance of the human body.

Continuous exposure
Exposure for durations exceeding the corresponding averaging time. Exposure for less than the averaging time is called short-term exposure.

Continuous wave (CW)
A wave whose successive oscillations are identical under steady-state conditions.

Coronary thrombosis
A blood clot which blocks one of the coronary arteries, leading to a heart attack.

Current density
A vector of which the integral over a given surface is equal to the current flowing through the surface; the mean density in a linear conductor is equal to the current divided by the cross-sectional area of the conductor. Unit: ampere per square meter (A m^{-2}).

Diastole
The period of relaxation of heart muscle, following contraction (systole).

Dielectric constant
See Permittivity.

Dielectric material
A class of materials that act as electric insulators. For this class, the conductivity is presumed to be zero, or very small. The positive and negative charges in dielectrics are tightly bound together so that there is no actual transport of charge under the influence of a field. Such material alters electromagnetic fields because of induced charges formed by the interaction of the dielectric with the incident field.

Differentiation (cellular)
The development of a specialised cellular structure and function from less specialised "precursor" cells such as stem cells which is generally accompanied by a loss of proliferative capacity.

Dipole
A centre-fed open antenna excited in such a way that the standing wave of current is symmetrical about the mid point of the antenna.

Dose
A term for the amount of a chemical or physical agent delivered to a target organ. Since neither the target organ nor the mechanism of delivery are well understood for most biological effects of EMF fields, an EMF dose can sel-

dom be defined, and the concept of exposure metric (see below) is used instead.

Dose-response relationship
Mathematical description of the relationship between the dose and occurrence of the disease.

Dosimetry
Measurement or determination by calculation of the internal electric field strength or induced current density, or of the specific absorption (SA) or specific absorption rate (SAR) distribution in humans or animals exposed to electromagnetic fields.

Double blind study
A volunteer study in which the subject and the experimenter until completion are unaware of whether exposure is to the agent under test or to a neutral or comparison agent, in order to avoid unconscious subjective bias affecting the study outcome.

Duty factor
The ratio of the sum of pulse durations to a stated averaging time. For repetitive phenomena, the averaging time is the pulse repetition period.

Electric and magnetic fields or electromagnetic fields (EMF)
The combination of time-varying electric and magnetic fields.

Electric field
A vector field E measured in volts per metre (V m^{-1}).

Electric field strength (*E*)
Force exerted by an electric field on an electric point charge, divided by the electric charge. Expressed in newtons per coulomb or volts per metre (N C^{-1} = V m^{-1}).

Electrical ground
The earth or a metal surface placed in contact with the earth, or connected to the earth with a conductor.

Electrocardiogram (ECG)
A recording of the electrical activity of the heart from electrodes placed on the body.

Electroencephalogram (EEG)
A recording of the electrical activity of the brain from electrodes placed on the head.

Electromagnetic energy
The energy stored in an electromagnetic field. Expressed in joule (J).

Electromagnetic interference (EMI)
Degradation of the performance of a device, a piece of equipment, or a system caused by an electromagnetic disturbance.

Electroretinogram (ERG)
A recording of the electrical activity of the retina from electrodes placed on the surface of the eye and the head.

Embryo
The stage of prenatal development between the fertilised ovum and the completion of major organ development. In humans, this occurs in the first trimester.

Enteric nervous system
Comprises the intrinsic neurons of the gut, about the same in number (approximately 100 million) as those of the spinal cord, and which exhibit a high degree of independence from the central nervous system.

Epidemiology
The study of the distribution of disease in populations and of the factors that influence this distribution.

Epilepsy
Epileptic seizures arise from an excessively synchronous and sustained discharge of a group of neurons; a persistent increase in neuronal excitability is a key feature.

Event-related (or evoked) potential (ERP or EP)
A recording of the electrical activity of the brain after a stimulus event, such as a visual or auditory stimulus (resulting in VEPs and AEPs respectively). Late components are associated with cognitive processing.

Exposure
The subjection of a person to electric, magnetic, or electromagnetic fields or to contact currents other than those originating from physiological processes in the body and other natural phenomena.

Exposure standard
A standard that limits EMF exposure to humans. See Standard.

Exposure, intermittent
This term refers to alternating periods of exposure and absence of exposure varying from a few seconds to several hours. If exposure lasting a few minutes to a few hours alternates with periods of absence of exposure lasting 18-24 hours (exposure repeated on successive days), “repeated exposure” might be a more appropriate term.

Exposure, long term
This term indicates exposure during a major part of the lifetime of the biological system involved; it may, therefore, vary from a few weeks to many years in duration.

Exposure metric
A single number that summarizes an electric and/or magnetic field exposure over a period of time. An exposure metric is usually determined by a combination of the instrument’s signal processing and the data analysis performed after the measurement.

Exposure, partial-body
Exposure that results when EMF are substantially non-uniform over the body. Fields that are non-uniform over volumes comparable to the human body may occur due to highly directional sources, standing waves, re-radiating sources, or in the near field region of a radiating structure.

Exposure, short term
Exposure for durations less than the corresponding averaging time.

Exposure, whole-body
Pertains to the case in which the entire body is exposed to the incident electromagnetic energy or the case in which the cross section (physical area) of the body is smaller than the cross section of the incident radiation beam.

Extremities
Limbs of the body.

Fetus (foetus)
The stage of prenatal development between the embryo and birth.

Fibrillation (ventricular)
The loss of organised ventricular contractions of the heart.

Field strength
The magnitude of the electric or magnetic field, normally the root-mean-square value.

Free radicals
Highly reactive chemical species (part of a molecule) with an unpaired electron.

Free space
An ideal perfectly homogeneous medium possessing a relative dielectric constant of unity, in which there is nothing to reflect, refract, or absorb energy. A perfect vacuum possesses these qualities.

Frequency
The number of cycles completed by electromagnetic waves in 1 s; usually expressed in hertz (Hz).

Frequency response
An instrument's output as a function of frequency relative to the magnitude of the input signal. Specification of an instrument's frequency response includes the type of filter and its bandwidth.

Gene expression
The production of a functional protein or an RNA molecule from genetic information (genes) encoded by DNA.

Genotoxin
An agent which damages DNA and RNA.

Geomagnetic fields
Magnetic fields originating from the earth (including the atmosphere). Predominantly a static magnetic field, but includes some oscillating components and transients.

Guideline
A recommended limit for a substance or an agent intended to protect human health or the environment.

Haematology
The study of blood; its formation, normal composition, function and pathology.

Harmonic
A frequency which is a multiple of the frequency under consideration.

Health
A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

Health hazard
A biological effect that is detrimental to health or well-being.

Immune system
The body's primary defence against abnormal growth of cells (i.e. tumours) and infectious agents such as bacteria, viruses, and parasites.

Impedance, wave
The ratio of the complex number (vector) representing the transverse electric field at a point, to that representing the transverse magnetic field at that point. Expressed in ohm (Ω).

Implantation
The attachment of the early embryo to the uterine wall.

In vitro
Experimental studies of cells or tissues, usually in a sustaining oxygenated, fluid medium. Literally means “in glass”, isolated from the living organism and artificially maintained, as in a test tube or culture dish.

In vivo
Occurring within the whole living body. ‘In life’; experimental studies of processes in living organisms.

Latency
The time between exposure to an injurious agent and the manifestation of a response.

Leukocyte
A white blood cell.

Lymphocyte
White blood cells produced in lymphoid tissue that initiate adaptive, antigen-specific immune responses. Some T-lymphocytes are cytotoxic; B-lymphocytes secrete antibodies.

Macrophage
A phagocytic cell derived from myeloid progenitor cells found in various tissues.

Magnetic field strength (*H*)
A field vector, *H*, that is equal to the magnetic flux density divided by the permeability of the medium. Expressed in units of amperes per meter (A m^{-1}).

Magnetic flux density (*B*)
The force on a moving unit positive charge at a point in a magnetic field per unit velocity. A vector field quantity, *B*, expressed in tesla (T).

Malignant
Neoplasms or tumours that have become invasive.

Meta-analysis
Analysis of data pertaining to the same topic that have been collected in several different studies. Usually refers to an analysis based on published findings from individual studies, rather than on the original data sets (see Combined analysis).

Metabolic rate
See Resting metabolic rate.

Metabolism
The biochemical reactions by which energy is made available for the use of an organism from the time a nutrient substance enters, until it has been utilized and the waste products eliminated.

Metastasis
Tumour cells that leave their site of origin and migrate to other sites in the body.

Micronucleus
Chromosome fragments that have not been lost on cell division.

Mutation
A stable heritable change in the DNA at a specific site in the in the genome of a cell by an agent (mutagen) such as ionising radiation.

Natural killer (NK) cells
Lymphocytes that are not antigen-specific but nevertheless bind to and kill certain tumour and virus-infected cells.

Neonate, neonatal
Newly born.

Neoplasm
New growth of abnormal tissue.

Neural network
Group of interacting neurons.

Neural tube defect
A defect of the newly formed precursor of the central nervous system, commonly anencephaly (failure of brain to develop), encephalocele (cyst of the brain), and spina bifida (defects in the closure of the neural tube).

Neuron
Nerve cell, specialised for the transmission of neural information.

Neurotransmitter
A substance released by a neuron that causes a post-synaptic response that is relatively quick in onset (< 1 ms) and short (< 10's ms) in duration, as distinct from the more prolonged action of neuromodulators.

Neutrophil
Phagocytic white blood cells derived from myeloid progenitor cells.

Non-differential measurement errors
Errors in exposure assessment that do not depend on whether or not someone develops the disease under study.

Occupational exposure
Exposure experienced by adults who are generally exposed under known conditions and are trained to be aware of potential risk and to take appropriate precautions.

Odds ratio
The ratio of the odds of disease occurrence in a group with exposure to a factor to that in an unexposed group; within each group, the odds are the ratio of the numbers of diseased and non-diseased individuals.

Oncogene
A gene which contributes to cancer in a dominant fashion through the mutation and/or abnormal expression of a gene (proto-oncogene) involved in regulating cell proliferation.

Operant behaviour
Behaviour, such as pressing a lever, which is "shaped" by rewards (such as food pellets) or punishment (such as a mild electric shock).

Organogenesis
The process of organ formation in developing organisms.

Peripheral nervous system (somatic)
The part of the nervous system that mainly deals with the voluntary and conscious aspects of neural control such as voluntary muscle (motor) contraction and sensations such as those of warmth or pressure. The cell bodies lie within the spinal cord, but the peripheral nerves (axons) terminate on muscle fibres or in specialised sensory receptors throughout the body.

Permeability
The scalar or tensor quantity whose product by the magnetic field strength is the magnetic flux density. Note: For isotropic media, the permeability is a scalar; for anisotropic media, a matrix.
Synonym: absolute permeability. If the permeability of a material or medium

is divided by the permeability of vacuum (magnetic constant) μ_0, the result is termed relative permeability (μ). Unit: henry per metre (H m^{-1}).

Permittivity; dielectric constant
A constant defining the influence of an isotropic medium on the forces of attraction or repulsion between electrified bodies. Symbol: ε. Unit: farad per metre (F m^{-1}).

Permittivity, relative
The ratio of the permittivity of a dielectric to that of a vacuum. Symbol: ε_r.

Phase
Of a periodic phenomenon, the fraction of a period through which the time has advanced relative to an arbitrary time origin.

Phosphene
The perception of flickering light in the periphery of the visual field induced by non-visual means such as a trans-retinal electric current.

Prospective study
An epidemiological study in which data on exposures and disease outcome are collected as the events occur, unlike a retrospective study (see below). Some cohort studies are conducted prospectively.

Public exposure
All exposure to EMF experienced by members of the general public, excluding occupational exposure and exposure during medical procedures.

Recall bias
Bias resulting from the tendency of a class of subjects to recall relevant events better than other subjects.

Reference level
EMF exposure level provided for practical exposure assessment purposes to determine whether the basic restrictions are likely to be exceeded. Some reference levels are derived from relevant basic restrictions using measurement and/or computational techniques and some address perception and adverse indirect effects of exposure to EMF.

Reinforcement (behavioural)
An action such as reward or punishment that increases the likelihood of a certain behaviour.

Relative risk
The ratio of the disease rate in the group under study to that in a comparison group, with adjustment for confounding factors such as age, if necessary.

Reproductive effects
Effects on reproduction which may include, but not be limited to, alterations in sexual behaviour, onset of puberty, fertility, gestation, parturition, lactation, pregnancy outcomes, premature reproductive senescence, or modifications in other functions that are dependent on the integrity of the reproductive system.

Resonance
The change in amplitude occurring as the frequency of the wave approaches or coincides with a natural frequency of the medium.

Retrospective study
An epidemiological study in which data on exposures and disease outcome are collected some time after the event, unlike a prospective study (see above). Examples include case-control studies and some cohort studies.

Root-mean-square (RMS)
Certain electrical effects are proportional to the square root of the mean value of the square of a periodic function (over one period). This value is known as the effective value or the root-mean-square (RMS) value, since it is derived by first squaring the function, determining the mean value of the squares obtained, and extracting the square root of the mean value to determine the end result.

Safety factor
A reduction factor incorporated into limits in standards or guidelines that allows for uncertainties in the determination of a threshold level of exposure, above which established health effects begin to appear.

Selection bias
Bias resulting from a faulty way to select subjects for a study. Epidemiological studies depend on a reliable comparison between subjects with a disease and a reference population as to their exposure. If the subjects chosen for a study are not representative of the corresponding population, the comparison becomes flawed and the association between disease and exposure becomes biased.

Shield
A mechanical barrier or enclosure provided for protection. The term is modified in accordance with the type of protection afforded; e.g., a magnetic shield is a shield designed to afford protection against magnetic fields.

Short term exposure
See exposure, short term

Significance level
The probability of obtaining a result at least as extreme as that observed in the absence of a raised risk. A result that would arise less than 1 in 20 times in the absence of an underlying effect is often referred to as being “statistically significant”.

Sinus arrhythmia
The normal variation of heart rate during the breathing cycle.

Spatial average
The root mean square of the field over an area equivalent to the vertical cross section of the adult human body, as applied to the measurement of electric or magnetic fields in the assessment of whole-body exposure.

Spot measurements
Magnetic field measurements taken at various individual locations throughout a room or area.

Standard
1) A documented agreement containing technical specifications or other precise criteria to be used consistently as rules, guidelines or definitions of characteristics to ensure that materials, products, processes and services are fit for their purpose.
2) A legally enforceable limit for a substance or an agent intended to protect human health or the environment. Exceeding the standard could result in unacceptable harm.

Static field
A field vector that does not vary with time.

Statistical power
The probability that, with a specified degree of confidence, an underlying effect of a given magnitude will be detected in a study.

Synapse
A junction between two neurons, or between a neuron and a muscle fibre, that allows the transmission of electrical information, usually by means of a chemical transmitter (neurotransmitter) released from the presynaptic terminal of one neuron onto the closely juxtaposed post-synaptic terminal of the other.

Systole
The period of contraction of heart muscle following relaxation (diastole).

Teratogen
An agent that can cause birth defects.

Threshold
The lowest dose of an agent at which a specified measurable effect is observed and below which it is not observed.

Thrombosis
Blocking of an artery or vein by a blood clot.

Time-weighted average (TWA)
The average of various measurements, each of which is given more or less weight according to how much time a person is likely to spend in the spot where that measurement was taken. The term is used more generally to indicate the average of field levels over a specific amount of time. This is one method used to summarize exposure to exposure to magnetic fields.

Transcription factor
A protein that binds to a DNA sequence with a “regulatory” function thereby, directly or indirectly, affecting the initiation of transcription.

Transformation
Conversion of cells to a state of unrestrained growth in culture, resembling or identical with a tumour-forming (tumorigenic) state.

Transgenic organism
A genetically modified organism, which has foreign DNA such as a gene stably integrated into its genome.

Transients
Brief bursts of high frequency fields, usually resulting from mechanical switching of AC electricity.

Transmission lines
High voltage power lines that carry large quantities of power over large distances.

Tumour
A growth of tissue resulting from abnormal cell proliferation.

Tumour initiator
An agent that can produce an initial carcinogenic event such as a mutation.

Tumour progression
The process by which initiated and promoted cells become increasingly malignant.

Tumour promoter
An agent that can stimulate the proliferation (clonal expansion) of initiated cells.

Tumour suppressor gene
A normal cellular gene involved in regulating cell proliferation whose mutation and/or abnormal expression can contribute to cancer in a recessive manner.

Vasoconstriction
The contraction of blood vessels, making them narrower.

Vasodilatation (or vasodilation)
The relaxation of blood vessels, making them wider.

Vigilance tasks
Responding to unusual and infrequent stimuli (signals) occurring against a background of usual and frequent stimuli (events). Vigilance can be either visual or auditory.

Voltage-gated ion channel
Cell membrane proteins that allow the passage of particular ion species across the cell membrane in response to the opening of a molecular "gate" which is steeply sensitive to the transmembrane voltage. They are associated with electrical excitability.

Wavelength (λ)
The distance between two successive points of a periodic wave in the direction of propagation, in which the oscillation has the same phase. Symbol: λ. Unit: metre (m).

Wild type (gene)
The gene that is found in nature or in the standard laboratory stock for a given organism.

Working memory
An active system for temporarily storing and manipulating information needed in the execution of complex cognitive tasks.

16 RESUME ET RECOMMANDATIONS RELATIVES AUX ETUDES A MENER

La présente monographie des critères d'hygiène de l'environnement porte sur les effets éventuels sur la santé d'une exposition à des champs électriques et magnétiques d'extrêmement basse fréquence (EBF). On y examine les caractéristiques physiques des champs EBF ainsi que les sources d'exposition et le mesurage des champs. Toutefois, ses principaux objectifs sont d'examiner la littérature scientifique sur les effets biologiques d'une exposition aux champs EBF afin de pouvoir évaluer les risques pour la santé associés à l'exposition à ces champs et d'utiliser cette évaluation du risque sanitaire pour formuler des recommandations relatives aux programmes de protection sanitaire à l'intention des autorités nationales.

Les fréquences qui nous occupent sont situées au-dessus de 0 Hz et jusqu'à 100 kHz. La majorité des études a porté sur les effets des champs magnétiques à la fréquence des réseaux (50 ou 60 Hz), quelques études seulement portant sur les champs électriques à ces mêmes fréquences. En outre, un certain nombre d'études a été réalisé sur les champs magnétiques de très basse fréquence (VLF, 3–30 kHz), liés aux champs magnétiques à gradient commuté utilisés dans l'imagerie par résonance magnétique et aux champs VLF plus faibles, émis par les terminaux à écran cathodique et les postes de télévision.

Ce document récapitule les principales conclusions et recommandations de chaque section ainsi que les conclusions générales du processus d'évaluation des risques sanitaires. Les termes utilisés dans cette monographie pour indiquer le "poids de la preuve" en faveur d'un effet donné sur la santé sont les suivants. Les éléments d'appréciation sont "limités" lorsqu'ils ne se rapportent qu'à une seule étude ou lorsqu'il reste des questions sans réponse concernant la conception, la conduite ou l'interprétation d'un certain nombre d'études. On dit que les éléments d'appréciation sont "insuffisants" lorsque les études ne peuvent être interprétées comme montrant la présence ou l'absence d'un effet du fait d'insuffisances importantes sur le plan qualitatif ou quantitatif, ou lorsqu'aucune donnée n'est disponible.

On a également recensé des lacunes importantes dans les connaissances et on a résumé dans la section intitulée "Recommandations de recherche" les études nécessaires pour les combler.

16.1 Résumé

16.1.1 Sources, mesurage et expositions

Les champs électriques et magnétiques existent partout où de l'électricité est produite, transmise ou distribuée dans des lignes ou des câbles électriques, ou utilisée dans des appareils électriques. Depuis que l'électricité fait partie intégrante de notre mode de vie moderne, ces champs sont omniprésents dans notre environnement.

L'intensité du champ électrique se mesure en volts par mètre (V m^{-1}) ou en kilovolts par mètre (kV m^{-1}) et l'induction magnétique en teslas (T), ou plus communément en milliteslas (mT) ou en microteslas (μT).

Dans les habitations, l'exposition aux champs magnétiques à la fréquence du réseau ne montre pas de variations spectaculaires dans le monde. La moyenne géométrique du champ magnétique dans les habitations se situe entre 0,025 et 0,07 μT en Europe et entre 0,055 et 0,11 μT aux Etats-Unis. Les valeurs moyennes du champ électrique dans les habitations sont de l'ordre de plusieurs dizaines de volts par mètre. Au voisinage de certains appareils domestiques, les valeurs instantanées du champ magnétique peuvent atteindre quelques centaines de microteslas. A proximité des lignes électriques à haute tension, les champs magnétiques atteignent près de 20 μT et les champs électriques jusqu'à plusieurs milliers de volts par mètre.

Peu d'enfants subissent, là où ils habitent, des expositions à des champs magnétiques de 50 ou 60 Hz dont la moyenne dans le temps est supérieure aux niveaux associés avec une incidence accrue de leucémie infantile (voir section 16.1.10). Près de 1 à 4% d'entre eux ont des expositions moyennes supérieures à 0,3 μT et seuls 1 à 2% des expositions médianes supérieures à 0,4 μT.

L'exposition professionnelle, bien qu'elle soit principalement due à des champs à la fréquence du réseau, peut également comporter l'exposition à d'autres fréquences. Les expositions moyennes au champ magnétique sur les lieux de travail se sont avérées plus élevées au sein des "professions liées à l'électricité" que dans les autres, telles que par exemple le travail de bureau. Elles sont comprises entre 0,4 et 0,6 μT pour les électriciens et les ingénieurs en électricité et autour de 1,0 μT pour les agents travaillant sur les lignes électriques, les expositions les plus élevées concernant les soudeurs, les conducteurs de trains et les opérateurs de machines à coudre (plus de 3 μT). Les expositions maximales aux champs magnétiques sur les lieux de travail peuvent atteindre près de 10 mT et sont invariablement associées à la présence de conducteurs transportant des courants forts. Dans le secteur de l'alimentation électrique, les agents peuvent être exposés à des champs électriques atteignant 30 kV m^{-1}.

16.1.2 Champs électriques et magnétiques dans l'organisme

L'exposition à des champs électriques et magnétiques EBF externes induit des champs et des courants électriques dans l'organisme. La dosimétrie décrit le rapport entre le champ externe et les champ électriques et la densité de courant induits dans l'organisme, ou d'autres paramètres associés à l'exposition à ces champs. Le champ électrique et la densité de courant induits localement présentent un intérêt particulier parce qu'ils sont en rapport avec la stimulation des tissus excitables tels que nerfs et muscles.

Le corps de l'homme et des animaux perturbe sensiblement la distribution spatiale d'un champ électrique EBF. Aux fréquences basses, le corps est un bon conducteur et les lignes du champ perturbé à l'extérieur de l'organisme sont presque perpendiculaires à la surface du corps. Des charges

oscillantes sont induites à la surface de l'organisme exposé et ce sont elles qui produisent des courants dans l'organisme. Les principales caractéristiques de la dosimétrie concernant l'exposition de l'homme aux champs électriques EBF sont les suivantes:

- Le champ électrique à l'intérieur de l'organisme est normalement cinq ou six fois plus faible que le champ électrique externe.
- Lorsque le champ vertical est la cause principale de l'exposition, la direction dominante des champs induits est également verticale.
- Pour un champ électrique externe donné, les champs induits les plus forts le sont dans le corps humain en contact parfait avec le sol par l'intermédiaire des pieds (mise à la terre électrique) et les champs les plus faibles dans le corps isolé du sol ("espace libre").
- Le courant total circulant dans un organisme en contact parfait avec le sol est déterminé par la taille et la forme de l'organisme (notamment la posture), plutôt que par la conductivité des tissus.
- La distribution des courants induits dans les divers organes et tissus est déterminée par la conductivité de ces tissus et organes.
- La distribution d'un champ électrique induit est également fonction des conductivités, mais moins que celle du courant induit.
- Il existe également un phénomène indépendant dans lequel le courant est produit dans l'organisme du fait d'un contact avec un objet conducteur situé dans un champ électrique.

Concernant les champs magnétiques, la perméabilité des tissus est la même que celle de l'air, de sorte que le champ dans les tissus est le même que le champ extérieur. Le corps de l'homme et des animaux ne perturbe pas sensiblement ce champ. La principale interaction des champs magnétiques est l'induction, suivant la loi de Faraday, de champs électriques et des densités de courant associées dans les tissus conducteurs. Les principales caractéristiques de la dosimétrie concernant l'exposition de l'homme aux champs magnétiques EBF sont les suivantes:

- Le champ et le courant électrique induit dépendent de l'orientation du champ extérieur. Les champs induits dans l'organisme dans son ensemble sont plus grands lorsque le champ est aligné de l'avant vers l'arrière du corps, mais, pour certains organes, les valeurs les plus élevées s'observent lorsque le champ est appliqué de côté.
- Les champs électriques les plus faibles sont induits par un champ magnétique orienté le long de l'axe vertical du corps.
- Pour une intensité et une orientation donnée du champ magnétique, l'intensité des champs électriques induits dans un organisme augmentent avec sa taille.

- La distribution du champ électrique induit est modifiée par la conductivité des divers organes et tissus. Ceux-ci ont un effet limité sur la distribution de la densité du courant induit.

16.1.3 Mécanismes biophysiques

Il faut évaluer la plausibilité des divers mécanismes proposés d'interaction directe et indirecte des champs électriques et magnétiques EBF. En particulier, on veut savoir si on peut distinguer un "signal" produit dans un processus biologique par l'exposition à un champ, d'un bruit aléatoire intrinsèque, et si le mécanisme remet en question les principes et connaissances scientifiques actuels. De nombreux mécanismes ne deviennent plausibles qu'à des intensités de champs supérieures à un certain niveau. Néanmoins, l'absence de mécanismes plausibles répertoriés n'exclut pas la possibilité d'effets sur la santé même avec des champs très faibles, pour autant qu'on respecte les principes scientifiques fondamentaux.

Parmi les nombreux mécanismes proposés concernant l'interaction directe des champs avec le corps humain, il en est trois qui pourraient opérer à des intensités de champs plus faibles que les autres: les champs électriques induits dans les réseaux de neurones, les paires de radicaux libres et la présence de magnétite.

Les champs électriques induits dans les tissus par l'exposition à des champs électriques ou magnétiques EBF vont directement stimuler les fibres nerveuses simples myélinisées, et il s'agit d'un mécanisme plausible sur le plan biophysique, lorsque l'intensité du champ interne dépasse quelques $V\ m^{-1}$. Des champs beaucoup plus faibles peuvent modifier la transmission synaptique dans les réseaux neuronaux, au contraire des cellules isolées. Ce traitement du signal par les systèmes nerveux est communément employé par les organismes multicellulaires pour détecter les signaux environnementaux faibles. On a proposé une limite inférieure pour la discrimination par les réseaux nerveux de 1 mV/m, mais, d'après les données actuelles, des valeurs seuils situées autour de 10 à 100 $mV\ m^{-1}$ semblent plus probables.

Le mécanisme des paires de radicaux libres est une modalité acceptée par laquelle les champs magnétiques peuvent modifier des types particuliers de réactions chimiques. On décrit généralement une augmentation de la concentration de radicaux libres sous exposition à des champs faibles et une diminution dans des champs intenses. On a observé ces augmentations dans des champs magnétiques de moins de 1 mT. Il semblerait qu'il y ait un lien entre ce mécanisme et le système de navigation des oiseaux au cours de leur migration. Pour des raisons théoriques et parce que les modifications produites par les champs magnétiques EBF et statiques sont analogues, on pense que des champs à la fréquence du réseau, bien moins intenses que le champ géomagnétique d'environ 50 μT, sont peu susceptibles d'être biologiquement importants.

Les cristaux de magnétite, qui sont de petits cristaux ferromagnétiques d'oxyde de fer de diverses formes, se retrouvent dans les tissus animaux et humains, même si c'est à l'état de traces. Comme les radicaux libres,

ils ont été reliés au système d'orientation et de navigation des animaux migrateurs, bien que la présence de quantités de magnétite à l'état de traces dans le cerveau humain ne lui confère pas d'aptitude à détecter le champ géomagnétique faible. Les calculs basés sur des hypothèses extrêmes laissent à penser que le seuil des effets des champs EBF sur les cristaux de magnétite se situe autour de 5 μT.

Les autres interactions biophysiques directes des champs, comme la cassure des liaisons chimiques, les forces exercées sur les particules chargées et les divers mécanismes de "résonance" en bande étroite ne sont pas considérées comme apportant des explications plausibles aux interactions avec les champs rencontrés dans les environnements publics et professionnels.

Concernant les effets indirects, la charge électrique de surface induite par les champs électriques peut être perçue et entraîner des microchocs douloureux lorsque l'on touche un objet conducteur. Des courants de contact peuvent se produire lorsque, par exemple, de jeunes enfants touchent un robinet de baignoire dans certaines habitations. Cela produit de petits champs électriques, peut-être au-dessus du niveau de bruit de fond, dans la moelle osseuse. Toutefois, on ignore s'ils présentent un risque pour la santé.

Les lignes à haute tension produisent des nuages d'ions chargés électriquement par suite de la décharge par effet couronne. Il semble qu'elles pourraient accroître le dépôt des polluants de l'air sur la peau et dans les voies aériennes, avec d'éventuelles conséquences indésirables pour la santé. Toutefois, il semble peu probable que les ions de la couronne aient plus qu'un effet minime, si ce n'est nul, sur les risques sanitaires à long terme même chez les sujets les plus exposés.

Aucun des trois mécanismes directs évoqués ci-dessus ne semble constituer une cause plausible d'incidence accrue des maladies aux niveaux d'exposition généralement rencontrés. En réalité, ils ne deviendraient plausibles qu'à des intensités bien plus élevées, et les mécanismes indirects n'ont pour l'instant pas été suffisamment étudiés. Cette absence de mécanisme répertorié plausible n'exclut pas la possibilité d'effets indésirables pour la santé, mais crée véritablement un besoin de preuves plus solides venant de la biologie et de l'épidémiologie.

16.1.4 Neurocomportement

L'exposition à des champs électriques à la fréquence du réseau provoque des réponses biologiques bien définies, allant de la perception simple à la gêne, par biais des effets de la charge électrique de surface. Ces réponses dépendent de l'intensité du champ, des conditions environnementales ambiantes et de la sensibilité individuelle. Les seuils de perception directe chez 10% des volontaires se situent entre 2 et 20 kV m^{-1}, tandis que 5% trouvent que des valeurs de 15 à 20 kV m^{-1} sont gênantes. La décharge d'étincelles qu'émet une personne avec le sol est douloureuse pour 7% des volontaires dans un champ de 5 kV m^{-1}. Les seuils pour une décharge à partir d'un objet chargé à travers une personne ayant les pieds au sol dépend de la taille de l'objet et exigent par conséquent une évaluation précise.

Les champs magnétiques de forte intensité et pulsés peuvent stimuler les tissus nerveux périphériques ou centraux; de tels effets peuvent se produire au cours des examens d'imagerie par résonance magnétique (IRM) et sont utilisés dans la stimulation magnétique transcrânienne. Le seuil de champ électrique nécessaire pour provoquer une stimulation nerveuse directe pourrait ne pas dépasser quelques volts par mètre (V/m). Ce seuil est probablement constant sur une gamme de fréquences située entre quelques hertz (Hz) et quelques kilohertz (kHz). Les personnes souffrant d'épilepsie ou prédisposées à cette maladie risquent d'être plus sensibles aux champs électriques EBF induits dans le système nerveux central (SNC). En outre, la sensibilité à la stimulation électrique du SNC semble très probablement être associée à des antécédents familiaux de crises convulsives et à l'utilisation d'antidépresseurs tricycliques, de neuroleptiques et autres médicaments qui abaissent le seuil convulsivogène.

La fonction de la rétine, qui fait partie du SNC, peut être modifiée par l'exposition à des champs magnétiques EBF beaucoup plus faibles que ceux qui provoquent une stimulation nerveuse directe. Une sensation d'éclairs lumineux, appelés phosphènes magnétiques ou magnéto-phosphènes, résulte de l'interaction du champ électrique induit avec les cellules de la rétine électriquement excitables. La valeur seuil du champ électrique induit dans le liquide extracellulaire de la rétine a été estimée entre 10 et 100 mV m^{-1} à 20 Hz. Cependant, une incertitude considérable est attachée à ces valeurs.

Les données relatives à d'autres effets neuro-comportementaux observés dans les études sur des volontaires, par exemple les effets sur l'activité électrique du cerveau, la cognition, le sommeil, l'hypersensibilité et l'humeur sont moins nettes. En général, ces études ont été effectuées à des niveaux d'exposition situés au-dessous de ceux nécessaires pour provoquer les effets décrits ci-dessus et n'ont produit que des effets au mieux subtils et transitoires. Les conditions nécessaires pour déclencher ces réponses ne sont aujourd'hui pas bien connues. Il semblerait qu'il existe des effets sur le temps de réaction et sur une moindre précision observée dans l'exécution de certaines tâches cognitives, ce que viennent conforter les résultats d'études sur l'activité électrique générale du cerveau. Les études cherchant à déterminer si les champs magnétiques modifient la qualité du sommeil ont donné des résultats variables. Il est possible que cette variabilité puisse être attribuée en partie aux différences observées dans la conception de ces études.

Certaines personnes affirment être hypersensibles aux champs électromagnétiques en général. Toutefois, les données des études de provocation en double aveugle laissent à penser que les symptômes rapportés ne sont pas liés à l'exposition aux champs magnétiques EBF.

Il n'y a que des données contradictoires et peu concluantes indiquant que l'exposition aux champs électriques et magnétiques EBF puissent provoquer des symptômes dépressifs ou des suicides. Ainsi, ces données sont considérées comme insuffisantes.

Chez les animaux, la possibilité qu'une exposition aux champs EBF puisse modifier les fonctions neuro-comportementales a été explorée sous divers angles et pour toute une série de conditions d'exposition. Peu d'effets ont été établis avec certitude. Il y a des preuves convaincantes que les champs électriques à la fréquence du secteur peuvent être détectés par les animaux, très probablement par suite d'effets de charge de surface, et puissent provoquer une stimulation ou un stress bénin transitoire. Chez le rat, le seuil de détection se situe entre 3 et 13 kV m^{-1}. On a montré que des champs supérieurs à 50 kV m^{-1} provoquaient une réaction d'aversion chez les rongeurs. Les autres modifications éventuelles dues aux champs sont moins bien définies; les études en laboratoire n'ont permis d'obtenir que des effets subtils et transitoires. Il semblerait que l'exposition aux champs magnétiques puisse moduler les fonctions des systèmes de neurotransmetteurs opioïdes et cholinergiques dans le cerveau, ce qui est conforté par les résultats d'études s'intéressant aux effets sur l'analgésie et sur l'acquisition et l'exécution de tâches liées à la mémoire spatiale.

16.1.5 Système neuroendocrinien

Les résultats des études effectuées chez des volontaires, ainsi que des études épidémiologiques en milieu résidentiel et professionnel, laissent à penser que le système neuroendocrinien n'est pas affecté par l'exposition à des champs électriques ou magnétiques à la fréquence du réseau. Cela vaut particulièrement pour les concentrations circulantes d'hormones spécifiques du système neuroendocrinien, notamment la mélatonine, libérée par l'épiphyse, et pour un certain nombre d'hormones impliquées dans le contrôle du métabolisme et de la physiologie de l'organisme libérées par l'hypophyse. On a parfois observé des différences infimes dans la chronologie de la libération de la mélatonine associées à certaines caractéristiques de l'exposition, mais ces résultats n'ont pas été uniformes. Il est très difficile d'éliminer certains facteurs de confusion dus à toutes sortes d'éléments environnementaux et du mode de vie qui pourraient également modifier les concentrations d'hormones. La plupart des études en laboratoire sur les effets de l'exposition aux EBF sur les concentrations nocturnes de mélatonine chez des volontaires ont montré qu'elle n'avait aucun effet lorsqu'on avait pris soin de neutraliser les éventuels facteurs de confusion.

Parmi les nombreuses études réalisées chez l'animal pour analyser les effets des champs électriques et magnétiques à la fréquence du réseau sur les concentrations pinéales et sériques de mélatonine chez le rat, certaines ont rapporté que l'exposition entraînait une suppression nocturne de la mélatonine. Les changements de concentration de mélatonine observés dans des études antérieures portant sur des expositions à des champs électriques allant jusqu'à 100 kV m^{-1} n'ont pas pu être reproduits. Les résultats d'une série d'études plus récentes, qui ont montré que les champs magnétiques polarisés circulairement supprimaient les concentrations nocturnes de mélatonine, ont perdu du poids du fait de comparaisons inappropriées entre animaux exposés et témoins historiques. Les données d'autres expériences réalisées chez les rongeurs, couvrant des degrés d'intensité allant de quelques microteslas à

5 mT, ont été ambiguës, certains résultats montrant une dépression de la mélatonine et d'autres aucune modification. Chez les animaux se reproduisant à une saison déterminée, la preuve d'un effet de l'exposition à des champs à la fréquence du réseau sur les concentrations de mélatonine et sur l'état reproductif dépendant de la mélatonine est principalement négative. Aucun effet convaincant sur les concentrations de mélatonine n'a été observé dans une étude réalisée chez des primates non humains chroniquement exposés à des champs à la fréquence du réseau, bien qu'une étude préliminaire effectuée sur deux animaux ait rapporté une suppression de la mélatonine en réponse à une exposition irrégulière et intermittente.

Les effets de l'exposition à des champs EBF sur la production de mélatonine ou sa libération dans des épiphyses isolées ont été variables, bien que relativement peu d'études in vitro aient été effectuées. Les éléments de preuve indiquant que l'exposition aux EBF interfère avec l'action de la mélatonine sur les cellules de cancer du sein in vitro sont particulièrement intéressants. Toutefois, ce système souffre de l'inconvénient que les lignées cellulaires montrent fréquemment en culture une dérive génotypique et phénotypique qui peut empêcher leur transfert entre laboratoires.

Aucun effet réplicable n'a été observé sur les hormones liées au stress de l'axe hypophyso-surrénalien de toutes sortes d'espèces de mammifères, à l'exception possible d'un stress de courte durée faisant suite au début d'une exposition à un champ électrique EBF suffisamment intense pour être perçu. De la même façon, alors que peu d'études ont été effectuées, on a observé des effets principalement négatifs ou irréguliers au niveau des concentrations d'hormones de croissance et d'hormones participant au contrôle de l'activité métabolique, ou associées au contrôle de la reproduction et du développement sexuel.

Dans l'ensemble, ces données n'indiquent pas que les champs électriques et/ou magnétiques EBF modifient le système neuroendocrinien et ont des répercussions indésirables sur la santé humaine, et les éléments de preuve sont donc considérés comme insuffisants.

16.1.6 Troubles neurodégénératifs

L'hypothèse a été émise suivant laquelle l'exposition aux champs EBF serait associée à plusieurs maladies neurodégénératives. Concernant la maladie de Parkinson et la sclérose en plaques, le nombre d'études est faible et rien ne permet de penser qu'il y ait une association avec ces maladies.

Pour la maladie d'Alzheimer et la sclérose latérale amyotrophique (SLA), davantage d'études ont été publiées. Certains de ces rapports laissent à penser que les personnes ayant des professions dans le secteur de l'électricité pourraient avoir un risque accru de SLA. Jusqu'ici, aucun mécanisme biologique n'a été établi qui pourrait expliquer une telle association, la maladie ayant pu apparaître à cause de facteurs de confusion liés à ce type de professions, par exemple les chocs électriques. Dans l'ensemble, les éléments en faveur d'une association entre exposition aux EBF et SLA sont considérés comme insuffisants. Les quelques études portant sur l'association entre

exposition aux EBF et maladie d'Alzheimer ont donné des résultats variables. Toutefois, la meilleure qualité des études axées sur la morbidité par Alzheimer, plutôt que sur la mortalité, n'indique aucune association. Dans l'ensemble, les éléments en faveur d'une association entre l'exposition aux EBF et la maladie d'Alzheimer sont insuffisants.

16.1.7 Troubles cardio-vasculaires

Les études expérimentales sur l'exposition à court et long terme indiquent que si le choc électrique constitue un risque manifeste pour la santé, les autres effets cardio-vasculaires dangereux associés aux champs EBF ont peu de chances de se produire aux niveaux d'exposition communément rencontrés dans l'environnement naturel ou professionnel. Bien qu'on ait signalé dans la littérature diverses modifications cardio-vasculaires, la majorité des effets sont mineurs et les études n'ont pas donné de résultats homogènes. Aucune des études de la morbidité et de la mortalité des maladies cardio-vasculaires n'a montré d'association avec l'exposition, sauf une. Le fait de savoir s'il existe une association entre l'exposition et l'altération du contrôle autonome du coeur donne lieu à bien des conjectures. Dans l'ensemble, les éléments dont on dispose ne sont pas en faveur d'une association entre exposition aux EBF et maladie cardio-vasculaire.

16.1.8 Immunologie et hématologie

Les données concernant les effets des champs électriques ou magnétiques EBF sur des constituants du système immunitaire sont généralement peu homogènes. La plupart des populations cellulaires et marqueurs fonctionnels ne sont pas perturbés par l'exposition. Cependant, dans certaines études humaines réalisées avec des champs allant de 10 μT à 2 mT, on a observé des modifications des cellules Natural Killer (NK), qui ont montré à la fois une augmentation et une diminution de leur nombre, et dans la numération leucocytaire totale qui a montré soit une absence de modification, soit une diminution du nombre de leucocytes. Dans des études réalisées chez l'animal, on a observé une diminution de l'activité des cellules NK chez la souris femelle, mais pas chez les mâles ni chez des rats des deux sexes. Les numérations leucocytaires ont également montré une certaine variabilité, avec des diminutions ou une absence de modification, rapportées dans différentes études. Les expositions auxquelles étaient soumis les animaux allaient de 2 μT à 30 mT. La difficulté qu'il y a à interpréter les effets potentiels de ces données sur la santé est due aux grandes variations enregistrées dans les conditions d'exposition et environnementales, ainsi qu'au nombre relativement faible de sujets testés et à la vaste gamme des paramètres biologiques étudiés.

Il y a eu peu d'études sur les effets des champs magnétiques EBF sur le système hématologique. Dans les expériences évaluant les numérations leucocytaires différentielles, les expositions allaient de 2 μT à 2 mT. Aucun effet constant de l'exposition aiguë aux champs magnétiques EBF ou aux champs magnétiques et électriques EBF combinés n'a été trouvé dans les études réalisées chez l'homme ou chez l'animal.

Par conséquent, d'une manière générale, les éléments en faveur d'effets des champs électriques ou magnétiques EBF sur les systèmes immunitaire et hématologique sont considérés comme insuffisants.

16.1.9 Reproduction et développement

Dans l'ensemble, les études épidémiologiques n'ont pas montré d'association entre leurs résultats dans le domaine de la reproduction de l'homme et l'exposition maternelle ou paternelle à des champs EBF. Il existe des éléments en faveur d'un risque accru de fausse-couche associé à l'exposition maternelle au champ magnétique, mais ils sont insuffisants.

Les effets d'expositions aux champs électriques EBF jusqu'à 150 kV m^{-1} ont été évalués chez plusieurs espèces de mammifères, notamment dans des études sur l'exposition de grands groupes et sur plusieurs générations. Les résultats montrent systématiquement qu'il n'y a aucun effet indésirable sur le développement.

L'exposition de mammifères aux champs magnétiques EBF jusqu'à 20 mT n'entraîne pas de malformations externes, squelettiques ou viscérales grossières. Certaines études montrent une augmentation des anomalies mineures du squelette chez le rat et la souris. Ces variations sont relativement courantes dans les études de tératologie et sont souvent considérées comme sans signification biologique. Toutefois, des effets subtils des champs magnétiques sur le développement squelettique ne peuvent être écartés. Très peu d'études ont été publiées sur les effets sur la reproduction et il est impossible d'en tirer des conclusions.

Plusieurs études sur des modèles expérimentaux autres que mammifères (embryons de poulets, poissons, oursins et insectes) ont donné des résultats indiquant que les champs magnétiques EBF de l'ordre du microtesla peuvent perturber le début du développement. Mais les résultats de ces modèles expérimentaux ont moins de poids dans l'évaluation générale de la toxicité sur le développement que ceux des études correspondantes réalisées chez les mammifères.

Dans l'ensemble, les éléments en faveur d'effets sur le développement et la reproduction sont insuffisants.

16.1.10 Cancer

La classification du Centre International de Recherche sur le Caner (CIRC, IARC) des champs magnétiques EBF comme étant "peut-être cancérogènes pour l'homme" (IARC, 2002) est basée sur l'ensemble des données disponibles en 2001. L'examen de la littérature dans la présente monographie des critères d'hygiène de l'environnement est principalement axé sur des études publiées après l'analyse du CIRC.

Epidémiologie

La classification du CIRC a été fortement influencée par les associations observées dans les études épidémiologiques sur la leucémie infantile.

Le fait de classer ces éléments comme étant limités n'est pas modifié avec l'adjonction de deux études sur la leucémie infantile publiées après 2002. Depuis la publication de la monographie du CIRC, les éléments relatifs à d'autres cancers chez l'enfant restent insuffisants.

Un certain nombre de rapports a été publié à la suite de la monographie du CIRC concernant le risque de cancer du sein chez la femme adulte associé à l'exposition à des champs magnétiques EBF. Ces études sont de taille plus importante que les précédentes et moins susceptibles de présenter des biais et sont dans l'ensemble négatives. Elles ont donc considérablement affaibli les éléments en faveur d'une association entre exposition à des champs magnétiques EBF et risque de cancer du sein chez la femme et ne vont plus du tout dans le sens d'une telle association.

Dans le cas des tumeurs cérébrales et des leucémies chez l'adulte, les nouvelles études publiées après la monographie du CIRC ne modifient pas la conclusion selon laquelle les éléments en faveur d'une association entre champs magnétiques EBF et ces maladies restent insuffisants.

Pour les autres maladies et tous les autres cancers, les éléments restent insuffisants.

Etudes sur les animaux de laboratoire

Il n'existe actuellement aucun modèle animal approprié de la forme de leucémie infantile la plus commune, la leucémie aiguë lymphoblastique. Trois études indépendantes à grande échelle effectuées chez le rat n'ont fourni aucune preuve d'un effet des champs magnétiques EBF sur l'incidence des tumeurs mammaires spontanées. La plupart des études rapportent l'absence d'effets des champs magnétiques EBF sur la leucémie ou le lymphome dans les modèles murins. Plusieurs études à grande échelle et à long terme effectuées chez des rongeurs n'ont montré aucune augmentation systématique d'aucun type de cancer, notamment des tumeurs hématopoïétiques, mammaires, cérébrales et cutanées.

Un nombre non négligeable d'études a examiné les effets des champs magnétiques EBF sur les tumeurs mammaires induites chimiquement chez le rat. Elles ont obtenu des résultats variables qui peuvent être dus entièrement ou partiellement à des différences dans les protocoles expérimentaux, par exemple à l'utilisation de sous-souches particulières. La plupart des études sur les effets de l'exposition à des champs magnétiques EBF sur des modèles de leucémie/lymphome chimiquement induits ou induits par le rayonnement n'ont pas montré d'effets. Les études sur les lésions hépatiques précancéreuses, les tumeurs cutanées et cérébrales chimiquement induites ont en majorité rapporté l'absence d'effets. Une étude a signalé une accélération de la genèse tumorale cutanée induite par les UV après exposition à des champs magnétiques EBF.

Deux groupes ont signalé des niveaux accrus de lésions des brins d'ADN dans le tissu cérébral suite à une exposition *in vivo* à des champs magnétiques EBF. Toutefois, d'autres groupes, en utilisant toutes sortes de

modèles murins de génotoxicité, n'ont trouvé aucun signe d'effets génotoxiques. Les résultats des études s'intéressant aux effets non génotoxiques en rapport avec le cancer ne permettent pas de tirer des conclusions.

Dans l'ensemble, rien ne permet de penser que l'exposition à des champs magnétiques EBF seule puisse provoquer des tumeurs. Les éléments indiquant que l'exposition à un champ magnétique EBF peut favoriser le développement d'une tumeur lorsqu'elle est associée à des facteurs cancérogènes sont insuffisants.

Etudes in vitro

En général, les études sur les effets de l'exposition de cellules à un champ EBF ont montré qu'il n'y avait pas d'effets génotoxiques pour des intensités de champ inférieures à 50 mT. Il existe cependant une exception notable, à savoir les données d'études récentes signalant une altération de l'ADN à des champs aussi faibles que 35 µT; cependant, ces études sont encore en cours d'évaluation et notre compréhension de ces résultats reste incomplète. Tout porte également à croire que les champs magnétiques EBF peuvent interagir avec des agents altérant d'ADN.

Il n'y a pas de preuve nette d'une activation des gènes associés au contrôle du cycle cellulaire par des champs magnétiques EBF. Cependant, il faut encore mener des études systématiques analysant la réponse de l'ensemble du génome.

De nombreuses autres études à l'échelle cellulaire, par exemple sur la prolifération cellulaire, le phénomène d'apoptose, le signal calcique et la transformation maligne, ont donné des résultats non homogènes ou ne permettant pas de tirer de conclusions.

Conclusion générale

Les nouvelles études réalisées chez l'homme, chez l'animal et in vitro et publiées depuis la monographie du CIRC en 2002 ne modifient en rien la classification générale des champs magnétiques EBF, considérés comme cancérogènes possibles pour l'homme.

16.1.11 Evaluation du risque pour la santé

D'après la Constitution de l'OMS, la santé est un état de bien-être physique, mental et social complet et pas simplement l'absence de maladie ou d'infirmité. Une évaluation du risque est un cadre conceptuel pour un examen structuré des informations utiles à l'estimation des résultats sur la santé ou l'environnement. L'évaluation du risque sanitaire peut être utilisée comme un élément de la gestion du risque qui englobe toutes les activités nécessaires pour parvenir à des décisions relatives au fait qu'une exposition exige ou non des mesures particulières et la mise en oeuvre de celles-ci.

Dans l'évaluation des risques pour la santé de l'homme, de solides données concernant l'homme, chaque fois qu'elles sont disponibles, sont généralement plus instructives que celles recueillies chez l'animal. Les

études chez l'animal et les études in vitro peuvent étayer les données des études chez l'homme, combler les lacunes laissées par les études chez l'homme, ou être utilisées pour prendre une décision relative aux risques lorsque les études chez l'homme sont insuffisantes ou absentes.

Toutes les études, qu'elles aient des résultats positifs ou négatifs (présence ou absence d'effets), doivent être évaluées et jugées pour elles-mêmes puis toutes ensembles à partir des données disponibles. Il est important de déterminer dans quelle mesure une série d'éléments modifie la probabilité pour qu'une exposition provoque un résultat. Les éléments de preuve de l'existence d'un effet sont généralement renforcés si les résultats de différents types d'études (épidémiologiques et expérimentales) laissent entrevoir la même conclusion et/ou lorsque de multiples études du même type donnent le même résultat.

Effets aigus

Des effets biologiques aigus ont été établis pour une exposition aux champs électriques et magnétiques EBF dans la gamme de fréquences allant jusqu'à 100 kHz, effets qui peuvent avoir des conséquences indésirables sur la santé. Par conséquent, des limites d'exposition sont nécessaires. Il existe des directives internationales qui traitent de cette question. L'observance de ces directives assure une protection suffisante contre les effets aigus.

Effets chroniques

Les données scientifiques laissant à penser que l'exposition quotidienne chronique à des champs magnétiques à la fréquence du réseau, de faible intensité (au-dessus de 0,3–0,4 μT), constitue un risque pour la santé sont basées sur des études épidémiologiques mettant en évidence un profil homogène de risque de leucémie infantile accru. Les incertitudes de cette évaluation du risque incluent le biais de sélection des témoins et les erreurs de classification de l'exposition sur la relation entre champs magnétiques et leucémie infantile. En outre, pratiquement toutes les données de laboratoire et toutes les données mécanistiques ne vont pas dans le sens d'une association entre champs magnétiques EBF de faible intensité et modifications de fonctions biologiques ou de l'état sanitaire. Ainsi, tout bien considéré, les éléments de preuve ne sont pas suffisamment solides pour être considérés comme établissant un lien de causalité, mais le sont suffisamment pour rester préoccupants.

Bien que l'on n'ait pas pu établir une relation de cause à effet entre l'exposition à un champ magnétique EBF et la leucémie infantile, son effet possible sur la santé publique a été calculé en partant du principe de causalité de façon à fournir un élément potentiellement utile à la politique de santé. Toutefois, ces calculs dépendent fortement de la distribution de l'exposition et d'autres hypothèses et sont par conséquent très imprécis. En partant du principe que l'association est causale, le nombre de cas de leucémie infantile dans le monde qui pourrait être attribué à l'exposition peut, selon les estimations, se situer entre 100 et 2400 cas par an. Toutefois, cela ne représente que

0,2 à 4,9% de l'incidence annuelle totale des cas de leucémie, estimée à 49 000 dans le monde en 2000. Ainsi, dans le contexte mondial, l'impact sur la santé publique, pour autant qu'il y en ait, serait limité et incertain.

On a étudié un certain nombre d'autres maladies à la recherche d'une association éventuelle avec une exposition aux champs magnétiques EBF. Parmi elles figurent des cancers de l'enfant et de l'adulte, la dépression, le suicide, des dysfonctionnements de l'appareil reproducteur, des troubles du développement, des modifications immunologiques et des maladies neurologiques. Les données scientifiques en faveur d'un lien entre champs magnétiques EBF et l'une quelconque de ces maladies sont beaucoup plus ténues que pour la leucémie infantile et, dans certains cas (par exemple, s'agissant des maladies cardio-vasculaires ou du cancer du sein), elles sont suffisantes pour que l'on soit assuré que les champs magnétiques EBF ne provoquent pas ces maladies.

16.1.12 Mesures de protection

Il est essentiel de mettre en application des limites d'exposition de façon à se protéger des effets indésirables établis de l'exposition aux champs électriques et magnétiques EBF. Ces limites d'exposition doivent être basées sur un examen rigoureux de toutes les données scientifiques pertinentes.

Seuls des effets aigus ont été établis et il existe deux directives internationales relatives aux limites d'exposition (ICNIRP, 1998a; IEEE, 2002) destinées à protéger contre ces effets.

En même temps que ces effets aigus attestés, il existe des incertitudes concernant l'existence d'effets chroniques, à cause des éléments limités qui existent en faveur d'un lien entre exposition aux champs magnétiques EBF et leucémie infantile. Par conséquent, il est justifié de faire appel à des stratégies prudentes. Toutefois, il n'est pas recommandé de réduire les valeurs limites figurant dans les normes relatives à l'exposition jusqu'à un niveau arbitraire au nom du principe de précaution. De telles pratiques sapent les fondements scientifiques sur lesquels les limites sont basées et risquent de constituer une approche coûteuse, mais pas nécessairement efficace, d'assurer la protection.

La mise en œuvre d'autres types de mesures de précaution adaptées pour réduire l'exposition est raisonnable et justifiée. Toutefois, l'énergie électrique apporte des bienfaits évidents sur le plan sanitaire, social et économique et il ne faut pas que ces mesures les mettent en péril. Qui plus est, étant donné la faiblesse des éléments en faveur d'un lien entre exposition aux champs magnétiques EBF et leucémie infantile et les effets limités sur la santé publique si un tel lien existe, il est malaisé de déterminer les bienfaits qu'apporterait pour la santé une réduction de l'exposition. Ainsi, le coût des mesures de précaution doit être très bas. Le coût de la mise en oeuvre des réductions d'exposition variera d'un pays à l'autre, ce qui fait qu'il est très difficile de formuler une recommandation générale visant à équilibrer les coûts face à un risque potentiel imputable aux champs EBF.

Compte tenu de ce qui précède, les recommandations qui suivent ont été formulées.

- Les responsables de l'élaboration des politiques sanitaires doivent établir des lignes directives concernant l'exposition aux champs EBF à l'intention du grand public et des entreprises. Les directives internationales constituent la meilleure source d'orientation, aussi bien pour les niveaux d'exposition que pour les principes de l'évaluation scientifique des risques.
- Les responsables de l'élaboration des politiques doivent mettre en place un programme de protection contre les champs EBF comportant la mesure des champs de toutes origines pour veiller à ce que les limites d'exposition ne soient pas dépassées pour le grand public et lors d'expositions professionnelles.
- A condition de ne pas mettre en péril les bienfaits apportés sur le plan sanitaire, social et économique par l'énergie électrique, la mise en œuvre de mesures de précaution à très bas coût afin de réduire l'exposition est raisonnable et justifiée.
- Les responsables de l'élaboration des politiques sanitaires, les autorités locales et les fabricants doivent mettre en œuvre des mesures à très bas coût lorsqu'ils construisent de nouvelles installations et conçoivent un nouvel équipement, notamment de nouveaux appareils.
- Il faut envisager d'apporter des modifications aux pratiques de l'ingénierie afin de réduire l'exposition aux EBF des appareils ou dispositifs, à condition qu'elles se conjuguent avec d'autres avantages, par exemple une meilleure sécurité ou un coût faible ou nul.
- Lorsque l'on envisage d'apporter des changements aux sources EBF existantes, il faut étudier les possibilités de réduction du champ EBF en même temps que les aspects liés à la sécurité, à la fiabilité et au volet économique du projet.
- Les autorités locales doivent faire appliquer les réglementations relatives aux installations électriques afin de réduire les courants de terre non intentionnels lorsque l'on construit de nouvelles installations ou que l'on refait les installations existantes, tout en conservant la sécurité. Des mesures proactives visant à recenser les violations de ces règles ou les problèmes existants dans les installations électriques seraient coûteuses et peu susceptibles d'être justifiées.
- Les autorités nationales doivent mettre en œuvre une stratégie de communication efficace et ouverte pour permettre une prise de décision éclairée par toutes les parties prenantes ; celle-ci doit comprendre des informations sur la façon dont les personnes peuvent réduire leur propre exposition.

- Les autorités locales doivent améliorer la planification des installations émettrices de champs EBF, notamment en procédant à des consultations plus larges entre l'industrie, les pouvoirs publics locaux et les citoyens lorsqu'il s'agit d'implanter d'importantes sources EBF.
- Les pouvoirs publics et l'industrie doivent promouvoir des programmes de recherche visant à réduire l'incertitude des données scientifiques concernant les effets sanitaires de l'exposition aux champs EBF.

16.2 Recommandations en matière de recherche

La détermination des lacunes dans les connaissances relatives aux effets sanitaires possibles d'une exposition aux champs EBF constitue une part essentielle de cette évaluation du risque sanitaire. Il en a résulté les recommandations qui suivent relatives à la recherche à venir (résumées au Tableau 1).

La priorité des priorités pour la recherche est de s'intéresser aux fréquences intermédiaires, se situant communément entre 300 Hz et 100 kHz, étant donné l'actuel manque de données les concernant. Une très faible partie du corpus de connaissances nécessaires pour une évaluation du risque a été rassemblée et la plupart des études existantes ont donné des résultats variables, qui doivent être mieux étayés. Les normes générales de constitution d'une base de données sur les fréquences intermédiaires, qui soit suffisante pour l'évaluation du risque sanitaire, comprennent l'évaluation de l'exposition, des études épidémiologiques, des études sur l'homme en laboratoire et des études sur l'animal et sur les cellules (in vitro) (ICNIRP, 2003; ICNIRP, 2004; Litvak et al., 2002).

Pour toutes les études sur des volontaires, il est obligatoire que la recherche sur les sujets humains soit effectuée en conformité totale avec les principes éthiques, y compris les dispositions de la déclaration d'Helsinki (WMA, 2004).

Pour les études de laboratoire, on accordera la priorité aux réponses notifiées (i) pour lesquelles il y a au moins quelques éléments de réplication ou de confirmation, (ii) qui sont potentiellement en rapport avec la cancérogenèse (par exemple, la génotoxicité), (iii) qui sont suffisamment solides pour permettre une analyse mécanistique et (iv) qui se produisent dans des modèles mammifères ou humains.

16.2.1 Sources, mesurage et expositions

La caractérisation plus précise des habitations ayant une exposition élevée aux EBF dans différents pays, afin de déterminer la contribution relative des sources internes et externes, ainsi que l'influence des pratiques en matière d'installation électrique/de mise à la terre et autres caractéristiques des habitations, pourraient fournir des indications concernant une méthode pertinente de mesure de l'exposition pour les évaluations épidémiologiques. Mieux connaître l'exposition fœtale et infantile aux champs EBF en est une

composante importante, surtout s'agissant de l'exposition à un chauffage électrique par le sol ou aux transformateurs dans les immeubles.

On soupçonne que, dans certains cas d'exposition professionnelle, les limites d'exposition aux champs EBF des directives actuelles sont dépassées. Davantage d'informations sont nécessaires sur l'exposition professionnelle (y compris aux fréquences qui ne sont pas celles du réseau) liée par exemple à l'entretien des lignes sous tension, au travail à l'intérieur ou à proximité de l'entrefer des aimants d'IRM (et donc des champs EBF à gradient commuté) et aux réseaux de transport de l'électricité. De la même façon, des connaissances supplémentaires sont nécessaires concernant l'exposition du grand public qui pourrait approcher les limites des directives, notamment s'agissant de sources telles que les systèmes de sécurité, les systèmes de démagnétisation des bibliothèques, les appareils de cuisson par induction et de chauffage de l'eau.

L'exposition à des courants de contact a été proposée comme explication possible de l'association entre champs magnétiques EBF et leucémie infantile. Des recherches sont nécessaires dans des pays autres que les Etats-Unis d'Amérique afin d'évaluer la possibilité que les pratiques de mise à la terre et de plomberie utilisées dans les habitations donnent naissance à des courants de contact. Ces études auront la priorité dans les pays dans lesquels les résultats épidémiologiques concernant les EBF et la leucémie infantile sont significatifs.

16.2.2 Dosimétrie

Dans le passé, la plupart des recherches en laboratoire était fondée sur les courants électriques induits dans l'organisme, et la dosimétrie était ainsi axée sur cette quantité. Ce n'est que récemment que les travaux ont commencé à explorer les rapports entre exposition externe et champs électriques induits. Pour mieux comprendre les effets biologiques, on a besoin de davantage de données sur les champs électriques internes dans différentes conditions d'exposition.

Il faudrait procéder à une estimation des champs électriques internes dus à l'influence combinée des champs électriques et magnétiques externes dans différentes configurations. L'addition vectorielle des champs électriques et magnétiques qui sont sans relation de phase et variables dans l'espace est nécessaire pour déterminer les restrictions de base à respecter.

Très peu d'évaluations ont été effectuées sur des modèles précis de femme enceinte et de fœtus comportant une modélisation anatomique appropriée. Il est important d'estimer l'éventuelle induction de champs électriques chez le fœtus en relation avec le problème de la leucémie infantile car les expositions tant professionnelles que résidentielles de la mère sont importantes.

Il faut affiner encore les modèles micro-dosimétriques pour pouvoir tenir compte de l'architecture cellulaire des réseaux nerveux et autres systèmes infra-organiques complexes dont on sait qu'ils sont plus sensibles

aux effets induits par le champ électrique. Ce processus de modélisation doit également se pencher sur les influences s'exerçant sur les potentiels électriques de la membrane cellulaire et sur la libération des neurotransmetteurs.

16.2.3 Mécanismes biophysiques

Il y a trois sujets principaux pour lesquels il y a des limites évidentes à la compréhension que l'on a des mécanismes: les paires de radicaux libres, les particules magnétiques présentes dans l'organisme et le rapport signal/bruit dans les systèmes multicellulaires, tels que les réseaux neuronaux.

Le mécanisme des paires de radicaux libres est l'un des mécanismes d'interaction de faible intensité les plus plausibles, mais il reste à montrer qu'il est capable d'assurer la médiation d'effets importants dans le métabolisme et le fonctionnement cellulaire. Il est particulièrement important de comprendre quelle est la limite inférieure d'exposition à laquelle il agit, de façon à pouvoir estimer s'il pourrait ou non constituer un mécanisme pertinent de cancérogenèse. Etant donné les études récentes dans lesquelles les espèces oxygénées radicalaires ont été augmentées dans les cellules immunitaires exposées aux champs EBF, il est recommandé d'utiliser comme modèle cellulaire, pour l'analyse du potentiel de ce mécanisme des paires de radicaux libres, des cellules du système immunitaire qui produisent des espèces oxygénées radicalaires dans le cadre de leur réponse immunitaire.

Bien que la présence de particules magnétiques (cristaux de magnétite) dans le cerveau humain ne semble pas, d'après ce que l'on sait actuellement, conférer une sensibilité aux champs magnétiques EBF environnementaux, les approches théoriques et expérimentales à venir devraient déterminer si une telle sensibilité pourrait exister dans certaines conditions. En outre, toute modification du mécanisme des paires de radicaux libres évoqué ci-dessus, engendrée par la présence de magnétite, devrait être recherchée.

Il convient d'analyser de façon approfondie la mesure dans laquelle des mécanismes multicellulaires opèrent dans le cerveau pour augmenter le rapport signal/bruit, afin d'élaborer un cadre théorique permettant de quantifier le phénomène ou de déterminer ses limites. L'étude complémentaire du seuil et de la fréquence de réponse dans les réseaux neuronaux de l'hippocampe et d'autres parties du cerveau devrait être effectuée in vitro.

16.2.4 Neuro-comportement

Il est recommandé d'effectuer des études sur des volontaires en laboratoire sur les effets possibles sur le sommeil et sur la réalisation de tâches mentalement éprouvantes, au moyen d'approches méthodologiques harmonisées. Il faut préciser les réponses dose-réponse à des densités de flux magnétique supérieures à celles utilisées auparavant, et pour une gamme élargie de fréquences (c'est-à-dire dans la gamme des kilohertz).

Les études sur des adultes volontaires et sur les animaux laissent à penser que des effets cognitifs aigus peuvent se produire avec les expositions à court terme à des champs électriques ou magnétiques intenses. La caractérisation de ces effets est très importante pour l'élaboration de limites relatives à l'exposition, mais on manque de données précises concernant les effets dépendant du champ chez l'enfant. La mise en oeuvre d'études en laboratoire de la cognition et des modifications de l'électroencéphalogramme (ECG) enregistrées chez les personnes exposées aux champs EBF est recommandée, notamment chez les adultes régulièrement soumis à une exposition professionnelle et chez les enfants.

Les études comportementales sur des animaux immatures offrent un indicateur utile des effets cognitifs éventuels chez l'enfant. Les effets possibles d'une exposition pré- et postnatale aux champs magnétiques EBF sur le développement du système nerveux et la fonction cognitive devraient être étudiés. Ces études pourraient être utilement complétées par l'analyse des effets de l'exposition aux champs magnétiques EBF et aux champs électriques induits sur la croissance des cellules nerveuses au moyen de coupes de cerveaux ou de neurones en culture.

Il est nécessaire de s'intéresser plus avant aux conséquences sanitaires potentielles que laissent entrevoir les données expérimentales montrant des réponses opioïdes et cholinergiques chez l'animal. Les études portant sur la modulation des réponses opioïdes et cholinergiques chez l'animal doivent être étendues et il convient de définir des paramètres d'exposition et le fondement biologique de ces réponses comportementales.

16.2.5 Système neuroendocrinien

La base de données existante relative à la réponse neuroendocrinienne n'indique pas que l'exposition aux champs EBF pourrait avoir des effets indésirables sur la santé humaine. Par conséquent, aucune recommandation relative à des recherches supplémentaires n'est formulée.

16.2.6 Troubles neurodégénératifs

Plusieurs études ont montré un risque accru de sclérose latérale amyotrophique dans les "professions liées à l'électricité". On considère qu'il est important d'étudier cette association plus avant, de façon à découvrir si les champs magnétiques EBF font partie des causes de cette maladie neurodégénérative rare. Cette recherche demande de grandes études de cohortes prospectives comportant des informations sur l'exposition aux champs magnétiques EBF, aux chocs électriques et à d'autres facteurs de risque.

Il n'est pas certain que les champs magnétiques EBF constituent un facteur de risque de la maladie d'Alzheimer. Les données actuellement disponibles ne sont pas suffisantes et cette association doit être analysée de façon approfondie. L'utilisation des données de morbidité plutôt que de mortalité revêt une importance particulière.

16.2.7 Troubles cardio-vasculaires

Des recherches plus approfondies sur l'association entre champs magnétiques EBF et risque de maladie cardiovasculaire ne sont pas considérées comme une priorité.

16.2.8 Immunologie et hématologie

Les modifications observées dans les paramètres immunitaires et hématologiques d'adultes exposés aux champs magnétiques EBF ont montré des variations et il n'y a pratiquement aucune donnée issue de la recherche qui soit disponible sur les enfants. Par conséquent, la recommandation est de mener des études sur les effets de l'exposition aux EBF sur le développement des systèmes immunitaires et hématopoïétiques chez le jeune animal.

16.2.9 Reproduction et développement

Il semblerait qu'il y ait un risque accru de fausse couche associé à l'exposition aux champs magnétiques EBF. Etant donné l'effet potentiellement important pour la santé publique d'une telle association, une recherche épidémiologique approfondie est recommandée.

16.2.10 Cancer

La priorité des priorités pour la recherche dans ce domaine consiste à résoudre le conflit entre les données épidémiologiques (qui montrent une association entre l'exposition aux champs magnétiques EBF et un risque accru de leucémie infantile) et les données expérimentales et mécanistiques (qui ne sont pas en faveur d'une telle association). Il est recommandé que les épidémiologistes et les spécialistes des sciences expérimentales collaborent dans ce domaine. Pour que les nouvelles études épidémiologiques soient instructives, elles doivent être axées sur de nouveaux aspects de l'exposition, sur l'interaction potentielle avec d'autres facteurs ou sur les groupes fortement exposés, ou doivent être novatrices à un autre titre dans ce domaine de recherche. De plus, il est également recommandé de mettre à jour les analyses existantes groupées, en ajoutant les données des études récentes et en donnant un nouvel éclairage à ces analyses.

Les études sur les tumeurs cérébrales chez l'enfant ont donné des résultats variables. Comme pour la leucémie infantile, une analyse groupée des études sur ces tumeurs serait très instructive et elle est donc recommandée. Une telle analyse globale peut, à peu de frais, donner un aperçu plus vaste et meilleur des données existantes, notamment sur l'existence d'un biais de sélection et, si les études sont suffisamment homogènes, peut offrir une meilleure estimation du risque.

Concernant le cancer du sein chez l'adulte, des études plus récentes ont montré de façon convaincante qu'il n'y avait aucune association avec l'exposition aux champs magnétiques EBF. Par conséquent, d'autres recherches sur une telle association devraient se voir accorder une très faible priorité à l'avenir.

Concernant la leucémie et le cancer du cerveau chez l'adulte, la recommandation est de mettre en œuvre de grandes cohortes de sujets exposés professionnellement qui existent. Les études sur l'exposition professionnelle, les analyses et les méta-analyses groupées relatives à la leucémie et au cancer du cerveau ont donné des résultats variables et peu concluants. Toutefois, de nouvelles données ont été publiées par la suite qui devraient être utilisées pour actualiser ces analyses.

La priorité est d'examiner les données épidémiologiques en établissant des modèles animaux et in vitro appropriés pour les réponses aux champs magnétiques EBF de faible intensité, modèles qui soient largement transférables d'un laboratoire à l'autre.

Les modèles de rongeurs transgéniques utilisés pour l'étude de la leucémie infantile doivent être développés de façon à fournir des modèles animaux expérimentaux permettant d'étudier les effets de l'exposition aux champs magnétiques EBF. Par ailleurs, pour les études existantes sur l'animal, la majorité des données disponibles indiquent qu'il n'y a pas d'effets cancérogènes dus aux seuls champs magnétiques EBF. Il faut par conséquent accorder un rang de priorité élevé aux études in vitro et chez l'animal dans lesquelles les champs magnétiques EBF sont rigoureusement évalués en tant que cofacteurs de la cancérogenèse.

Concernant les autres études in vitro, les expériences faisant état d'effets génotoxiques de l'exposition à un champ magnétique EBF intermittent doivent être reproduites.

16.2.11 Mesures de protection

Il est recommandé d'effectuer des recherches sur l'élaboration de politiques de protection sanitaire et sur la mise en oeuvre de celles-ci dans les secteurs où il n'y a pas de certitude scientifique, plus précisément sur le recours au principe de précaution, l'interprétation de ce dernier et l'évaluation des effets des mesures de précaution prises contre les champs magnétiques EBF et autres agents rangés dans les "cancérogènes possibles pour l'homme". Lorsqu'il y a incertitude quant au risque sanitaire potentiel qu'un agent représente pour la société, des mesures de précaution peuvent être justifiées pour garantir la protection appropriée du grand public et des travailleurs. Seules des recherches limitées ont été effectuées dans ce domaine pour les champs magnétiques EBF et, parce qu'elles sont importantes, des recherches complémentaires sont nécessaires. Elles permettront peut-être aux pays d'intégrer le principe de précaution dans leurs politiques de protection de la santé.

Il est conseillé de procéder à une recherche approfondie sur la perception du risque et la communication sur les risques spécifiquement axée sur les champs électromagnétiques. Les facteurs psychologiques et sociologiques qui influent sur la perception du risque en général ont été largement étudiés. Toutefois, une recherche limitée a été menée pour analyser l'importance relative de ces facteurs dans le cas des champs électromagnétiques ou pour répertorier d'autres facteurs qui seraient spécifiques aux

champs électromagnétiques. Les études récentes laissent à penser que les mesures de précaution qui véhiculent implicitement des messages de risque peuvent modifier la perception du risque en augmentant ou en réduisant l'inquiétude. Des études approfondies dans ce domaine sont par conséquent justifiées.

Il convient de mener à bien une recherche sur l'élaboration d'une analyse coût-bénéfice/coût-efficacité afin d'atténuer l'exposition aux champs magnétiques EBF. Le recours à des analyses coût/bénéfice et coût/efficacité, afin d'évaluer si une orientation politique est bénéfique pour la société, a fait l'objet de recherches dans de nombreux secteurs de l'action des pouvoirs publics. L'élaboration d'un cadre qui recensera les paramètres nécessaires pour pouvoir effectuer cette analyse s'agissant des champs magnétiques EBF est nécessaire. Vu les incertitudes de l'évaluation, il faudra incorporer des paramètres quantifiables et non quantifiables.

Tableau 1. Recommandations de recherche

Sources, mesures et expositions	**Priorité**
Caractérisation approfondie des habitations soumises à une forte exposition au champ magnétique EBF dans différents pays	Moyenne
Recensement des lacunes dans les connaissances concernant l'exposition professionnelle aux EBF, par exemple s'agissant de l'IRM	Elevée
Evaluation de la capacité des installations électriques domestiques, en dehors des Etats-Unis d'Amérique, à induire des courants de contact chez l'enfant	Moyenne
Dosimétrie	
Dosimétrie numérique complémentaire reliant les champs électriques et magnétiques externes aux champs électriques internes, en particulier s'agissant de l'exposition à des champs électriques et magnétiques combinés dans diverses orientations	Moyenne
Calcul des champs et courants électriques induits chez la femme enceinte et chez le fœtus	Moyenne
Affinement des modèles micro-dosimétriques prenant en compte l'architecture cellulaire des réseaux nerveux et autres systèmes tissulaires complexes	Moyenne
Mécanismes biophysiques	
Etude approfondie des mécanismes des paires de radicaux dans les cellules immunitaires qui génèrent des espèces radicalaires de l'oxygène dans le cadre de leur fonction phénotypique	Moyenne
Etude théorique et expérimentale approfondie du rôle possible de la magnétite dans la sensibilité au champ magnétique EBF	Faible

Détermination des seuils de réponse aux champs électriques internes induits par les EBF sur les systèmes multicellulaires, comme les réseaux nerveux, à l'aide de méthodes théoriques et in vitro	Elevée
Neurocomportement	
Etudes cognitives, sur le sommeil et l'EEG de volontaires, notamment des enfants et des sujets exposés professionnellement, dans un large éventail de fréquences EBF à des densités de flux élevées	Moyenne
Etudes de la fonction cognitive chez l'animal après exposition pré- et postnatale	Moyenne
Etude approfondie des réponses opioïdes et cholinergiques chez l'animal	Faible
Troubles neurodégénératifs	
Etudes complémentaires sur le risque de sclérose latérale amyotrophique dans les professions liées à l'électricité et en rapport avec une exposition à un champ magnétique EBF et de maladie d'Alzheimer en rapport avec l'exposition à un champ magnétique EBF	Elevée
Immunologie et hématologie	
Etudes sur les conséquences de l'exposition à un champ magnétique EBF sur le développement des systèmes immunitaires et hématopoïétiques chez le jeune animal	Faible
Reproduction et développement	
Etude complémentaire sur le lien éventuel qui existerait entre fausses couches et exposition à un champ magnétique EBF	Faible
Cancer	
Actualisation des analyses groupées existantes sur la leucémie infantile à l'aide des nouvelles données	Elevée
Analyses groupées des études existantes sur les tumeurs cérébrales chez l'enfant	Elevée
Mise à jour des méta-analyses existantes relatives à la leucémie et aux tumeurs cérébrales chez l'adulte et aux cohortes de sujets exposés professionnellement	Moyenne
Mise au point de modèles murins transgéniques de leucémie infantile utilisables dans les études sur les EBF	Elevée
Evaluation des effets co-cancérogènes au moyen d'études in vitro chez l'animal	Elevée
Tentative de reproduction des études de génotoxicité in vitro	Moyenne
Mesures de protection	
Recherche sur l'élaboration de politiques de protection de la santé et sur leur mise en oeuvre dans les secteurs où il n'y a pas de certitude scientifique	Moyenne

Recherche complémentaire sur la perception du risque et la communication sur les risques axée sur les champs électromagnétiques	Moyenne
Elaboration d'une analyse coût-bénéfice/coût-efficacité pour l'atténuation des champs EBF	Moyenne

17 РЕЗЮМЕ И РЕКОМЕНДАЦИИ ДЛЯ ДАЛЬНЕЙШИХ ИССЛЕДОВАНИЙ

В настоящей монографии, посвященной медицинским критериям окружающей среды (МКОС), рассматриваются возможное влияние на здоровье воздействия электрического и магнитного полей сверхнизкой частоты (СНЧ). В монографии рассматриваются физические характеристики полей СНЧ, а также источники излучения и измерения. Однако главная цель состоит в обзоре научной литературы, касающейся биологических эффектов воздействия полей СНЧ для того, чтобы оценить риск для здоровья, возникающий в связи с воздействием этого поля, и использовать эту оценку риска для здоровья для составления рекомендаций, предназначенных для национальных органов, занимающихся программами защиты здоровья.

Рассматриваемые частоты находятся в диапазоне от 0 Гц до 100 кГц. Значительное большинство исследований проводилось в отношении магнитных полей промышленной частоты (50 или 60 Гц) и лишь немногие исследования касались электрических полей промышленной частоты. Кроме того, было проведено несколько исследований, касающихся полей очень низких частот (ОНЧ, 3–30 кГц), магнитных полей переменного градиента, применяющихся в магнитно-резонансной томографии, и более слабых полей ОНЧ, создаваемых видеодисплейными терминалами и телевизорами.

В данной главе обобщаются основные выводы и рекомендации по каждому разделу, а также общие выводы в отношении процесса оценки риска для здоровья. В монографии для выражения убедительности данных по отношению к определенному медицинскому результату используются следующие термины. Данные именуются «ограниченными», когда они являются результатом лишь одного исследования или когда имеются нерешенные вопросы, касающиеся постановки, проведения или интерпретации ряда исследований. Термин «неадекватные» данные используется в тех случаях, когда исследования нельзя истолковать таким образом, чтобы показать наличие либо отсутствие какого-либо эффекта вследствие существенных качественных или количественных ограничений или в тех случаях, когда данные отсутствуют.

Были также выявлены основные пробелы в информации и исследования, которые необходимо провести для ликвидации этих пробелов, они были обобщены в разделе, озаглавленном «Рекомендации в отношении научных исследований».

17.1 Резюме

17.1.1 Источники, измерения и воздействия на организм человека

Электрические и магнитные поля существуют повсюду, где генерируется, транспортируется или распределяется электроэнергия по

линиям или кабелям электропередачи или используется в электрических приборах. Поскольку использование электричества является неотъемлемой частью нашего современного образа жизни, эти поля повсеместно существуют в нашем окружении.

Напряженность электрического поля измеряется в вольтах на метр (В/м) или в киловольтах на метр (кВ/м), а в отношении магнитных полей индукция изменяется в теслах (Тл) или чаще в миллитеслах (мТл) или в микротеслах (мкТл).

Воздействие магнитных полей промышленной частоты в местах проживания людей в различных странах мира отличается незначительно. Среднее геометрическое значение интенсивности магнитного поля в домашних условиях колеблется от 0,025 и 0,07 мкТл в Европе и 0,055 и 0,11 мкТл в США. Среднее значение напряженности электрического поля в домашних условиях находится в пределах нескольких десятков вольт на метр. В непосредственной близости от некоторых приборов мгновенные значения магнитной индукции могут составлять несколько сотен микротесла. Вблизи линий электропередачи магнитные поля достигают приблизительно 20 мкТл, а напряженность электрических полей может составлять несколько тысяч вольт на метр.

Лишь незначительное количество детей подвержены воздействию магнитных полей частотой 50 или 60 Гц в домашних условиях ,с уровнями, усредненными по времени воздействия, превышающими уровни, которые обусловливают повышенную заболеваемость детей лейкемией (см. Раздел 17.1.10). Приблизительно 1%-4% подвергаются воздействию магнитной индукции, превышающей 0,3 мкТл и лишь 1%–2% подвергаются усредненному воздействию, превышающему 0,4 мкТл.

Производственное воздействие, хотя и обусловленное, главным образом, полями промышленной частоты, может также включать в себя воздействие других частот. Средняя экспозиция к магнитному полю на рабочем месте оказалась выше у работников «электрических профессий», нежели у лиц с другими занятиями, такими как работа в офисе, и составляла от 0,4–0,6 мкТл для электриков и электроинженеров до приблизительно 1,0 мкТл для рабочих, обслуживающих линии электропередачи, при наиболее высоких уровнях воздействия для таких профессий, как сварщики, водители электровозов и операторы швейных машин (свыше 3 мкТл). Максимальная интенсивность магнитного поля на рабочем месте может достигать приблизительно 10 мТл, и это неизменно связано с высокими значениями пропускаемого в проводах электротока. В секторе электроснабжения работающие могут подвергаться воздействию электрических полей, значение которых составляет до 30 кВ/м.

17.1.2 Электрические и магнитные поля в организме

При воздействии внешних электрических и магнитных полей сверхнизких частот в организме наводятся электрические поля и токи. При помощи измерений выявлена взаимосвязь между внешними полями и наведенным электрическим полем и плотностью тока в организме или другими параметрами, обусловленными воздействием этих полей. Локально индуцированное электрическое поле и плотность тока представляют особый интерес, поскольку они могут стимулировать возбудимые ткани, такие как нервные и мышечные волокна.

Организм человека и животных в значительной степени видоизменяет пространственное распределение электрического поля СНЧ. На низких частотах тело является хорошим проводником, и искаженные линии поля вне организма практически перпендикулярны поверхности тела. На поверхности подвергающегося воздействию организма возникают колеблющиеся заряды, которые индуцируют токи внутри организма. Основные результаты дозиметрии, касающиеся воздействия электрических полей СНЧ на организм человека, выглядят следующим образом:

- Электрическое поле, имеющееся внутри организма, обычно обладает напряженностью на пять или шесть порядков меньшей, чем внешнее электрическое поле.
- При действии на организм поля преимущественно вертикальной направленности, преобладающая направленность наведенных полей также вертикальна.
- При данном внешнем электрическом поле наиболее сильные поля наводятся в теле человека, ноги которого плотно контактируют с землей (электрически заземлены), и наиболее слабые поля наводятся в теле, изолированном от земли (в “свободном пространстве”).
- Общий ток, протекающий в теле, находящемся в тесном контакте с землей, определяется преимущественно габаритами и формой тела (включая позу), а не проводимостью тканей.
- Распределение наведенных токов по различным органам и тканям определяется проводимостью этих тканей.
- Распределение наведенного электрического поля также обусловлено проводимостью, однако в меньшей степени, нежели наведенный ток.
- Имеет место также явление, состоящее в том, что в теле возникает ток при наличии контакта с проводящим предметом, находящимся в электрическом поле.

Что касается магнитных полей, то для них проницаемость тканей та же, что и проницаемость воздуха, поэтому магнитное поле в тканях такое же, как и внешнее поле. Организмы человека и животных не вносят существенного возмущения в поле. Основным результатом воздействия магнитных полей является индукция электрических полей, открытая Фарадеем и обусловленная плотностью тока в проводящих тканях. Основные результаты измерения воздействия магнитных полей СНЧ на организм человека состоят в следующем:

- Наведенное электрическое поле и ток зависят от ориентации внешнего поля. Наведенные поля в организме в целом достигают наибольшего значения в тех случаях, когда линии поля идут в направлении от фронтальной к задней части тела, однако в отношении отдельных органов наивысшие значения достигаются в тех случаях, когда линии поля имеют боковую направленность (от края до края).
- Наиболее слабые электрические поля индуцируются магнитным полем, ориентированным вдоль вертикальной оси тела.
- При определенной напряженности и ориентации магнитного поля более сильные электрические поля наводятся в более массивном теле.
- Распределение наведенного электрического поля обусловлено проводимостью различных органов и тканей. Они оказывают ограниченное влияние на распределение плотности наведенного тока.

17.1.3 Биофизические механизмы

Различные предлагаемые механизмы прямого и косвенного взаимодействия электрических и магнитных полей СНЧ изучаются на предмет обоснованности, в частности, в какой степени “сигнал”, индуцированный в биологическом процессе в результате воздействия какого-либо поля, может быть выделен из флуктуационного шума, и противоречит ли этот механизм научным принципам и нынешним научным знаниям. Действие многих механизмов становится очевидным лишь при значениях поля, превышающих определенный уровень. Тем не менее, отсутствие выявленных очевидных механизмов не исключает возможности воздействия на здоровье даже при весьма низких уровнях поля при условии того, что это не противоречит основным научным принципам.

Из многочисленных предлагаемых механизмов прямого взаимодействия полей с организмом человека выделяются три механизма в качестве вероятно действующих при более низких интенсивностях поля, нежели другие: индуцированные электрические поля в нейронных сетях радикальные пары и магнетиты.

Электрические поля, наведенные в тканях электрическими или магнитными полями СНЧ, непосредственно стимулируют одиночные миелиновые нервные волокна биофизически понятным образом в тех случаях, когда напряженность внутреннего поля превышает несколько вольт на метр. В отличие от отдельных клеток значительно более слабые поля могут оказывать влияние на синаптическую передачу в нейронных сетях . Подобная обработка сигналов нервными системами обычно используется многоклеточными организмами для выявления слабых сигналов окружающей среды. Было высказано предположение, что нижним пределом интенсивности сигнала, различаемого нейронной сетью, является 1 мВ/м, однако, учитывая современные данные, более вероятными представляются пороговые значения в диапазоне 10–100 мВ/м.

Механизм действия радикальных пар является общепринятым пониманием того, каким образом магнитные поля могут оказывать влияние на специфические типы химических реакций, обычно путем увеличения концентрации реактивных свободных радикалов в слабых полях и снижения концентраций в сильных полях. Эти увеличения проявлялись в магнитных полях с индукцией менее 1 мТл. Имеются определенные данные, увязывающие этот механизм со способностью перелетных птиц определять направление перелета. Также, исходя из теоретических предпосылок, и в силу того, что изменения, вызываемые СНЧ и постоянными магнитными полями сходны, предполагается, что поля промышленной частоты с интенсивностью значительно меньшей, чем геомагнитное поле с индукцией около 50 мкТл, вряд ли могут иметь существенное биологическое значение.

Магнетитовые кристаллы, мелкие ферромагнитные кристаллы оксидов железа различной формы, присутствуют в тканях животных и человека, хотя и в незначительных количествах. Подобно свободным радикалам их присутствие связывают со способностью мигрирующих животных к ориентированию и навигации, хотя присутствие чрезвычайно малых количеств магнетита в мозге человека не наделяет его способностью выявлять наличие слабого геомагнитного поля. Расчеты, основанные на крайних предположениях, позволяют сделать вывод о том, что нижний предел эффектов воздействия полей СНЧ на магнетитовые кристаллы составляет 5 мкТл.

Другие виды прямого биофизического воздействия полей, такие как нарушение химических связей, воздействие на заряженные частицы и различные механизмы узкополосного “резонанса” не рассматриваются, что продиктовано желанием дать достоверное объяснение воздействию полей, которое имеет место в повседневной жизни и

Что касается непрямых эффектов, поверхностные электрические заряды, индуцируемые электрическими полями могут ощущаться, они могут приводить к болезненным микроударам при соприкасании с проводящим предметом. Контактные токи могут

возникать, когда, например, дети касаются водопроводного крана в ванной. При этом возникают незначительные электрические поля в костном мозге, значение которых, возможно, превышает фоновый уровень. Однако, представляет ли это риск для здоровья, неизвестно.

Высоковольтные линии электропередач продуцируют большое количество электрически заряженных ионов при коронном разряде. Предполагается, что они способствуют отложению переносимых воздухом загрязняющих веществ на коже и в дыхательных путях, что, возможно, отрицательно сказывается на здоровье. Однако представляется маловероятным, чтобы ионы, появляющиеся в результате коронного разряда, обладали более чем незначительным или вообще каким-либо влиянием на долгосрочный риск для здоровья даже у тех лиц, которые экспонированы в наибольшей степени.

Ни один из трех прямых механизмов не представляет собой достоверную причину увеличения заболеваемости при тех уровнях воздействия, которым обычно подвергаются люди. Фактически они становятся достоверными при более значительных уровнях, а косвенные механизмы изучены в недостаточной степени. Подобное отсутствие установленного достоверного механизма не исключает возможности неблагоприятного влияния на здоровье, но порождает необходимость располагать более прочными фактическими данными из области биологии и эпидемиологии.

17.1.4 Нейроповедение

Воздействие электрических полей промышленной частоты вызывает вполне определенные биологические реакции - от ощущения раздражения вплоть до поверхностных электрических разрядов. Эти реакции зависят от напряженности поля, условий окружающей среды и индивидуальной чувствительности. Порог непосредственного восприятия у 10% добровольцев находился в пределах от 2 до 20 кВ/м, в то время как у 5% было выявлено раздражающее действие, при напряженности поля 15–20 кВ/м . Искровые разряды от человека к земле воспринимали как болезненные 7% добровольцев, находившихся в поле с напряженностью в 5 кВ/м. Пороговое значение для разряда от заряженного предмета через заземленного человека зависит от габаритов этого предмета и поэтому требует конкретной оценки.

Поле высокой напряженности, быстро пульсирующие магнитные поля могут стимулировать ткани периферической или центральной нервной системы. Подобные явления могут возникать во время проведения магниторезонансной томографии и используются при транскраниальной магнитной стимуляции. Пороговое значение наведенного электрического поля для прямой стимуляции нерва может находиться на уровне всего лишь нескольких вольт на метр. Это пороговое значение, по-видимому, является постоянным в диапазоне частот от нескольких герц до нескольких килогерц. Лица, страдающие эпилепсией или предрасположенные к ней, по-видимому, являются

более чувствительными к индуцированным СНЧ электрическим полям в центральной нервной системе (ЦНС). Кроме того, чувствительность к электростимуляции ЦНС, по-видимому, обусловлена наличием в семье людей, страдающих эпилептическими припадками, а также использованием трициклических антидепрессантов, нейролептиков и других лекарств, понижающих эпилептический порог.

На функцию сетчатки, являющейся частью ЦНС, могут оказать влияние гораздо более слабые СНЧ магнитные поля , нежели те, которые вызывают прямую нервную стимуляцию. Ощущения вспышек света, именуемые «магнитными фосфенами» или «магнитофосфенами», возникают в результате взаимодействия индуцированного электрического поля с электрически возбудимыми клетками сетчатки. Пороговая напряженность наведенного электрического поля в околоклеточной жидкости сетчатки, согласно подсчетам, составляет от 10 до 100 мВ/м на частоте 20 Гц. Однако этим значениям присуща значительная неопределенность.

Менее ясными представляются данные в отношении других нейроповеденческих результатов, полученных в ходе исследований с участием добровольцев, такие как влияние на электрическую активность мозга, когнитивные функции, сон, сверхчувствительность и настроение. В целом подобные исследования проводились при уровнях воздействия ниже тех, которые необходимы для того, чтобы индуцировать вышеописанные явления. В результате были получены данные, в лучшем случае свидетельствующие о слабых и преходящих последствиях. Условия, необходимые для того, чтобы уяснить подобные реакции, в настоящее время определены недостаточно четко. Имеются данные, позволяющие предположить наличие обуславливаемого полем влияния на время реакции и снижение тщательности выполнения некоторых когнитивных задач, что подтверждается результатами исследований в отношении общей электрической активности мозга. Исследования в отношении того, оказывают ли магнитные поля влияние на качество сна, дают неоднородные результаты. Возможно, эта неоднородность частично объясняется различиями в постановке исследований.

Некоторые люди заявляют о своей повышенной чувствительности к электромагнитным полям в целом. Однако данные двойных слепых провокационных исследований позволяют предположить, что заявляемые симптомы не связаны с воздействием электромагнитных полей.

Имеются лишь разнородные и неубедительные данные о том, что воздействие электрических и магнитных полей СНЧ вызывает депрессивные симптомы или суициды. В силу этого данные считаются недостаточными.

Что касается животных, то возможность того, что воздействие полей СНЧ может влиять на нейроповеденческие функции, изучалась в

ряде различных направлений при различных условиях воздействия. Неопровержимых результатов получено было немного. Имеются убедительные свидетельства того, что электрические поля промышленной частоты могут ощущаться животными скорее всего путем ощущения поверхностного заряда и могут вызывать кратковременное возбуждение или легкий стресс. Крысы чувствуют наличие поля в диапазоне интенсивностей от 3 до 13 кВ/м. Было обнаружено, что грызуны не переносят напряженность поля, превышающую 50 кВ/м. Другие возможные последствия, обусловленные воздействием поля, определены в значительно меньшей степени; лабораторные исследования свидетельствуют лишь о незначительных и кратковременных эффектах. Имеются данные о том, что воздействие магнитных полей может изменить действие опиоида и холинергических нейромедиаторных систем мозга. Это подтверждается результатами исследований, в которых изучалось воздействие полей на обезболивание, а также на пространственное запоминание и выполнение пространственных задач.

17.1.5 Нейроэндокринная система

Результаты исследований, проведенных с участием добровольцев, а также эпидемиологических исследований в местах проживания и в условиях производственных воздействий, позволяют предположить, что на нейроэндокринную систему не оказывает неблагоприятного влияния воздействие электрических или магнитных полей промышленной частоты. Это относится в особенности к уровням циркуляции специфических гормонов в нейроэндокринной системе, в том числе мелатонина, выделяемого шишковидной железой, а также ряда гормонов, участвующих в управлении обменом веществ и физиологическими процессами, которые выделяются гипофизом. Незначительные отличия наблюдались в отношении времени выделения мелатонина, что было обусловлено некоторыми особенностями воздействия, однако эти результаты не проявляются последовательно. Весьма трудно устранить возможное вмешательство различных экологических факторов и факторов образа жизни, которые могут также отражаться в уровнях гормонов. В большинстве лабораторных исследований по изучению эффектов воздействия полей СНЧ на уровни мелатонина у добровольцев в ночное время, после того, как были приняты меры, исключающие влияние мешающих факторов, никакого эффекта обнаружено не было.

Было проведено большое количество исследований на животных с целью изучения результатов воздействия электрических и магнитных полей промышленной частоты на уровни мелатонина в шишковидной железе и в сыворотке у крыс. В некоторых исследованиях отмечалось, что воздействие полей приводило к супрессии мелатонина в ночное время. Изменения в уровнях мелатонина, впервые наблюдавшиеся в ранних исследованиях при воздействии электрического поля до 100 кВ/м, повторно получать не

удалось. Результаты ряда более недавних исследований, в которых показывалось, что циркулярно поляризованные магнитные поля понижают уровень мелатонина в ночное время, слабо выглядят на фоне неподходящих сравнений с результатами, полученными для данных животных и более ранними результатами. Данные, полученные в результате других экспериментов с грызунами, в которых уровни интенсивности магнитного поля изменялись в диапазоне от нескольких микротесла до 5 мТл, носили двойственный характер в связи с тем, что в некоторых опытах происходило подавление мелатонина, а в других не отмечалось никаких изменений. У животных с сезонным циклом размножения результаты воздействия полей промышленной частоты на уровень мелатонина и обуславливаемый мелатонином репродуктивный статус, главным образом, отрицательные. Никаких убедительных свидетельств в отношении уровней мелатонина не было обнаружено в исследовании на человекообразных обезьянах, хронически подвергаемых воздействию полей промышленной частоты, хотя в более раннем исследовании с использованием двух животных отмечалась супрессия секреции мелатонина в результате нерегулярного и интермиттирующего воздействия полей.

Результаты воздействия СНЧ полей на продукцию и выделение мелатонина в изолированной шишковидной железе различались, хотя исследований in vitro проводилось немного. Данные о том, что воздействие полей СНЧ вмешивается в воздействие мелатонина на раковые клетки молочной железы, вызывают интерес. Однако недостатком этого является тот факт, что в клеточных линиях нередко наблюдается генотипическая и фенотипическая изменчивость в культуре, которая может препятствовать воспроизводству эксперимента в других лабораториях.

Никаких устойчивых результатов обнаружено не было в отношении обуславливающих стресс гормонов гипофизарно-адреналиновой оси у различных видов млекопитающих при одном возможном исключении возникновения кратковременного стрессового состояния, возникающего в связи с воздействием электрического поля СНЧ на достаточно заметном уровне. Аналогичным образом, несмотря на то, что было проведено небольшое количество исследований, наблюдались большей частью отрицательные или противоречивые результаты в отношении уровней гормона роста и гормонов, участвующих в регулировании метаболизма или связанных с контролем репродуктивного и сексуального развития.

В целом, эти данные не указывают на то, что электрические и/или магнитные поля СНЧ оказывают влияние на нейроэндокринную систему таким образом, чтобы это производило неблагоприятное воздействие на здоровье человека, и поэтому эти данные считаются недостаточными.

17.1.6 Нейродегенеративные расстройства

Высказывалось предположение, что воздействие полей СНЧ обусловливает ряд нейродегенеративных заболеваний. В отношении болезни Паркинсона и множественного склероза количество исследований было незначительным, и доказательства взаимосвязи с этими заболеваниями отсутствуют. Что касается болезни Альцгеймера и бокового амиотрофического склероза, было опубликовано больше исследований. В ряде этих сообщений высказывается предположение, что лица, работающие в электроустановках, имеют больший риск бокового амиотрофического склероза. До сих пор не установлено никакого биологического механизма, который мог бы объяснить эту взаимосвязь, хотя это явление могло иметь место вследствие наличия неучтенных факторов, связанных с электрическими профессиями, как, например, удары электротоком. В целом, данные о взаимосвязи между воздействием полей СНЧ и боковым амиотрофическим склерозом считаются недостаточными.

Результаты нескольких исследований взаимосвязи между воздействием полей СНЧ и болезнью Альцгеймера противоречивы. Однако более качественные научные исследования, в которых основное внимание уделяется не смертности, а заболеваемости болезнью Альцгеймера, не указывают на какую-либо взаимосвязь. В целом, данные о взаимосвязи между воздействием полей СНЧ и болезнью Альцгеймера недостаточны.

17.1.7 Сердечно-сосудистые расстройства

Экспериментальные исследования как кратковременного, так и длительного воздействия указывают на то, что хотя электрошок является явной опасностью для здоровья, другие опасные последствия сердечно-сосудистого характера, связанные с полями СНЧ вряд ли могут возникнуть при уровнях воздействия, которые обычно имеют место в производственной и окружающей среде. Хотя в литературе сообщалось о различных сердечно-сосудистых изменениях, большинство последствий незначительны, и результаты, как в рамках самих исследований, так и при сравнении с другими исследованиями, противоречивы. За одним исключением: ни в одном из исследований по поводу заболеваемости и смертности, обусловленных сердечно-сосудистыми заболеваниями, не показана взаимосвязь с воздействием электрических или магнитных полей. Вопрос о том, существует ли взаимосвязь между воздействием полей и нарушением автономного контроля сердца, остается предметом догадок. В целом, данные не свидетельствуют о связи между воздействием полей СНЧ и сердечно-сосудистыми заболеваниями.

17.1.8 Иммунология и гематология

Данные о воздействии электрических или магнитных полей СНЧ на компоненты иммунной системы обычно противоречивы. На многие клеточные популяции и функциональные маркеры поля не

оказывают никакого влияния. Однако в некоторых исследованиях с участием человека и с использованием полей от 10 мкТл до 2 мТл наблюдались изменения в естественных клетках-киллерах, число которых как уменьшалось, так и увеличивалось, а также в клетках белой крови, число которых оставалось без изменений или уменьшалось. В исследованиях на животных у самок мышей отмечалось уменьшение активности естественных клеток-киллеров, однако этого не наблюдалось у самцов мышей или у крыс обоего пола. Подсчет числа клеток белой крови также был противоречивым. В различных исследованиях сообщалось об уменьшении их числа или об отсутствии каких-либо изменений. В опытах на животных использовался еще более широкий диапазон - от 2 мкТл до 30 мТл. Трудность толкования потенциального влияния на здоровье при указанных данных объясняется значительными колебаниями в условиях воздействия полей и окружающих условий, сравнительно небольшим числом тестируемых субъектов и широким разнообразием конечных результатов.

Было проведено несколько исследований в отношении воздействия магнитных полей СНЧ на гематологическую систему. В ходе экспериментов по оценке дифференциации количества клеток красной крови дозы воздействия изменялись в диапазоне от 2 мкТл до 2 мТл. Никаких последовательных результатов острого воздействия магнитных полей СНЧ или сочетанного электрического и магнитного поля СНЧ не было обнаружено при проведении исследований с участием человека или животных.

В силу этого, в целом, данные в отношении последствий воздействия электрических или магнитных полей СНЧ на иммунную и гематологическую систему считаются недостаточными.

17.1.9 Воспроизводство и развитие

В целом, эпидемиологические исследования не указывают на какую-либо взаимосвязь нарушений репродуктивной функции человека в связи с воздействием полей СНЧ на мать или отца. Имеются некоторые данные об увеличении риска выкидыша, связанного с воздействием магнитного поля на будущую мать, однако эти данные являются недостаточными.

Воздействие электрических полей СНЧ с уровнями вплоть до 150 кВ/м изучалось на нескольких видах млекопитающих. Сюда относятся изучение крупных популяций и воздействие полей на протяжении нескольких поколений. Результаты исследований устойчиво указывают на отсутствие каких-либо отрицательных последствий для развития.

Воздействие магнитных полей СНЧ с уровнями до 20 мТл на млекопитающих не приводит к значительным нарушениям формирования внешних признаков, внутренних органов или скелета. В некоторых исследованиях указывается на увеличение частоты

незначительных скелетных аномалий у крыс и мышей. Скелетные изменения являются сравнительно распространенным результатом тератологических исследований и нередко считаются биологически незначимыми . Однако нельзя исключать трудноуловимые влияния магнитных полей на развитие скелета. Исследований, в которых рассматриваются репродуктивные последствия, было опубликовано очень мало, и из них нельзя делать каких-либо выводов.

В нескольких исследованиях на экспериментальных моделях, не относящихся к классу млекопитающих (куриные эмбрионы, рыбы, морские ежи и насекомые), сообщается о результатах, которые указывают на то, что магнитные поля СНЧ в пределах микротеслы могут вносить нарушения в ранние этапы развития. Однако результаты изучения экспериментальных моделей, не относящихся к млекопитающим, имеют меньшую ценность при общей оценке токсичности в отношении развития, нежели исследования в этой области, касающиеся млекопитающих.

В целом, данные о последствиях для развития и репродуктивной системы являются недостаточными.

17.1.10 Онкологические заболевания

Классификация МАИР, относящая магнитные поля СНЧ к "возможно канцерогенным для человека" (IARC, 2002) основана на всех имеющихся данных до 2001 года включительно. Обзор литературы в данной монографии посвящен главным образом исследованиям, появившимся после обзора МАИР.

Эпидемиология

Классификация МАИР в значительной мере опирается на взаимосвязи, выявленные в ходе эпидемиологических исследований лейкозов у детей. Классификационная характеристика этих данных в качестве имеющих ограниченный характер не изменяется в связи с добавлением двух дополнительных исследований в области лейкозов у детей, опубликованных после 2002 года. Со времени публикации монографии МАИР данные в отношении других онкологических заболеваний у детей остаются недостаточными.

После публикации монографии МАИР появился ряд сообщений, касающихся риска рака молочной железы у взрослых, обусловленного воздействием магнитного поля СНЧ. Эти исследования шире, чем предыдущие и более беспристрастные, и в целом они дают отрицательный ответ. С наличием этих исследований данные о взаимосвязи между воздействием магнитного поля СНЧ и риском рака молочной железы, значительно ослабили свою позицию и не свидетельствуют о взаимосвязи подобного рода.

По поводу рака головного мозга и лейкозов у взрослых, новые исследования, опубликованные после монографии МАИР, не меняют

вывод о том, что общий объем данных о взаимосвязи между магнитными полями СНЧ и риском этих заболеваний остается недостаточным.

Для всех других видов онкологических болезней, данные по-прежнему остаются недостаточными.

Лабораторные исследования на животных

В настоящее время подходящая животная модель для наиболее распространенной формы детского лейкоза, острого лимфобластного лейкоза, отсутствует. Три независимых крупномасштабных исследования, где были использованы крысы, не дали никаких данных в отношении взаимосвязи между воздействием магнитных полей СНЧ и заболеваемостью спонтанным раком молочной железы. В большинстве исследований сообщается об отсутствии связи воздействия магнитных полей СНЧ с лейкозом или лимфомой у грызунов. В нескольких крупномасштабных и продолжительных исследованиях с использованием грызунов не было выявлено какого-либо устойчивого увеличения заболеваемости каким-либо онкологическим заболеванием, в т.ч. заболеванием кроветворных органов, молочной железы, головного мозга и кожи.

В значительном числе исследований изучалось воздействие магнитных полей СНЧ на химически индуцированные опухоли молочной железы у крыс. Непоследовательность полученных результатов может объясняться в целом или частично различиями в проведении экспериментов, такими как использование специфических линий. Большинство исследований воздействия магнитного поля СНЧ на модели лейкоза/лимфомы, индуцированные химическим путем или радиацией, дают отрицательный ответ. В исследованиях повреждений печени, предшествующих новообразованиям, опухолей кожи, индуцированных химическим путем, и опухолей головного мозга сообщается главным образом об отрицательных результатах. В одном исследовании сообщается об активизации индуцированных ультрафиолетом опухолей кожи после воздействия магнитных полей СНЧ.

Две группы сообщают об увеличении числа разрывов цепочек ДНК в тканях головного мозга после воздействия in vivo магнитными полями СНЧ. Однако в других группах, использовавших различные модели генотоксичности у грызунов, данных о генотоксичности обнаружено не было. Результаты исследований, в которых изучалось не генотоксическое воздействие применительно к раку, неубедительны.

В целом, свидетельства о том, что воздействие магнитных полей СНЧ само по себе вызывает опухоли, отсутствуют. Данные о том, что воздействие магнитного поля СНЧ в сочетании с канцерогенами может активизировать развитие опухоли, недостаточны.

Исследования in vitro

Обычно в исследованиях воздействия поля СНЧ на клетки не выявляется генотоксичности при интенсивности поля менее 50 мТл. Заметным исключением являются данные недавнего исследования, в котором сообщается о повреждении ДНК при магнитной индукции всего лишь 35 мкТл. Однако эти исследования еще оцениваются, и, как мы понимаем, результаты являются неполными. Все больше появляется данных о том, что магнитные поля СНЧ могут взаимодействовать с агентами, наносящими повреждения ДНК.

Явные доказательства того, что активация при помощи магнитных полей СНЧ генов, участвующих в управлении клеточным циклом, отсутствуют. Однако систематические исследования с целью анализа реакции генома в целом еще необходимо провести.

Во многих других исследованиях на клеточном уровне, например в отношении клеточной пролиферации, апоптоза, кальциевой сигнализации и злокачественной трансформации, получены непоследовательные и неубедительные результаты.

Общий вывод

Опубликованные после монографии МАИР 2002 г. новые исследования на человеке, животных и in vitro не изменяют общую классификацию магнитных полей СНЧ как возможного канцерогена для человека.

17.1.11 Оценка риска для здоровья

В соответствии с Уставом ВОЗ здоровье является состоянием полного физического, душевного и социального благополучия, а не только отсутствием болезней и физических дефектов. Оценка риска представляет собой концептуальную схему структурированного изучения информации, имеющей отношение к медицинским или экологическим последствиям. Оценка риска для здоровья может использоваться в качестве вводного элемента процесса управления факторами риска, который охватывает все действия, которые необходимо произвести, чтобы решить, необходимо ли предпринимать какие-либо конкретные меры в отношении данной опасности, а также принятие этих мер.

При оценке риска для здоровья, достоверные данные в отношении здоровья человека, в тех случаях, когда они имеются, обычно более информативны, чем данные, полученные на животных. Исследования на животных и исследования in vitro могут подкреплять данные исследований о здоровье человека, заполнять пробелы в изучении здоровья человека или использоваться при принятии решений в опасных случаях, когда исследований с участием человека недостаточно или когда они отсутствуют.

Всякие исследования, имеющие как положительные, так и отрицательные результаты, необходимо подвергать оценке и обсуждать, исходя из их собственных достоинств, а затем рассматривать их все в совокупности, придерживаясь метода весомости доказательств. Важно определить, в какой степени какая-либо совокупность доказательств изменяет вероятность того, что определенное воздействие вызывает некий результат. Данные в отношении последствий обычно более убедительны, если результаты различных видов исследований (эпидемиологических и лабораторных) указывают на один и тот же вывод и/или когда многие исследования одного и того же типа приводят к одинаковому результату.

Острые эффекты

Острые биологические эффекты были установлены в связи с воздействием электрических и магнитных полей от крайне и сверхнизких до ОНЧ в диапазоне частот до 100 кГц. Это воздействие может иметь отрицательные последствия для здоровья. В силу этого необходимо устанавливать пределы воздействия. Существуют международные рекомендации по данному вопросу. Соблюдение этих рекомендаций обеспечивает надлежащую защиту от острых последствий.

Хронические эффекты

Научные данные, позволяющие предположить, что ежедневное хроническое низкоинтенсивное (более 0,3–0,4 мкТл) воздействие магнитного поля промышленной частоты представляет собой риск для здоровья, основаны на эпидемиологических исследованиях, свидетельствующих об устойчивой картине увеличения риска развития лейкоза у детей. Неопределенность оценки риска связана с тем, какое влияние может оказать неправильная классификация отклонений в контрольной и экспонированной выборках на наблюдаемую взаимосвязь между магнитными полями и лейкозами у детей. Кроме того, практически все лабораторные и механистические данные не свидетельствуют о взаимосвязи между слабыми магнитными полями СНЧ и нарушениями биологических функций или состоянием заболевания. Таким образом, в целом данные не являются достаточно убедительными, чтобы их можно было рассматривать в качестве причинных, однако они достаточно весомы, чтобы оставаться предметом озабоченности.

Несмотря на то, что причинная связь между воздействием магнитного поля и детскими лейкозами не установлена, возможное влияние его на здоровье населения должно было бы рассчитываться, допуская причинно-следственную связь, для того, чтобы включать это в политику как потенциально полезный элемент. Вместе с тем подобные расчеты в значительной степени зависят от распределения воздействия и других предположений и в силу этого являются неточными. Если

исходить из того, что взаимосвязь является причинной, то количество случаев лейкозов у детей во всем мире, которые могли бы быть обусловлены воздействием магнитного поля, согласно расчету может составить от 100 до 2400 случаев в год. Однако это составляет 0,2 – 4,9% от общего числа случаев лейкозов, которое во всем мире в 2000 г. составляло 49 000. Таким образом, в глобальном плане влияние на здоровье населения, если таковое имеется, будет ограниченным и неопределенным. Был изучен ряд других заболеваний на предмет возможной обусловленности воздействием магнитного поля СНЧ. К ним относятся онкологические заболевания детей и взрослых, депрессия, самоубийства, репродуктивные дисфункции, нарушение развития, иммунологические модификации и неврологические болезни. Научные данные, подтверждающие взаимосвязь между магнитными полями СНЧ и каким-либо из заболеваний, гораздо слабее, чем в отношении лейкозов у детей, а в некоторых случаях (например, в том, что касается сердечно-сосудистых заболеваний или рака молочной железы) данные достаточны для того, чтобы была уверенность в том, что магнитные поля не являются причиной заболевания.

17.1.12 Мероприятия по защите

Для защиты против выявленных негативных последствий воздействия электрических и магнитных полей СНЧ необходимо устанавливать предельные уровни их воздействия. Эти нормативы должны быть определены на основе тщательного изучения всех необходимых научных данных.

Определенным образом были выявлены лишь эффекты острых воздействий, и для защиты от них разработаны две международные рекомендации, касающиеся предельно допустимых уровней воздействия (ICNIRP, 1998a; IEEE, 2002).

Наряду с определенно выявленными эффектами острых воздействий существуют неопределенности о наличии эффектов хронических воздействий в силу ограниченности данных о взаимосвязи между воздействием магнитных полей СНЧ и лейкозами у детей. Поэтому необходимо проявлять осторожный подход. Однако во имя предосторожности не рекомендуется занижать до какого-либо произвольного уровня нормативы предельных уровней воздействия, определенные в рекомендациях. Это подрывает научные основы, на которых построены эти нормативы, и, возможно, окажется дорогостоящим и необязательно эффективным способом защиты.

Осуществление других приемлемых мер предосторожности по снижению воздействия поля обоснованно и необходимо. Однако электроэнергия приносит несомненную пользу в здравоохранении, социальной и экономической областях, и меры предосторожности не должны ставить под угрозу эти преимущества. Кроме того, учитывая недостаточность данных о взаимосвязи между воздействием полей СНЧ и детскими лейкозами, а также ограниченное влияние на здоровье

населения, если такая взаимосвязь имеется, преимущества мер по снижению воздействия полей на здоровье неясны. Таким образом, расходы на меры предосторожности должны быть весьма незначительными. Стоимость осуществления мер по снижению влияния полей в различных странах будет различна, что затрудняет разработку общей рекомендации в отношении уравновешивания расходов с потенциальной угрозой полей СНЧ.

Ввиду вышеизложенного, рекомендуется нижеследующее.

- Разработчикам политики необходимо устанавливать нормативы воздействия полей СНЧ, как для населения в целом, так и для условий профессиональных воздействий. Наилучшим руководством для определения обоих уровней воздействия и принципов научного пересмотра их являются международные рекомендации.
- Разработчикам политики необходимо организовать программы защиты от электрических и магнитных полей СНЧ, предусматривающие измерения полей от всех источников, с тем чтобы предельно допустимые уровни воздействия не превышались ни для населения в целом, ни для работающих.
- При условии того, что медицинские, социальные и экономические блага, предоставляемые электроэнергией, не поставлены под угрозу, оправдано и необходимо осуществление как можно более дешевых мер предосторожности по снижению воздействия полей.
- Разработчикам политики, плановикам и производителям необходимо предусматривать соблюдение дешевых мер защиты при строительстве новых сооружений и проектировнаии нового оборудования, включая электроприборы.
- Следует предусматривать внесение изменений в инженерную практику, направленных на снижение воздействия полей СНЧ, создаваемых оборудованием или приборами при условии, что при этом сохраняются другие дополнительные преимущества, такие как бóльшая безопасность и достигается это при незначительных или нулевых расходах.
- При переходе от одного типа оборудования к другому наряду с соображениями безопасности, надежности работы и экономичности необходимо учитывать проблему снижения интенсивности полей СНЧ, создаваемых этими приборами.
- Местным органам при строительстве новых установок или при замене старых, не упуская из внимания вопросы безопасности, необходимо регламентировать прокладку кабелей и проводов таким образом, чтобы это способствовало снижению непроизвольно возникающих токов в земле.

Активные меры по выявлению нарушений или существующих проблем в проложенных электрокабелях могут оказаться дорогостоящими и вряд ли будут оправданы.

- Национальным органам необходимо осуществлять эффективную и открытую стратегию коммуникаций, с тем чтобы все участники принимали информированные решения. Эта стратегия должна предусматривать информацию в отношении того, каким образом отдельные лица могут сами снизить воздействие полей.
- Местные органы должны улучшить планирование установок, являющихся источником СНЧ электромагнитных полей, предусматривая более активную консультацию с промышленностью, местным правительством и гражданами в процессе определения местоположения основных источников электромагнитных полей СНЧ.
- Правительство и промышленность должны содействовать проведению научно-исследовательских программ, направленных на понижение уровня неопределенности научных данных в отношении последствий воздействия полей СНЧ на человека.

17.2 Рекомендации для научных исследований

Выявление пробелов в знаниях, касающихся возможных последствий воздействия полей СНЧ для здоровья является главной составной частью оценки этого риска для здоровья. Нижеследующие рекомендации (обобщенные в Таблице 1) излагаются в отношении дальнейших научных исследований.

В качестве важнейшей необходимости требуется проведение дальнейших исследований в отношении промежуточных частот , под которыми обычно понимаются частоты от 300 Гц до 100 кГц, учитывая имеющийся пробел в этой области. Очень небольшой объем данных из необходимой базы знаний для оценки риска для здоровья был собран, и в большинстве существующих исследований результаты непоследовательны и нуждаются в дополнительном подтверждении. Общие требования формирования достаточной базы данных в отношении промежуточных частот с точки зрения оценки риска для здоровья состоят в оценке воздействия, эпидемиологических и лабораторных исследованиях с участием человека, а также в исследованиях на животных и на клеточном уровне (in vitro) (ICNIRP, 2003; ICNIRP, 2004; Litvak et al., 2002).

Для всех исследований с участием добровольцев настоятельно необходимо, чтобы исследования с участием человека проводились в полном согласии с этическими принципами, учитывая положения Хельсинской декларации (WMA, 2004).

Что касается лабораторных исследований, необходимо уделять приоритетное внимание опубликованным результатам, (i) в отношении которых имеются хотя бы скудные данные о воспроизведении или подтверждении, (ii) которые потенциально имеют отношение к канцерогенезу (например, генотоксичность), (iii) которые достаточно убедительны для использования механистического анализа и (iv) в которых присутствуют системы млекопитающих или человека.

17.2.1 Источники, измерения и воздействие на организм

Дальнейшая классификация жилья в различных странах, где имеет место высокий уровень воздействия полей СНЧ, с целью определения сравнительного воздействия внутренних и внешних источников полей, влияния порядка прокладки проводов и заземления, а также других характеристик жилья может помочь выявить соответствующие количественные характеристики воздействия, необходимые для эпидемиологической оценки. Важной частью этого является лучшее понимание воздействия полей СНЧ на плод в утробе матери и на детей, в особенности воздействие нагревательных электрокабелей в панелях пола жилых помещений и трансформаторов в многоквартирных зданиях.

Есть подозрение, что в некоторых случаях производственного воздействия СНЧ полей нынешние рекомендуемые нормативы экспозиции превышаются. Необходимо иметь больше информации в отношении воздействия полей (включая частоты, отличные от промышленной), связанных с условиями работы, например, работа по обслуживанию воздушных линий электропередачи под напряжением, работа внутри или вблизи створа магнита магнитно-резонансного томографа (и в силу этого воздействие полей СНЧ с переменным градиентом) и работа на транспортных системах. Аналогичным образом необходимо располагать дополнительными знаниями о подверженности воздействию населения, которое может оказаться близким к рекомендуемым нормативам, в том числе со стороны таких источников, как системы безопасности, библиотечные системы размагничивания, индукционное приготовление пищи и водонагревательные приборы.

Воздействие контактных токов предлагалось в качестве возможного объяснения взаимосвязи магнитных полей СНЧ с лейкозом у детей. Необходимы исследования в других странах, помимо США, для оценки возможности того, что порядок заземления электропроводки в жилых домах и прокладки водопроводов может способствовать возникновению контактных токов в жилье. Подобные исследования должны проводиться в приоритетном порядке в странах, в которых эпидемиологические данные в отношении полей СНЧ и лейкозов у детей вызывают озабоченность.

17.2.2 Дозиметрия

В прошлом большая часть лабораторных исследований основывалась на наведенных в организме электрических токах в качестве основного измеряемого параметра, и поэтому дозиметрические показатели определялись этим количественным фактором. Лишь недавно стали проводить работу по изучению взаимосвязи между воздействием внешнего поля и индуцированными электрическими полями. Чтобы лучше понимать биологические эффекты, необходимо иметь больше данных о внутренних электрических полях, возникающих при различных внешних воздействиях.

Необходимо произвести расчеты внутренних электрических полей, вызываемых совместным воздействием внешних электрических и магнитных полей в различных сочетаниях. Расчеты векторного сложения колебаний в различной фазе и воздействия электрических и магнитных полей в соответствии с их пространственным изменением необходимы для оценки основных вопросов, касающихся соблюдения нормативов.

До сих пор проводилось очень мало расчетов по перспективной модели беременной женщины и плода с учетом необходимого анатомического моделирования. Важное значение имеет расчет вероятного возрастания индукции электрических полей в плоде с точки зрения возможности возникновения лейкозов у детей. При этом большую роль играет производственное и внепроизводственное воздействие поля на материнский организм .

Имеется необходимость дополнительного усовершенствования микродозиметрических моделей, учитывающих клеточную архитектуру нейронных сетей и других сложных систем органов, которые более чувствительны к воздействию наведенных электрических полей. Этот процесс моделирования также должен принимать во внимание влияние на электрические потенциалы клеточной мембраны и на выделение нейромедиаторов.

17.2.3 Биофизические механизмы

Имеются три основных области, где довлеют очевидные ограничения для нынешнего понимания таких механизмов как механизма радикальных пар, магнитных частиц в организме и соотношений сигнал-шум в многоклеточных системах, таких как нейронные сети.

Механизм радикальных пар является одним из более вероятных механизмов низкоинтенсивного взаимодействия, однако еще надо доказать, что он способен вызывать значительные изменения в клеточном метаболизме и функциях. Особенно важно понять нижний предел воздействия, на котором он проявляется, с тем чтобы судить о том, может или не может этот механизм иметь отношение к

канцерогенезу. Учитывая недавние исследования, при которых в иммунных клетках, подвергавшихся воздействию полей СНЧ, происходило усиление активных форм кислорода, рекомендуется использовать в качестве клеточных моделей для изучения возможностей механизма радикальных пар клетки иммунной системы, которые генерируют реактивные формы кислорода.

Хотя наличие магнитных частиц (магнетитовые кристаллы) в головном мозге человека согласно нынешним данным, не свидетельствует о какой-либо чувствительности к магнитным полям СНЧ в окружающей среде, в дальнейших теоретических и экспериментальных работах необходимо изучить, может ли при определенных условиях подобная чувствительность существовать. Кроме того, следует продолжить изучение всех влияний, которые может оказывать наличие магнетитов на вышеупомянутый механизм радикальных пар.

Необходимо проводить дальнейшее изучение того, в какой степени функционируют в мозгу многоклеточные механизмы в плане улучшения соотношения сигнал-шум, с тем, чтобы разработать теоретические принципы количественного исчисления этого явления или определения его предельных значений. Методом in vitro необходимо проводить дальнейшее изучение порога и частотной реакции нейронных сетей в гиппокампе и других частях мозга.

17.2.4 Нейроповедение

Рекомендуется проводить лабораторные исследования с привлечением добровольцев по вопросу о возможном влиянии полей на сон и на выполнение задач, требующих умственного напряжения, придерживаясь согласованной методологии,. Необходимо выявить зависимость реакции от интенсивности поля при более высоких значениях магнитной индукции, по сравнению с использовавшимися ранее, а также в широком диапазоне частот (т.е. в килогерцовом диапазоне).

Исследования с участием взрослых добровольцев и с использованием животных позволяют предположить, что при кратковременном воздействии интенсивных электрических или магнитных полей могут иметь место острые когнитивные последствия. Для разработки нормативов воздействия чрезвычайно важно представлять себе эти последствия, однако конкретные данные, касающиеся обусловленных полем результатов воздействия на организм детей, отсутствуют. Рекомендуется провести лабораторные исследования когнитивной функции и изменений в электроэнцефалограмме (ЭЭГ) у лиц, подвергшихся воздействию полей СНЧ, в том числе взрослых, регулярно подвергающихся производственным воздействиям, а также у детей.

Поведенческие исследования с использованием детенышей животных могут дать ценные данные для изучения возможных

когнитивных последствий у детей. Следует изучить возможные последствия пре- и постнатального воздействия магнитных полей СНЧ на развитие нервной системы и когнитивные функции. Полезным дополнением к этим исследованиям может оказаться изучение последствий воздействия магнитных полей СНЧ и наведенных электрических полей на рост нервных клеток с использованием срезов головного мозга и нейронных культур.

Имеется необходимость дальнейшего изучения потенциальных последствий для здоровья, о которых позволяют предполагать экспериментальные данные об опиоидных и холинергических реакциях у животных. Следует расширить изучение модификации опиоидных и холинергических реакций у животных и определить параметры воздействия и биологическую основу подобных поведенческих реакций.

17.2.5 Нейроэндокринная система

Существующая база данных в отношении реакции нейроэндокринной системы не указывает на то, что воздействие полей СНЧ оказывает неблагоприятное влияние на здоровье человека. Поэтому в рекомендациях в отношении дополнительных исследований нет необходимости.

17.2.6 Нейродегенеративные расстройства

В ряде исследований наблюдалось увеличение риска бокового амиотрофического склероза у лиц, по роду занятий связанных с электричеством. Считается важным изучить эту взаимосвязь более подробно для того, чтобы выявить, участвуют ли магнитные поля СНЧ в возникновении этого редкого нейродегенеративного заболевания. Для этого требуется проведение крупномасштабных проспективных когортных исследований с информацией о воздействии магнитного поля СНЧ, о наличии ударов электрическим током, а также о воздействии других потенциальных факторов риска.

Остается сомнительным, являются ли магнитные поля СНЧ фактором риска в развитии болезни Альцгеймера. Имеющиеся в настоящее время данные недостаточны, и эту взаимосвязь необходимо изучить более подробно. Особое значение имеет использование данных о заболеваемости, а не о смертности.

17.2.7 Сердечно-сосудистые нарушения

Дополнительные исследования взаимосвязи между магнитными полями СНЧ и риском сердечно-сосудистых заболеваний приоритетными не считаются.

17.2.8 Иммунология и гематология

В изменениях, наблюдаемых в отношении иммунологических и гематологических параметров у взрослых, подвергшихся воздействию

магнитных полей СНЧ, обнаруживается непоследовательность, а также в основном отсутствуют данные исследований в отношении детей. Поэтому рекомендация состоит в том, чтобы проводить исследования о последствиях воздействия полей СНЧ на развитие иммунной и кроветворной систем у животных раннего возраста.

17.2.9 Репродуктивные аспекты и развитие

Имеются определенные данные об увеличении риска выкидыша, обусловленного воздействием магнитного поля СНЧ. Принимая во внимание потенциально значимое влияние подобной взаимосвязи на здоровье населения, рекомендуется проведение дополнительных эпидемиологических исследований.

17.2.10 Онкологические заболевания

Наиболее приоритетным вопросом в этой области является разрешение противоречий между эпидемиологическими данными (которые указывают на взаимосвязь между воздействием магнитного поля СНЧ и увеличением риска лейкозов у детей) и экспериментальными и механистическими данными (которые на эту взаимосвязь не указывают). По этому вопросу рекомендуется проведение совместной работы эпидемиологов и ученых экспериментаторов. Чтобы новые эпидемиологические исследования оказались информативными, они должны быть сосредоточены на новых аспектах воздействия поля, на потенциальном взаимодействии с другими факторами или на группах лиц, подвергшихся высокоинтенсивному воздействию, или иным образом быть новаторскими в этой области исследований. Кроме того, также рекомендуется обновить существующие сводные данные путем дополнения данными недавних исследований и путем нового понимания результатов анализа.

Исследования в области рака головного мозга у детей дают неоднозначные результаты. Также как и в случае лейкозов у детей, сводный анализ исследований рака мозга у детей должен быть весьма информативным, и в силу этого таковой рекомендуется. Сводный анализ подобного рода может при небольшой стоимости дать более глубокое и более совершенное понимание существующих данных, включая возможность селекции ошибок при отборе, и, в том случае, если исследования достаточно однородны, может содействовать получению наиболее точной оценки риска.

Что касается рака молочной железы у взрослых, в самых последних исследованиях убедительно показано, что нет никакой взаимосвязи с воздействием магнитных полей СНЧ. Поэтому дополнительным исследованиям этой взаимосвязи следует придавать второстепенное значение.

В отношении лейкозов у взрослых и рака головного мозга рекомендация состоит в том, чтобы обновить информацию по

существующим крупным когортам лиц, подвергающимся производственным воздействиям Результаты исследований в области медицины труда, совокупных данных и мета-анализов по лейкозам и раку головного мозга неоднозначны и неубедительны. Однако недавно были опубликованы новые данные, и их следует использовать для обновления вышеуказанных результатов.

Первоочередные действия состоят в том, чтобы изучить эпидемиологические данные путем реализации моделей in vitro и с использованием животных по исследованию реакций на низкоинтенсивные магнитные поля СНЧ, которые могли бы применяться в условиях различных лабораторий.

Следует разработать трансгенные модели грызунов для изучения лейкозов у детей, с тем чтобы имелись необходимые экспериментальные животные модели для изучения последствий воздействия магнитного поля СНЧ. В противном случае, согласно имеющимся сегодня результатам исследований на животных, изолированно одни магнитные поля СНЧ не оказывают никакого канцерогенного действия. Поэтому приоритетный характер следует придавать исследованиям in vitro и на животных, в которых магнитные поля СНЧ были бы тщательно изучены в качестве сопутствующих канцерогенным факторам.

Что касается других исследований in vitro, то эксперименты, в которых сообщается о генотоксичных эффектах интермиттирующего воздействия магнитного поля СНЧ, должны быть повторены в других условиях.

17.2.11 Мероприятия по защите

Проведение исследований в области разработки политики охраны здоровья и осуществление этой политики в тех областях, где имеется научная неопределенность, рекомендуется, в особенности в отношении мер предосторожности, толкование мер предосторожности и оценки воздействия мер предосторожности с точки зрения магнитных полей СНЧ и других агентов, классифицируемых в качестве «возможных канцерогенов для человека». В тех случаях, когда имеется неуверенность в отношении потенциального риска для здоровья, создаваемого каким-либо агентом, для общества, должны быть обеспечены меры предосторожности, с тем чтобы создать необходимую защиту для населения и работающих. По данному вопросу, касающемуся воздействия магнитных полей СНЧ, было проведено лишь ограниченное число исследований, и в силу важности этого вопроса необходимо заниматься более активными исследованиями. Это может помочь странам сделать меры предосторожности частью своей политики в области охраны здоровья.

Рекомендуется проведение дополнительных исследований в отношении восприятия риска и коммуникации, которые конкретно затрагивают вопрос об электромагнитных полях. Психологические и

социологические факторы, которые влияют на восприятие риска в целом, были всесторонне изучены. Однако число исследований, направленных на анализ сравнительного значения этих факторов в случае электромагнитных полей или по выявлению других факторов, которые обусловлены электромагнитными полями, является ограниченным. Недавние исследования позволяют предположить, что меры предосторожности, некоторые несут в себе сообщения о риске, могут изменить восприятие риска, усиливая или сглаживая озабоченность этим вопросом. Поэтому необходимы более глубокие исследования в этой области.

Следует проводить исследования по разработке методов анализа издержки-преимущества/издержки-эффективность с точки зрения уменьшения воздействия магнитных полей СНЧ. Использование методов анализа издержки–преимущества и издержки–эффективность для оценки того, является ди данная политическая опция преимуществом для общества, было изучено во многих областях общественной политики. Необходима разработка схемы, которая установит параметры, необходимые для того, чтобы проводить такое изучение магнитных полей СНЧ. В силу неопределенности оценки необходимо предусматривать параметры, которые поддаются количественной оценке, и те, которые не поддаются такой оценке.

Таблица 1. Рекомендации для дальнейших исследований

Источники, измерения и воздействия	Приоритетность
Дальнейшая характеристика жилых помещений с высоким воздействием магнитного поля СНЧ в различных странах	Средняя
Выявление пробелов в знаниях относительно воздействия полей СНЧ на рабочих местах, как например при магниторезонансной томографии	Высокая
Изучение возможности возникновения контактных токов у детей в связи с особенностями электропроводки в жилых помещениях вне США	Средняя
Дозиметрия	
Дополнительные дозиметрические расчеты, увязывающие внешние электрические и магнитные поля с внутренними электрическими полями, в особенности в том, что касается совокупного воздействия электрических и магнитных полей различной ориентации	Средняя
Расчет индуцированных электрических полей и токов у беременных женщин и в плоде	Средняя
Дальнейшее уточнение микродозиметрических моделей, учитывающих клеточную архитектуру нейронных сетей и другие сложные системы подорганов	Средняя

Биофизические механизмы	
Дальнейшие исследования механизмов радикальных пар в иммунных клетках, которые генерируют активные формы кислорода в процессе своей фенотипической функции	Средняя
Дальнейшие теоретические и экспериментальные исследования возможной роли магнетитов в чувствительности к магнитному полю СНЧ	Низкая
Определение пороговых реакций на внутренние электрические поля, индуцированные полями СНЧ, в многоклеточных системах, таких как нейронные сети, с использованием теоретических методов и методов in vitro	Высокая
Нейроповедение	
Когнитивные исследования, изучение сна и электроэнцефалограмм у добровольцев, в том числе у детей и лиц, подверженных воздействию полей по роду работы с применением широкого диапазона частот СНЧ при высоких плотностях потока	Средняя
Исследование влияния пре- и постнатального воздействия полей на последующее развитие когнитивной функции у животных	Средняя
Дальнейшее изучение опиоидных и холинергических реакций у животных	Низкая
Нейродегенеративные расстройства	
Дополнительное изучение риска бокового амиотрофического склероза у «лиц электрических профессий» в связи с экспозицией к СНЧ магнитному полю, а также болезни Альцгеймера в связи с воздействием магнитного поля СНЧ	Высокая
Иммунология и гематология	
Изучение последствий воздействия магнитного поля СНЧ на развитие иммунной и кроветворной систем у животных раннего возраста	Низкая
Репродуктивные аспекты и развитие	
Дополнительные исследования возможной связи между выкидышем и воздействием магнитного поля СНЧ	Низкая
Онкологические заболевания	
Обновление новой информацией существующих сводных результатов в отношении лейкозов у детей	Высокая
Совокупный анализ существующих исследований возникновения опухолей мозга у детей	Высокая
Обновление существующих мета-анализов, касающихся лейкозов у взрослых и опухолей мозга, а также когорт лиц, подверженных профессиональному воздействию полей по роду своих занятий	Средняя

Создание моделей детского лейкоза на базе трансгенных грызунов для использования в изучении полей СНЧ	Высокая
Оценка совместного канцерогенного действия путем исследований in vitro и на животных	Высокая
Попытка воспроизводства исследований в области генотоксичности, проводимых in vitro	Средняя
Защитные меры	
Исследования по разработке политики в области охраны здоровья и осуществление мер в тех областях, где имеется научная неопределенность	Средняя
Дальнейшие исследования в области восприятия риска и коммуникаций в отношении электромагнитных полей	Средняя
Разработка методов анализа издержки-преимущества / издержки-эффективность для смягчения результатов воздействия полей СНЧ	Средняя

18 RESUMEN Y RECOMENDACIONES PARA ESTUDIOS POSTERIORES

En la presente monografía sobre Criterios de Salud Ambiental (EHC) se abordan los posibles efectos en la salud de la exposición a campos eléctricos y magnéticos de frecuencias extremadamente bajas (ELF). En ella se examinan las características físicas de los campos ELF, así como las fuentes de exposición y la medición. Sin embargo, sus principales objetivos son la revisión de la literatura científica sobre los efectos biológicos de la exposición a campos de ELF, a fin de evaluar cualquier riesgo para la salud proveniente de la exposición a dichos campos y utilizar esta evaluación de los riesgos de salud en la formulación de recomendaciones a las autoridades nacionales sobre los programas de protección de la salud.

Las frecuencias bajo consideración están comprendidas en el rango por encima de 0 Hz a 100 kHz. La inmensa mayoría de los estudios se han realizado sobre campos magnéticos en frecuencia de energía (50 ó 60 Hz) y muy pocos utilizando campos eléctricos en frecuencia de energía. Además, se han realizado varios estudios sobre campos de muy baja frecuencia (VLF, 3–30 kHz), campos magnéticos de gradientes invertidos utilizados en la imaginología de resonancia magnética y campos de VLF más débiles que emiten los monitores de visualización y los televisores.

En este capítulo se resumen las principales conclusiones y recomendaciones de cada sección, así como las conclusiones globales del proceso de evaluación de los riesgos de salud. Los términos utilizados en esta monografía para describir el peso de la evidencia para un resultado de salud determinado son los siguientes. Se dice que la evidencia es "limitada" cuando se reduce a un solo estudio o cuando hay cuestiones por resolver en relación con el diseño, la realización o la interpretación de varios estudios. La evidencia es "insuficiente" cuando no se puede interpretar que los estudios demuestran la presencia o la ausencia de un efecto debido a limitaciones cualitativas o cuantitativas importantes, o cuando no se dispone de datos.

También se encontraron brechas fundamentales en los conocimientos, y en la sección titulada "Recomendaciones para la investigación" se han resumido las investigaciones necesarias para llenar esas brechas.

18.1 Resumen

18.1.1 Fuentes, mediciones y exposiciones

Donde quiera que se genera, transmite o distribuye electricidad en tendidos o cables eléctricos o se utiliza en aparatos eléctricos existen campos eléctricos y magnéticos. Dado que el uso de la electricidad forma parte integrante de nuestro sistema de vida moderno, estos campos están omnipresentes en nuestro ambiente.

La unidad de intensidad de campo eléctrico es el voltio por metro ($V\ m^{-1}$) o el kilovoltio por metro ($kV\ m^{-1}$) y para los campos magnéticos la densidad de flujo se mide en teslas (T), o más habitualmente en militeslas (mT) o en microteslas (μT).

La exposición residencial a campos magnéticos en frecuencia de energía no registra grandes variaciones en todo el mundo. La media geométrica del campo magnético en los hogares oscila entre 0,025 y 0,07 μT en Europa y entre 0,055 y 0,11 μT en los Estados Unidos. Los valores medios de los campos eléctricos entre el hogar son del orden de varias decenas de voltios por metro. En las proximidades de determinados aparatos eléctricos, los valores instantáneos del campo magnético pueden llegar a ser de unos pocos cientos de microteslas. Cerca de las líneas de energía, los campos magnéticos llegan a ser de alrededor de 20 μT y los campos eléctricos de varios miles de voltios por metro.

Son pocos los niños que tienen una exposición residencial promedio en el tiempo a campos magnéticos de 50 ó 60 Hz superior a los niveles asociados con un aumento de la incidencia de la leucemia infantil (ver la sección 18.1.10). Entre el 1% y el 4% tienen una exposición media superior a 0,3 μT y sólo del 1% al 2% tienen una exposición media que supera los 0,4 μT.

La exposición ocupacional, aunque predominantemente debido a los campos en frecuencia de energía, también puede incluir otras frecuencias. Se ha encontrado que el promedio de la exposición a campos magnéticos en el lugar de trabajo para las ocupaciones relacionadas con la electricidad es superior al de otros trabajos tales como el trabajo de oficina, con valores que oscilan entre 0.4–0.6 μT para los electricistas y los ingenieros eléctricos y alrededor de 1.0 μT en los trabajadores de líneas de energía, siendo máxima la exposición de los soldadores, los maquinistas de ferrocarril y los operadores de máquinas de coser (por encima de 3 μT). Las exposiciones máximas a campos magnéticos en el lugar de trabajo pueden llegar a ser de alrededor de 10 mT y están asociadas de manera invariable con la presencia de conductores portadores de corrientes altas. En la industria del suministro de energía eléctrica, los trabajadores pueden estar expuestos a campos eléctricos de hasta 30 kV m^{-1}.

18.1.2 Campos eléctricos y magnéticos dentro del cuerpo

La exposición a campos eléctricos y magnéticos externos de frecuencias extremadamente bajas induce campos eléctricos y corrientes dentro del cuerpo. La dosimetría describe la relación entre los campos externos y el campo eléctrico y la densidad de corriente inducidos en el cuerpo, u otros parámetros asociados con la exposición a estos campos. El campo eléctrico y la densidad de corriente inducidos localmente son de especial interés debido a que están relacionados con la estimulación de los tejidos excitables, tales como los nervios y los músculos.

Los cuerpos de las personas y animales perturban significativamente la distribución espacial de un campo eléctrico de ELF. En bajas frecuencias, el cuerpo es un buen conductor y las líneas del campo perturbado externas al cuerpo son casi perpendiculares a la superficie de éste. En la superficie del cuerpo expuesto se inducen cargas oscilantes, que a su vez inducen corrientes dentro del cuerpo. Las características fundamentales de la

dosimetría para la exposición de las personas a campos eléctricos ELF son las siguientes:

- El campo eléctrico dentro del cuerpo suele ser de cinco a seis órdenes de magnitud inferior al campo eléctrico externo.
- Cuando la exposición es fundamentalmente al campo vertical, la dirección predominante de los campos inducidos también es vertical.
- Para un campo eléctrico externo determinado, los campos inducidos más fuertes corresponden al cuerpo humano en perfecto contacto con el suelo a través de los pies (eléctricamente aterrado) y los campos inducidos más débiles corresponden al cuerpo aislado del suelo (en "espacio libre").
- El flujo total de corriente en un cuerpo en perfecto contacto con el suelo esta determinado por el tamaño y la forma del cuerpo (incluida la postura) antes que la conductividad de los tejidos.
- La distribución de las corrientes inducidas a través de los diversos órganos y tejidos está determinada por la conductividad de dichos tejidos.
- La distribución de un campo eléctrico inducido también es afectada por la conductividad, pero menos que la corriente inducida.
- También hay un fenómeno independiente en el que la corriente se produce en el cuerpo por medio del contacto con un objeto conductor situado en un campo eléctrico.

Para los campos magnéticos, la permeabilidad de los tejidos es igual a la del aire, de manera que el campo en un tejido es igual al campo externo. Los cuerpos de las personas y de los animales no perturba significativamente el campo. La principal interacción de los campos magnéticos corresponde a la inducción de Faraday de campos eléctricos y las densidades de corriente asociadas en los tejidos conductores. Las características fundamentales de la dosimetría para la exposición de los seres humanos a campos magnéticos de ELF son las siguientes:

- El campo eléctrico y la corriente inducidos dependen de la orientación del campo externo. Los campos inducidos en el cuerpo considerado en conjunto son máximos cuando el campo está alineado de la parte anterior a la posterior del organismo, pero en algunos órganos concretos los valores máximos corresponden al campo alineado de un costado al otro.
- Los campos eléctricos más débiles son inducidos por un campo magnético orientado a lo largo del eje vertical del cuerpo.
- Para una intensidad y una orientación determinadas del campo magnético, se inducen campos eléctricos más altos en los cuerpos de mayor tamaño.

- La distribución del campo eléctrico inducido es afectada por la conductividad de los diversos órganos y tejidos. Éstos tienen un efecto limitado en la distribución de la densidad de corriente inducida.

18.1.3 Mecanismos biofísicos

Se examina la posibilidad de diversos mecanismos de interacción directa e indirecta propuestos para los campos eléctricos y magnéticos de ELF, en particular si una "señal" generada en un proceso biológico por la exposición a un campo se puede discriminar del ruido aleatorio inherente, y si el mecanismo desafía los principios científicos y los conocimientos científicos actuales. Muchos mecanismos se hacen posibles solamente en campos por encima de una intensidad determinada. No obstante, la ausencia de mecanismos posibles identificados no excluye la posibilidad de efectos en la salud incluso con niveles de campo muy bajos, siempre que se sigan los principios científicos básicos.

Entre los numerosos mecanismos propuestos para la interacción directa de los campos dentro del cuerpo humano, hay tres que destacan más que los otros por su potencial actuación a niveles más bajos del campo: los campos eléctricos inducidos en redes neurales, los pares de radicales y la magnetita.

Los campos eléctricos inducidos en los tejidos por la exposición a campos eléctricos o magnéticos de ELF estimulan directamente las fibras nerviosas mielinizadas aisladas de una forma posible desde el punto de vista biofísico cuando la intensidad del campo interno es superior a algunos voltios por metro. La transmisión sináptica en las redes neurales, en contraposición a las células aisladas, se puede ver afectada por campos mucho más débiles. Los organismos multicelulares suelen utilizar tal procesamiento de la señal por los sistemas nerviosos para detectar señales ambientales débiles. Para la discriminación en la red neural, se ha propuesto un límite inferior de 1 mV m^{-1}, pero de acuerdo con la evidencia actual parecen más probables valores umbral de alrededor de 10–100 mV m^{-1}.

El mecanismo par radical es una manera aceptada en que los campos magnéticos pueden influir en tipos específicos de reacciones químicas, por lo general aumentando las concentraciones de radicales libres reactivos en los campos bajos y reduciéndolas en los campos altos. Este aumento se ha visto en campos magnéticos de menos de 1 mT. Existe algunas evidencias que vinculan este mecanismo a la navegación de las aves durante la migración. Sobre una base teórica y debido a que los cambios producidos por los campos magnéticos de ELF y estáticos son similares, se sugiere que es poco probable que los campos en frecuencias de energía muy inferiores al campo geomagnético de unos 50 μT tenga mucha importancia biológica.

En los tejidos de los animales y seres humanos se encuentran cristales de magnetita, pequeños cristales ferromagnéticos de óxido de hierro de diversas formas, aunque en cantidades insignificantes. Al igual que los radicales libres, se han relacionado con la orientación y la navegación en los ani-

males migratorios, aunque la presencia de cantidades insignificantes de magnetita en el cerebro humano no confiere la capacidad de detectar el débil campo geomagnético. Los cálculos basados en hipótesis extremas parecen indicar para los efectos de los campos de ELF en los cristales de magnetita un límite inferior de 5 μT.

Otras interacciones biofísicas directas de los campos, tales como la ruptura de enlaces químicos, las fuerzas sobre las partículas cargadas y los diversos mecanismos de "resonancia" de banda estrecha, no parecen explicar de manera verosímil las interacciones en los niveles de campo encontrados en los entornos público y ocupacional.

Con respecto a los efectos indirectos, la carga eléctrica superficial inducida por campos eléctricos puede se percibida y dar lugar a microchoques dolorosos al tocar un objeto conductor. Se pueden producir corrientes de contacto cuando, por ejemplo, los niños pequeños tocan un grifo en la bañera de algunos hogares. Esto produce en la médula ósea pequeños campos eléctricos, posiblemente por encima de los niveles de ruido de fondo. Sin embargo, se desconoce si representan un riesgo para la salud.

Las líneas de energía eléctrica de alto voltaje producen nubes de iones con carga eléctrica como consecuencia de la descarga de tipo corona. Se ha sugerido que podría aumentar la deposición sobre la piel y en las vías respiratorias dentro del cuerpo de los contaminantes del aire, posiblemente con efectos adversos en la salud. Sin embargo, parece probable que los iones del efecto corona tengan efectos escasos o nulos en los riesgos de salud a largo plazo, incluso en las personas más expuestas.

Ninguno de los tres mecanismos directos considerados anteriormente parece ser una causa posible del aumento de incidencia de enfermedades a los niveles de exposición que suele encontrar la población. De hecho, solamente comienzan a ser posibles a niveles varios órdenes de magnitud superiores, y los mecanismos indirectos todavía no se han investigado suficientemente. Esta ausencia de un mecanismo posible identificado no excluye la posibilidad de efectos adversos en la salud, pero hace necesaria la obtención de evidencias más sólidas a partir de la biología y la epidemiología.

18.1.4 Neurocomportamiento

La exposición a campos eléctricos en frecuencia de energía provoca respuestas biológicas bien definidas, que van desde la percepción hasta las molestias, por medio de los efectos de la carga eléctrica superficial. Estas respuestas dependen de la intensidad del campo, las condiciones ambientales y la sensibilidad individual. Los umbrales para la percepción directa por el 10% de un grupo de voluntarios fueron de 2 a 20 kV m^{-1}, mientras que el 5% encontraron molestias con 15–20 kV m^{-1}. Se observó que la descarga de chispas de la persona al suelo era dolorosa en el 7% de los voluntarios en un campo de 5 kV m^{-1}. Los umbrales para la descarga a partir de un objeto cargado a través de una persona aterrada eléctricamente dependen del tamaño del objeto, por lo que se requiere una evaluación específica.

Los campos magnéticos rápidamente pulsantes de intensidad elevada pueden estimular el tejido nervioso periférico o central; tales efectos se pueden presentar durante los procedimientos de imaginología por resonancia magnética (IRM) y se utilizan en la estimulación magnética transcraneal. Las intensidades umbrales de un campo eléctrico inducido para la estimulación directa de los nervios podrían ser de apenas unos voltios por metro. El umbral probablemente es constante dentro de un rango de frecuencias entre unos pocos hertzios y algunos kilohertzios. Es probable que las personas que sufren epilepsia o están predispuestas a ella sean más susceptibles a los campos eléctricos de ELF inducidos en el sistema nervioso central (SNC). Además, la sensibilidad del SNC al estímulo eléctrico está probablemente asociada con un historial familiar de convulsiones y el uso de antidepresivos tricíclicos, agentes neurolépticos y otros fármacos que reducen el umbral de convulsión.

La función de la retina, que forma parte del SNC, puede verse afectada por la exposición a campos magnéticos de ELF mucho más débiles que los causantes de una estimulación directa de los nervios. La interacción del campo eléctrico inducido con las células de la retina excitables eléctricamente da lugar a una sensación de destellos luminosos, denominados fosfenos magnéticos o magnetofosfenos. Las intensidades umbral de los campos eléctricos inducidos en el fluido extracelular de la retina se ha estimado que están comprendidas entre unos 10 y 100 mV m^{-1} a 20 Hz. Sin embargo, existe una incertidumbre considerable la en relación con estos valores.

La evidencia de otros efectos neurocomportamentales en estudios con voluntarios, tales como los efectos en la actividad eléctrica del cerebro, la cognición, el sueño, la hipersensibilidad y el humor, son menos claras. En general, dichos estudios se han realizado con niveles de exposición por debajo de los necesarios para inducir los efectos descritos anteriormente, y en el mejor de los casos solamente se han obtenido evidencias de efectos sutiles y transitorios. Las condiciones necesarias para que se den tales respuestas no están bien definidas por el momento. Hay algunos indicios que parecen indicar la existencia de efectos dependientes del campo sobre el tiempo de reacción y sobre la precisión reducida en la realización de algunas funciones cognitivas, que están respaldados por los resultados de estudios sobre la actividad eléctrica general del cerebro. En los estudios en los que se investigó si los campos magnéticos afectaban a la calidad del sueño se han reportado resultados inconsistentes. Es posible que estas inconsistencias puedan atribuirse en parte a diferencias en el diseño de los estudios.

Algunas personas afirman que son hipersensibles a los CEM en general. Sin embargo, los resultados obtenidos en estudios doble ciego de provocación parecen indicar que los síntomas notificados no guardan relación con la exposición a dichos campos.

Las únicas evidencias que la exposición a campos eléctricos y magnéticos de ELF provoca síntomas depresivos o el suicidio son inconsistentes y no concluyentes. Por lo tanto, la evidencia es considerada inadecuada.

En animales, se ha estudiado desde varias perspectivas la posibilidad de que la exposición a campos de ELF afecte a las funciones neurocomportamentales, utilizando una serie de condiciones de exposición. Son pocos los efectos sólidamente establecidos. Existe evidencia convincente que los animales pueden detectar campos eléctricos en frecuencia de energía, muy probablemente como consecuencia de los efectos de la carga superficial, que pueden provocar agitación transitoria o un estrés ligero. En las ratas, la gama de detección está comprendida entre 3 y 13 kV m^{-1}. Se ha comprobado que los roedores muestran rechazo hacia las intensidades de campo superiores a 50 kV m^{-1}. Otros posibles cambios dependientes del campo no están bien definidos; los estudios de laboratorio solamente han proporcionado evidencias de efectos sutiles y transitorios. Existen algunas evidencias que la exposición a campos magnéticos puede modular las funciones de los sistemas de neurotransmisores opioides y colinérgicos en el cerebro, respaldadas por los resultados de estudios en los que se investigaron los efectos en la analgesia y en la adquisición y el desempeño de funciones de memoria espacial.

18.1.5 Sistema neuroendocrino

Los resultados de varios estudios en voluntarios, así como de estudios epidemiológicos residenciales y ocupacionales, sugieren que el sistema neuroendocrino no es afectado adversamente por la exposición a campos eléctricos o magnéticos en frecuencias de energía. Esto se aplica particularmente a los niveles circulantes de hormonas específicas del sistema neuroendocrino, como la melatonina, liberada por la glándula pineal (epífisis), y a varias hormonas liberadas por glándula pituitaria (hipófisis) que intervienen en el control del metabolismo y la fisiología del cuerpo. A veces se observaron ligeras diferencias en el tiempo de la liberación de la melatonina relacionadas con ciertas características de la exposición, pero estos resultados no fueron consistentes. Es muy difícil eliminar la posible confusión debida a diversos factores ambientales y al estilo de vida que también podrían influir en los niveles hormonales. En la mayor parte de los estudios de laboratorio sobre los efectos de la exposición a campos de ELF en los niveles nocturnos de melatonina en voluntarios no se encontró ningún efecto cuando se tuvo cuidado en el control de los posibles factores de confusión.

Del gran número de estudios en animales que investigan los efectos de los campos eléctricos y magnéticos en frecuencias de energía sobre los niveles de la melatonina pineal (en la epífisis) y en el suero, algunos reportaron que la exposición provocaba la supresión nocturna de la melatonina. Los cambios en los niveles de melatonina observados por primera vez en los estudios iniciales de exposición a campos eléctricos de hasta 100 kV m^{-1} no pudieron reproducirse. Los resultados de una serie de estudios más recientes, que mostraban que los campos magnéticos polarizados circularmente suprimían los niveles nocturnos de melatonina, fueron debilitados por las comparaciones inapropiadas entre los animales expuestos y los controles históricos. Los datos de otros experimentos en roedores, que abarcaban niveles de intensidad comprendidos desde unos pocos microteslas a 5 mT, fueron

equívocos, con algunos mostrando depresión de la melatonina, mientras que en otros no se observaron cambios. En animales de reproducción estacional, la evidencia de un efecto de la exposición a campos en frecuencia de energía sobre los niveles de la melatonina y en el estatus reproductivo dependiente de ésta son predominantemente negativas. En un estudio con primates no humanos sometidos a una exposición crónica a campos en frecuencia de energía no se detectó ningún efecto convincente en los niveles de melatonina, aunque en un estudio preliminar en el que se utilizaron dos animales se reporto la supresión de la melatonina en respuesta a una exposición irregular e intermitente.

Los efectos de la exposición a campos de ELF sobre la producción o liberación de melatonina en glándulas pineales aisladas fueron variables, aunque se han realizado relativamente pocos estudios in vitro. Las evidencias que la exposición a campos de ELF interfiere con la acción de la melatonina en las células de cáncer de mama in vitro son complicadas. Sin embargo, este sistema presenta el inconveniente que frecuentemente las líneas celulares muestran deriva genotípica y fenotípica en el cultivo que puede obstaculizar la transferibilidad posibilidad de transferencia entre laboratorios.

No se han observado efectos consistentes en las hormonas relacionadas con el estrés del eje hipófisis-glándulas suprarrenales en diversas especies de mamíferos, con la posible excepción de un estrés de corta duración tras el inicio de la exposición a campos eléctricos ELF de niveles suficientemente altos para poder percibirlos. Similarmente, si bien son pocos los estudios que se han realizado, en la mayoría se han observado efectos negativos o inconsistentes en los niveles de hormona del crecimiento y de las hormonas que intervienen en el control de la actividad metabólica o están asociadas con el control de la reproducción y el desarrollo sexual.

Considerados en conjunto, estos datos no indican que los campos eléctricos y/o magnéticos de ELF afecten al el sistema neuroendocrino de manera que se produzcan efectos adversos en la salud humana, por lo que las pruebas se consideran inadecuadas.

18.1.6 Trastornos neurodegenerativos

Se ha planteado la hipótesis que la exposición a campos de ELF puede estar asociada con varias enfermedades neurodegenerativas. En relación con la enfermedad de Parkinson y la esclerosis múltiple, el número de estudios ha sido pequeño y no hay evidencias de asociación con estas enfermedades. En el caso de la enfermedad de Alzheimer y la esclerosis lateral amiotrófica (ELA), se han publicado más estudios. Algunos de estos informes parecen indicar que las personas que trabajan en ocupaciones relacionadas con la electricidad podrían tener mayor riesgo de esclerosis lateral amiotrófica (ELA). Hasta ahora no se ha establecido ningún mecanismo biológico que pueda explicar esta asociación, aunque podría haber surgido debido a factores de confusión relacionados con las ocupaciones vinculadas a la electricidad, como los choques eléctricos. En conjunto, se considera que

las pruebas de la asociación entre la exposición a campos de ELF y la esclerosis lateral amiotrófica son (inadecuadas) insuficientes.

Los pocos estudios en los que se ha investigado la asociación entre la exposición a campos ELF y la enfermedad de Alzheimer son contradictorios. Sin embargo, los estudios de mayor calidad que se concentraron en la morbilidad de la enfermedad de Alzheimer más que en la mortalidad no indicaron una asociación. En conjunto, las pruebas de una asociación entre la exposición a campos ELF y la enfermedad de Alzheimer son insuficientes.

18.1.7 Trastornos cardiovasculares

Los estudios experimentales de exposición tanto de corta como de larga duración indican que, si bien el choque eléctrico representa un peligro evidente para la salud, es improbable que se produzcan otros efectos cardiovasculares peligrosos asociados con los campos de ELF a los niveles de exposición ambiental u ocupacional comúnmente encontrados. Aunque se han reportado diversos cambios cardiovasculares en la literatura, la mayoría de los efectos son pequeños y los resultados no han sido consistentes en los estudios y entre ellos. Con una sola excepción, ninguno de los estudios de la morbilidad y mortalidad de las enfermedades cardiovasculares ha mostrado una asociación con la exposición. La posibilidad de que exista una asociación específica entre la exposición y el control autónomo alterado del corazón sigue siendo una mera especulación. En conjunto, las pruebas no respaldan una asociación entre la exposición a campos de ELF y las enfermedades cardiovasculares.

18.1.8 Inmunología y hematología

Las evidencias de los efectos de los campos eléctricos o magnéticos de ELF sobre los componentes del sistema inmunológico en general son inconsistentes. En muchos casos las poblaciones celulares y los marcadores funcionales no fueron afectados por la exposición. Sin embargo, en algunos estudios en seres humanos con campos desde 10 μT a 2 mT se observaron cambios en las células asesinas naturales (citolíticas) , que mostraron tanto un aumento como una disminución de su número, y en la cuenta total de células blancas (leucocitos), sin cambios o con una disminución del número. En estudios en animales, se observó una actividad reducida de las células citolíticas en ratones hembras, pero no en los machos ni en las ratas de ambos sexos. También en la cuenta de células blancas el recuento de leucocitos se obtuvieron resultados inconsistentes, con una disminución o ningún cambio en los distintos estudios. La gama de exposición de los animales fue aún más amplia, de 2 μT a 30 mT. La dificultad para interpretar el impacto potencial de estos datos en la salud radica en las grandes variaciones de las condiciones de exposición y ambientales, el número relativamente pequeño de individuos sometidos a prueba y la amplia variedad de efectos finales.

Son pocos los estudios realizados sobre los efectos de los campos magnéticos de ELF en el sistema hematológico. En los experimentos de evaluación de la cuenta diferencial de células blancas (leucocitos), las exposi-

ciones fueron desde 2 μT a 2 mT. No se han encontrado efectos consistentes de la exposición aguda a campos magnéticos de ELF o a campos eléctricos y magnéticos de ELF combinados ni en los estudios con personas ni con animales.

Por consiguiente, de manera global las evidencias de los efectos de los campos eléctricos o magnéticos de ELF en los sistemas inmunológico y hematológico se consideran insuficientes.

18.1.9 Reproducción y desarrollo

En conjunto, los estudios epidemiológicos no han demostrado que haya una asociación entre resultados adversos en la reproducción humana con la exposición materna o paterna a campos de ELF. Hay algunas evidencias de un aumento del riesgo de aborto asociado con la exposición materna a campos magnéticos, pero son insuficientes.

Se han evaluado exposiciones a campos eléctricos de ELF de hasta 150 kV m^{-1} en varias especies de mamíferos, incluidos estudios con grupos de gran tamaño y exposiciones durante varias generaciones. Los resultados, consistentemente, no mostraron ningún efecto adverso en el desarrollo.

La exposición de mamíferos a campos magnéticos de ELF de hasta 20 mT no da lugar a malformaciones externas, viscerales o esqueléticas graves. Algunos estudios muestran un aumento de pequeñas anomalías esqueléticas, tanto en ratas como en ratones. En estudios teratológicos son relativamente frecuentes las variaciones en el esqueleto, las cuales frecuentemente se consideran biológicamente insignificantes. Sin embargo, no se pueden excluir sutiles efectos de los campos magnéticos en el desarrollo del esqueleto. Se han publicado muy pocos estudios en los que se aborden los efectos en la reproducción, y de ellos no se puede extraer ninguna conclusión.

En varios estudios sobre modelos experimentales no mamíferos (embriones de pollo, peces, erizos de mar e insectos) se han reportado resultados mostrando que los campos magnéticos de ELF a niveles de microteslas pueden alterar el desarrollo inicial. Sin embargo, los resultados de los modelos experimentales no mamíferos en la evaluación global de la toxicidad en el desarrollo tienen un valor menor que los obtenidos en los estudios correspondientes con mamíferos.

En conjunto, las pruebas de efectos en el desarrollo y la reproducción son insuficientes.

18.1.10 Cáncer

La clasificación de la Agencia Internacional de Investigación del Cáncer (IARC) de los campos magnéticos de ELF como “posiblemente carcinogénicos para los seres humanos” (IARC, 2002) se basa en todos los datos disponibles hasta 2001 inclusive. El examen de la literatura en la presente monografía de los Criterios de Salud Ambiental se concentra principalmente en los estudios publicados después de la revisión de la IARC.

Epidemiología

En la clasificación de la IARC influyeron fuertemente las asociaciones observadas en los estudios epidemiológicos sobre la leucemia infantil. La clasificación de esta evidencia como limitada no cambia con la adición de dos estudios sobre leucemia infantil publicados después de 2002. Desde la publicación de la monografía de la IARC, las evidencias de otros casos de cáncer infantil siguen siendo insuficientes.

Con posterioridad a la monografía de la IARC se han publicado varios informes relativos al riesgo de cáncer de mama en mujeres adultas asociado con la exposición a campos magnéticos de ELF. Estos estudios son más amplios que los anteriores y menos susceptibles a sesgos, y en conjunto son negativos. Con estos resultados, la evidencia de una asociación entre la exposición a campos magnéticos de ELF y el riesgo de cáncer de mama en mujeres se debilitan considerablemente y no respaldan una asociación de este tipo.

En el caso del cáncer cerebral y la leucemia en adultos, los nuevos estudios publicados después de la monografía de la IARC no modifican la conclusión de que la evidencia global de una asociación entre los campos magnéticos de ELF y el riesgo de estas enfermedades siguen siendo insuficientes.

Para otras enfermedades y todos los demás tipos de cáncer, las pruebas permanecen insuficientes.

Estudios en animales de laboratorio

En la actualidad no hay ningún modelo animal adecuado para la forma más frecuente de leucemia infantil, la leucemia linfoblástica aguda. Tres estudios independientes de gran escala con ratas no proporcionaron ninguna evidencia de algún efecto de los campos magnéticos de ELF sobre la incidencia de tumores de mama espontáneos. La mayoría de los estudios no reportan ningún efecto de los campos magnéticos de ELF sobre la leucemia o los linfomas en modelos roedores. Varios estudios de gran escala de larga duración en roedores no han mostrado ningún aumento consistente de ningún tipo de cáncer, incluyendo tumores hematopoyéticos, de mama, cerebrales y de piel.

Un número sustancial de estudios examinaron los efectos de los campos magnéticos de ELF sobre tumores de mama inducidos por sustancias químicas en ratas. Se obtuvieron resultados inconsistentes, que pueden deberse totalmente o en parte a diferencias en los protocolos experimentales, tales como el uso de subrazas específicas. La mayoría de los estudios sobre los efectos de la exposición a campos magnéticos de ELF en modelos de leucemia/linfomas inducidos por sustancias químicas o por radiación fueron negativos. Los estudios de lesiones hepáticas preneoplásicas, tumores de piel inducidos por sustancias químicas y tumores cerebrales reportaron resultados predominantemente negativos. Un estudio reporto una aceleración de la tum-

origenesís cutánea inducida por radiaciones ultravioleta (UV) tras la exposición a campos magnéticos de ELF.

Dos grupos han reportado un aumento de los niveles de ruptura de las cadenas de ADN en el tejido cerebral tras la exposición in vivo a campos magnéticos de ELF. Sin embargo, otros grupos, utilizando una variedad de diferentes modelos de genotoxicidad en roedores, no encontraron ninguna evidencia de efectos genotóxicos. Los resultados de los estudios de investigación sobre los efectos no genotóxicos pertinentes al cáncer no son concluyentes.

En conjunto no hay ninguna prueba que la exposición a campos magnéticos de ELF provoque por sí sola la aparición de tumores. La evidencia que la exposición a campos magnéticos de ELF puede potenciar el desarrollo de tumores en combinación con carcinógenos es inadecuada (insuficiente).

Estudios in vitro

En general, los estudios de los efectos de la exposición de células a campos de ELF no han mostrado ninguna inducción de genotoxicidad para campos por debajo de 50 mT. La notable excepción es la evidencia obtenida en estudios recientes en los que se han descrito daños en el ADN con campos de una intensidad de apenas 35 μT; sin embargo, estos estudios todavía están siendo evaluados y la comprensión de estos hallazgos todavía es incompleta. También existe evidencia creciente que los campos magnéticos de ELF pueden interactuar con agentes causantes de daños en el ADN.

No hay ninguna evidencia clara de la activación por campos magnéticos de ELF de genes asociados con el control del ciclo celular. Sin embargo, todavía no se han realizado estudios sistemáticos en los que se analice la respuesta del genoma completo.

Muchos otros estudios celulares, por ejemplo sobre proliferación celular, apoptosis, señalización del calcio y transformación maligna, han dado resultados inconsistentes o no concluyentes.

Conclusión general

Los nuevos estudios en seres humanos, en animales e in vitro, publicados desde la monografía de 2002 de la IARC, no modifican la clasificación global de los campos magnéticos de ELF como posibles carcinógenos para los seres humanos.

18.1.11 Evaluación de los riesgos de salud

Según la Constitución de la OMS, la salud es un estado de completo bienestar físico, mental y social, y no solamente la ausencia de afecciones o enfermedades. La evaluación de riesgo es un marco conceptual para una revisión estructurada de la información pertinente a la estimación de los resultados para la salud o el ambiente. La evaluación de riesgo de salud se puede utilizar como un aporte a la gestión del riesgo que acompaña a todas

las actividades necesarias para adoptar decisiones sobre si una exposición requiere algunas acciones específicas y la aplicación de esas acciones.

En la evaluación de los riesgos para la salud humana, los datos válidos en seres humanos, siempre que se disponga de ellos, generalmente son más informativos que los obtenidos en animales. Los estudios en animales e in vitro pueden respaldar las pruebas procedentes de los estudios en seres humanos, llenar las brechas en la evidencia procedentes de los estudios en seres humanos o utilizarse para adoptar una decisión sobre los riesgos cuando los estudios en seres humanos son insuficientes o no existen.

Todos los estudios, ya sea con efectos positivos o negativos, necesitan ser evaluados juzgados por su propio valor, y luego en conjunto en un sistema basado en el peso de la evidencia. Es importante determinar en qué medida un conjunto de evidencias cambia la probabilidad de que la exposición dé lugar a un resultado. La evidencia de un efecto generalmente es reforzada si los resultados de distintos tipos de estudios (epidemiología y laboratorio) apuntan a la misma conclusión, o cuando estudios múltiples del mismo tipo dan el mismo resultado.

Efectos agudos

Se han establecido los efectos biológicos agudos para la exposición a campos eléctricos y magnéticos de ELF en el rango de frecuencias de hasta 100 kHz que pueden tener consecuencias adversas para la salud. Por consiguiente, se necesitan límites de exposición. Existen recomendaciones internacionales en las que se ha abordado esta cuestión. La observancia de estas recomendaciones proporciona una protección adecuada frente a los efectos agudos.

Efectos crónicos

La evidencia científica que sugiere que la exposición cotidiana crónica a campos magnéticos en frecuencia de energía de baja intensidad (por encima de 0,3–0,4 μT) representa un riesgo para la salud se basa en estudios epidemiológicos que demuestran que hay un patrón consistente de aumento del riesgo de leucemia infantil. Entre las incertidumbres que rodean la evaluación del peligro se incluyen el rol que que podrían desempeñar en la relación observada entre los campos magnéticos y la leucemia infantil el sesgo de selección de los controles y la clasificación errónea de la exposición. Además, virtualmente ninguna de las evidencias de laboratorio y mecanísticas respaldan una relación entre los campos magnéticos de ELF de bajo nivel y los cambios en la función biológica o el estado patológico. Por tanto, en el balance la evidencia no es lo suficientemente fuerte para considerar que hay una relación causal, pero sí para que se mantenga la preocupación.

Aunque no se ha establecido una relación causal entre la exposición a campos magnéticos y la leucemia infantil, se ha calculado el posible impacto en la salud pública suponiendo la existencia de causalidad, a fin de

proporcionar un aporte potencialmente útil a las políticas. Sin embargo, estos cálculos dependen en gran medida de las distribuciones de la exposición y de otras hipótesis, por lo que son muy imprecisos. Suponiendo que la asociación sea causal, se puede estimar que el número de casos de leucemia infantil en todo el mundo que podrían atribuirse a la exposición es del orden de 100 a 2400 al año. Sin embargo, esto representa 0,2 a 4,9% de la incidencia anual total de casos de leucemia, estimados en 49 000 en todo el mundo en el año 2000. Por tanto, en un contexto mundial las repercusiones en la salud pública, si las hay, serían limitadas y dudosas.

Se ha investigado la posible asociación de otras enfermedades con la exposición a campos magnéticos de ELF. Entre ellas están el cáncer tanto en niños como en adultos, la depresión, el suicidio, la disfunción reproductiva, los trastornos del desarrollo, las modificaciones inmunológicas y las enfermedades neurológicas. La evidencia científica que respalda una vinculación entre los campos magnéticos de ELF y cualquiera de estas enfermedades es mucho más débil que para la leucemia infantil, y en algunos casos (por ejemplo en las enfermedades cardiovasculares o el cáncer de mama) la evidencia es suficiente para tener la confianza que los campos magnéticos no son causa de la enfermedad.

18.1.12 Medidas de protección

Es esencial que se apliquen límites de exposición, a fin de proteger contra los efectos adversos establecidos de la exposición a campos eléctricos y magnéticos de ELF. Estos límites de exposición deberían basarse en un examen exhaustivo de toda la evidencia científica relevante.

Solamente se han establecido los efectos agudos, y hay dos recomendaciones internacionales de límites de exposición (ICNIRP, 1998a; IEEE, 2002) destinadas a la protección frente a estos efectos.

Además de estos efectos agudos conocidos, hay incertidumbres acerca de la existencia de efectos crónicos, debido a que las pruebas de una vinculación entre la exposición a campos magnéticos de ELF y la leucemia infantil son limitadas. Por consiguiente, se justifica la utilización de enfoques de precaución. Sin embargo, no se recomienda la reducción de los valores límites de las recomendaciones sobre la exposición a algún nivel arbitrario en aras de la precaución. Dicha práctica socava el fundamento científico en el que se basan los límites y probablemente sea una manera costosa y no necesariamente eficaz de proporcionar protección.

La aplicación de otros procedimientos apropiados de precaución para reducir la exposición es razonable y se justifica. Sin embargo, la energía eléctrica aporta evidentes beneficios a la salud, sociales y económicos, y los enfoques de precaución no deberían comprometer esos beneficios. Además, teniendo en cuenta, por una parte la debilidad de la evidencia de una vinculación entre la exposición a campos magnéticos de ELF y la leucemia infantil y por otra parte el limitado impacto en la salud pública si existe una vinculación, no están claros los beneficios para la salud de una reducción de la exposición. Así pues, los costos de las medidas de precaución deberían ser

muy bajos. Los costos de la aplicación de reducciones de la exposición variarán de un país a otro, por lo que resulta muy difícil formular una recomendación general para alcanzar un equilibrio entre los costos y los posibles riesgos derivados de los campos ELF.

En vista de lo expuesto, se recomienda lo siguiente.

- Los encargados de formular las políticas deberían establecer recomendaciones para la exposición a campos de ELF tanto del público en general como de los trabajadores. La mejor fuente de orientación para los niveles de exposición y los principios aplicables a la revisión científica son las recomendaciones internacionales.
- Los encargados de formular las políticas deberían establecer un programa de protección para los CEM ELF que incluya mediciones de los campos de todas las fuentes, a fin de asegurarse de que no se superen los límites de exposición del público en general o de los trabajadores.
- Siempre que no se pongan en peligro los beneficios para la salud, sociales y económicos de la energía eléctrica, es razonable y se justifica la aplicación de procedimientos de precaución de muy bajo costo para reducir la exposición.
- Los encargados de formular las políticas, los planificadores comunitarios y los fabricantes deberían aplicar medidas de muy bajo costo al construir nuevas instalaciones y diseñar nuevos equipos, incluyendo aparatos eléctricos.
- Se debe estudiar la introducción de cambios en las prácticas de ingeniería para reducir la exposición a campos de ELF procedentes de equipos o dispositivos, siempre que se obtengan otros beneficios adicionales, tales como mayor seguridad o un costo escaso o nulo.
- Cuando se planteen cambios en las fuentes existentes de campos ELF, se debería considerar los aspectos de seguridad, la fiabilidad y los aspectos económicos involucrados.
- Las autoridades locales deberían hacer cumplir las normas sobre las instalaciones eléctricas a fin de reducir corrientes a tierra accidentales cuando se construyan nuevos locales o cuando se renueven las instalaciones eléctricas ya existentes, manteniendo al mismo tiempo la seguridad. Las medidas preventivas para identificar infracciones o problemas existentes en las instalaciones eléctricas resultarían costosas y probablemente no estarían justificadas.
- Las autoridades nacionales deberían aplicar una estrategia eficaz y de comunicación abierta a fin de que todas las partes interesadas puedan adoptar decisiones fundamentadas; debe estar incluida la

información sobre la manera en que las personas pueden reducir su propia exposición.

- Las autoridades locales deben mejorar la planificación de las instalaciones emisoras de CEM ELF, incluyendo el mejoramiento de las consultas entre la industria, los gobiernos locales y los ciudadanos al establecer las principales fuentes de emisión de CEM ELF.
- Los gobiernos y la industria deberían promover programas de investigación para reducir la incertidumbre de la evidencia científica sobre los efectos de la exposición a campos ELF en la salud.

18.2 Recomendaciones para la investigación

La identificación de las brechas en los conocimientos relativos a los posibles efectos en la salud de la exposición a campos de ELF es una parte esencial de la presente evaluación de los riesgos de salud. Como consecuencia, se han formulado las siguientes recomendaciones para investigación adicional (resumidas en la Tabla 1).

Es primordial la necesidad de realizar nuevas investigaciones sobre las frecuencias intermedias (FI), usualmente comprendidas entre 300 Hz y 100 kHz, dada la presente falta de datos en esta área. Es muy escasa la base de conocimientos de la cual se dispone y que se necesita para la evaluación de los riesgos de salud, y en la mayoría de los estudios existentes se han obtenido resultados inconsistentes, que es necesario comprobar ulteriormente. Los requisitos generales para establecer una base de datos de FI que sea suficiente a la hora de evaluar los riesgos de salud incluye la evaluación de la exposición, estudios epidemiológicos, estudios humanos de laboratorio y estudios en animales y celulares (in vitro) (ICNIRP, 2003; ICNIRP, 2004; Litvak et al., 2002).

En los estudios de laboratorio se debe conceder prioridad a las respuestas reportadas (i) para las cuales exista por lo menos alguna evidencia de replicación o confirmación, (ii) que sean potencialmente pertinentes a la carcinogénesis (por ejemplo de genotoxicidad), (iii) que sean suficientemente sólidas para permitir un análisis mecanístico y (iv) que se produzcan en sistemas de mamíferos o seres humanos.

18.2.1 Fuentes, mediciones y exposiciones

La caracterización ulterior de los hogares con un exposición elevada a campos de ELF en los distintos países, a fin de identificar la contribución relativa de las fuentes internas y externas, la influencia de las prácticas de instalación del tendido eléctrico/aterramiento eléctrico y otras características del hogar, puede servir de ayuda para identificar un sistema de medición de la exposición pertinente a la evaluación epidemiológica. Un componente importante de esto es el mejor entendimiento de la exposición fetal e infantil a campos de ELF, especialmente los procedentes de la

exposición residencial a la calefacción eléctrica debajo del piso en los domicilios y de los transformadores en los edificios de viviendas.

Se sospecha que en algunos casos de exposición ocupacional se superan los límites presentes de las recomendaciones sobre campos de ELF. Se necesita más información sobre la exposición (incluso a frecuencias que no son de energía) relacionada con el trabajo, por ejemplo, mantenimiento de líneas con tensión, el trabajo dentro o cerca del núcleo central de las magnetos de los aparatos de IRM (y en consecuencia con los campos de ELF de gradiente conmutada) y el trabajo en sistemas de transporte. Asimismo, se necesitan más conocimientos acerca de la exposición del público general que pueda acercarse a los límites de las recomendaciones, incluyendo fuentes tales como los sistemas de seguridad, los sistemas de desmagnetización de las bibliotecas, las cocinas de inducción y los calentadores de agua.

Se ha propuesto la exposición a corrientes de contacto como una posible explicación de la asociación de los campos magnéticos de ELF con la leucemia infantil. Es necesario realizar investigaciones en países distintos de los Estados Unidos para evaluar la posibilidad de que las prácticas de aterramiento eléctrico residenciales y la ductería de agua potable en las viviendas den lugar a corrientes de contacto. Dichos estudios tendrían prioridad en los países con resultados epidemiológicos importantes con respecto a los campos de ELF y la leucemia infantil.

18.2.2 Dosimetría

La mayor parte de las investigaciones de laboratorio realizadas en el pasado se basaban en corrientes eléctricas inducidas en el cuerpo como métrica básica, de manera que la dosimetría se concentraba en esta cantidad. Sólo en fechas recientes se ha comenzado a explorar la relación entre la exposición externa y los campos eléctricos inducidos. Para comprender mejor los efectos biológicos, se necesitan más datos sobre los campos eléctricos internos en distintas condiciones de exposición.

Se debe realizar un cálculo de los campos eléctricos internos, debido a la influencia combinada de los campos eléctricos y magnéticos externos en distintas configuraciones. Es necesaria la adición vectorial de las contribuciones fuera de fase y con variaciones espaciales de los campos eléctricos y magnéticos para evaluar el cumplimiento de las restricciones básicas.

Son muy pocos los cálculos que se han realizado sobre modelos avanzados de la mujer embarazada y el feto con modelos anatómicos apropiados. Es importante evaluar el posible aumento de la inducción de campos eléctricos en el feto en relación con el tema de la leucemia infantil. En este sentido son importantes la exposición ocupacional materna y residencial.

Existe la necesidad de seguir perfeccionando los modelos microdosimétricos, con el objetivo de tener en cuenta la estructura celular de las redes neurales y otros sistemas suborgánicos complejos identificados como más sensibles a los efectos de los campos eléctricos inducidos. En este proceso de modelamiento también se debe tener presente la influencia en los

potenciales eléctricos de la membrana celular y en la liberación de neurotransmisores.

18.2.3 Mecanismos biofísicos

Existen tres áreas principales en los que son evidentes los límites del entendimiento actual de los mecanismos: el mecanismo par radical, las partículas magnéticas en el cuerpo y la relación señal a ruido en los sistemas multicelulares, tales como las redes neuronales.

El mecanismo par radical es uno de los mecanismos más verosímiles de interacción de bajo nivel, pero todavía no se ha demostrado que es capaz de mediar efectos significativos en el metabolismo y la función celular. Es particularmente importante entender el límite inferior de exposición al cual actúa, de manera que se pueda determinar si puede ser o no un mecanismo importante para la carcinogénesis. Teniendo en cuenta los estudios recientes en los que aumentaron las especies de oxígeno reactivo en células inmunitarias expuestas a campos de ELF, se recomienda el empleo de células del sistema inmunológico que generan especies de oxígeno reactivo como parte de su respuesta inmunitaria como modelos celulares para investigar el potencial del mecanismo par radical.

Aunque, de acuerdo con las evidencias actuales, la presencia de partículas magnéticas (cristales de magnetita) en el cerebro humano no parece conferir sensibilidad a los campos magnéticos de ELF del ambiente, se deberían explorar más enfoques teóricos y experimentales para estudiar si tal sensibilidad puede existir bajo determinadas condiciones. Además, se debería buscar cualquier modificación que pueda introducir la presencia de magnetita en el mecanismo par radical antes mencionado.

Se debe seguir investigando en qué medida actúan mecanismos multicelulares en el cerebro, de manera que mejoren las relaciones señal a ruido, a fin de desarrollar un marco teórico para su cuantificación o para determinar sus posibles límites. Se debe realizar investigación adicional del umbral y la respuesta de frecuencia de las redes neuronales en el hipocampo y en otras partes del cerebro utilizando métodos in vitro.

18.2.4 Neurocomportamiento

Se recomienda que los estudios de laboratorio basados en voluntarios sobre los posibles efectos en el sueño y en la realización de tareas que exijan un esfuerzo mental grande se lleven a cabo utilizando procedimientos metodológicos armonizados. Es necesario identificar las relaciones dosis-respuesta con densidades de flujo magnético superiores a las utilizadas anteriormente y con una gama amplia de frecuencias (es decir, en el rango de los kilohertz).

Los estudios realizados en voluntarios adultos y en animales sugieren que pueden producirse efectos cognitivos agudos con exposiciones de corto plazo a campos eléctricos o magnéticos intensos. La caracterización de tales efectos es muy importante para el desarrollo de orientación sobre la exposición, pero se carece de datos específicos concernientes a efectos

dependientes del campo en niños. Se recomienda la realización de estudios de laboratorio en la cognición y los cambios en los electroencefalogramas (EEG) en personas expuestas a campos de ELF, incluyendo adultos sujetos habitualmente a exposición ocupacional y niños.

Los estudios de comportamiento con animales inmaduros proporcionan un indicador útil de los posibles efectos cognitivos en los niños. Se deben estudiar los posibles efectos de la exposición prenatal y postnatal a campos magnéticos de ELF en el desarrollo del sistema nervioso y la función cognitiva. Sería útil complementar estos estudios con investigaciones sobre los efectos de la exposición a campos magnéticos de ELF y campos eléctricos inducidos en el crecimiento de las células nerviosas, utilizando rebanadas de cerebro o neuronas cultivadas.

Es necesario seguir investigando las consecuencias potenciales en la salud sugeridas por los datos experimentales que muestran respuestas opioides y colinérgicas en animales. Se deberian ampliar los estudios en los que se examina la modulación de las respuestas opioides y colinérgicas en animales y se debería definir los parámetros de exposición y la base biológica de estas respuestas de comportamiento.

18.2.5 Sistema neuroendocrino

La base de datos existente sobre la respuesta neuroendocrina no indica que la exposición a campos de ELF tenga impactos adversos en la salud humana. Por consiguiente, no se formula ninguna recomendación para nuevas investigaciones.

18.2.6 Trastornos neurodegenerativos

En varios estudios se ha observado un aumento del riesgo de esclerosis lateral amiotrófica en las “ocupaciones eléctricas”. Se considera importante realizar más investigación de esta asociación, a fin de descubrir si los campos magnéticos de ELF intervienen como causa de esta rara enfermedad neurodegenerativa. Esta investigación requiere estudios prospectivos de cohortes de gran envergadura con información sobre la exposición a campos magnéticos de ELF, a choques eléctricos así como exposición a otros posibles factores de riesgo.

Sigue siendo discutible si los campos magnéticos de ELF constituyen un factor de riesgo para la enfermedad de Alzheimer. Los datos disponibles en la actualidad no son suficientes, por lo que habría que estudiar más esta asociación. Tiene particular importancia el uso de datos sobre la morbilidad más que sobre la mortalidad.

18.2.7 Trastornos cardiovasculares

No se considera prioritaria la realización de investigaciones adicionales sobre la asociación entre los campos magnéticos de ELF y el riesgo de enfermedades cardiovasculares.

18.2.8 Inmunología y hematología

Los cambios observados en los parámetros inmunológicos y hematológicos en adultos expuestos a campos magnéticos de ELF mostraron inconsistencias, y esencialmente no se dispone de datos de investigación sobre niños. Por consiguiente, se recomienda la realización de estudios sobre los efectos de la exposición a campos de ELF en el desarrollo de los sistemas inmunológicos y hematopoyético en animales jóvenes.

18.2.9 *Reproducción y desarrollo*

Existen algunas evidencias de un aumento del riesgo de aborto asociado con la exposición a campos magnéticos de ELF. Teniendo en cuenta las repercusiones potencialmente elevadas de dicha asociación para la salud pública se recomienda la realización de nuevas investigaciones epidemiológicas.

18.2.10 Cáncer

La máxima prioridad de las investigaciones en esta área corresponde a la solución del conflicto entre los datos epidemiológicos (que muestran una asociación entre la exposición a campos magnéticos de ELF y un aumento del riesgo de leucemia infantil) y los datos experimentales y mecanísticos (que no respaldan esta asociación). Se recomienda la colaboración de epidemiólogos y científicos experimentales en este sentido. Para que los nuevos estudios epidemiológicos sean ilustrativos, se deben concentrar en nuevos aspectos de la exposición, en la interacción potencial con otros factores o en grupos muy expuestos, o bien introducir alguna otra innovación en esta esfera de investigación. Además, se recomienda también la actualización de los análisis combinados existentes, añadiendo datos de estudios recientes y aplicando nuevos conocimientos dentro del análisis.

En los estudios sobre el cáncer cerebral infantil se han obtenido resultados inconsistentes. Al igual con la leucemia infantil, el análisis de los estudios combinados sobre el cáncer cerebral infantil sería muy informativo, por lo que se recomienda. Un análisis de este tipo puede proporcionar sin grandes gastos mayor y mejor información sobre los datos existentes, incluyendo la posibilidad del sesgo de selección, y si los estudios son suficientemente homogéneos puede ofrecer la mejor estimación de riesgo.

En el caso del cáncer de mama en adultos, estudios más recientes han mostrado de manera convincente que no existe ninguna asociación con la exposición a campos magnéticos de ELF. Por consiguiente, la investigación adicional sobre esta asociación debe ser objeto de una prioridad muy baja.

En relación con la leucemia y el cáncer cerebral en adultos, se recomienda la actualización de las cohortes de gran envergadura existentes de personas expuestas ocupacionalmente. Los estudios ocupacionales, los análisis combinados y los metaanálisis para la leucemia y el cáncer cerebral han sido inconsistentes y no concluyentes. Sin embargo, posteriormente se han publicado nuevos datos que deberían utilizarse para actualizar estos análisis.

Se ha de conceder prioridad al abordar las evidencias epidemiológicas, mediante el establecimiento de modelos in vitro y animales apropiados para las respuestas a campos magnéticos de ELF de bajo nivel que sean ampliamente transferibles entre laboratorios.

Se deben desarrollar modelos de roedores transgénicos para la leucemia infantil, a fin de disponer de modelos de animales experimentales apropiados para estudiar los efectos de la exposición a campos magnéticos de ELF. De otra manera, para los estudios existentes en animales el peso de la evidencia es que no existen efectos carcinogénicos provenientes de los campos magnéticos de ELF actuando por sí solos. Por consiguiente, se debe conceder máxima prioridad a los estudios in vitro y en animales en los que se evalúen rigurosamente los campos magnéticos de ELF como cocarcinógenos.

Con respecto a otros estudios in vitro, se deben repetir los experimentos en los que se reportan los efectos genotóxicos de una exposición intermitente a campos magnéticos de ELF.

18.2.11 Medidas de protección

Se recomienda la realización de investigaciones sobre la formulación de políticas de protección de la salud y su aplicación en sectores con incertidumbre científica, en concreto sobre el uso del principio de precaución, su interpretación y la evaluación del impacto de las medidas de precaución para campos magnéticos de ELF y otros agentes clasificados como "posibles carcinógenos para los seres humanos". Cuando existen incertidumbres acerca del riesgo potencial para la salud que un agente plantea para la sociedad, medidas de precaución que pueden estar justificadas, a fin de asegurar la protección adecuada del público y los trabajadores. Son limitadas las investigaciones que se han realizado sobre este tema para campos magnéticos de ELF y, debido a su importancia, es necesario seguir investigando. Esto puede ayudar a los países a integrar el principio de precaución en sus políticas de protección de la salud.

Se aconsejan nuevas investigaciones sobre la percepción y comunicación del riesgo orientadas específicamente a los campos electromagnéticos. Se han investigado ampliamente los factores psicológicos y sociológicos que influyen en la percepción del riesgo en general. Sin embargo, han sido limitadas las investigaciones para analizar la importancia relativa de estos factores en el caso de los campos electromagnéticos o para identificar otros factores específicos de dichos campos. En estudios recientes se ha sugerido que las medidas de precaución que transmiten mensajes de riesgo implícitos pueden modificar la percepción del riesgo, aumentando o disminuyendo la preocupación. Por consiguiente, está justificada una investigación más profunda sobre este tema.

Se debe realizar la investigación sobre el desarrollo de un análisis de costo-beneficio / costo-efectividad para la mitigación de los campos magnéticos de ELF. El empleo del análisis de costo-beneficio y costo-efectividad para evaluar si una opción en materia de políticas es beneficiosa para la

sociedad se ha investigado en muchos sectores de las políticas públicas. Es necesario formular un marco que permita identificar qué parámetros son necesarios a fin de realizar este análisis para campos magnéticos de ELF. Debido a las incertidumbres en la evaluación, se necesitará incorporar parámetros cuantificables y no cuantificables.

Tabla 1. Recomendaciones para nuevas investigaciones

Fuentes, mediciones y exposiciones	**Prioridad**
Caracterización ulterior de los hogares con exposición elevada a campos magnéticos de ELF en distintos países	Media
Identificar las brechas en el conocimiento acerca de la exposición ocupacional a campos de ELF, tales como en las IRM	Alta
Evaluación de la capacidad de las instalaciones eléctricas residenciales fuera de los Estados Unidos para inducir corrientes de contacto en los niños	Media
Dosimetría	
Dosimetría computacional adicional de la relación de los campos eléctricos y magnéticos externos con los campos eléctricos internos, en particular con respecto a la exposición a campos eléctricos y magnéticos combinados en distintas orientaciones	Media
Cálculo de los campos eléctricos y las corrientes inducidos en las mujeres embarazadas y en el feto	Media
Mayor perfeccionamiento de los modelos microdosimétricos, teniendo en cuenta la estructura celular de las redes neurales y otros sistemas suborgánicos complejos	Media
Mecanismos biofísicos	
Mayor estudio de los mecanismos par radical en las células inmunitarias que generan especies de oxígeno reactivo como parte de su función fenotípica	Media
Nuevos estudios teóricos y experimentales de la posible función de la magnetita en la sensibilidad a campos magnéticos de ELF	Baja
Determinación de las respuestas umbral a campos eléctricos internos inducidos por campos de ELF en sistemas multicelulares, tales como las redes neurales, utilizando enfoques teóricos e in vitro	Alta
Neurocomportamiento	
Estudios de la función cognitiva, el sueño y el electroencefalograma (EEG) en voluntarios, con inclusión de niños y personas ocupacionalmente expuestas, utilizando un amplio rango de frecuencias de campos de ELF con densidades de flujo elevadas	Media
Estudios de la exposición prenatal y postnatal en la función cognitiva posterior en animales	Media
Nuevos estudios de las respuestas opioides y colinérgicas en animales	Baja

Trastornos neurodegenerativos	
Estudios adicionales del riesgo de esclerosis lateral amiotrófica en ocupaciones eléctricas y en relación con la exposición a campos magnéticos de ELF y de la enfermedad de Alzheimer en relación con la exposición a dichos campos	Alta
Inmunología y hematología	
Estudios de las consecuencias de la exposición a campos magnéticos de ELF sobre el desarrollo del sistema inmunitario y hematopoyético en animales jóvenes	Baja
Reproducción y desarrollo	
Further study of the possible link between miscarriage and ELF magnetic field exposure Estudio adicional de la posible vinculación entre el aborto y la exposición a campos magnéticos de ELF	Baja
Cáncer	
Actualización de los análisis combinados existentes de la leucemia infantil con nueva información	Alta
Análisis combinados de los estudios existentes sobre los tumores cerebrales infantiles	Alta
Update existing meta-analyses of adult leukaemia and brain tumour studies and of cohorts of occupationally exposed individuals Actualización de los meta análisis existentes de los estudios sobre la leucemia y los tumores cerebrales en adultos y de las cohortes de personas expuestas ocupacionalmente	Media
Desarrollo de modelos de leucemia infantil en roedores transgénicos para su utilización en estudios sobre los campos de ELF	Alta
Evaluación de los efectos cocarcinogénicos utilizando estudios *in vitro* y en animales	Alta
Intento de reproducción de estudios de genotoxicidad *in vitro*	Media
Medidas de protección / precautorias / prevención	
Investigación sobre la formulación de políticas de protección de la salud y su aplicación en sectores con incertidumbre científica	Media
Nuevas investigaciones sobre la percepción y la comunicación del riesgo orientadas a los campos electromagnéticos	Media
Desarrollo de un análisis costo-beneficio/costo efectividad para la mitigación de los campos de ELF	Media

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Electromagnetic fields act *via* activation of voltage-gated calcium channels to produce beneficial or adverse effects

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Abstract

The direct targets of extremely low and microwave frequency range electromagnetic fields (EMFs) in producing non-thermal effects have not been clearly established. However, studies in the literature, reviewed here, provide substantial support for such direct targets. Twenty-three studies have shown that voltage-gated calcium channels (VGCCs) produce these and other EMF effects, such that the L-type or other VGCC blockers block or greatly lower diverse EMF effects. Furthermore, the voltage-gated properties of these channels may provide biophysically plausible mechanisms for EMF biological effects. Downstream responses of such EMF exposures may be mediated through Ca^{2+}/calmodulin stimulation of nitric oxide synthesis. Potentially, physiological/therapeutic responses may be largely as a result of nitric oxide-cGMP-protein kinase G pathway stimulation. A well-studied example of such an apparent therapeutic response, EMF stimulation of bone growth, appears to work along this pathway. However, pathophysiological responses to EMFs may be as a result of nitric oxide-peroxynitrite-oxidative stress pathway of action. A single such well-documented example, EMF induction of DNA single-strand breaks in cells, as measured by alkaline comet assays, is reviewed here. Such single-strand breaks are known to be produced through the action of this pathway. Data on the mechanism of EMF induction of such breaks are limited; what data are available support this proposed mechanism. Other Ca^{2+}-mediated regulatory changes, independent of nitric oxide, may also have roles. This article reviews, then, a substantially supported set of targets, VGCCs, whose stimulation produces non-thermal EMF responses by humans/higher animals with downstream effects involving Ca^{2+}/calmodulin-dependent nitric oxide increases, which may explain therapeutic and pathophysiological effects.

Keywords: intracellular Ca^{2+} ● voltage-gated calcium channels ● low frequency electromagnetic field exposure ● nitric oxide ● oxidative stress ● calcium channel blockers

Introduction

An understanding of the complex biology of the effects of electromagnetic fields (EMFs) on human/higher animal biology inevitably must be derived from an understanding of the target or targets of such fields in the impacted cells and tissues. Despite this, no understanding has been forthcoming on what those targets are and how they may lead to the complex biological responses to EMFs composed of low-energy photons. The great puzzle, here, is that these EMFs are comprised of low-energy photons, those with insufficient energy to individually influence the chemistry of the cell, raising the question of how non-thermal effects of such EMFs can possibly occur. The author

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has found that there is a substantial literature possibly pointing to the direct targets of such EMFs and it is the goal of this study to review that evidence as well as review how those targets may lead to the complex biology of EMF exposure.

The role of increased intracellular Ca^{2+} following EMF exposure was already well documented more than 20 years ago, when Walleczek [1] reviewed the role of changes in calcium signalling that were produced in response EMF exposures. Other, more recent studies have confirmed the role of increased intracellular Ca^{2+} following EMF exposure, a few of which are discussed below. His review [1] included two studies [2, 3] that showed that the L-type voltage-gated channel blocker, verapamil could lower or block changes in response to EMFs. The properties of voltage-gated calcium channels (VGCCs) have been reviewed elsewhere [4]. Subsequently, extensive evidence has been published clearly showing that the EMF exposure can act to produce excessive activity of the VGCCs in many cell types [5–26] suggesting that these may be direct targets of EMF exposure. Many of these studies implicate specifically the L-type VGCCs such that various L-type calcium channel blockers can block responses to EMF exposure (Table 1). However, other studies have shown lowered responses produced by other types of calcium channel blockers including N-type, P/Q-type, and T-type blockers (Table 1), showing that other VGCCs may have important roles. Diverse responses to EMFs are reported to be blocked by such calcium channel blockers (Table 1), suggesting that most if not all EMF-mediated responses may be produced through VGCC stimulation. Voltage-gated calcium channels are essential to the responses produced by extremely low frequency (including 50/60 Hz) EMFs and also to microwave frequency range EMFs, nanosecond EMF pulses, and static electrical and magnetic fields (Table 1).

In a recent study, Pilla [27] showed that an increase in intracellular Ca^{2+} must have occurred almost immediately after EMF exposure, producing a Ca^{2+}/calmodulin-dependent increase in nitric oxide occurring in less than 5 sec. Although Pilla [27] did not test whether VGCC stimulation was involved in his study, there are few alternatives that can produce such a rapid Ca^{2+} response, none of which has been implicated in EMF responses. Other studies, each involving VGCCs, summarized in Table 1, also showed rapid Ca^{2+} increases following EMF exposure [8, 16, 17, 19, 21]. The rapidity of these responses rule out many types of regulatory interactions as being involved in producing the increased VGCC activity following EMF exposure and suggests, therefore, that VGCC stimulation in the plasma membrane is directly produced by EMF exposure.

Possible modes of action following VGCC stimulation

The increased intracellular Ca^{2+} produced by such VGCC activation may lead to multiple regulatory responses, including the increased nitric oxide levels produced through the action of the two Ca^{2+}/calmodulin-dependent nitric oxide synthases, nNOS and eNOS. Increased nitric oxide levels typically act in a physiological context through increased synthesis of cGMP and subsequent activation of protein kinase G [28, 29]. In contrast, in most pathophysiological contexts, nitric oxide reacts with superoxide to form peroxynitrite, a potent non-radical oxidant [30, 31], which can produce radical products, including hydroxyl radical and NO_2 radical [32].

Therapeutic bone-growth stimulation *via* Ca^{2+}/nitric oxide/cGMP/protein kinase G

An example of a therapeutic effect for bone repair of EMF exposure in various medical situations includes increasing osteoblast differentiation and maturation and has been reviewed repeatedly [33–44]. The effects of EMF exposure on bone cannot be challenged, although there is still considerable question about the best ways to apply this clinically [33–44]. Our focus, here, is to consider possible mechanisms of action. Multiple studies have implicated increased Ca^{2+} and nitric oxide in the EMF stimulation of bone growth [44–49]; three have also implicated increased cGMP and protein kinase G activity [46, 48, 49]. In addition, studies on other regulatory stimuli leading to increased bone growth have also implicated increased cGMP levels and protein kinase G in this response [50–56]. In summary, then, it can be seen from the above that there is a very well-documented action of EMFs in stimulating osteoblasts and bone growth. The available data, although limited, support the action of the main pathway involved in physiological responses to Ca^{2+} and nitric oxide, namely Ca^{2+}/nitric oxide/cGMP/protein kinase G in producing such stimulation.

Ca^{2+}/nitric oxide/peroxynitrite and pathophysiological responses to EMF exposures: the example of single-strand DNA breaks

As was noted above, most of the pathophysiological effects of nitric oxide are mediated through peroxynitrite elevation and consequent oxidative stress. There are many reviews and other studies, implicating oxidative stress in generating pathophysiological effects of EMF exposure [see for example 57–64]. In some of these studies, the rise in oxidative stress markers parallels the rise in nitric oxide, suggesting a peroxynitrite-mediated mechanism [64–67].

Peroxynitrite elevation is usually measured through a marker of peroxynitrite-mediated protein nitration, 3-nitrotyrosine (3-NT). There are four studies where 3-NT levels were measured before and after EMF exposure [66, 68–70]. Each of these studies provides some evidence supporting the view that EMF exposure increases levels of peroxynitrite and therefore 3-NT levels [66, 68–70]. Although these cannot be taken as definitive, when considered along with the evidence on oxidative stress and elevated nitric oxide production in response to EMF exposure, they strongly suggest a peroxynitrite-mediated mechanism of oxidative stress in response to EMFs.

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Table 1 EMF responses blocked or lowered by calcium channel blockers

Ref. no.	EMF type	Calcium channel	Cell type or organism	Response measured
2	Pulsed magnetic fields	L-type	Human lymphocytes	Cell proliferation; cytokine production
3	Static magnetic field (0.1 T)	L-type	Human polymorphonuclear leucocytes	Cell migration; degranulation
5	ELF	L-type	Rat chromaffin cells	Differentiation; catecholamine release
6	Electric field	L-type	Rat and mouse bone cells	Increased Ca^{2+}, phospholipase A2, PGE2
7	50 Hz	L-type	Mytilus (mussel) immunocytes	Reduced shape change, cytotoxicity
8	50 Hz	L-type	AtT20 D16V, mouse pituitary corticotrope-derived	Ca^{2+} increase; cell morphology, premature differentiation
9	50 Hz	L-type	Neural stem/progenitor cells	*In vitro* differentiation, neurogenesis
10	Static magnetic field	L-type	Rat	Reduction in oedema formation
11	NMR	L-type	Tumour cells	Synergistic effect of EMF on anti-tumour drug toxicity
12	Static magnetic field	L-type	Myelomonocytic U937 cells	Ca^{2+} influx into cells and anti-apoptotic effects
13	60 Hz	L-type	Mouse	Hyperalgesic response to exposure
14	Single nanosecond electric pulse	L-type	Bovine chromaffin cells	Very rapid increase in intracellular Ca^{2+}
15	Biphasic electric current	L-type	Human mesenchymal stromal cells	Osteoblast differentiation and cytokine production
16	DC & AC magnetic fields	L-type	β-cells of pancreas, patch clamped	Ca^{2+} flux into cells
17	50 Hz	L-type	Rat pituitary cells	Ca^{2+} flux into cells
18	50 Hz	L-type, N-type	Human neuroblastoma IMR32 and rat pituitary GH3 cells	Anti-apoptotic activity
19	Nanosecond pulse	L-type, N-type, P/Q-type	Bovine chromaffin cells	Ca^{2+} dynamics of cells
20	50 Hz	Not determined	Rat dorsal root ganglion cells	Firing frequency of cells
21	700–1100 MHz	N-type	Stem cell–derived neuronal cells	Ca^{2+} dynamics of cells
22	Very weak electrical fields	T-type	Sharks	Detection of very weak magnetic fields in the ocean
23	Short electric pulses	L-type	Human eye	Effect on electro-oculogram
24	Weak static magnetic field	L-type	Rabbit	Baroreflex sensitivity
25	Weak electric fields	T-type	Neutrophils	Electrical and ion dynamics
26	Static electric fields, 'capacitive'	L-type	Bovine articular chondrocytes	Agrican & type II collagen expression; calcineurin and other Ca^{2+}/calmodulin responses

EMF: electromagnetic field; ELF: extremely low frequency.

Such a peroxynitrite-mediated mechanism may explain the many studies showing the single-stranded breaks in DNA, as shown by alkaline comet assays or the similar microgel electrophoresis assay, following EMF exposures in most such studies [71–89], but not in all [90–97]. Some of the factors that are reported to influence whether such DNA single-strand breaks are detected after EMF exposure include the type of cell studied [79, 86], dosage of EMF exposure [78] and the type of EMF exposure studied [73, 77]. Oxidative stress and free radicals have roles, both because there is a concomitant increase in oxidative stress and because antioxidants have been shown to greatly lower the generation of DNA single-strand breaks following EMF exposure [72, 75, 81, 82] as has also been shown for peroxynitrite-mediated DNA breaks produced under other conditions. It has also been shown that one can block the generation of DNA single-strand breaks with a nitric oxide synthase inhibitors [82].

Peroxynitrite has been shown to produce single-strand DNA breaks [98–100], a process that is inhibited by many but not all antioxidants [99, 100]. It can be seen from this that the data on generation of single-strand DNA breaks, although quite limited, support a mechanism involving nitric oxide/peroxynitrite/free radical (oxidative stress). Although the data on the possible role of peroxynitrite in EMF-induced DNA single-strand breaks are limited, what data are available supports such a peroxynitrite role.

Discussion and conclusions

How do EMFs composed of low-energy photons produce non-thermal biological changes, both pathophysiological and, in some cases, potentially therapeutic, in humans and higher animals? It may be surprising that the answer to this question has been hiding in plain sight in the scientific literature. However, in this era of highly focused and highly specialized science, few of us have the time to read the relevant literature, let alone organize the information found within it in useful and critical ways.

This study shows that:

1 Twenty-three different studies have found that such EMF exposures act *via* activation of VGCCs, such that VGCC channel blockers can prevent responses to such exposures (Table 1). Most of the studies implicate L-type VGCCs in these responses, but there are also other studies implicating three other classes of VGCCs.

2 Both extremely low frequency fields, including 50/60 cycle exposures, and microwave EMF range exposures act *via* activation of VGCCs. So do static electric fields, static magnetic fields and nanosecond pulses.

3 Voltage-gated calcium channel stimulation leads to increased intracellular Ca^{2+}, which can act in turn to stimulate the two calcium/calmodulin-dependent nitric oxide synthases and increase nitric oxide. It is suggested here that nitric oxide may act in therapeutic/potentially therapeutic EMF responses *via* its main physiological pathway, stimulating cGMP and protein kinase G. It is also suggested that nitric oxide may act in pathophysiological responses to EMF exposure, by acting as a precursor of peroxynitrite, producing both oxidative stress and free radical breakdown products.

4 The interpretation in three above is supported by two specific well-documented examples of EMF effects. Electromagnetic fields stimulation of bone growth, modulated through EMF stimulation of osteoblasts, appears to involve an elevation/nitric oxide/protein kinase G pathway. In contrast to that, it seems likely that the EMF induction of single-stranded DNA breaks involves a Ca^{2+}/elevation/nitric oxide/peroxynitrite/free radical (oxidative stress) pathway.

It may be asked why we have evidence for involvement of VGCCs in response to EMF exposure, but no similar evidence for involvement of voltage-gated sodium channels? Perhaps, the reason is that there are many important biological effects produced in increased intracellular Ca^{2+}, including but not limited to nitric oxide elevation, but much fewer are produced by elevated Na^{+}.

The possible role of peroxynitrite as opposed to protein kinase G in producing pathophysiological responses to EMF exposure raises the question of whether there are practical approaches to avoiding such responses? Typically peroxynitrite levels can be highly elevated when both of its precursors, nitric oxide and superoxide, are high. Consequently, agents that lower nitric oxide synthase activity and agents that raise superoxide dismutases (SODs, the enzymes that degrade superoxide) such as phenolics and other Nrf2 activators that induce SOD activity [101], as well as calcium channel blockers may be useful. Having said that, this is a complex area, where other approaches should be considered, as well.

Although the various EMF exposures as well as static electrical field exposures can act to change the electrical voltage-gradient across the plasma membrane and may, therefore, be expected to stimulate VGCCs through their voltage-gated properties, it may be surprising that static magnetic fields also act to activate VGCCs because static magnetic fields do not induce electrical changes on static objects. However, cells are far from static. Such phenomena as cell ruffling [102,103] may be relevant, where thin cytoplasmic sheets bounded on both sides by plasma membrane move rapidly. Such rapid movement of the electrically conducting cytoplasm, may be expected to influence the electrical charge across the plasma membrane, thus potentially stimulating the VGCCs.

Earlier modelling of electrical effects across plasma membranes of EMF exposures suggested that such electrical effects were likely to be too small to explain EMF effects at levels reported to produce biological changes (see, for example [22]). However, more recent and presumably more biologically plausible modelling have suggested that such electrical effects may be much more substantial [104–109] and may, therefore, act to directly stimulate VGCCs.

Direct stimulation of VGCCs by partial depolarization across the plasma membrane is suggested by the following observations discussed in this review:

1 The very rapid, almost instantaneous increase in intracellular Ca^{2+} found in some studies following EMF exposure [8, 16, 17, 19, 21, 27]. The rapidity here means that most, if not all indirect, regulatory effects can be ruled out.

2 The fact that not just L-type, but three additional classes of VGCCs are implicated in generating biological responses to EMF

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exposure (Table 1), suggesting that their voltage-gated properties may be a key feature in their ability to respond to EMFs.

3 Most, if not all, EMF effects are blocked by VGCC channel blockers (Table 1).

4 Modelling of EMF effects on living cells suggests that plasma membrane voltage changes may have key roles in such effects [104–109]. Saunders and Jefferys stated [110] that 'It is well established that electric fields … or exposure to low frequency magnetic fields, will, if of sufficient magnitude, excite nerve tissue through their interactions with … voltage gated ion channels'. They further state [110] that this is achieved by direct effects on the electric dipole voltage sensor within the ion channel.

One question that is not answered by any of the available data is whether what is known as 'dirty electricity' [111–113], generated by rapid, in many cases, square wave transients in EMF exposure, also acts by stimulating VGCCs. Such dirty electricity is inherent in any digital technology because digital technology is based on the use of such square wave transients and it may, therefore, be of special concern in this digital era, but there have been no tests of such dirty electricity that determine whether VGCCs have roles in response to such fields, to my knowledge. The nanosecond pulses, which are essentially very brief, but high-intensity dirty electricity do act, at least in part, *via* VGCC stimulation (Table 1), suggesting that dirty electricity may do likewise. Clearly, we need direct study of this question.

The only detailed alternative to the mechanism of non-thermal EMF effects discussed here, to my knowledge, is the hypothesis of Friedman *et al.* [114] and supported by Desai *et al.* [115] where the apparent initial response to EMF exposure was proposed to be NADH oxidase activation, leading to oxidative stress and downstream regulatory effects. Although they provide some correlative evidence for a possible role of NADH oxidase [114], the only causal evidence is based on a presumed specific inhibitor of NADH oxidase, diphenyleneiodonium (DPI). However, DPI has been shown to be a non-specific cation channel blocker [116], clearly showing a lack of such specificity and suggesting that it may act, in part, as a VGCC blocker. Consequently, a causal role for NADH oxidase in responses to EMF exposure must be considered to be undocumented.

In summary, the non-thermal actions of EMFs composed of low-energy photons have been a great puzzle, because such photons are insufficiently energetic to directly influence the chemistry of cells. The current review provides support for a pathway of the biological action of ultralow frequency and microwave EMFs, nanosecond pulses and static electrical or magnetic fields: EMF activation of VGCCs leads to rapid elevation of intracellular Ca^{2+}, nitric oxide and in some cases at least, peroxynitrite. Potentially therapeutic effects may be mediated through the Ca^{2+}/nitric oxide/cGMP/protein kinase G pathway. Pathophysiological effects may be mediated through the Ca^{2+}/nitric oxide/peroxynitrite pathway. Other Ca^{2+}-mediated effects may have roles as well, as suggested by Xu *et al.* [26].

Conflicts of interest

The author confirms that there are no conflicts of interest.

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United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

FEB - 7 2014

In Reply Refer To: (ER 14/0001) (ER 14/0004).

Mr. Eli Veenendaal
National Telecommunications and Information
Administration
U.S. Department of Commerce
1401 Constitution Avenue, N.W.
Washington, D.C. 20230

Dear Mr. Veenendaal:

The Department of the Interior (Department) has reviewed the above referenced proposal and submits the following comments and attachment for consideration. Because the First Responder Network Authority (FirstNet) is a newly created entity, we commend the U.S. Department of Commerce for its timely proposals for NEPA implementing procedures.

The Department believes that some of the proposed procedures are not consistent with Executive Order 13186 Responsibilities of Federal Agencies to Protect Migratory Birds, which specifically requires federal agencies to develop and use principles, standards, and practices that will lessen the amount of unintentional take reasonably attributed to agency actions. The Department, through the Fish and Wildlife Service (FWS), finds that the proposals lack provisions necessary to conserve migratory bird resources, including eagles. The proposals also do not reflect current information regarding the effects of communication towers to birds. Our comments are intended to further clarify specific issues and address provisions in the proposals.

The Department recommends revisions to the proposed procedures to better reflect the impacts to resources under our jurisdiction from communication towers. The placement and operation of communication towers, including un-guyed, unlit, monopole or lattice-designed structures, impact protected migratory birds in two significant ways. The first is by injury, crippling loss, and death from collisions with towers and their supporting guy-wire infrastructure, where present. The second significant issue associated with communication towers involves impacts from non-ionizing electromagnetic radiation emitted by them (See Attachment).

In addition to the 147 Birds of Conservation Concern (BCC) species, the FWS has listed an additional 92 species as endangered or threatened under the Endangered Species Act. Together with the bald and golden eagle, this represents 241 species of birds whose populations are in trouble or otherwise merit special protection, according to the varying criteria of these lists. The Department suggests that FirstNet consider preparing a programmatic environmental impact statement (see attachment) to determine and address cumulative impacts from authorizing FirstNet projects on those 241 species for which the incremental impact of tower mortality, when

added to other past, present, and reasonably foreseeable future actions, is most likely significant, given their overall imperiled status. Notwithstanding the proposed implementing procedures, a programmatic NEPA document might be the most effective and efficient method for establishing best management practices for individual projects, reducing the burden to individual applicants, and addressing cumulative impacts.

Categorical Exclusions
The Department has identified 13 of the proposed categorical exclusions (A-6, A-7, A-8, A-9, A-10, A-11, A-12, A-13, A-14 A-15, A-16, A-17, and A-19) as having the potential to significantly affect wildlife and the biological environment. Given this potential, we want to underscore the importance of our comments on FirstNet's procedural guidance under Environmental Review and Consultation Requirements for NEPA Reviews and its list of extraordinary circumstances in Appendix D.

Environmental Review and Consultation Requirements for NEPA Reviews
To ensure there are no potentially significant impacts on birds from projects that may otherwise be categorically excluded, the Department recommends including the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act to the list of requirements in this section.

Extraordinary Circumstances
To avoid potentially significant impacts on birds from projects that may otherwise be categorically excluded, the Department recommends including species covered under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act to the list of environmentally sensitive resources. Additionally, adding important resources to migratory birds such as sites in the Western Hemisphere Shorebird Reserve Network and Audubon Important Bird Areas to the paragraph on areas having special designation or recognition would help ensure their consideration when contemplating use of a categorical exclusion.

Developing the Purpose and Need
The Department recommends inclusion of language that would ensure consideration of all other authorities to which NEPA is supplemental as opposed to simply the FirstNet mission. As currently written, the procedures are limited to ensuring the purpose and need considers the FirstNet mission. If strictly applied, this approach would severely limit the range of reasonable alternatives, and likely preclude consideration of more environmentally benign locations or construction practices.

Environmental Review Process, Apply NEPA Early in the Process, Where Action is by Non-Federal Entity
The Department recommends that FirstNet be required to coordinate with federal agencies having jurisdiction by law or special expertise on construction and lighting of its network of towers.

Thank you for the opportunity to comment on the draft document. If you have any questions concerning the comments, please contact Diana Whittington, NEPA Migratory Bird lead, at (703) 358-2010. If you have any questions regarding Departmental NEPA procedures, contact Lisa Treichel, Office of Environmental Policy and Compliance at (202) 208-7116.

Sincerely,

Willie R. Taylor
Director, Office of Environmental Policy
and Compliance

Enclosure

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Enclosure A

Background

The placement and operation of communication towers, including un-guyed, unlit, monopole or lattice-designed structures, impact protected migratory birds in two significant ways.

The first is by injury, crippling loss, and death from collisions with towers and their supporting guy-wire infrastructure, where present. Mass mortality events tend to occur during periods of peak spring and fall songbird bird migration when inclement weather events coincide with migration, and frequently where lights (either on the towers and/or on adjacent outbuildings) are also present. This situation has been well documented in the U.S. since 1948 in the published literature (Aronoff 1949, see Manville 2007a for a critique). The tallest communication towers tend to be the most problematic (Gehring *et al.* 2011). However, mid-range (~400-ft) towers as proposed by the First Responder Network Authority (FirstNet, a newly created entity under the Department of Commerce) can also significantly impact protected migratory birds, as can un-guyed and unlit lattice and monopole towers (Gehring *et al.* 2009, Manville 2007a, 2009, 2013a). Mass mortalities (more than several hundred birds per night) at unguyed, unlit monopole and lattice towers were documented in fall 2005 and 2011 in the Northeast and North Central U.S. (*e.g.*, Manville 2007a). It has been argued that communication towers including "short" towers do not impact migratory birds, including at the population level (*e.g.*, Arnold and Zink 2011), but recent findings have contradicted that assertion (Manville 2007a, 2013a, Longcore *et al.* 2012, 2013).

The second significant issue associated with communication towers involves impacts from non-ionizing electromagnetic radiation emitted by these structures. Radiation studies at cellular communication towers were begun circa 2000 in Europe and continue today on wild nesting birds. Study results have documented nest and site abandonment, plumage deterioration, locomotion problems, reduced survivorship, and death (*e.g.*, Balmori 2005, Balmori and Hallberg 2007, and Everaert and Bauwens 2007). Nesting migratory birds and their offspring have apparently been affected by the radiation from cellular phone towers in the 900 and 1800 MHz frequency ranges – 915 MHz is the standard cellular phone frequency used in the United States. However, the electromagnetic radiation standards used by the Federal Communications Commission (FCC) continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today. This is primarily due to the lower levels of radiation output from microwave-powered communication devices such as cellular telephones and other sources of point-to-point communications; levels typically lower than from microwave ovens. The problem, however, appears to focus on very low levels of non-ionizing electromagnetic radiation. For example, in laboratory studies, T. Litovitz (personal communication) and DiCarlo *et al.* (2002) raised concerns about impacts of low-level, non-thermal electromagnetic radiation from the standard 915 MHz cell phone frequency on domestic chicken embryos – with some lethal results (Manville 2009, 2013a). Radiation at extremely low levels (0.0001 the level emitted by the average digital cellular telephone) caused heart attacks and the deaths of some chicken embryos subjected to hypoxic conditions in the laboratory while controls subjected to hypoxia were unaffected (DiCarlo *et al.* 2002). To date, no independent, third-party field studies have been conducted in North America on impacts of tower electromagnetic radiation on migratory birds. With the European field and U.S. laboratory evidence already available,

independent, third-party peer-reviewed studies need to be conducted in the U.S. to begin examing the effects from radiation on migratory birds and other trust species.

Discussion

Collision Deaths and Categorical Exclusions

Attempts to estimate bird-collision mortality at communication towers in the U.S. resulted in figures of 4-5 million bird deaths per year (Manville 2005, 2009). A meta-review of the published literature now suggests, based on statistically determined parameters, that mortality may be 6.8 million birds per year in Canada and the U.S.; the vast majority in the United States (Longcore *et al.* 2012). Up to 350 species of birds have been killed at communication towers (Manville 2007a, 2009). The Service's Division of Migratory Bird Management has updated its voluntary, 2000 communication tower guidelines to reflect some of the more recent research findings (Manville 2013b). However, the level of estimated mortality alone suggests at a minimum that FirstNet prepare an environmental assessment to estimate and assess the cumulative effects of tower mortality to protected migratory birds.

A second meta-review of the published mortality data from scientific studies conducted in the U.S. and Canada (Longcore *et al.* 2013) strongly correlates population effects to at least 13 species of Birds of Conservation Concern (BCC, USFWS 2008). These are mortalities to BCC species based solely on documented collisions with communication towers in the U.S. and Canada, ranging from estimated annual levels of mortality of 1 to 9% of their estimated total population. Among these where mortality at communication towers was estimated at over 2% annually are the Yellow Rail, Swainson's Warbler, Pied-billed Grebe, Bay-breasted Warbler, Golden-winged Warbler, Prairie Warbler, and Ovenbird. Longcore *et al.* (2013) emphasized that avian mortality associated with anthropogenic sources is almost always reported in the aggregate, *i.e.*, "number of birds killed," which cannot detect species-level effects necessary to make effective and meaningful conservation assessments, including determining cumulative effects. These new findings strongly suggest the need for at least an environmental assessment by FirstNet, or more likely, an environmental impact statement.

Radiation Impacts and Categorical Exclusions

There is a growing level of anecdotal evidence linking effects of non-thermal, non-ionizing electromagnetic radiation from communication towers on nesting and roosting wild birds and other wildlife in the U.S. Independent, third-party studies have yet to be conducted in the U.S. or Canada, although a peer-reviewed research protocol developed for the U.S. Forest Service by the Service's Division of Migratory Bird Management is available to study both collision and radiation impacts (Manville 2002).

As previously mentioned, Balmori (2005) found strong negative correlations between levels of tower-emitted microwave radiation and bird breeding, nesting, and roosting in the vicinity of electromagnetic fields in Spain. He documented nest and site abandonment, plumage deterioration, locomotion problems, reduced survivorship, and death in House Sparrows, White Storks, Rock Doves, Magpies, Collared Doves, and other species. Though these species had historically been documented to roost and nest in these areas, Balmori (2005) did not observe these symptoms prior to construction and operation of the cellular phone towers. Balmori and Hallberg (2007) and Everaert and Bauwens (2007) found similar strong negative correlations

among male House Sparrows. Under laboratory conditions, DiCarlo *et al.* (2002) raised troubling concerns about impacts of low-level, non-thermal electromagnetic radiation from the standard 915 MHz cell phone frequency on domestic chicken embryos – with some lethal results (Manville 2009). Given the findings of the studies mentioned above, field studies should be conducted in North America to validate potential impacts of communication tower radiation – both direct and indirect – to migratory birds and other trust wildlife species.

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Cancer induction molecular pathways and HF-EMF irradiation

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ABSTRACT

The response of cells to different types of electromagnetic fields can be induced by low-level (athermal) high frequency (HF) electromagnetic fields (EMFs) exposure associated with mobile phone technologies. There are many examples of biological effects involving the epigenome. EMFs could trigger protein activation mediated by ligands, such as Ca^{2+}, that alter the conformation of binding proteins, especially the NADPH plasmic membrane oxidase, so inducing increased formation of reactive oxygen species (ROS) that may alter proteomic functions. Classical anti-apoptotic and procarcinogenic signaling pathways that are commonly found activated in human malignancies and in inflammation mainly involve the transcription factor NF-κB. The microenvironment that exists during chronic inflammation can contribute to cancer progression. The data support the proposition that long term HF-EMF exposure associated with improper use of cell phones can potentially cause cancer.

Keywords: Cell Membrane; Chronic Inflammation; EMF Exposure; Gene Expression; Cancer; Carcinogenesis; NF-κB

1. INTRODUCTION

Global system for mobile communication (GSM), which being used in most of the countries, has a frequency of either 900 or 1800 MHz. This low-energy (non-thermal) radiation is emitted not only by cell phones themselves, but also by the base stations. There are many examples of biological effects resulting from low-level (athermal) EMF exposure [1-4].

The environment is a well-established source of damaging or disrupting influences on cellular function. In the past, studies of the mechanisms by which such disruptions occur have focused largely on either direct toxic effects on cellular function at the protein or cell signaling level, or mutagenic effects that impact the genome [4]. In recent years there has been a growing appreciation for the potential for environmental influences to disrupt the epigenome and mechanisms of epigenetic regulation within the cell. Indeed, because of the inherent lability of the epigenome, this represents a primary target for environmentally induced disruption [5].

Chronic inflammation has long been associated with the development of cancer [6-8]. Although inflammation is part of the defense response, paradoxically it can lead to important health disorders. Since it was discovered in the 19th century, chronic inflammation has been proven to be involved both at the initiation/promotion and progression phases of carcinogenesis [9]. This is mainly due to the fact that inflammatory response is followed by a proliferative cellular effect in tissus (basal cell hyperplasia, papillary elongation) [10].

An office workers cohort with high EMF exposure showed a cancer increase, with a high risk of malignant melanoma. School teachers exposed to a type of Radio-frequency radiation (RFR) had increased incidence of malignant melanoma and thyroid cancer [11]. Pooling of data from Nordic countries and part of the UK yielded a significantly increased risk of glioma and a significantly increased risk of acoustic neurinoma related to use of mobile phones for a period of 10 years or more on the side of the head where the tumour developed [12,13]. In an Israeli study, where study subjects tended to report

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substantially heavier use of mobile phones, results suggest a possible relation between heavy mobile phone use and risk of parotid gland tumours [14]. Several reports have indicated that EMFs enhance free radical activity in cells particularly via the Fenton reaction [15,16].

2. CELL RESPONSES

Duckweed growth and peroxidase activity was evaluated after exposure in a Gigahertz Transversal Electromagnetic (GTEM) cell to electromagnetic fields of frequencies 400, 900, and 1900 MHz. Growth of plants exposed for 2 h to 23 V/m electric field of 900 MHz significantly decreased in comparison with the control, while an electric field of the same strength but at 400 MHz did not have such effect. At both frequencies a longer exposure mostly decreased the growth and the highest electric field (390 V/m) strongly inhibited the growth. Exposure of plants to lower field strength (10 V/m) for 14 h caused significant decrease at 400 and 1900 MHz while 900 MHz did not influence the growth. Peroxidase activity in exposed plants varied, depending on the exposure characteristics. Observed changes were mostly small, except in plants exposed for 2 h to 41 V/m at 900 MHz where a significant increase (41%) was found. Therefore, the effects of EMFs strongly depended on the characteristics of the field exposure [17].

Exposure of tomato plants to non-thermal high frequency electromagnetic field (HF-EMF, 900 MHz, 5 $V \cdot m^{-1}$) for 10 min led to show a direct relationship between HF-EMF exposure and responses at the level of gene expression [1]. There was no direct link between the amplitude of the stimulation and the amplitude of the plant response, which suggested the concept of an "all-or-nothing" response with a threshold of induction [18]. The energy used in the electromagnetic exposure (900 MHz, 5 $V \cdot m^{-1}$, 10 min) was very low (close to 0.1 W dissipated in 200 m^3) and did not produce any thermal effect [1,18]. The genesis and/or transmission of the informative signal were rapid and strongly dependent upon calcium. Expression of Hsp70 [19], and tumor suppressor p53 [20] are also affected by microwave irradiation.

Electromagnetic irradiation emitted from mobile phones (frequency 900 MHz) induces expression of proteins in various cells [21-23]. The specific absorption rate (SAR) level to which cells were exposed was 2.8 W/kg. The effects observed were not caused by bulk heating of the cells [22]. Among the proteins whose expression is induced by mobile phone irradiation are transcription factors [21]. The proteomes of the same cell type (endothelium) but derived from different vascular beds (umbilical vein and brain microvasculature) differ widely in their expression. The effect is frequency-dependent. When cells were exposed for 1 h at an average SAR of 2.0 W/kg and examined immediately thereafter, 1800 MHz GSM radiation exposure had only very limited effect on the proteome of human endothelial cell line EA.hy926, as compared with the effect of 900 MHz GSM radiation [24]. Mobile phone radiation might alter protein expression in human skin, with a SAR of 1.3 W/kg induced in the skin, below the ICNIRP (International Commission on Non-Ionizing Radiation Protection) safety guidelines (2.0 W/kg), for one hour [25].

Paulraj and Behari [26] indicated DNA single strand break and decrease in level of protein kinase at 2.45 GHz [27]. More recently, Kesari and Behari [28] reported that microwave (2.45 GHz) exposure cause infertility by decreasing sperm count and an increase in apoptosis.

Tkalec *et al*. [29] showed that non-thermal exposure to the radiofrequency fields can induce mitotic aberrations in root meristematic cells of *A. cepa*. The observed effects were markedly dependent on the field frequencies (400 and 900 MHz) applied as well as on field strength and modulation. They also indicate that mitotic effects of RF-EMF could be due to impairment of the mitotic spindle.

Microwave (MW) exposure at the water resonance frequency, *i.e*. exposure to radiofrequencies between about 1 GHz and 300 GHz, was able to induce alteration of the mitotic apparatus and apoptosis as a function of the applied power densities (5 and 10 mW/cm^2), together with a moderate reduction in the rate of cell division. After an exposure time of 15 min the proportion of aberrant spindles and of apoptotic cells was significantly increased, while the mitotic index decreased as well, as compared to the untreated V79 cells. Ballardin *et al*. [30] hypothesised that short-time MW exposures at the water resonance frequency cause, in V79 cells, reversible alterations of the mitotic spindle, this representing, in turn, a pro-apoptotic signal for the cell line.

Another mechanism that could be involved in the formation of aberrant spindles concerns the polar protein structures**.** Microtubule fibers represent extremely dynamic structure which functioning depends on dynamical instability that is continuously binding and releasing of free tubule proteins. One can reasonably assume that the external EM radiation might interact with polar cytoskeletal structure. This structure greatly contributes to the balance between internal physiological electrostatic forces. Depending on the dipole moment, an external electric field could theoretically disturb the equilibrium [31] and increase the number of free cytoplasmatic tubulin proteins following a mechanism of depolarization of tubulins involved in the formation of the mitotic apparatus. Recently, it has been shown that electromagnetic field (90 V/m at 835 MHz) exposure can induce significant increases of mitotic disturbances in human-hamster hybrid cells [32].

3. EMF-TARGET MOLECULE INTERACTIONS

Energy transfer of Microwaves (MW) is conducted through two mechanisms, dipole rotation and ionic conduction [33]. Blank and Soo [34] examined the EMF effects on electron transfer and concluded that EMF accelerate all linked redox reactions. Blank [35] considered examples of direct effects of electric and magnetic fields on charge transfer in biological systems, and reported the structural changes driven by such effects. He concluded that conformational changes arising from alterations in charge distribution play a key role in membrane transport proteins, including ion channels. Thus, weak EMFs can control and amplify biological processes through their effects on charge distribution [3].

EMFs could interact with moving charges or charged species [36] which are implicated in various biological processes. Moreover, HF-EMF may lead to ion movement, directly or indirectly, and particularly near the plasma membrane [37] and this could initiate the biological response. Ligands, such as Ca^{2+}, alter the conformation of proteins and hence control their receptor function. EMF exposure produces changes in binding probability of the ligand. Occupation of one protein site by a ligand changes its conformation. This suggests that EMF could trigger a transition from a random array to an ordered array of phase transition in proteins [38]. Calcium has been well recognised as a signaling factor involved in the regulation of a wide range of cellular processes involving cell proliferation.

Panagopoulos *et al*. [39] have suggested that oscillating ions during forced vibration will also exert mechanical force-pressure on the plasma membrane able to upset the membrane electrochemical balance, under certain conditions, by opening or closing mechanically gated channel proteins, like some Ca influx channels. The irregular gating of ion channels caused by the forced vibration of the free ions, induced by external oscillating EMFs, is a fact that could upset the electrochemical balance of the plasma membrane and, consequently, the whole cell function.

4. TRANSDUCTION SIGNALS AND ONCOGENE EXPRESSION

Currently, cancer is recognized as a disease associated with both genetic and epigenetic alterations, and both of these components cooperate and complement each other to initiate and promote cancer development and progression [40]. The carcinogenic process can be associated to a modification of gene expression regulation; the modification of the signal cascade into the cell can induce the dysregulation of transcription factor activities (overexpression, activation, uninhibition…) through the activation of specific cellular messengers. Free radicals play an essential role in the activation of certain signaling pathways [6]. The effects of reactive oxygen species (ROS) on cell proliferation occurred exclusively at low or transient concentrations of radicals that can stimulate proliferation and enhanced survival in a wide variety of cell types [41]. ROS can play a very important physiological role as secondary messengers. This includes regulation of the cytosolic calcium concentration, which itself regulates biological activities, regulation of protein phosphorylation and activation of certain transcription factors such as Nuclear Factor NF-κB and the AP-1 family factors [41-43].

In general, the balance between the production and scavenging of ROS leads to homeostasis. Disturbance of this equilibrium can alter normal cellular processes; it often occurs in tumour cells [44]. The cumulative production of ROS through either endogenous or exogenous insults is termed oxidative stress and is common for many types of cancer with altered redox regulation of cellular signaling pathways [45]. A sustained oxidative stress has been associated with several steps of carcinogenesis, including malignant transformation and achievement of a metastatic phenotype [46]. Thornber *et al.* [47] have shown that, in large cell lymphoma the nucleophosmin-anaplastic lymphoma kinase (NPM-ALK) induces the production of reactive oxygen species (ROS) by a pathway involving the arachidonic acid-metabolizing enzymes of the lipoxygenase (LOX) family. The NPM-ALK chimeric gene encodes a constitutively activated tyrosine kinase that has been shown to be a potent oncogene.

Several MAPkinases, signal transducers and activators of transcription, Akt/protein kinase B and phospholipase D-signaling pathways are all activated by ROS [48,49] but in some cases, activation is indirect [50].

Cadmium (Cd) is a toxic metal causing nephrotoxicity, immunotoxicity, osteotoxicity and tumors after prolonged exposure. Cd-generated ROS are often accompagnied by activation of redox sensitive transcription factors, such as NF-κB, and alteration of ROS-related gene expression. Acquired Cd tolerance with aberrant gene expression plays important roles in chronic Cd toxicity and carcinogenesis [51]. Chronic inflammation induced by biological, chemical and physical agents, is associated with increased risk of tumors development in various organs and tissues. Association of cancer with chronic inflammation has been described, in particular, in pathological processes in organs of the digestive system, where the risk of carcinogenesis increases as much as chronic inflammation occurs (esophagitis, gastritis, hepatitis etc.). Mediators of inflammation, which contribute to the process of malignant transformation, affect many aspects of cancer cell behavior, including pro-

liferation, differentiation and apoptosis. Inflammation contributes to initiation and promotion, *i.e*. to malignant transformation of normal cells and to tumor progression due to production of both proinflammatory cytokines and various forms of reactive oxygen and nitrogen species. Significant activation of NF-κB can stimulate malignant transformation and progression, providing antiapoptotic and proliferative signals.

Developmental signaling pathways that regulate normal stem cell self-renewal have been shown to be active in numerous human cancers [52]. Inflammatory breast cancer (IBC) is an uncommon disease accounting for 1% - 5% of all breast cancers [53,54]. Experimental evidence now solidly validates the HER2 oncogene hypothesis and etiologically links amplification of the HER2 gene locus with human cancer pathogenesis [55]. HER2 protein overproduction is not only seen in breast cancer but also uncommonly in cancers of the esophagus, stomach, ovaries and endometrium. Mutations in the HER2 gene are found rarely in these cancers but overexpression appears to be the principal mechanism by which HER2 mediates tumorigenesis in these cancers [56].

5. SIGNAL TRANSDUCTION AND EMF SIGNALING PATHWAYS

Mitogen-activated-phospho-kinase (MAPK) family pathway control cell proliferation, metabolism and cell survival in response to tissue injury, infection, malignancy and other diseases. Activation of the MAPK cascades leads to phosphorylation of transcription factors that bind to the upstream regulatory elements on the gene promoter, relative to the transcription initiation site. Three out of four MAPK cascades are differentially activated by Extremely Low Frequency (ELF EMF) (ELF-EMF) [57].

The signaling pathways and stress responses are activated by EMF. Friedman *et al.* [58] have shown that the initial step in transmitting extracellular EMF information from the plasma membrane to the nucleus of the cell occurs when NADH oxidase rapidly generates ROS. These ROS stimulate matrix metalloproteinases, and then activate the extracellular signal regulated kinase (ERK-1/2) cascade. These changes in activity of the protein kinases pathways can consequently regulate the physiological response of the exposed cells and organisms, and therefore are major regulators of the effects of electromagnetic fields at mobile phone frequencies.

Data indicate that, prior to the stress responses, mobile phone irradiation induces an immediate intracytoplasmic effect which activates ERK signalling to induce further transcription of a variety of genes [59]. The fact that the stress-related cascades, which are known to be activated by heat or other related stressors, were not activated, in the time course of Friedman *et al.* [58] experiments, indicates that the activation of ERKs is induced by other mechanisms. It has been reported that within 10 min of cell phone exposure, two MAPKinase cascades, p38 and ERK1/2, are activated [60].

Both ELF and RF radiations can upregulate the HSP70 gene and induce elevated levels of the Hsp70 protein. This effect on RNA transcription and protein stability is controlled by specific protein transcription factors that are elements of the mitogen MAPK cascade. EMF can also stimulate serum response factor which binds to the serum response element (SRE) through ERK MAPK activation and is associated with injury and repair *in vivo* and *in vitro*. The SRE site is on the promoter of an early response gene, c-fos, which under specific cellular circumstances has oncogenic properties. The c-fos promoter is EMF-sensitive [61,62].

Activation of NF-κB and AP-1, the downstream of the MAPK or PI3K-Akt signaling pathways, are involved in many pathological processes, such as inflamemation, cancer cell adhesion, invasion, migration, and angiogenesis [63,64]. NF-κB and AP-1 transcription factors function as crucial regulators of inflammatory and immune responses as well as of cell survival. They have been implicated in cellular transformation and tumorigenesis. The NF-κB pathway is required for the development of tumours in a mouse model of lung adenocarcinoma [65]. Elevated P13K/PDK/Akt or NF-κB signaling (or both) have been correlated with advanced tumor progression and poor prognosis in patients with breast cancer [66,67].

NF-κB is maintained in the cytoplasm through interactions with an inhibitor of NF-κB (IκB), but upon dissociation, it moves into the nucleus and promotes cancer cells proliferation, angiogenesis, and metastasis. Carcinogens and tumour promoters involving toxic metals, UV radiation, phobol esters, asbestos, alcohol and benzo (α) pyrene are among the external stimuli that activate NF-κB [68]. Hepatitis B viral proteins (HBx) have oncogenic properties by activation of different promoter elements and then trigger activation of transcription factors such as AP-1 and NF-κB [45,69].

In fact NF-κB is a transcriptional factor that regulates a battery of genes that are critical to innate and adaptive immunity, cell proliferation, inflammation, and tumor development [70]. Increasing evidence suggests that the physiological NF-κB-associated pathways are dysregulated in numerous malignancies [66,71-74]. The activation of NF-κB-dependent anti-apoptotic genes may promote IBC tumorigenesis and, other inflammation-associated tumor types [75]. The NF-κB pathway appears to play a major role in IBC, possibly contributing to the unusual phenotype and aggressiveness of this form of breast cancer [76]. DNA microarrays studies of

IBC have shown abnormal expression of several NF-κB target genes [77,78]. Activated NF-κB translocates to the nucleus and binds to the DNA to initiate expression of genes that enhances cell proliferation and survival [67, 73,79].

Indeed, activation of the transcription factor NF-κB, one of the most investigated nuclear transcription factors, has been found to control multiple cellular processes in cancer including inflammation, transformation, proliferation, angiogenesis, invasion, metastasis, chemoresistance and radioresistance. NF-κB is constitutively active in most cancer cells, and its suppression inhibits the growth of tumor cells, leading to the concept of "NF-κB addiction" in cancer cells. As NF-κB is the key transcription factor involved in inflammation, and inflammation is frequently associated with cancers, many of the signaling pathways implicated in cancer are likely to be networked to the activation of NF-κB. NF-κB interacts with many transcription factors and transcriptional regulators [80].

Chronic inflammation has been associated with the development of cancer. Molecular biology studies have shown that there are genes, which when "activated" (oncogenes) or "inactivated" (tumour suppressor genes) contribute to the clonal expansion of an initiated stem cell. Cancer would thus be a disease of homeostasis [45]. Any exposure, including prolonged low-intensity ELF and RF exposures that result in increased free radical production may be considered a plausible biological mechanism for carcinogenesis [6].

6. CONCLUSIONS: HYPOTHETIC MODELISATION

Oncogenesis is suggested to be mediated by a sustained and not a transient ERK activation [58] that could be an explanation for the possible increased cancer risk that may be associated with base station antenna. RF field studies have shown that RFF exposure is followed by the stimulation of cell proliferation and activation of stress proteins [57]. In the present overview, production of ROS by mobile phone irradiation, a process that has already been evidenced in previous studies [81,82], is suggested to be induced by the activation of NADH oxidase, which appears to be an early target of mobile phone irradiation. These events appear to occur within seconds and could initiate subsequent activation of pathways that lead to phosphorylation of ERKs. Several components of the proposed model (**Figure 1**) have been implicated in activation of the ERK cascade in different cellular systems.

Microwave effects have been always mainly observed in stem cells. This result suggests both significant misbalance in double strand break (DSB) repair and severe

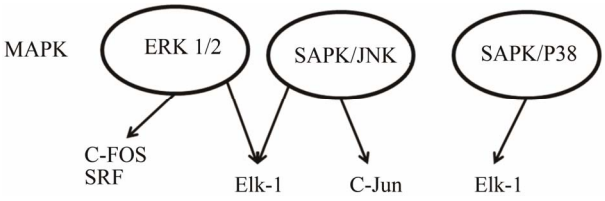

Figure 1. The mitogen activated protein kinase (MAPK) signaling cascades identified to date are: extracellular signal regulated kinase 1/2 (ERK), c-Junterminal kinase (JNK), p38-MAPK and stress activated protein kinase (SAPK). Elements of the three MAPkinase pathways that have been identified as activated by EMF are shown in the shaded circles, according to Weisbrot *et al*. [57].

stress responses. Findings that stem cells are most sensitive to microwave exposure and react more strongly to EMF than do differentiated cells may be important for cancer risk assessment and indicate that stem cells are the most relevant model for studying mobile-induced intracellular communication signals [83].

Brain cell cultures of mice were exposed to 10.715 GHz with specific absorbtion rate (SAR) of 0.725 W/kg signals for 6 h in 3 days at 25˚C to access the changes in the micronucleus (MNi) assay and in the expression of 11 proapoptotic and antiapoptotic genes. It was found that MNi rate increased 11-fold and STAT3 expression decreased 7-fold in the cell cultures exposed to RF. Cell phones which spread RF may damage DNA and change gene expression in brain cells. The data support the proposition that cell phones may have a potential to cause hazardous effects on the genome; however, in *in vivo* conditions, the duration of exposure and the capacity of DNA repair may prevent the development of cancer [84].

An interesting question raised in studies is what could be the early molecular target of mobile phone irradiation. Results of Friedman *et al*. [58] indicated that the early target could be NADH oxidase, which is localized in the plasma membrane and converts EMF irradiation into ROS.

However, the earliest target receptor of HF-EMF could be calcium ions stored on the external surface of cell membrane. The proposed HF-EMF induction pathway is resumed in **Figures 2** and **3**. Near the plasma membrane, EMFs could induce Ca^{++} ion movement, directly or indirectly, and activate NAD(P)H oxydase, a calcium-dependent enzyme. Its activity leads to the production of superoxide ion and hydrogene peroxide. Alternatively, the production of ROS would also activate several calcium channels, then enhancing the calcium ion concentration that is required for signal transduction. ROS can function as cellular second messengers that are likely to modulate the action of many different proteins, so leading to a variety of responses. The nuclear trans-

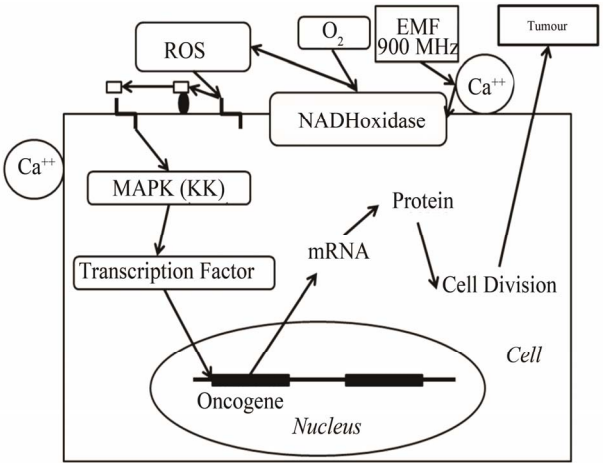

Figure 2. Cell survival after EMF stimuli. Schematic representation of proposed mechanism that mediates the phosphorylation of transcription factors upon mobile phone irradiation. EMFs (900 MHz) could shift calcium ions that trigger changes in the nearby enzyme NAD(P)H oxidase. The enzyme generates ROS that can induce membrane proteins which in formation of the signal message. Signal transduction could activate calciproteins, then MAP kinases and transcription factors that would activate oncogene expression. In turn, EMFs (900 MHz) could activate calcium channels that would allow the induction of the cell transduction signal cascade.

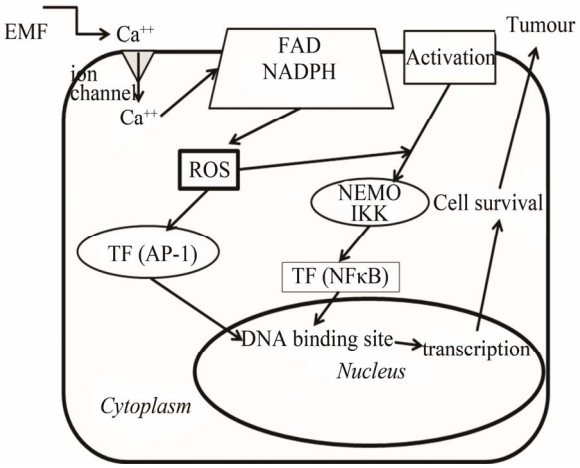

Figure 3. Cell transduction signal after EMF stimuli. Following targeting various agents (activation) on cell membrane, IκB proteins are phosphorylated by a protein kinase complex (IKK) and a regulation element (NEMO), then IκB is ubiquitinated. Proteasomal degradation is proceeded allowing the translocation of the NF-κB complexes in the nucleus where they bind to the gene promoters which are invoved in cell response [91]. EMF can activate a cell membrane calcium channel which allows triggering of membrane NADPH oxidase. The latter enzyme is part of a mechanism producing reactive oxygen species (ROS) that can activate transcription factors (TF) such as AP-1 and/or NF-κB. Oxidizing stimuli in the cytosol lead to post-translational transcription factor modification that facilitates translocation to the nucleus. The transcription factor can bind to the DNA site of oncogene promoters that trigger cell survival and tumour development.

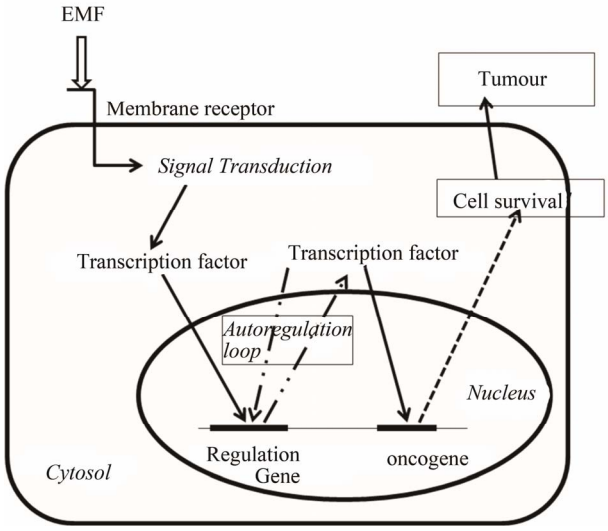

Figure 4. Cell survival homeostasis after EMF stimuli. EMF could trigger cell signal transduction through membrane receptor. Activated transcription factors would allow the expression of genes involved in cell survival together with transcription factor genes resulting in permanent cell survival and tumour development.

cription factor, NF-κB, is maintained in the cytoplasm through interactions with its inhibitor of IκB, but upon dissociation, as previously indicated, it moves into the nucleus and promotes cancer cell proliferation, angiogenesis, and metastasis (**Figure 2**). In addition, EMF could activate ion movements thus allowing the activation of calcium channels, activating NAD(P)H oxidase and inducing signal transduction for oncogene expression (**Figure 3**). Consequently a modelling of cell survival homeostasis following EMF stimuli can be proposed (**Figure 4**). The EMF stimuli might trigger the expression of transcription factors that could develop some type of permanent loop of gene expression. Transcription factors could thus induce the permanent expression of oncogenes involved in survival and proliferation of cancer cells (**Figure 4**).

The microenvironment that is associated with chronic inflammation can contribute to cancer progression [7,85]. Macrophages are key mediators of the interaction between inflammation, immunity and cancer. The role of macrophages in cancer has recently received special attention due to the discovery of their tumor-promoting effects [86-88]. Inhibition in macrophages activity during tumorigenesis at certain check points may interfere with host-suppressive effects on metastasis formation, and suggests that timing and cell specificity may be key determinants of the impact of specific NF-κB inhibitors used as cancer therapy [89]. Tumor growth increases inflammation and recent data have indicated that in cancer, high oxidative stress can be detected [7].

Panagopoulos and Margaritis [90] showed that GSM

900 MHz radiation is slightly more bioactive than Digital Cellular System (DCS) 1800 MHz radiation, at the same exposure durations and under equivalent radiation intensities. Exposure to mobile telephony radiation may have adverse health effects and thus mobile telephony use should be restricted within more rigorous defined limits of exposure. Since radiation intensity in their experiments was 45 and 90 times lower than the current exposure limits for 900 and 1800 MHz, respectively, this suggests the need for a significant reduction of the current exposure limits.

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http://www.sott.net/article/289952-Animal-Magnetism-How-the-magnetic-field-influences-animal-navigation

Animal Magnetism: How the magnetic field influences animal navigation

Tricia Edgar
decodedscience.com
Sun, 30 Nov 2014 15:40 CET

The migration of the monarch butterfly seems like it's magic, but it's actually guided by the magnetic field.
Sometimes, ecology is quite visible. When an owl catches a mouse, we see that connection very clearly. When a river floods, we see how water shapes a landscape.

Ecology can also be less visible. The soil is a good example of this: There is so much life in that brown material beneath our feet, but since we live on top of it, soil life can be difficult for us to visualize.

Sometimes, ecology is invisible.

What forces guide monarch butterflies as they migrate to a place they've never seen? When animals interact with the Earth's magnetic field, these invisible influences play a big role in animals' behavior.

Many animals can sense the Earth's magnetic field

How do you navigate through your everyday life? You likely use landmarks such as street signs or buildings. If you're not relying on a device to keep time, you could use the sun's position in the sky to tell you the time of day, and unless you live near the Arctic Circle, the presence of light or dark tells you whether it's day or night.

Humans use many environmental cues to tell them when and where to move, and for a long time, scientists thought that animals relied on similar environmental cues to find their way around.

However, in 1957, a Frankfurt scientist named Hans Fromme noticed that the robins he'd placed in a cage were getting restless. It was fall, and they kept on moving to the southwest part of the cage. Why were they doing this? Yes, the robins in Germany migrate to Spain to the winter, but their behavior puzzled him: these robins were in a closed room, without the sun or the stars to guide them.

They could not tell that it was fall, and they could not use the position of the sun and the stars to tell where Spain was. He decided that they must be using the Earth's magnetic field to guide them in their attempted migration.

How animals navigate

Just as we might use street signs, a GPS, and a map to navigate our way around a city, animals use multiple means of navigation. They use environmental clues such as temperature, light levels, and the availability of food sources to trigger migration. **They use the sun, moon, and stars to help them make their way to breeding grounds.**

Some animals use landmarks to show where they should go, while others such as salmon use the smell of a particular river to guide them home. While they usually use it together with other navigational methods, animals also use the earth's magnetic field as their compass.

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What's behind the amazing navigational abilities of birds? While they use the sun and the stars to navigate, birds also use the Earth's magnetic field.
How does the magnetic field influence animal behavior?

Since Fromme's time, many experiments on animal behavior have determined that organisms as diverse as bacteria and hamsters can detect the intensity of the Earth's magnetic field and the angle at which it intersects with the Earth.

The most visible interaction between animals and the magnetic field comes every year as animals migrate from cold to warm climates and back again. To navigation-challenged humans, animal migration can seem almost magical.

How do animals like salmon, leatherback turtles, butterflies, and hummingbirds manage to migrate thousands of miles? It turns out that it's not magic at all: **it's an invisible ecological**

interaction.

An inner compass is very important to migrating animals, particularly on days when it's overcast and hard to navigate using the sun or the stars.

In a 2014 study of monarch butterflies, researchers from the University of Massachusetts Medical School discovered that migrating monarchs orient themselves to the south - even in the absence of cues from the sun. This means that even when it's overcast, butterflies can continue moving southward to their winter home.

An alignment with the magnetic field can also help organisms move within their immediate environment. According to Kirschvink and Diaz-Ricci's work published in the *Bioeletromagnetics Supplement*, magnetotactic bacteria align with the Earth's magnetic field to seek out the area between mud and water in their aquatic environments. This is the best place for the bacteria to live.

Animal magnetoception: Where is this built-In compass?

When humans use a compass, it's visible in our hands. If animals have a compass, where is it? For a long time, studies of animal behavior showed animals aligning themselves with the earth's magnetic field, but no one knew exactly how they managed to figure it out. However, **research has discovered that many species contain small quantities of magnetite, the same material used in the ancient lodestones that humans used to guide their journeys.**

In 2012, research published in the *Proceedings of the National Academy of Sciences* discovered that rainbow trout have a good nose for figuring out directions. In their olfactory system, the trout have some cells that contain tiny quantities of magnetite. Researchers isolated these cells by looking for cells that aligned with the magnetic field and discovered that the cells contained magnetic components.

While people have not studied the magnetoreceptor anatomy of all animals that migrate, **many organisms - including humans - contain particles of magnetite within their bodies.** In the case of the magnetic bacteria, the bacteria contain magnetosomes, particles of magnetite or iron sulfide tucked into their cells.

It seems that animals that use the magnetic field to navigate may come with a built-in compass, **but there may be more than one type of compass. The bodies of animals such as birds and the fruit fly contain proteins called cryptochromes. When these proteins are exposed to blue light, they form molecules with electrons that spin in specific ways depending on the earth's magnetic field.** Researchers think that these cryptochromes could help some animals navigate.

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Although it’s controversial, some scientists think that electromagnetic interference from humans could interfere with animal migration.

Human impacts on the Earth's magnetic field

Humans have an impact on so many aspects of the earth's ecology. While wrangling with the magnetic field might seem like an activity that is out of our reach, **human-induced electromagnetic noise could be a concern for migrating animals.**

In a 2014 study published in the journal *Nature*, laboratory studies on robins showed birds that were exposed to background electromagnetic noise had trouble discerning which way was south.

While other studies have not seen the same impact from everyday background noise, **it's prudent to be aware that human-induced electromagnetic disturbances could have an impact on some animals' highly-tuned sensory systems.**

Animal navigation: Migration and the Earth's magnetic field

Animal navigation has long fascinated humans. We enjoy watching the geese migrate overhead as fall approaches, but for a long time, no one knew how they managed to find their way.

While it's not completely clear how all animals navigate using the Earth's magnetic field, recent investigations of animal anatomy have drawn us closer to the answer to this perplexing question.

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Cancer Trends During the 20th Century

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Abstract

Purpose: To review development trends and possible relations between different cancers in Sweden and in other countries to better understand causing mechanisms.

Materials and methods: We used publicly available databases on cancer incidence and mortality to highlight trends and trend breaks. The data were used for correlation studies between different forms of cancers as reported from different counties within Sweden, and from other countries.

Results: Some cancer forms correlate to malignant melanoma while others, like leukaemia, do not relate to melanoma at all. Asthma is a disease that has a sharp trend break just as these cancers show around 1955.

Conclusions: There is a common environmental stress that accelerates several cancer forms such, as colon cancer, lung cancer, breast cancer, bladder cancer and malignant melanoma. Every effort should be taken to identify and eliminate this stress.

Introduction

There are a number of cancers that still are lacking good explanations as to their cause. The cancer report from *Socialstyrelsen* 1997[1] states that the causing mechanisms behind bladder-, breast-, colon- and prostate cancers still are unknown. Considerable doubt rests also with the popular explanation that sunburn is causing the drastic increased incidence in skin melanoma and death rates since 1955. Another problem that has not been solved is why we see such an explosive increase of asthma and allergies from about the same time.

In this paper, we will take a closer look at the statistics of all these diseases in an attempt to narrow down the range of possible causing mechanisms.

Methods

We used databases on cancer incidence and mortality for Sweden as well as for other countries to derive cancer trends over time.[1-3] We also combined results from a death-cause register and a cancer incidence register in Sweden to investigate if people who died from lung cancer or breast cancer had earlier in life suffered from skin melanoma.[4] Correlation characteristics were calculated between different cancer types, both within Sweden and between different countries.

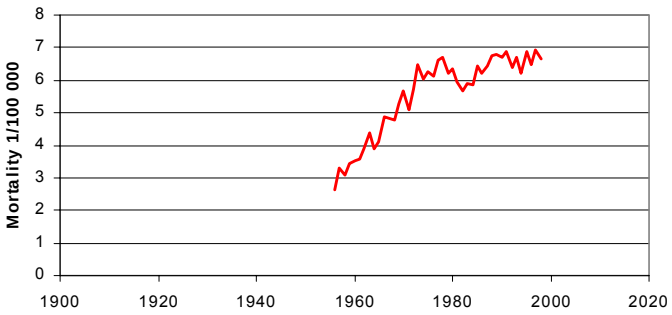

Figure 1. Mortality due to bladder cancer in Sweden since 1956.

Results

Bladder, prostate, melanoma, colon and breast cancers

Figure 1 shows the development of bladder cancer since 1955. In 1979 this disease had a reduction in the numbers dying annually, but since 1982 the rate is increasing again. Due to lack of data we can only see the development from 1955.

Figure 2 gives the drastic increase in Sweden in prostate cancer since 1951. Increasing trends can be noticed in 1955, 1970 and 1982, while a period of decreasing numbers started in 1979, just as for bladder cancer.

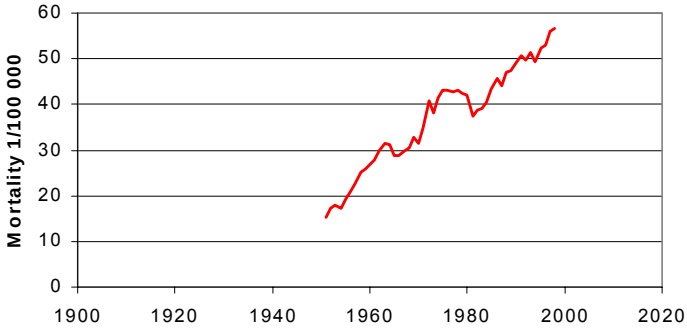

Figure 2. Development of prostate cancer death rates in Sweden since 1951.

Figure 3 shows the mortality for skin melanoma in Sweden. Data before 1955 is not published by the authorities, but was retrieved from a library.[5] The raw data shows that the 'natural' death rate increased from about 30 per year in 1912 to 50 in 1954. This gives an increase of 0.5 more victims per year. From 1955 it increased to 325 in 1996, which gives an increase by almost 7 victims per year, i.e. 14 times more than before 1955.

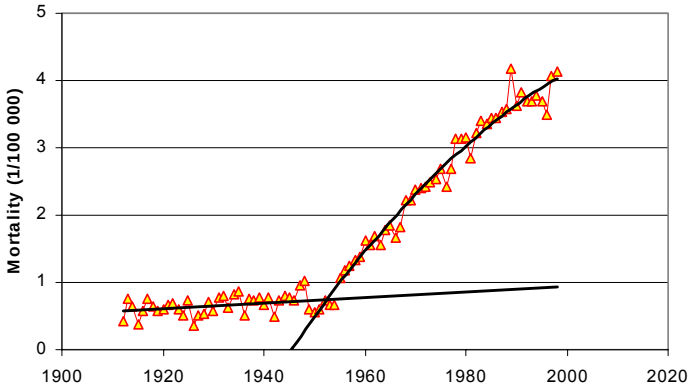

Figure 3. Skin melanoma mortality in Sweden since 1912.

Figure 4 gives the development of lung cancer death rate in Sweden.

Figure 5 gives the development of female breast cancer deaths in Sweden. Breast cancer screening started after 1975 to be gradually introduced in the country, which might explain part of the stabilisation. Better treatment in general is also altering these types of graphs. It should be noticed that breast cancer incidence has not levelled off, but continues to increase. This means that the causing mechanism behind breast cancer has not been properly addressed, but only methods of treatment and early diagnostics.

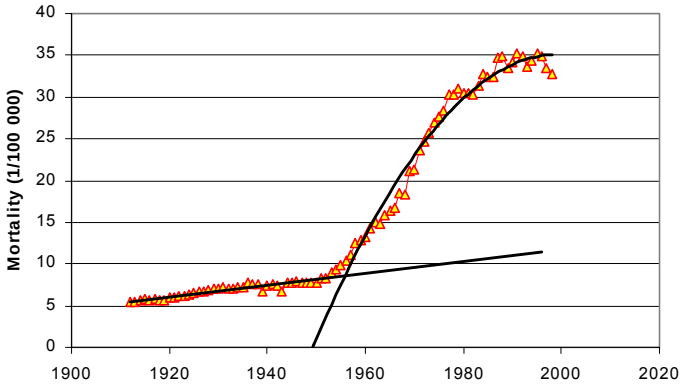

Figure 4. Lung cancer death rates in Sweden.

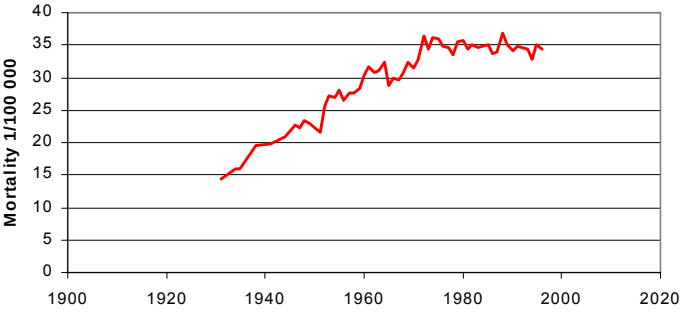

Figure 5. Development of female breast cancer mortality.

Figure 6 gives the development of colon cancer mortality since 1931. The mortality is increasing between 1920-1940 and starts to increase again around 1955 and 1969. A reduction is noticed from 1979.

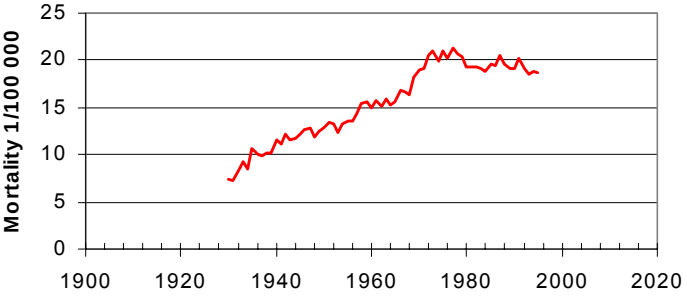

Figure 6. Mortality due to colon cancer in Sweden.

Asthma

Figure 7 shows the prevalence of asthma among 18-year-old males in Sweden.[6] The same graph also gives the percentage of 18-year-old males in Finland who were rejected at the military conscription test due to asthma.[7] These data are only available up to 1989. Before 1960 this level was essentially zero or at a very low level. Again, the graph indicates that a drastic change was made to the environmental conditions around 1960 or before 1960.

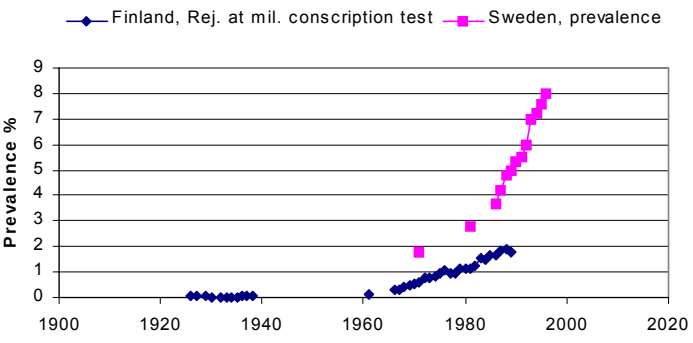

Figure 7. Asthma prevalence among Swedish 18-year-old males and the rejection rate at military conscription test due to asthma in Finland.[6,7]

Figure 8 gives the general asthma prevalence in the Swedish population according to a number of studies, summarised in ref. 8.

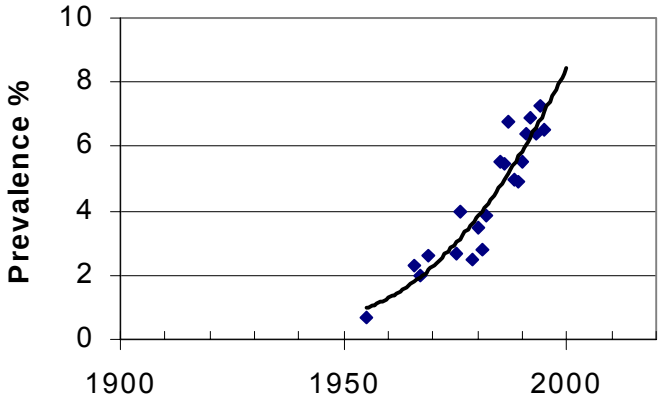

Figure 8. General asthma prevalence in the Swedish population.[8]

International cancer correlations

According to a recent study,[9] breast and prostate cancers are correlated. References 2 and 9 give the incidences from different regions in the world. People who move from low- to high-incidence countries also increase their incidence.[9] Figure 9 is a plot of prostate cancer mortality versus breast cancer mortality in a number of countries (Age standardised rates adjusted).

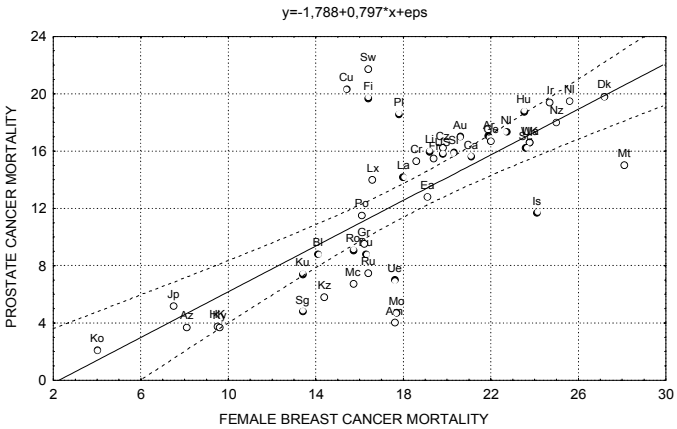

Figure 9. Breast and prostate cancer mortalities correlate. b=0.74; p<0.00001

Since we see a correlation between breast cancer and prostate cancer, it might be of interest to see if other cancers correlate. Figure 10 is a plot of melanoma and breast cancer incidences from 40 countries.[2] Here an association is also evident. Each dot is a specific country. See also Table 1.

Swedish cancer death rates

Figure 11 shows the development of different cancer death rates in Sweden, expressed as a percentage of reported rates in 1996. The graph also includes breast cancer incidence expressed in the same way. It is obvious that the graphs are quite similar, with a major trend break around 1955 and a short period of improvement around 1980. Colon cancer starts to increase already after 1920 and has a very clear reduction around 1980.

From Figure 11 it is clear that these cancer forms have a very similar development, although colon mortality seems to have been triggered already in 1920. The average development for the rest of the cancers

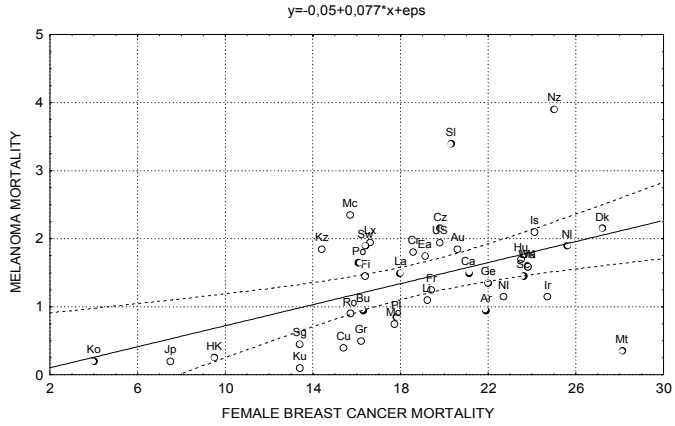

Figure 10 An association is noticed between breast cancer and skin melanoma mortality. b=0.49; p=0.00151

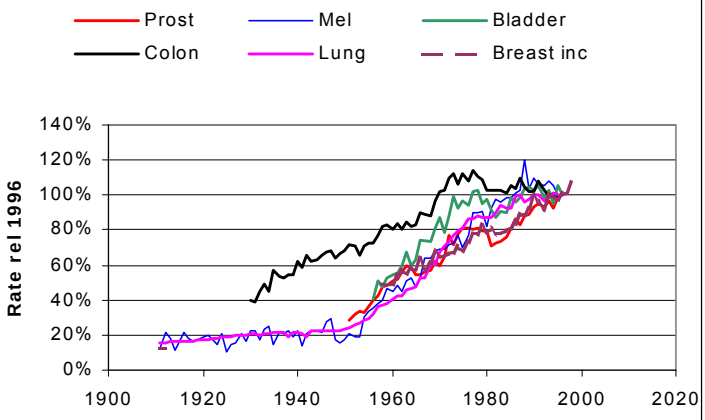

Figure 11. Cancer death rates and breast cancer incidence in Sweden expressed as a percentage of their values in 1996.

11 is given in Figure 12. In the same graph the number of persons per year who have been registered as sick for more than one year is also plotted. Again, 1979 seems to be a magic year of health improvement, while 1997 looks to be another year of disaster. It may predict that the cancer mortality for 1999 and onwards will also increase.

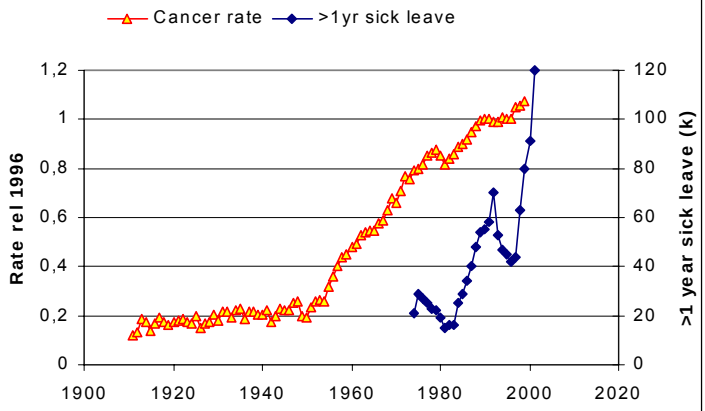

Figure 12. The average cancer rate relative to 1996 for bladder, melanoma, prostate, lung and breast cancers and the number of persons on sick leave for more than one year.

Figure 13 gives a similar graph where the 'illness factor' in Sweden has been plotted since 1955. There is obviously a clear relationship between this factor and cancer mortality.

Discussion

The authorities never publish the drastically increasing cancer mortality as shown in figures 11-13. First of all, data before 1955 has always been locked out from publicly available databases. Secondly,

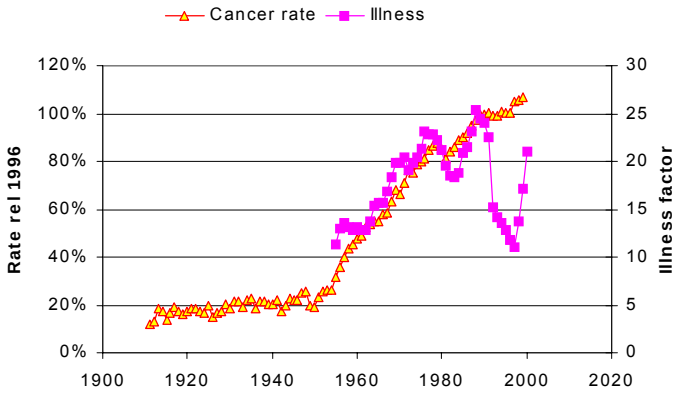

Figure 13. The similarity between the 'illness factor' and cancer mortality for the cancers analysed. Since 1997 the illness factor has increased drastically and continues to do so in 2001.

and even worse, trends for obviously exposure-time-dependent cancers are effectively neutralised by use of age-standardised ratios (ASR). This procedure assumes that the increasing cancer incidence is a natural effect of growing old and thus the age standardised mortality will stay the same although the population gets older. By doing this, the responsible institutions can show to the authorities that the mortality is in control and in effect not increasing at all despite the fact that it is. Furthermore, several cancer mortalities are not published before 1969, which makes it difficult to notice the sharp trend breaks that are present at that year. The responsible authorities do not agree that there is any trend break of interest at all.[13] Nothing speaks for either a trend break in cancer incidence or that a large number of cancers would depend on electromagnetic fields.

Figure 5 shows that breast cancer deaths started to increase long ago, maybe in 1920. This curve has an almost linear increase that flattens out around 1975. But since death rates are influenced by improvements in the medical treatment, it may be better to look at incidence data (rate of people getting ill per year) rather than on death rates.

Figure 14 shows that the incidence rate continues to grow even though the mortality levelled off after 1975. This implies that we have improved the treatment but not at all addressed the cause of this disease. It is interesting to note that breast cancer incidence also shows an improvement in 1979 and a few years onwards, just as the prostate, bladder and colon cancer death-rate graphs do.

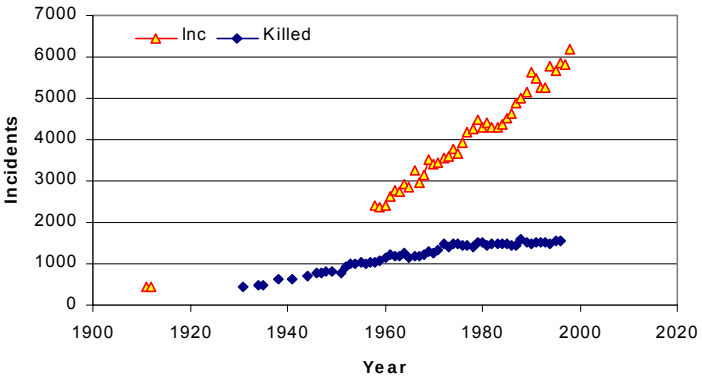

Figure 14. Development of female breast cancer cases in Sweden.

Skin melanoma is a cancer that started to explode in 1955 (see Figure 3). It is interesting to note that a similar steep increase in melanoma mortality was also reported from Queensland, Australia, when comparing 1951-1959 with 1964-1967.[10] This increase was related to the introduction of high power TV broadcasting transmitters. Skin melanoma has also been associated with the expansion of broadcasting networks in Sweden, Norway, Denmark and USA.[11] Lung cancer has an almost identical development, as melanoma has had in Sweden with a scale factor of 10 (see Figures 3 and 4).

Augustsson and Stierner[14, 15] presented statistics on the location of

moles, melanocytes and melanoma on the human body. Figure 15 is a summary picture of all these moles. Figure 16 gives the dot density for different parts of the body. It is interesting to note the similarity to induced vertical currents in the body due to radio frequent electromagnetic fields (RF) as has been presented in ref. 16 (see Figure 17).

Augustsson and Stierner[14, 15] noticed that the largest mole density

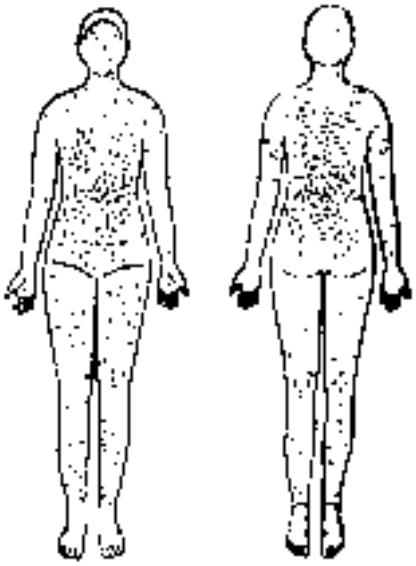

Figure 15. The combined distribution of dysplastic naevi and melanoma ('dots') over the human body.[14-15]

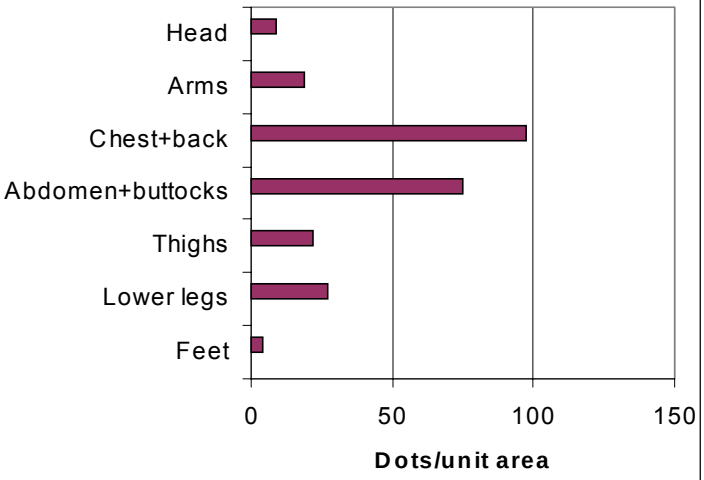

Figure 16. The number of 'dots' per unit skin area according to Figure 15.

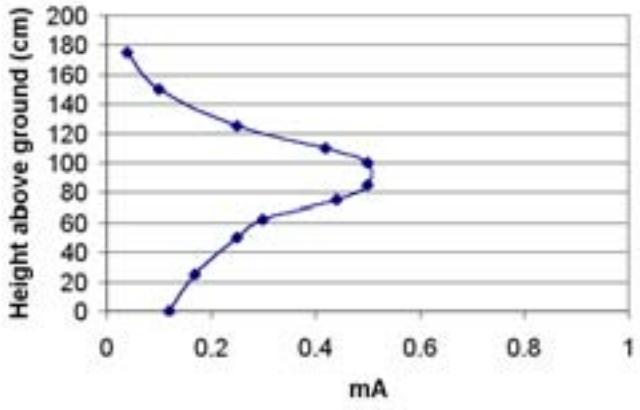

Figure 17. Induced vertical1 current distribution for isolated, shoe-wearing, grounded or ground-topped human model at 27.12 MHz under near-field exposure conditions.[16]

was found in areas that were not normally exposed to sunshine. Thus, they concluded that intermittent or minimal exposure to UV radiation was more dangerous than continuous exposure. We think that the explanation is quite different from that. The induced currents from RF exposure are largest at these parts of the body so the mole density should be expected to follow the same pattern.

Cancers in the Swedish counties

Figure 18 shows the correlation between a number of cancers and melanoma in the 26 different Swedish counties. Table 2 gives the respective beta-values. It is worth noticing that leukaemia does not correlate to these cancer types at all.

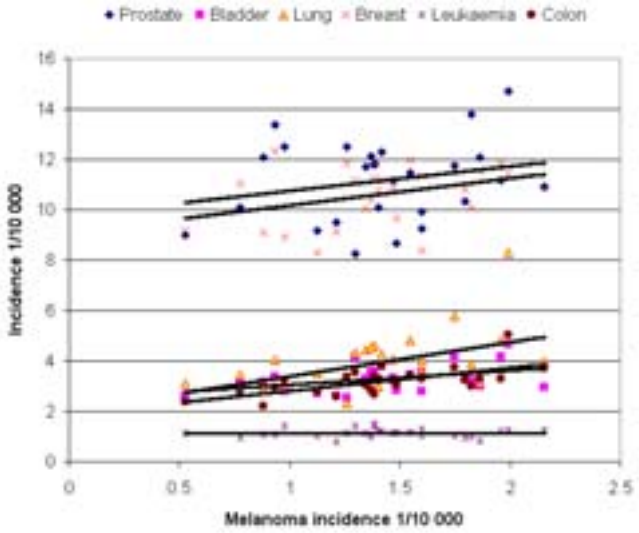

Figure 18. Several cancers correlate with skin melanoma in the 26 different Swedish counties, but leukaemia does not.

A closer look at the lung cancer mortality shows a development very similar to skin melanoma (see Figures 3-4). The average consumption of cigarettes in Sweden has decreased from 1,946 cigarettes per year per capita in 1980 to 1,200 in 1995, although the mortality has continued to increase; however, the increase has been lower than that for skin melanoma.

In Figure 19 we plotted the annual melanoma deaths vs. lung deaths in Sweden for each year from 1912 to 1996 (beta = 0,982).

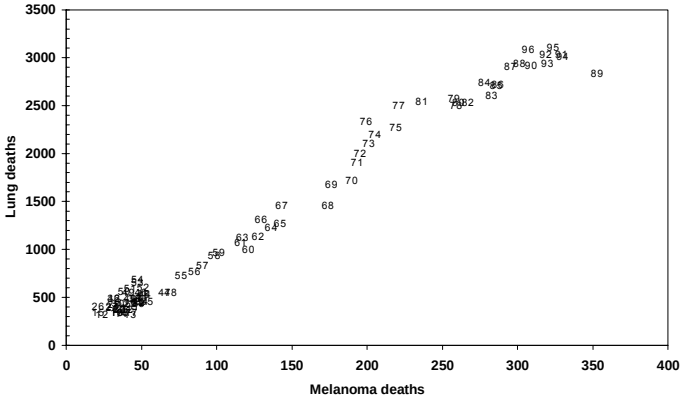

Figure 19. Melanoma and lung cancer deaths for different years.

In order to test by other means if lung cancer and breast cancer are related to skin melanoma, we combined two databases: the Swedish Cancer Register and the Death Cause Register of Sweden.[4] The records of those who died from breast cancer or lung cancer were searched for any treatment for skin melanoma earlier in their lives. As a reference, all other death causes except breast, lung or melanoma cancers were also searched for the same. A specific, non-cancer death

cause was ischemic heart disease, which also was searched for any melanoma treatment.

The data was collected over the time period 1970-1998. The results show the fraction (%) of the deceased who earlier in life had been treated against skin melanoma:

All death causes: ... 0.21% (>2.5 millions deaths)
Breast cancer: ..... 0.37% (42,610 deaths)
Lung cancer: ..... 0.33% (71,956 deaths)
Heart Disease: ..... 0.24% (821,367 deaths)

We conclude that breast cancer and lung cancer are linked to skin melanoma, since people who died due to breast or lung cancer had an increased melanoma incidence by a factor of 1.67 (0.35/0.21). This was further underscored by the strong geographical relationship between melanoma incidence and lung, breast or colon cancer incidence. The large numbers involved in this analysis exclude the possibility that the results are just a matter of coincidence.

Figures 20 and 21 show that colon cancer relates to skin melanoma and that lung cancer and bladder cancer are strongly correlated. Figures 22 and 23 show that cigarette consumption is not a strong common factor for these cancers. See Table 2, data is from 1989-1993.

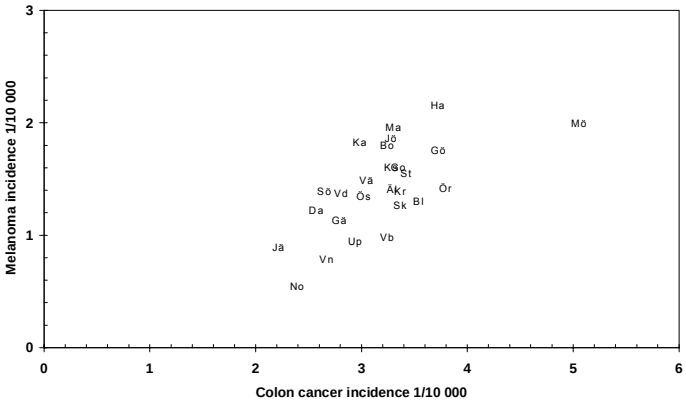

Figure 20. Melanoma incidence versus colon incidence in the 26 counties of Sweden. b=0.655; p=0.000207. R^2=0.43

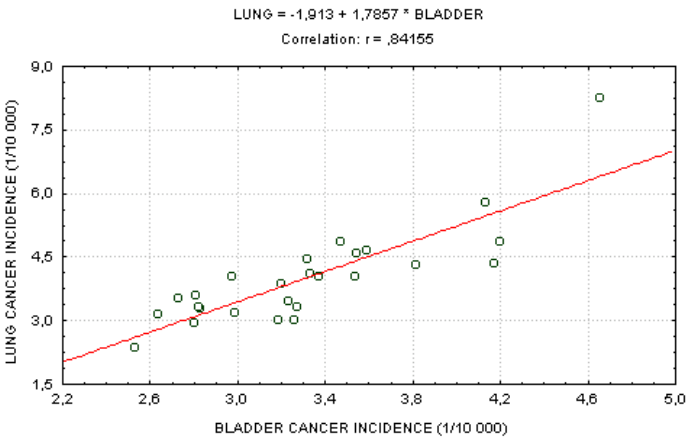

Figure 21. Lung cancer and bladder cancer incidence in the Swedish counties are strongly correlated. b=0.842; p<0.00001. R^2=0.71

A multi-regression analysis of lung cancer mortality in 22 different countries showed a relation to both cigarette consumption and melanoma mortality. Cig-beta=0.679 and Mel-beta=0.528 with p=0.00212.

Finally, we looked at all cancer deaths reported since 1912 and plotted the result in Figure 24. Trend-breaks are quite visible in 1920, 1955, 1970 and in 1979.

In 1920 we got MW radio, in 1955 we got FM radio and TV1, in 1969-70 we got TV2 and colour TV and in 1978 several of the old AM broadcasting transmitters were disrupted, all according to ref. 12.

Improvements in prostate cancer deaths have been reported in

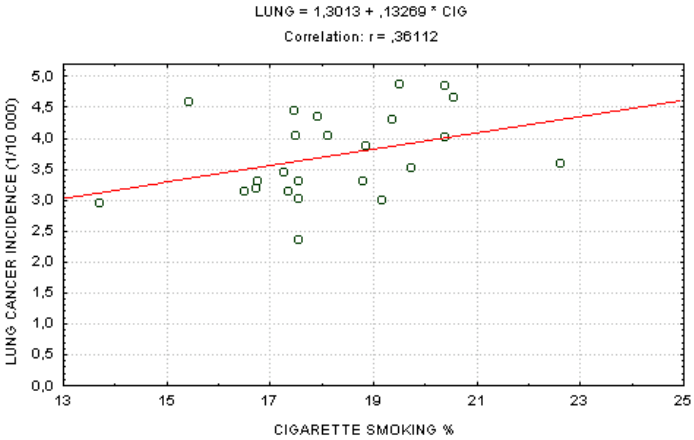

Figure 22. The correlation between lung cancer incidence and cigarette consumption (% of the population that is smoking cigarettes) is weak in the Swedish counties. R^2=0.13.

Figure 23. Bladder cancer incidence does not correlate well to cigarette consumption in Sweden. R^2=0.07

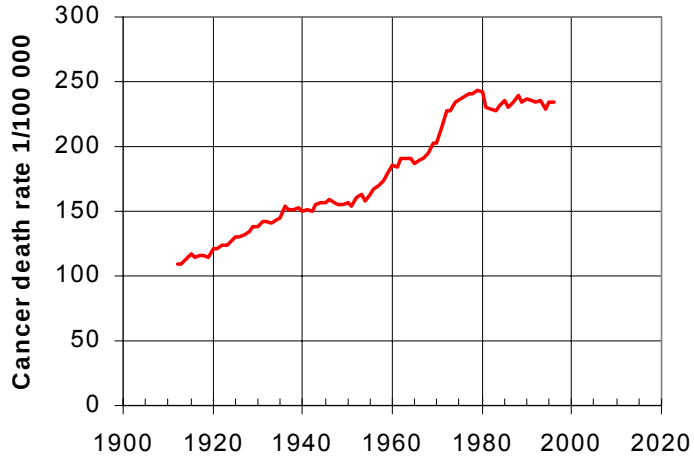

Figure 24. The mortality shows clear trend-breaks in 1920, 1955, 1970 and in 1979.

USA. Figure 25 gives the number of prostate cancer deaths and the number of AM stations still active. Since 1990 the number of active AM stations has been steadily decreasing.

Figure 26 gives the development of cancer mortalities in different countries.

Conclusions

1. Breast, bladder, prostate, lung, colon and cutaneous melanoma cancers are all associated with each other. Figures 15-17 and ref. 11 relate melanoma to radio-frequency EMF.

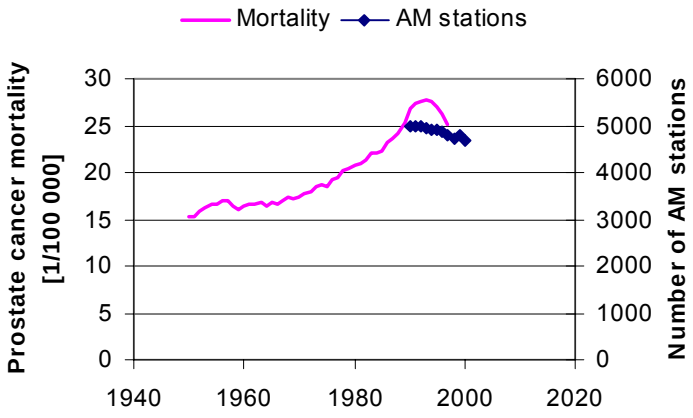

Figure 25. A sharp decline in number of men killed by prostate cancer has been noticed in USA since 1990. At the same time the number of AM stations have started to decline.

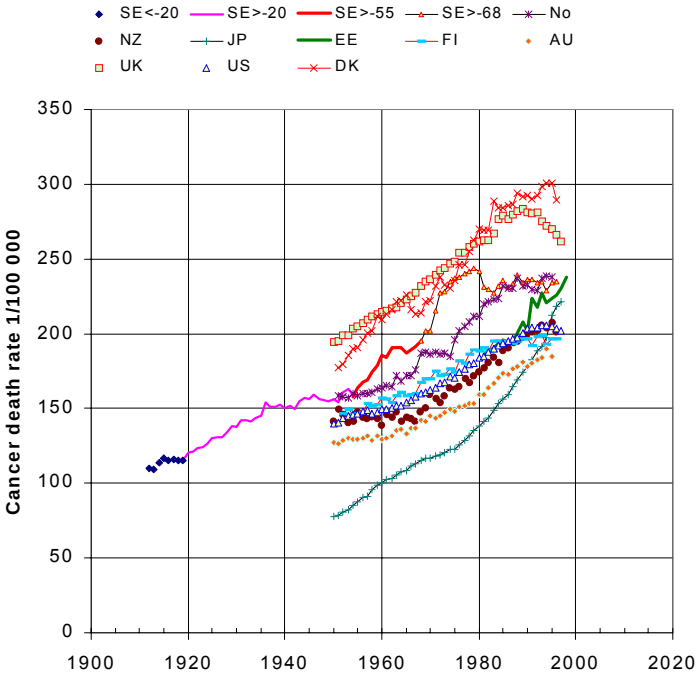

Figure 26. Cancer mortality development in several countries since 1950.

2. Figure 18 indicates that leukaemia has nothing to do with melanoma. Somewhat more unexpected is the strong relation between melanoma and colon cancer and between lung cancer and bladder cancer.
3. Since the cancer mortality trend-breaks coincide with expansion or disruption of public broadcasting in Sweden, studies regarding the influence from electromagnetic fields on cancer and asthma development cannot be further delayed.
4. Lung cancer mortality has a multiple correlation to both cigarette consumption and skin melanoma mortality.
5. Since closing down of public radio transmitters seems to have a strong effect in reducing cancer mortality, public air radio transmission should be avoided.
6. Age-standardised ratios should be used with care when presenting cancer rates that are dependent on exposure times.

Similar trend-breaks as found in Sweden can be noticed for other countries. Figure 26 shows, for example, that Estonia (EE) had a steep increase in the cancer mortality in 1991, the year that the 'western' FM radio-frequencies were allowed and introduced all over the country.

Acknowledgements

This study was financially supported by the Swedish Cancer and Allergy Foundation (Cancer och Allergifonden). We are grateful to Charlotte Björkenstam at the Epidemiological Centre of Sweden, EpC, for support in extracting death and incidence data from the public databases.

We thank Ms Margareta Krook-Brandt at the Karolinska Institute for expert support with the statistical evaluations.

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Larger scale reproductions of the figures in this article may be obtained from ACNEM, in grey-scale or colour.

Cancers	Beta	p-level
Breast – Prostate	0.74	<0.00001
Breast – Melanoma	0.49	0.00151
Breast - Colon	0.671	<0.00001
Prostate - Colon	0.66	0.00001
Prostate - Melanoma	0.43	0.0053
Bladder - Melanoma	0.31	0.049
Colon - Melanoma	0.400	0.0105

Table 1. Correlation parameters between different cancer mortalities in the examined countries.

Cancers	Beta	p-value
Melanoma - Colon	0.655	0.000207
Bladder – Lung	0.842	<0.00001
Lung - Colon	0.664	0.000115
Bladder - Breast	0.519	0.00558
Melanoma - Leukaemia	0.016	0.94

Table 2. Correlation coefficients between incidence rates of different cancers in the Swedish communities.

http://losangeles.cbslocal.com/2015/05/05/woman-cuts-family-off-from-wifi-over-health-concerns/

Woman Cuts Family Off From WiFi Over Health Concerns

May 5, 2015 11:17 PM By Lisa Sigell

LOS ANGELES (CBSLA.com) — A local mother's health concerns prompted her to cut her family off from wireless and wants more research conducted into the safety of WiFi.

In the Lawson household, cassette tapes are still in use, as are landline telephones.

Not in use, however, are cellphones, iPads, iPods nor absolutely no wireless connections to the outside world.

"You're just thinking, 'I want to live,' " said Anura Lawson, a mother and teacher.

Lawson says she started feeling sick in 2012 soon after the Los Angeles Department of Water and Power installed a wireless smart meter on her home.

There are 52,000 of these smart meters being tested in L.A., and the DWP says they're safe.

But some people claim the radio waves they emit trigger health problems.

"I began to feel dizzy at first," Lawson said. "Migraines. Heart palpitations."

Lawson's daughter, Amira, 22, also experienced trouble.

"My brain was running slower, and I was like, 'I don't know what's going on,' " she said.

"There is a syndrome called electromagnetic hypersensitivity," said Robert Nagourney, an oncologist in Long Beach and professor at UC Irvine.

"There are two kinds of radiation we speak about. One is ionizing, and one is nonionizing," Nagourney said. "In ionizing radiation, clearly, there's a great risk of DNA damage, mutation and cancer."

This danger has not been proven with nonionizing radiation, which is the type emitted by cellphones, smart meters and WiFi.

But with our 21st century explosion of wireless, Nagourney says "we're bathed in this type of radiation."

"Does it cause medical illnesses? Great question. Difficult to answer," the doctor said.

For the Lawson family, who consider themselves sensitive to electromagnetic fields, the smart meter had to go.

Once they got their analogue meter back, Lawson said they felt better healthwise.

But a 1 ½ years later, Lawson says her symptoms returned.

“I began to have migraines. I began to have the heart palpitations,” she said.

It coincided with a change at work as Lawson is an eighth-grade English teacher at Johnnie Cochran Middle School.

In March 2014 to facilitate its iPad program, Lawson says, the “LAUSD decided to install WiFi within my school site.”

With her health deteriorating, Lawson testified before the Board of Education.

“I’m the parent of six children. I want to be around to see them grow up,” she had said. “When I am in the WiFi classroom, I don’t feel good at all.”

“There were a lot of people that were concerned about putting WiFi in the classroom,” said Bill Piazzi, the LAUSD’s environmental assessment coordinator, whose job it is to make sure classrooms are safe.

Where there are WiFi access points, Piazza says, they use a very sophisticated piece of equipment, which measures radio-frequency output.

“We looked very hard at the potential exposures in the classroom,” he said. “No matter where we went, it’s all low.”

Piazza showed CBS2 an emissions report from a classroom that had WiFi.

“These are 30 kids streaming in a classroom, and these are the exposures that they’re getting,” he said “Look how low that is.”

Still, the board in September agreed to turn off the WiFi in Lawson’s classroom.

Now, she is believed to be the first public school teacher in the U.S. granted a health accommodation for electromagnetic hypersensitivity.

“I think the district did a very good job in making a reasonable accommodation for her,” Piazza said.

Lawson’s accommodation applies to her classroom only. To keep her children away from WiFi exposure, her four youngest are being educated at home.

The Lawson’s have Internet at home, but it’s only through a wired connection.

Over the past three years, Lawson says, she has encountered plenty of doubters, which Nagourney says is too bad.

“People are of different sensitivities. We know that one person can get a bee sting and nothing happens. Another person goes into anaphylactic shock. It’s the same bee sting. Different reaction,” he said.

Nagourney says the likelihood of WiFi emissions causing illness is small, “but the chance is not zero.”

Lawson says she would like to see the issue thoroughly researched and believes the newness of wireless makes it impossible to fully understand now how it might one day affect one’s health.

Thus, she’s keeping her kids away from it for as long as she can.

“Teaching doesn’t have to involve a device,” she said. “I think that our students unfortunately are the Guinea pigs, and I don’t think that’s right.”

The LAUSD says it is continuing to study all safety data with respect to WiFi. To view the most recent reports, click **here**.

Lawson has started an online petition to get WiFi out of California classrooms. For more information, click **here**. To reach Nagourney, click **here**.

Story produced by Geri Shaftel Constant, CBS2 Medical Producer.

Electromagnetic Cover-Up

Attempts to water down a US Government report linking exposure to electromagnetic fields to cancer have provoked charges of a cover-up.

A two-year study commissioned by the US Environmental Protection Agency (EPA) has concluded that there is a significant link between exposure to extremely low frequency (ELF) radiation and the occurrence of human cancer. The study group's report *An Evaluation of the Potential Carcinogenicity of Electromagnetic Fields*, was made available in June amid much publicity.[1] However, it has emerged that the conclusions of the EPA assessors have been watered down significantly in the published version of the report, prompting charges of a cover-up.

Early drafts of the report, which were leaked to various sections of the American media, recommended that ELF electromagnetic fields (EMFs) be classified as "probable human carcinogens".[2] The EPA assessors also recommended that radio-frequency and microwave radiation be designated as "possible" carcinogens.[3]

As originally drafted, the summary of the report stated that although the biological mechanisms by which non-ionizing radiation might cause cancer in humans are unknown, animal tests and epidemiological studies "are suggestive of a causal relationship". According to the New York-based newsletter *Microwave News*, the following paragraph concluded the draft summary — until it was deleted in mid-March by Dr William Farland, Director of EPA's Office of Health and Environmental Assessment, the body which prepared the report:

> "Concerning exposure to fields associated with 60 Hz electrical power distribution, the conclusion reached in this document is that such exposure is a 'probable' carcinogen risk factor, corresponding to 'B1' degree of evidence that it is a risk factor. This conclusion is based on 'limited' evidence of carcinogenicity [in] humans which is supported by laboratory research indicating that the carcinogenic response observed in humans has a biological basis, although the precise mechanisms [are] only vaguely understood."[4]

As published, however, the report concludes that studies of leukaemia, lymphoma and brain cancer in children and adults occupationally exposed to extremely low frequency EMFs, "show a consistent pattern of response that suggests, but *[does] not prove*, a causal link." The recommendation that ELF radiation be classified as a "probable human carcinogen" has also been deleted from the officially-released version, as has the recommendation on classifying radio-frequency and microwave radiation as "possible" carcinogens. The deletions were made by Farland because there was, in his judgement, an absence of both a mechanism of interaction and an observed dose-response relationship.

Positive Association

Despite the deletions ordered by Farland, other sections in the report underline the original conclusions. For example, after evaluating the 28 studies of occupational exposure to EMFs, the report states:

> "The occupational studies seem to suggest the likelihood that there exists a positive association of leukaemia and central nervous system cancer with employment in jobs that have a high potential for exposure to EMFs."

And assessing six studies of childhood cancer and EMFs, the report concludes:

> "The case-control studies of children residentially exposed to magnetic fields provide evidence of a positive association of a risk of certain types of cancer, namely leukaemia, central nervous system cancers and lymphoma. Because these measured risks are low in all of these studies the possibility that some unknown confounder is responsible cannot be eliminated. However, because of the consistent positive findings and suggested site concordance, chance is not likely to be the explanation."

Referring to the work of both the Polish researcher Szmigielski, and Dr Bill Guy at the University of Washington, on the effects of radio-frequency radiation, it is stated that:

> "The clear positive findings of Szmigielski et al. show that radio-frequency fields without low frequency components stimulate the growth of tumours and indicate that they may act as a tumour promoter, or a modifying factor in the development of tumours, the role of tissue heating as a mechanism for this effect is not clear."

Comments such as these are the strongest yet made by a US government agency on the connection between human cancer and chronic exposure to electromagnetic fields from sources such as powerlines, visual display units, household appliances, radio broadcast and microwave systems. It is reported that the question of how to deal with EMFs is being debated at the highest levels of the Bush Administration. Indeed, the White House was briefed in early March by EPA officials on the report's original recommendations.

Simon Best

Notes and References

1. Copies of the report can be obtained from: The Environmental Protection Agency, 401 Main Street SW, Washington, DC 20460, USA. Tel: (202) 382-5898. Currently, there are five independent studies on the link between childhood cancer and EMFs being carried out in Europe and North America.
2. *Nature* 345, 7 June, 1990, p.463.
3. Other substances currently listed under classification B (probable human carcinogen) of the EPA's five-fold "weight of evidence" categorization, include PCBs, DDT and formaldehyde, while category C (possible human carcinogen) includes methyl chloride and saccharin. Class A (human carcinogen) includes asbestos and benzene, while Classes D and E refer to lack of evidence of carcinogenicity.
4. *Microwave News*, May/June 1990.

CNProject no.
SSPE-CT-2004-502173
Project title
EMF-NET: EFFECTS OF THE EXPOSURE TO ELECTROMAGNETIC FIELDS: FROM SCIENCE TO PUBLIC HEALTH AND SAFER WORKPLACE

Instrument:
Co-ordination action
Thematic Priority:
Priority 8, POLICY ORIENTED RESEARCH ï AREA 2.3, Call Identifier FP6-2002-SSP-1

Deliverable D17: Report on health effects of RF with recommendations for non-ionising radiation protection and research needs

REPORT ON HEALTH EFFECTS OF RADIOFREQUENCY FIELDS

Start date of project: March 2004 Duration: 48 months

Organisation name of lead contractor for this deliverable:
International Agency for Research on Cancer, Lyon, France

Person in charge:
Professor Elisabeth Cardis (ecardis@creal.cat) *now at CREAL, Barcelona*

Revision [ ]

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	**PU**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

CONTENT

Introduction

The primary natural source of RF fields is the sun. Human-made sources, however, emit the majority of fields in the immediate environment of the community, home or the workplace. Most RF fields found in the environment are due to commercial radio and TV broadcasting and to telecommunications facilities (Table 1). RF sources in the home include microwave ovens, DECT telephones and Wi-Fi routers. In the workplace, there are a number of industrial processes which use RF fields: dielectric heaters used for wood lamination and the sealing of plastics; industrial induction heaters and microwave ovens, medical diathermy equipment to treat pain and inflammation of body tissues and electrosurgical devices for cutting and welding tissues.

Table 1: RF range: frequencies and type of device or service (adapted from Mathes)

Frequency Range	Frequency	Type of Device or Service
30 - 300 kHz	LF (low)	LF broadcast and long range radio
300 - 3000 kHz	MF (medium)	AM radio, radio navigation, ship to shore
3 - 30 MHz	HF (high)	CB radio, amateurs, HF radio communications and broadcast
30 - 300 MHz	VHF (very high)	FM radio, VHF TV, emergency services
300 - 3000 MHz	UHF (ultra high)	UHF TV, paging, mobile telephones, amateur radios, DECT
3 -30 GHz	SHF (super high)	Microwaves, satellite communications, radar, point to point microwave communications, Wi-Fi
30 - 300 GHz	EHF (extremely high)	Radar, radio, astronomy, short link microwave communications

Today the largest source of RF for the general public is the use of mobile telephones. Except when phones are used in a hands-free position or used to send data, mobile telephones are generally held against the head when a call is being made and the antenna receives and sends the signal. The head of the user is in the near field of the source because of the distance of the antenna to the head is typically a few centimetres. Due to this close proximity, most of the RF energy is absorbed in the brain hemisphere on the side where the phone is used, mainly (50ï 60%) in the temporal lobe. The average relative SAR is highest in the temporal lobe (6ï 15%, depending on frequency, of the spatial peak SAR in the most exposed region of the brain) and the cerebellum (2ï 10%) and decreases very rapidly with increasing depth, particularly at higher frequencies(Cardis et al. 2008).

Occupational exposures, on the other hand, can differ from mobile phone exposures in a number of important respects:

- They may occur for more prolonged periods. For example, working next to an industrial heater may expose the subject to radiation for eight hours a day, five days a week, over a number of years.
- They may expose larger areas of the body. Mobile phones tend to expose on a small area of the body adjacent to the ear; whereas some pieces of industrial machinery may expose the entire body to radiation.

This is the third and final report on epidemiological studies of health effects of RF fields. The first two reports focused on new literature published during the project period of EMF-NET, whereas

the final report will make an assessment of the totality of the available epidemiological scientific evidence. Included in the assessment are scientific studies that have been published primarily in peer reviewed scientific journals. The studies have been identified through systematic searches in PubMed, ISI Web of Science, scrutinizing reference lists of published papers and reports, and through participation in scientific conferences focused on biological effects of electromagnetic fields.

Evaluation

Whereas the original objective of WP3 was to evaluate the epidemiological evidence for health effects of EMF exposure, an evaluation of the effects of RF was not possible within the lifespan of the EMF-Net project because of delays in publication of the results of the international analyses within INTERPHONE, the largest epidemiological study to date. The International Agency for Research on Cancer (IARC) and World Health Organization (WHO) evaluations have likewise not yet taken place because of this delay.

The current report is therefore limited to a critical review of the evidence to date. It is, at present, premature to draw conclusions concerning the presence or absence of health effects from RF at ñathermal levelsò.

Where available studies existed, the following outcomes have been reviewed:

1. Cancer outcomes
    a. Brain and CNS tumours in adults
    b. Other tumours
2. Fertility and pregnancy outcome
3. Cardiovascular effects
4. Other possible health effects

The list is based on the ñKey Issueò list of Main Task 1 (MT1) of EMF-NET, and corresponds to the endpoints evaluated in WP2.1 Laboratory studies, for which evidence from epidemiological studies of RF are available.

Exposure assessment

As there is at present no known biophysical interaction mechanism for potential health effects of athermal, levels of RF it is not obvious which aspect of exposure is the most relevant.

Where efforts have been made to use an exposure metric, studies have generally focused on estimates of the amount of RF energy absorbed, measured by SAR (the specific energy absorption rate i.e. energy absorption rate per unit mass (measured in W kgī 1)) in mobile phone studies, or on the total RF electromagnetic field exposure.

Residential exposure

As discussed below, most residential studies in relation to RF transmitters are of ecological design. Exposure assessment methods in these studies are generally very crude, based on the measured distance between a house and nearby RF sources. Spot measurements have, however, been used in two recent case-control studies to validate exposure prediction models (Ha et al. 2007;Merzenich et al. 2008), showing a better correlation between measurements and the models than between measurements and distance from the source.

A number of studies have also considered RF exposure from cordless telephones at home (Hardell et al. 2006c;Hardell et al. 2006b;Schuz et al. 2006a;Schuz et al. 2006b). Information on the use of

these telephones has been obtained, together with information on mobile phone use, from questionnaires and include dates of start and stop of use, type of cordless phone and, in the German study, location of the base station in the house or apartment.

Integrated measurements over longer time periods (1-7 days) have also been made in recent RF exposure assessment studies (Thomas et al. 2008;Röösli et al. 2008;Viel et al. 2008) with the use of personal RF meters. These meters allow estimation of exposure in most of the frequency bands of concern for environmental exposure (including TV, radio, mobile phones ï handsets and base stations -, Wifi and DECT routers). These instruments have not, however, yet been used in any of the analytical epidemiological studies published to date.

Occupational exposure

Occupational studies are also characterized by rather crude exposure assessment, sometimes limited to investigations of disease risk associated with individual job titles, or to grouping of occupational titles thought to be exposed to RF. In some of the studies, workers in the groupings considered were also exposed to ELF and it is difficult to separate RF and ELF exposed workers.

Recent studies (Karipidis et al. 2007;Berg et al. 2006) have used detailed occupational history, in conjunction with assessments by occupational hygienists and, in the Karipidis study, linkage with an EMF Job-Exposure Matrix (JEM) to infer exposure levels.

Mobile phones

Most studies to date have been based on historical use of mobile phones rather than any estimate of RF ñexposureò.

Information collected in cohort studies has been limited ï the fact of having a subscription, and, in some instances, the date of start of the subscription and the type of network.

Case-control studies have provided the opportunity of collecting much more detailed information at the individual level. Exposure variables generally collected include: ever having been a regular user (this variable was defined differently in different studies ï within INTERPHONE, it was defined a priori as at least one call per week on average for a period of 6 months or more), time (years) since first regular use, cumulative number of calls, and cumulative duration of calls. For analyses of cancer risk, exposure variables were generally censored some time (often 1 year) before the reference date. Cumulative number and cumulative duration of calls have also been analyzed, generally excluding use with hands-free devices. Use in different time windows has also been analysed in some papers.

Because the absorption of RF energy from phones is localized, if a risk exists it is likely to be greatest for tumours in regions with greatest energy absorption. Most (97ï 99% depending on frequency) appears to be absorbed in the brain hemisphere on the side where the phone is used, mainly in the temporal lobe. The average relative SAR is highest in the temporal lobe and the cerebellum and decreases very rapidly with increasing depth, particularly at higher frequencies. Analyses of risk by location of tumour are therefore essential for the interpretation of results studies of brain tumours in relation to mobile phone use (Cardis et al. 2008).

Major efforts are therefore underway to evaluate the amount of RF energy at the site of the tumour in case-control studies of brain and central nervous system (CNS) tumours.

In the glioma analyses of the Japanese INTERPHONE study (Takebayashi et al. 2008), the maximum amount of RF energy absorbed inside the tumour was estimated. Within INTERPHONE; efforts are underway at the international level to develop an RF ñexposure

gradientò to estimate the amount of RF energy absorbed at the location of the probably origin of the tumour, taking into account the subject´s mobile phone use history as well as historical characteristics of phones (including radiation pattern) and networks in participating countries. This gradient is not yet available, however, in the studies published to date.

An important issue in the interpretation of results of case-control studies that rely on self-reported history of mobile phone use is the potential for errors and biases in recall of amount of phone use. Within INTERPHONE; validation studies have been conducted to evaluate potential error in the recall of phone, indicating that phone use was subject to moderate systematic and substantial random error (Berg et al. 2005;Vrijheid et al. 2006;Vrijheid et al. 2008a;Hours et al. 2007b;Parslow et al. 2003;Hepworth et al. 2006;Samkange-Zeeb et al. 2004;Tokola et al. 2008). Errors appear to be larger for duration of calls than for number of calls, and phone use appears to be under-estimated by light users and over-estimated by heavy users. Comparison of a sample of cases and controls in three countries showed little evidence for differential recall errors overall or in recent time periods, but apparent overestimation by cases in more distant time periods (Vrijheid et al. 2008a).

Laterality of phone use is also subject to recall error and to differential reporting between cases and controls. Hence reported increases in the risk of some tumour types for ipsilateral use in long-term users that are described below, are currently difficult to interpret. These could reflect a real association (since, as indicated above, RF energy absorption is very localised) or an artefact related to laterality recall bias.

Studies of health effects from environmental sources of RF other than phones

Point sources (broadcasting towers and mobile phone base stations)

Epidemiological studies completed so far have mostly looked at cancer incidence broadcasting towers, using an ecological design. Only two case-control studies have been conducted to date. Ecologic studies are subject to a number of methodological problems, which limit their usefulness for studies of low levels of RF (Cardis and Estève 1991;Goldberg and Cardis 1994). It is difficult to ensure an adequate choice of the geographical areas to be compared: the choice of boundaries of the study regions may exaggerate or diminish the apparent significance of an association. Information on levels of exposure, on confounding factors and population movements is rarely available. In the best of cases, crude estimates of exposure by sub-regions may be available, or sub-regions may be classified as a function of their distance (which may not be a good surrogate for exposure level) from a source of exposure. Because individual exposures are not determined, a causal relationship is not easy to infer and studies are subject to the "ecological fallacy" – the failure of group level data to properly reflect individual level associations – (Greenland and Morgenstern 1989;Piantadosi et al. 1988). In most instances therefore, a "negative" ecological study (i.e. a study in which no increase in risk is observed) cannot be interpreted to mean that no risk exists, and can only provide an upper bound for the risk estimate. A "positive" correlation study, on the other hand, may be difficult to interpret because of potential biases and confounding. Reported clusters (rather than actual epidemiological studies) are even more difficult to interpret as they may suffer a number of methodological limitations (including completeness of case ascertainment and validation of diagnoses) in addition to those of formal ecological studies (Gavin and Catney 2006).

Case-control studies

In Korea, a case-control study of childhood leukaemia and brain cancer (0-14 years) was conducted (Ha et al. 2007) in order to investigate the possible relation with RF exposure from AM radio broadcasting tower, previously reported in an ecological study (Ha et al. 2003;Park et al. 2004). Controls were individually matched to the cases on age and sex and were chosen among patients with a respiratory illness. The study included 1,928 leukaemia cases and 956 brain cancer cases from 14 South Korean hospitals using the South Korean Medical Insurance Data System, and 3,082 controls. A prediction program incorporating a geographic information system was used to estimate total and peak RF exposure at the subjectsô home address from 31 AM radio transmitters with a power of 20 kW or more. An elevated OR was seen for all types of leukaemia combined (OR 2.15, 95% CI 1.00, 4.67) among children who resided within 2 km of the nearest AM radio transmitter as compared with those resided more than 20 km from it. The corresponding OR for lymphocytic leukaemia was 1.69 (95% CI 0.69, 3.72). In analyses by level of RF exposure, no association was found for brain cancer. A significantly increased risk of lymphocytic leukaemia was found in the highest quartile of peak RF exposure (OR 1.40, 95% CI 1.04, 1.88; peak exposure > 0.6 V/m) for lymphocytic, but not for myelocytic leukaemia (Ha et al. 2008). In this corrected analysis, no association was found, however, with total RF exposure, contrary to the results originally published (Ha et al. 2007).

A case-control study was conducted in West Germany to evaluate the possible link between RF from broadcasting towers and the risk of leukaemia in children (0-14 years) (Merzenich et al. 2008). Analyses included 1,959 cases diagnosed between 1984 and 2003, registered in the German Childhood Cancer Registry and living in municipalities near Germanyôs strongest emitting television and radio broadcasting towers. Individual exposure to RF at the subjectsô home address 1 year before diagnosis was estimated with a field strength prediction program. The OR for leukaemia was 1.04 (95% confidence interval: 0.65, 1.67) among children living within 2 km of the nearest broadcast transmitter compared with those living at a distance of 10-<15 km. It was 1.31 (95% CI 0.80, 2.15) when analyses were restricted to lymphoid leukaemia and 1.56 (95% CI 0.77, 3.16) when further restricted to AM transmitters. No association was found, however, between the estimated level of RF exposure and the risk of leukaemia. The OR for leukaemia (all types combined) was 0.86 (95% confidence interval: 0.67, 1.11) when upper (>/=95%/0.701 V/m) and lower (<90%/0.504 V/m) quantiles of the RF distribution were compared. An analysis of AM and FM transmitters separately did not show increased risks of leukaemia. Validation of the field strength prediction programme, show a better correlation of spot measurements with field strength predictions than with distance from the broadcasting towers.

A combined analysis of the lymphocytic leukaemia results from Korea and Germany found no association with total RF exposure (Schuz and Ahlbom 2008). ORs for living within 2 km of broadcasting towers are of similar magnitude in both studies, however.

Ecological studies

In the USA, spatial clustering of childhood cancer around a large microwave tower was studied in the city of San Francisco, over the period 1973-88. The study included 51 leukaemia, 35 brain cancers and 37 lymphatic cancers and found no association between risk of these diseases and distance from the tower (Selvin et al. 1992).

In the USA, a case-control study was conducted to evaluate the etiology of a cluster of childhood acute leukaemia on the Waianae Coast, Hawaii. The study included 12 cases diagnosed between 1979 and 1990 and 48 controls. Children who lived within 4.2km of the radio towers (median distance) had a non-significantly increased risk of leukaemia (OR 2.0, 95% CI 0.06-8.3) (Maskarinec et al. 1994).

A study of cancer incidence and mortality among residents in the ñinnerò (three municipalities close to the towers) and ñouterò areas (six municipalities which were more distant) around the television towers in Northern Sydney (Australia) was carried out (Hocking et al. 1996). An increased incidence and mortality of childhood leukaemia in the inner area was observed. These data were reanalysed by municipality by (McKenzie et al. 1998) after adding other municipalities close to the towers. The excess of childhood leukaemia was restricted to one of the inner area municipalities. When this municipality was excluded, there was no increased incidence and mortality for childhood leukaemia.

A geographical study of cancer incidence was conducted around the Sutton Coldfield television and FM radio transmitter in the West Midlands, England, following a report of a cluster of leukaemias and lymphomas (Dolk et al. 1997b). The risk of adult leukaemia within 2 km was 1.83 (95% confidence interval 1.22-2.74), and there was a significant decline in risk with distance from the transmitter (p = 0.001). These findings appeared to be consistent over the periods 1974-1980, 1981-1986. A further, more comprehensive study, carried out around 20 television and radio transmission towers in the UK, found no increased risk of adult or childhood leukaemia for persons residing within 2 km (O/E ratio=0.97, 95% CI 0.8-1.2, based on 79 cases) or 10 kms of transmitters. A small significant decline in risk of adult leukaemia with distance from transmitters was seen, however, in the 2-10 km range (Dolk et al. 1997a).

In Italy, a study of childhood leukaemia incidence and adult and adolescent leukaemia mortality was conducted around the powerful Vatican Radio broadcast transmitters in a northern suburb of Rome (Michelozzi et al. 2002). The study covered a 10-km area around the transmitter, with a population of around 50,000. Overall, 40 adult and adolescent leukaemia deaths and 8 childhood leukaemia cases were observed in the study area during the study period (1987-1998 for mortality, 1987-1999 for incidence), compared to 37.4 and 6.5 expected, respectively. For childhood leukaemia, a non-significantly increased risk (SIR 6.1, 95% CI 0.4, 27.5) was seen for residence within 2 km of the transmitter, based on one case, as well as a significant trend of increasing SIR with decreasing distance (p=0.036). Among adolescents and adults, two deaths were reported among men living within 2 km of the transmitter (SMR 2.9, 95% CI 0.5, 9.0) and none in women, and there was a trend of increasing SMR with decreasing distance, which was statistically significant only in men (p=0.03). Results of this study are based on very small numbers of cases.

An ecological study of cancer incidence was conducted in South Korea (Ha et al. 2003) in areas close to 42 AM radio transmitters (11 high-power transmitters ï 100-1500 kW ï and 31 low-power transmitters). Incidence rates were calculated for all cancers, leukaemia, malignant lymphoma, brain and breast cancer in 2km-radius areas around each transmitter, as well as in control areas for the period 1993-1996. Slightly increased rates were seen in high-power transmitter areas compared to low transmitter areas, for all of the outcomes studied; they were significantly increased only for all cancers combined (based on 1,636 cases in high-power areas) and for brain cancer in women (based on about 20 cases). In analyses of individual transmission sites, significant increases of total cancer incidence were observed in 9 out of 11 high-power sites, of leukaemia incidence in 2 and of brain cancer in one; there was no evidence for a relation between the incidence ratio and power level of the transmitter. Numbers of cases for individual cancer types were small, however, particularly when considering individual areas.

An ecological study of cancer mortality was also conducted, in 1994-1995, in South Korea (Park et al. 2004) in 10 RF-exposed areas (defined as regions that included AM radio broadcasting towers of over 100 kW), and in 40 control areas. All cancer mortality was found to be significantly higher in the exposed areas (directly standardised mortality rate ratio (MRR) 1.29, 95%CI = 1.12, 1.49). There was no apparent trend in MRR by electrical power level, however. Mortality from virtually all specific types of cancers considered was also increased (although not statistically significantly

so) in the exposed areas compared to the control areas, in men as well as in women, raising the issue of comparability of the populations in the exposed and control areas. In analyses by age at death, leukaemia mortality was found to be significantly elevated in exposed areas among children (MRR 2.29, 95% CI 1.05, 5.98, based on 11 deaths in the exposed areas) and in adolescents and young adults (MRR 2.44, 95% CI 1.07, 5.24 based on 11 deaths in the exposed areas).

A cross-sectional study of randomly selected inhabitants living in urban and rural areas for near to 10 selected base stations was conducted in Austria to evaluate the possible effect of base stations on subjective symptoms and cognitive performance (Hutter et al. 2006). Cognitive tests were performed on 365 subjects, and their wellbeing and sleep quality were assessed. Field strength of high-frequency electromagnetic fields was measured in bedrooms of 336 households, and the maximum exposure from the base station was computed. Significant relations were found for a number of symptoms, particularly headaches, after adjustment for age, sex, region, mobile phone use and fear of adverse health effects of base stations. No clear difference was found in sleep quality or cognitive performance, although a slightly faster reaction in perceptual speed was associated with higher exposure level.

A cross-sectional health study was conducted in Cyprus in two villages near the Akrotiri salt lake site (part of the UK Sovereign Base Areas Administration, containing a military air base and a large antenna array) and in one control village about 15 km away from the site (Preece et al. 2007). The objective was to compare electromagnetic profile and health status of the population in these villages. The population in the villages totalled about 800 and 350 in Akrotiri and Asomatos (the two villages near the site) and 1,000 in the control village. The prevalence of specific symptoms and diseases was investigated using specifically designed questionnaires, a risk perception survey and collection of health and mortality data from available registry and other sources. The questionnaires were distributed to each household, with response rates of 87%, 77% and 92% respectively in Akrotiri, Asomatos and the control village. Spot RF measurements were also made at a number of places in each village using Delta-T multichannel loggers and portable Narda EMR 20C meter. Overall, during military transmissions, the field strengths were higher in the exposed villages than in the control area (average readings 0.5-0.6 V/m versus <0.01 V/m), though the contribution of the frequencies used by the military antennae (17.6 MHz) was only 10-20% (the dominant sources of RF were cell phone and national broadcast systems). The frequency of reported migraine, headache and dizziness was significantly higher in the exposed villages than in the control village (ORs 2.7, 3.7 and 2.7 respectively ï p<0.001 for each), and higher in Akrotiri than in Asomatos, where, despite similar levels of exposure, the antennae visibility and the aircraft noise are less important. No significant difference was seen in relation to pregnancy, child birth, diabetes, asthma, respiratory problems and most infections. The residents of the exposed village generally had a poorer view of their health status than those of the control village; they also had a higher level of perceived risk, particularly in Akrotiri, from noise and electromagnetic ñpollutionò. These differences could account for the higher reported frequency of migraine, headache and dizziness.

Cordless telephones

Cordless phones have been used extensively in homes since the 1980´s, relying on an analogue system emitting in the 800-900 MHz range, since the late 1990´s however, DECT (Digital Enhanced Cordless Technology) phones, relying on a digital system emitting in the 1900 Mhz range have rapidly taken over the market.

The possible association between the use of cordless telephones and brain tumours has been assessed in studies in Sweden and in Germany

Associations between the use of cordless phones (type unspecified) have been reported in the Swedish studies (Hardell et al. 2006b;Hardell et al. 2006a;Hardell et al. 2005c) for malignant brain tumours, acoustic neurinomas and T-cell lymphomas. Risk appeared to increase with latency and amount of use. The German study did not, however, report an association between the risk of glioma or meningioma and the use of DECT telephones (at home or at work) or with location of the DECT base station close to the bed (Schuz et al. 2006a;Schuz et al. 2006b).

Studies of health effects from occupational sources of RF

The relation between cancer risk and occupation involving RF or microwave (MW) radiation exposure as been studied both in cohort and case-control studies. They are summarised in the sections below. Results of the most informative studies are given in Table 1: the studies in which no effort was made to separate RF from lower frequency radiation are not reported here.

All cancers

The most widely publicised study of the potential effects of microwave radiation was the study of 1827 embassy employees (and their dependants) who lived and worked in the United States Embassy in Moscow between 1953 and 1976 (Lilienfeld et al. 1978). Workplace measurements between 1963 and 1975 detected microwave radiation of maximum 0.05 W/m^2 lasting 9 hours per day at frequencies between 0.5 and 10 Ghz. Cancer mortality was compared to that of 2561 employees from other US embassies in East European countries as well as to that of the US population. Results showed no differences in health status between those who worked or lived in the Moscow embassy and the comparison groups (see Table 1 for comparison with US population). The small number of cancer deaths (17 in total, including two leukaemia), however, makes the study non-informative.

A cohort study of over 40,000 US enlisted naval personnel and aviation workers exposed to microwave radiation during the Korean War (1950-1954) was carried out by (Robinette et al. 1980). Approximately half were chosen among personnel with ñlow exposureò (radiomen, radarmen and aviation electricianôs mates) and half with ñhigh exposureò (electronics technicians, fire-control technicians and aviation electronics technicians). Potential exposure to microwave radiation was assessed in terms of environmental measurements, occupational duties, length of time in occupation and power of equipment at the time of exposure for all deaths from disease, homicide or suicide and for a 5% sample of the cohort. Mortality and morbidity data were obtained from military records. No difference in all cause or cancer mortality or morbidity was seen among the high exposure and low exposure groups or among workers categorised by level of potential exposure after a 20 year follow-up (Robinette et al. 1980) and no difference in mortality rates after 40 years of follow-up (Groves et al. 2002).

A large study of 128,000 Polish military career personnel serving at any time during the period 1971-1985 was followed for cancer morbidity over the same time period using data from military hospital records (Szmigielski 1996). Data on exposure of personnel to RF/MW, obtained from measurements of RF/MW field intensities at and around service posts, served to classify personnel as exposed or non-exposed. A significantly elevated SIR was found for the exposed group compared to non-exposed group for all cancers (Table 1). This result is difficult to interpret, however, as the methods are not clearly described and the authors appear to have invested more effort into finding exposures among the cancer cases than among the personnel that had not been diagnosed with cancer, which could lead to bias.

The bias introduced by this kind of procedure will inevitably lead to findings of increased cancer risks, even if no such associations exist; and no weight can be given these studies in an evaluation of the scientific evidence regarding this question

An investigation of cancer mortality in amateur radio operators in Washington State and California was conducted by linking the US Federal Communications Commission Amateur Radio Station and/or Operator licence file (n=67,829) with the death files in those two states for 1979-1984 (Milham S Jr 1988a). A significantly decreased SMR was found for all cancers, based on a very large number of deaths (2 485) (Table 1). No information about levels of RF exposure was available in this study. When the analyses were carried out by license class (which partly reflect number of years of use), SMRôs were also below 1 (Milham S Jr 1988b).

An investigation of cancer among Norwegian female radio and telegraph operators working at sea was conducted by linking the Norwegian Telecom cohort (2 619) with the Cancer Registry of Norway for 1961-91 (Tynes et al. 1996). No information about individual exposures to RF was provided ï the exposed group was defined as the entire cohort. Workplace RF spot measurements were performed in the radio rooms of the ships; exposure levels varied with location; at the operatorôs desks, however, they were below the detection level. A slight non-significant increase in all cancer incidence was observed compared to the general Norwegian population (Table 1).

A retrospective cohort study of cancer incidence among 22,197 male police officers employed in Ontario (Canada) police departments was conducted by linking the police employee records with the Ontario Cancer Registry for 1964-95 (Finkelstein 1998). No information about individual exposures to radar emissions was provided - the exposed group was defined as the entire cohort. No increased incidence was seen for all cancers compared to the general population of Ontario (Table 1).

The mortality of a cohort of Italian plastic-ware workers exposed to radiofrequency (RF)-electromagnetic fields generated by dielectric heat sealers was investigated over the period 1962-92 (Lagorio et al. 1997). Workers were classified into 3 groups based on their job title and period of assignment: RF-sealer operators (302 women and 4 men), other labourers and white collar workers. Only the first group was considered to be exposed to RF and findings of a survey in the mid 1980´s showed that in that period, before procedures were adopted to limit exposures, recommended IRPA-ICNIRP limits of 10 W/m^2 were frequently exceeded. Analyses were restricted to women workers (481 in total) because of the small number of men RF-sealer operators. The SMR for all malignant neoplasms was 2.0 (95% CI 0.7, 4.3, based on 6 deaths). One leukaemia death was observed among RF-sealers, compared to 0.2 expected. The small number of subjects in this study limits the interpretation of these results.

Cancer mortality was studied in the cohort of all US Motorola workers employed between 1976 and 1996 (Morgan et al. 2000). This cohort was of interest because of the relatively high prevalence of RF exposure of the employees who are involved in designing, manufacturing and testing of wireless devices. A job-exposure matrix allowed the categorisation of workers into four groups on the basis of their likely level of RF exposure (background, low, moderate and high, with average score values of 0, 1, 6 and 100 W respectively). The cohort included 195,775 workers who contributed 2.7 million person-years (PYs) of follow-up during the period 1976-1996. For peak exposure, the moderate and high RF exposure categories included 12,911 and 11,710 workers, respectively, and 7.2% and 6.5% of the total PYs of follow-up. (When usual exposure was considered, the numbers were smaller 8,097 and 8,907 workers, respectively, and 4.3 and 4.9% of the total PYs of follow-up).A substantial healthy worker effect was observed in this cohort, though the SMR for all cancer deaths is not given. Numbers of deaths by specific types of cancer were small among the workers classified as moderately or highly exposed based on their peak exposure: 7 CNS deaths, 21 deaths from neoplasm of the lymphatic and haematopoietic system (Table 1).

Brain cancer

Results of brain cancer analyses in relation to occupations involving RF/MW field exposures were also reported in all the cohort studies described above. The number of brain cancer cases in all but three studies (Milham S Jr 1988a;Finkelstein 1998;Groves et al. 2002) was very small (<=10). These studies do not therefore provide information on the risk of brain cancer from RF exposure. In the Milham study, a small, non-significant increased risk was seen (Table 1). When analyses were carried out by licence class, elevated SMRôs were found among general and advanced class license holders (SMR 1.8, based on 11 cases in each group ï confidence interval not given), two groups thought by the authors to be long term users (Milham S Jr 1988b). In the Finkelstein study, police officers had a slightly reduced brain cancer incidence than the general population, although this was not statistically significant. In the Groves study, subjects in the high-exposure stratum also had a non-significantly reduced risk of brain tumours.

Brain cancer in relation to occupations involving RF/MW field exposures was also studied in two case-control studies (Grayson 1996;Thomas et al. 1987). (Grayson and Lyons 1996) carried out a case-control study nested within a cohort of male air force workers. The study included 230 cases and 920 controls matched on year of birth and race. A complete lifetime occupational history was obtained by questionnaire. A job title-time exposure matrix utilising potential intensity scores was used to estimate potential exposure to RF/MW fields. Results showed a small excess risk of brain tumours for workers ever exposed to RF/MW fields after adjustment for age, race and military rank based on 94 exposed cases (Table 1); no association was seen between level of exposure and brain cancer risk, however.

A case-control study of brain and CNS tumours was carried out in three states in the US (Thomas et al. 1987). The study included 435 cases and 386 controls, matched on age and year of death and area of residence. Lifetime occupational histories were obtained from interviews and occupations were classified with respect to MW/RF radiation by industrial hygienists. The relative risk for all brain tumours, adjusted for education level, was elevated among men ever exposed to MW/RF radiation, based on 69 exposed cases and was significantly elevated among men exposed for 20 or more years. The excess risk for MW/RF radiation-exposed was restricted to workers with electrical or electronic jobs, however, while no excess was seen for other MW/RF exposed workers. It is noted that an excess was also seen for workers who had electrical or electronic jobs not involving MW/RF exposure. It is thus unlikely that the observed increased risk among MW/RF exposed workers is related to the MW/RF exposure.

The effects of occupational exposure to radiofrequency EMF on brain tumours were assessed in the German Interphone study (Berg et al. 2006). Information from the core INTERPHONE questionnaire (which included information on the subjectôs occupational history and history of working with selected sources of exposure to ELF and RF) was used to classify subjectôs degree and likelihood of occupational exposure to RF, based on a review of the literature and on the opinion of industrial hygienists. The study included 381 meningioma and 366 glioma cases with 1494 controls (Berg et al. 2006). No significant association between occupational exposure to RF and risk of brain tumours was found. For glioma, the OR for highly exposed subjects (22 cases and 37 controls) was 1.22 (95% CI 0.69, 2.15), it was 1.39 (95% CI 0.67, 2.88 ï 13 cases and 20 controls) when restricted to high exposure for 10 years or more. For meningioma, the corresponding ORs were 1.34 (95% CI 0.61, 2.96 ï 11 cases and 17 controls ï for high exposure) and 1.55 (0.52, 4.62 ï 6 cases and 8 controls ï for high exposures for 10 years or more). These results are based on small numbers of subjects and need to be verified in further studies with higher sample size.

The possible relation between RF exposure and glioma was evaluated in the framework of a case-control study in Australia (Karipidis et al. 2007). The study included 416 cases of glioma

diagnosed between 1987 and 1991 in Melbourne and 422 controls matched by age, sex and postcode of residence. A detailed occupational history was obtained for each subject. Exposure to RF was assessed using a Finnish job exposure matrix (FINJEM), self-reports and expert hygienist review. 18 cases and 17 controls were classified as having been exposed to RF. No association was found between RF and risk of glioma (ORs respectively: 0.57 95%CI 0.16, 1.96; 1.80 95% CI 0.53, 6.13; and 0.89 95% CI 0.28, 2.81 in the lowest, middle and highest tertiles of exposures). Numbers of exposed subjects were small however in each of these exposure categories, with only 6 cases and 6 controls in the highest tertile of exposure (>52 W/m^2 years).

Lymphatic and haematopoietic cancers

Lymphatic and haematopoietic cancers (including leukaemia) were also analysed in relation to occupations involving RF/MW field exposures was also studied in the cohort studies described above. The number of cases in the Lilienfield and Tynes studies was very small (n=2) ï these studies do not therefore provide information on the risk of these tumours from RF exposure.

In the Milham study, a small, non-significant increased risk for leukaemia and for all lymphatic and haematopoietic cancers was seen (Table 1); the increase was significant for acute myeloid leukaemia (SMR 1.8, 95% CI 1.0-2.9, based on 15 cases); a non-significant increase was also seen for acute unspecified leukaemia. When analyses were carried out by licence class, elevated SMRôs were found among general (SMR 1.2, based on 26 cases ï confidence interval not given), and technician (SMR 1.6, based on 18 cases) class license holders, two groups thought by the authors to be long term users (Milham S Jr 1988a).

In the Szmigielski study, there was a large significant increased incidence of lymphatic and haematopoietic cancers was seen for military workers who worked in areas with high levels of pulse-modulated RF/MW radiation (Table 1). Among these malignancies, the increase was largest for chronic myelocytic leukaemia (SIR=13.9), acute myeloblastic leukaemia (SIR=8.6) and non-Hodgkin lymphomas (SIR=5.8) (Milham S Jr 1988a). As described above for all cancers, these results are difficult to interpret because of the unclear methodology used in this study.

In the second follow-up of Korean War Navy technicians (Groves et al. 2002), significantly elevated RRs were seen for leukaemia as a whole (Table 1) as well as for non-lymphocytic leukaemia (RR 1.82, 95% CI 1.05, 3.14 based on 20 deaths). Non-significantly increased RRs were also seen for ac. The risk was greatest (though not statistically significant) for acute non-lymphocytic leukaemia (RR 1.87, 95% CI 0.98, 3.58) and non significant increases were also seen for acute and chronic myeloid leukaemia (RR respectively 1.81 and 1.55 based on 11 and 5 cases respectively. In the Finkelstein study a non-significant reduction in risk of leukaemia was observed among police officers.

The study of US Motorola workers included 21 deaths from neoplasms of the lymphatic and haematopoietic system in workers classified on the basis of their peak exposure as moderately or highly exposed (10 in the highly exposed), 11 from leukaemia, 6 from NHL and 3 from HD (Morgan et al. 2000). No increased risk of these neoplasms was seen in comparison with workers with no exposure. The small numbers of cases limits, however, the exposure response analyses that can be done and their interpretation.

Other tumour types

Increases in risk of other specific tumours types (colorectal, breast, testicular, oesophageal/stomach) were also reported, but only in single studies (Table 1). Considering the number of tumour types examined in these studies, some of the significant results observed may have been due to chance.

Fertility and adverse pregnancy outcomes

Two studies of physiotherapists have been carried out to investigate the relationship between use of specialised equipment during pregnancy and the risk of adverse pregnancy outcomes.

In one study, members of the American Physical Therapy Association (n=42,403) were queried by mail as to pregnancy history and the use of microwave or radio frequency diathermy. (Ouellet-Hellstrom and Stewart 1993). A total of 1,753 reported miscarriages were compared to the same number of ñcontrolò pregnancies (any non-ectopic pregnancy, regardless of outcome). Women who reported use of microwave diathermy in the 6 months prior to conception and the first trimester of pregnancy were at increased risk of miscarriage (RR 1.28, 95% CI: 1.0-1.6). The risk increased with numbers of use of the equipment per month. It is noted that the information about miscarriage and exposure was self-reported, which may introduce a bias in the results.

A cohort study of delivery outcomes of 2,043 infants born to 2,018 physiotherapists in Sweden was conducted by linking the Medical Birth Register with the file of registered physiotherapists (Kallen et al. 1982). All 37 cases of major malformations and perinatal deaths were matched to two controls for maternal age, parity and time of delivery (n=74). Information on occupational exposures (including equipment used during pregnancy) was obtained from mothers by mail questionnaire. None of the mothers of cases used microwave equipment during pregnancy.

A cross-sectional study of employees of the Norwegian Navy (civilians and military, on ships and ashore) was conducted in 2002 through the use of a mail questionnaire (Mageroy et al. 2006). The overall response rate ws 58% (2,265 out of 3,878). Service aboard a missile torpedo boat, with HF, VHF and UHF transmitters in radars was associated with an increased prevalence ratio of congenital malformations (PR 4.0, 95% CI 1.9, 8.6) and still born and perinatal deaths (PR 4.1, 95% CI 1.7, 8.9) in offspring. These results are based on very small numbers ï 8 cases of congenital anomalies and 6 of stillbirths and deaths within 1 week of birth among the offspring of persons who had served on this boat. Further analyses restricted to military men who had completed their compulsory military service showed an increased risk of infertility among telecommunication (OR 1.72, 95% CI 1.04, 4.09) and radar/sonar (OR 1.18, 95%CI 1.27, 4.09) workers(Møllerløkken and Moen 2008).

A record linkage study was conducted in Norway to assess potential associations between paternal occupational exposure to RF and adverse pregnancy outcomes including birth defects (Mjøen et al. 2006). Information on occupation was obtained from census and an expert panel constructed an exposure classification (possible and probable exposure) based on job title. Data on reproductive outcomes was derived from the Medical Birth Registry of Norway. Among the 1.1 million births recorded in the period 1976-1995, information on paternal identity and occupation was available only for about 49%. No increased risks of congenital malformations as a group were observed. In the offspring of fathers most likely to have been exposed, an increased risk was observed for preterm birth (OR 1.08 95% CI 1.03, 1.15) and a decreased risk for cleft lip (OR 0.63 95% CI 0.41, 0.97). In the medium exposed group, an increased risk was observed for a category of ñother defectsò (OR 2.40 95% CI 1.22, 4.70), and a decreased risk for a category of ñother syndromesò (OR 0.75, 95% CI 0.56, 0.99) and upper gastrointestinal defects (OR 0.61, 95% CI 0.40, 0.93).

Heart disease

A cross-sectional survey of 5,187 male physiotherapists was carried out using a mailed questionnaire on personal health history, including use of diathermy (Hamburger et al. 1983). The prevalence of a number of health conditions was compared among groups classified into high and low exposure categories ï based on length of employment and frequency of treatment ï for exposure to various types of diathermy modalities (ultrasound, microwave, short-wave, infrared).

A significant association was seen between heart disease and frequent use of microwave (OR 2.5, 95% CI:1.1-5.8) diathermy. The response rate in the study was low (58%) however and information about health condition and exposure was self-reported, which may introduce a bias in the results.

Other

A questionnaire survey of subjective symptoms and health status was conducted in Sweden among RF plastic sealer operators (Wilen et al. 2004). The study included 35 sealers and 37 controls. A neurophysiological examination and 24 hour ECG were also conducted. Measurements showed that the RF operators were exposed to rather high electric and magnetic fields. RF sealers appeared to have a lower heard rate and more episodes of bradicardia than controls, to have a higher prevalence of fatigue, headaches and warmth sensation in the hands and a slightly disturbed discrimination ability compared to the control group. Numbers of subjects in this study are small and it is not clear from the methods how the controls were chosen and whether they might differ with respect to age, sex or other variables of importance for the endpoints studied.

Studies of health effects from mobile phones

Descriptive epidemiological studies

A number of descriptive studies have been conducted to assess the potential impact of mobile phone use on the risk of tumours either through analyses of time trends of brain and other types of tumours - see for example (Cook et al. 2003;Lahkola et al. 2007;Lonn et al. 2004b;Klaeboe et al. 2005;Roosli et al. 2007) or through analyses of distribution of laterality of tumours. While these studies did not identify any increases that could be correlated with increases in mobile phone use in these countries, such ecological analyses are limited in their ability to reveal potentially small increases in risk for diseases with a long latency period.

Cohort studies

Up to now, two cohort studies of mobile telephone studies have been conducted, one in the US and one in Denmark.

In the USA a large cohort study of over 250,000 portable and mobile telephone subscribers was undertaken to investigate all cause mortality for users of the two types of phones. After one year of follow-up, in 1994, no difference in overall mortality among these two groups (RR=0.86 90%C.I: 0.5-1.5 for portable vs. mobile phone users) (Rothman et al. 1996). The cohort was extended to include a second mobile phone operator (resulting cohort size 285,561 subjects) and information was obtained ï for non-corporate users ï concerning start of service date, number of minutes billed and numbers of calls made and received during 2 months in 1993. For legal reasons, the follow-up could not be prolonged and the length of follow-up for this cohort study is restricted to one year, yielding 95 deaths from cancer, including 2 from brain tumours and 4 from leukaemia among mobile phone users. This cohort therefore provides no information on risk of cancers related to RF radiation from mobile telephones.(Dreyer et al. 1999).

A similar study was conducted in Denmark, where a nationwide cohort was set-up including 420,095 persons with a first cellular non-corporate telephone subscription between 1982 and 1995 (Johansen et al. 2001). This cohort was followed-up for cancer morbidity through 2002 (Schuz et al. 2006c). Significant deficits were observed in the incidence of cancer in general (SIR = 0.95; 95% CI 0.93, 0.97, based on a total of 14,249 cancers), of smoking related cancers (SIR 0.88, 95% CI 0.86, 0.91 ï 3,758 cases) and of a number of other cancer types in men, compared to the

general population, suggesting that the population of mobile phone subscribers may have a healthier lifestyle than the general population in Denmark, and hence that the SIRs in this study may be underestimated. For brain tumours, an SIR of 0.97 was observed overall, based on 580 cases; when analyses were restricted to subjects who had subscriptions for 10 years or more, the SIR was significantly reduced (OR 0.66, 95% CI 0.44, 0.95), based on only 28 cases. The SIRs for acoustic neuromas (0.73), salivary gland tumours (0.77) and eye tumours (0.96) were not elevated; they are based on small numbers (32, 26 and 44 cases respectively) and no analyses are presented for long-term subscribers. There was also no increased risk of leukaemia (SIR 1.00, based on 341 cases). The use of information on subscriptions obtained from operators rather than from the study subjects, as is the case in most of the case-control studies described below, has the advantage of not being subject to recall bias. It does, however, carry other problems of its own. In particular, it happens fairly frequently that the subscriber is not the primary user of the phone, in particularly in a family. Further, no information is available on the actual amount of use of the phone and the fact of having had a subscription 10 years in the past does not necessarily mean the subject has used the phone for that long. Also, the cohort does not include persons with corporate subscriptions (who may in fact, particularly in early years, have been heavier users than those with personal subscriptions) or subjects who started their first subscription after 1995. As these subjects are included in the general population (i.e. the comparison population), SIRs in this study are likely underestimated. It is therefore difficult to draw conclusions from this study on the possible association between mobile phone use and the risk of cancer.

Case-control studies

The vast majority of studies of cancer risk in relation to the use of mobile telephones used a case-control rather than a cohort study design, focusing generally on tumours that arise in some of the tissues that absorb most of the RF energy during phone conversations, the CNS (glioma, meningioma and acoustic neurinoma) and the parotid gland.

All of the studies published to date, except the earliest studies (Inskip et al. 2001;Muscat et al. 2000;Muscat et al. 2002;Auvinen et al. 2002), have either been conducted either within the framework of the international collaborative INTERPHONE study (Cardis et al. 2007) or by the group of Hardell and collaborators in Sweden (Hardell et al. 2005b;Hardell et al. 2005a). The study designs are therefore summarised briefly here in order to avoid repetition in the individual subsections below.

Study design

Swedish Hardell studies

The studies by Hardell and collaborators included both men and women aged 20-80 at the time of diagnosis and living (unless otherwise specified in the sections below for specific tumour types) in the medical administrative areas of Stockholm, Uppsala/Örebro, Linköping and Gothenburg in Sweden.

Cases were identified from the regional cancer registries and had to have a histopathology record. An additional eligibility criterion compared to most other studies is that the case had to be still alive at the date of start of the study. One control was extracted from the Swedish Population Registry for each case and was matched for sex, age (in 5-year age groups) and geographical area. Information on mobile and cordless telephone use was collected through a mail questionnaire sent to both cases and controls, at least 6 months after the diagnosis for cases.

Questions were included about the type of phone, years of use and brand name, prefix of phone number (to identify analogue and digital phones) and, for each type of phone, mean number and length of daily calls, use of hands-free devices and side of the head on which the phone was generally used. Calculations of mobile phone variables (number of years of use, cumulative hours of use) did not include phone use in the year preceding the diagnosis for cases (and the same year for matched controls).

INTERPHONE studies

The national INTERPHONE studies were all based on a common core protocol (Cardis et al. 2007). INTERPHONE was set-up as a multinational caseï control study, to investigate whether mobile phone use increases the risk of cancer and, more specifically, whether the RF fields emitted by mobile phones are carcinogenic. The study focused on tumours arising in the tissues most exposed to RF fields from mobile phones: glioma, meningioma, acoustic neurinoma and parotid gland tumours.

Sixteen study centres in thirteen countries (Australia, Canada ï centres: Montreal, Ottawa, Vancouver ï, Denmark, Finland, France, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden, and the UKï centres: North and South) participated in INTERPHONE.

Study population

In Australia, Canada, France, Germany, Italy, Japan and New Zealand, the source population was restricted to major metropolitan areas where mobile phones were first introduced. Major treatment centres for the diseases of interest are concentrated in these areas and most of the population is unlikely to go out of the region for diagnosis and treatment. In Denmark, Finland, Israel, Norway and Sweden the study was largely nationwide. The UK-South study was restricted to the South East of England, urban and rural, and the UK-North study encompassed both urban areas and sparsely populated rural areas.

All residents in the study regions (men and women), aged 30 to 59 were eligible for the study; additional eligibility criteria, such as citizenship and proficiency in the local language were imposed in some study centres. The choice of age range aimed to maximise the likelihood of exposure. Mobile phone use is a relatively new phenomenon. Until the late 1990ôs, for economic and social reasons, mobile phone use was mainly restricted to people in the age range most likely to use the phones for business purposes (Cardis and Kilkenny 1999). In some instances, however, individual countries chose to widen the age range for the cases.

Case definition and ascertainment

Eligible cases were all residents of the study region diagnosed during the study period with a confirmed first primary glioma, meningioma, or acoustic neurinoma. Eight centres (Australia; Canada-Montreal, -Ottawa and -Vancouver; Denmark; Israel; Italy; Sweden) also included malignant parotid gland tumours. Because benign parotid gland tumours may be treated in a very large number of institutions, most centres found it logistically difficult to ensure complete ascertainment, and only Canada-Ottawa, Israel and Sweden included them. All diagnoses were either histologically confirmed or based on unequivocal diagnostic imaging.

Each centre established procedures for the rapid ascertainment of cases from participating diagnostic and treatment units, which was particularly important for glioma patients, whose health can deteriorate quickly. Close monitoring of case ascertainment was essential and study centres used secondary sources to improve ascertainment levels. Secondary sources included medical archives, hospital discharge and billing files, and hospital or regional cancer registries. Enrolment

of cases through secondary sources often implied longer delays in case ascertainment and consequently lower participation.

Control eligibility and selection

Controls were randomly selected from the source population. The sampling frame depended on the local situation. The study design called for controls to be individual- or frequency-matched to cases, with the number of controls varying according to the tumour type: 1 control per case for brain tumours; 2 for acoustic neurinoma; and 3 for parotid gland tumours. In Germany, two controls were selected for each brain tumour case. In Denmark controls found to have had any previous cancer (excluding non-melanocytic skin cancer) were excluded. Controls were matched at least on year of birth (within 5-year categories), sex and study region. In Israel controls were also matched on country of birth.

Controls were individually matched to cases in seven study centres (Canada-Ottawa, -Vancouver, France, Israel, Japan, New Zealand and UK-North). In the other centres, individual matching was conducted *post hoc*, with cases being assigned one or more controls (depending on the type of tumour), chosen to have been interviewed as close as possible in time to the case, from among those who fit the matching criteria.

Collection of information on individual study subjects

Whenever possible, consenting subjects were interviewed face-to-face by trained interviewers using a computer-assisted personal interview (CAPI) questionnaire. Only Finland used a paper version of the questionnaire. In situations where cases were quite ill or confused, a spouse or partner or other family member could assist in the interview. In exceptional cases, telephone interviews were conducted with difficult-to-reach subjects. When the study subject had died or was too ill to participate, a proxy respondent was interviewed where this was possible and permitted by ethics committees.

The study questionnaire covered demographic factors, mobile phone use (detailed below), use of other wireless communication devices including cordless DECT telephones, occupational exposures to EMF and other potential confounders or risk factors for the diseases of interest (including exposure to ionising radiation, smoking and the subjectôs personal and familial medical history). Specific questions on exposure to loud noise and hearing loss were asked of acoustic neurinoma cases and their controls (and of all controls in centres using frequency matching for all tumour types combined).

The questionnaire contained a detailed section on history of mobile phone use. These questions were asked only of regular mobile phone users (defined as those with an average of at least one call per week for a period of 6 months or more). A compendium of show cards of mobile phones, including pictures of hundreds of models, was compiled and updated during the course of the study to assist study subjects in recognising the phones they had used.

For each phone used, detailed questions were asked about the phone model, the operator, the initial pattern of use of the phone (including network operator and average number and duration of calls) and any subsequent changes in use. Questions were also asked about the proportion of time in which the phones were used in urban, suburban or rural settings, while stationary or moving in a vehicle, how often the antenna was extended, and whether headsets or hands-free kits were used. The side of the head on which the phone was usually held (i.e. the laterality of phone use) and the handedness (left or right-handed) of the subject were recorded.

Attained level of education was used as a proxy for SES. As education systems and attained levels do not have a direct correspondence from one country to another, country-specific options for

responses were used. Marital status and, where appropriate, education level of the spouse were also recorded.

Detailed diagnostic information was obtained from medical records for all cases interviewed and for non-interviewed cases in most study centres. This information included anatomical location and side of the tumour, its histopathology, including whether benign, malignant or of uncertain behaviour.

Since intracranial RF-energy deposition from mobile phones is non-uniform, with most of the energy absorbed in the vicinity of the phone, the probable location of the origin of the brain tumours was identified as precisely as possible so that the RF ñexposureò at that location could be evaluated. Neuro-radiologists in each centre reviewed the radiological images (MRI and CT scans) or records and recorded tumour location on a generic 3-dimensional grid map of the human head, made up of cubes 1 cm^3 in size, which was developed for the purpose. The cuts used in the grid correspond to the most commonly used acquisition planes in MRI and CT scans (sagittal, coronal and axial). The details of this methodology will be published separately.

Methodological studies

A number of methodological papers have been published or are in preparation (Vrijheid, Deltour et al, 2006; Vrijheid, Cardis et al, 2006; Cardis, Richardson et al, 2007; Berg et al, 2005; Hepworth et al, 2006; Parslow et al, 2003; Samkange-Zeeb et al, 2004; Lakhola et al, 2005; Cardis et al, 2008; Vrijheid et al 2008; Tokola et al, 2008; Vrijheid et al, accepted), addressing issues of study design, participation bias, recall error and exposure assessment that are essential in the interpretation of results from the study:

Validation studies were conducted to evaluate potential error in the recall of phone, indicating that of phone use was subject to moderate systematic and substantial random error (Vrijheid et al. 2007;Vrijheid et al. 2008a). Errors appeared to be larger for duration of calls than for number of calls, and phone use was under-estimated by light users and over-estimated by heavy users. Comparison of a sample of cases and controls in three countries showed little evidence for differential recall errors overall or in recent time periods, but apparent overestimation by cases in more distant time (Vrijheid et al. 2008a).

The possible effects of recall errors were evaluated using Monteï Carlo computer simulations. Results suggest that random recall errors can lead to a large underestimation in the risk of brain cancer associated with mobile phone use. The large random errors seen in the validation study were found to have larger impact than plausible systematic errors. Differential errors in recall had very little additional impact in the presence of large random errors (Vrijheid et al, 2006). However, the apparent overestimation by cases in more distant time periods could cause positive bias in estimates of disease risk associated with mobile phone use (Vrijheid et al, 2008).

Participation rates varied by tumour type and between cases and controls (Table 2). The overall participation was 65% for glioma cases, 78% for meningioma, 82% for acoustic neurinoma and 54% among controls and showed large variation across centres,. Among glioma cases, the major reason for non-participation was death or ill health; in controls it was refusal (65% of non-participants) and inability to contact (27%). The potential for selection bias was therefore evaluated, using information from non-response questionnaires completed by a sub-set of non-participants. This study suggests that refusal to participate is related to less prevalent use of mobile phones. This could result in a downward bias of 10 to 20%, depending on the scenario used, in odds ratios for regular mobile phone use (Vrijheid et al. 2008b).

Because exposure to RF from phones is localized, if a risk exists it is likely to be greatest for tumours in regions with greatest energy absorption. The spatial distribution of RF energy in the

brain was characterised, using results of measurements made on over 100 phones used in different countries. Most (97ï 99% depending on frequency) appears to be absorbed in the brain hemisphere on the side where the phone is used, mainly in the temporal lobe. The average relative SAR is highest in the temporal lobe and the cerebellum and decreases very rapidly with increasing depth, particularly at higher frequencies. Analyses of risk by location of tumour are therefore essential for the interpretation of results studies of brain tumours in relation to mobile phone use (Cardis et al. 2008;Varsier et al. 2008)

Assessment of exposure from mobile phones

The study used two main approaches to characterising exposure from use of mobile phones. The first depended only on the mobile phone use history derived from questionnaire responses and the second attempted to evaluate the amount of RF energy absorbed in different areas of the brain.

In both approaches, exposure was calculated up to a given reference date, which was set to one year before the date of the diagnosis of the case in each matched set. Evaluation of RF energy absorption required the localisation of the tumour, which was defined crudely in terms of the side of the head, or lobe of the brain, or more precisely, from the exact location of the tumour ascertained and recorded as described above. Exposure for controls was estimated at the location of the tumour of their matched case.

As described above, the responses to the CAPI questionnaire provided detailed information on historical patterns of mobile phone use for regular users. This information allowed the computation of relevant indices of exposure such as cumulative call time, average call duration and cumulative number of calls, overall and within specific time-windows, with and without use of hands free devices.

The distribution of RF energy absorption in the head varies according to a number of factors, including the type of telephone and network (frequency and type of transmission: digital or analogue, continuous or discontinuous, use of power control), as well as the actual patterns of use of the phone described above. There was no existing algorithm or set of coefficients that could be used to estimate exposure given a specific pattern of mobile phone use. A model was therefore developed and validated for such an algorithm, assessing the relative importance of the different factors and testing the adequacy of the proposed approach. The algorithm combines questionnaire responses with information on tumour location, the distribution of the specific absorption rate (SAR) of RF in the head (Cardis et al. 2008) and factors that modify the amount of RF energy emitted by the phone (Vrijheid et al, submitted).

Tumour risk

Brain and CNS tumours

All brain tumours

Auvinen and collaborators conducted a registry based case-control study of brain tumours and salivary gland cancers among cellular phone users in Finland (Auvinen et al. 2002). The study included all 398 brain tumour cases and 34 salivary gland cancers diagnosed in patients aged 20 to 69 years in Finland in 1996 and registered in the Finnish Cancer Registry. For each case, five age and sex matched controls were selected from the Population Registry. Record linkage allowed the collection of information (type of subscription ï analogue vs. digital ï and start and end date of subscription) from the two network operators that were operating in 1996 for cases and controls who had private mobile phone subscriptions. Use of 450 MHz analogue phones was excluded. The

proportion of mobile phone subscribers was low: 40 (10%) of the 398 brain tumour cases had had an analogue subscription (only 17 for more than 2 years) and 16 (3%) a digital subscription (1 for more than 2 years). The corresponding figures among controls were 134 (7%) and 89 (4%) respectively for analogue and digital subscriptions. The OR for ever having had a mobile phone subscription was 1.3 (95% CI 0.9, 1.8) overall ï 1.6 (95% CI 1.1, 2.3) for analogue only.

A case-control study of brain cancer was conducted in 5 US academic medical centres, in New York, Providence Rhode-Island and Boston, between 1994 and 1998 (Muscat et al. 2000). The study included 469 cases aged 18 to 80 years and 422 matched hospital controls (chosen among inpatients of the same hospital admitted for benign conditions or for cancers excluding leukaemia and lymphoma). An active mechanism was set-up to identify cases rapidly and interview them as soon as possible after their diagnosis. Information was collected using a structure questionnaire that included questions, for each type of mobile phone used (handled, bag, car), about subscriptions, number of years of use, minutes/hours of use per month, year of first use, manufacturer and average monthly bill. Information was also collected about the hand used to hold the telephone. Of 571 eligible cases approached, 469 (82%) were successfully interviewed. Among controls, the response rate was 90%. Use of mobile phones among the study subjects was still at the time of the study a rare phenomenon: 66 cases (14%) and 76 controls (18%) reported using them (OR 0.85, 95% CI 0.6, 1.2). The OR was below one for all histological categories or brain cancer except for neuroepitheliomatous cancers (OR 2.1, 95% CI 0.9, 4.7, based on 35 cases and 14 controls). The mean duration of use was less than 3 years in both cases and controls, and only 17 cases and 22 controls had used phones for 4 years or more.

A case-control study was also conducted in hospitals in Boston, Phoenix (Arizona) and Pittsburgh in the US (Inskip et al. 2001). The study included 782 cases (489 glioma, 197 meningioma and 96 acoustic neurinoma) diagnosed between 1994 and 1998 and 799 matched hospital controls with non-malignant conditions. Participation rate was 92% among cases and 86% among controls. A rapid ascertainment mechanism was set-up to identify the cases rapidly after their diagnosis and most (80%) were enrolled and interviewed within 3 weeks after their diagnosis. Again, in this study, use of mobile phones was a relatively recent phenomenon: 232 cases (29%) reported having used a mobile phone at least 5 times, 139 reported regular use and 22 had used one for 5 years or more. The OR for regular use was 0.8 (95% CI 0.6, 1.1).

Glioma

Within the above mentioned registry based case-control study in Finland (Auvinen et al. 2002), analyses were also conducted for glioma specifically, based on 198 cases and their matched controls. Again, the proportion of subscribers was small: 26 out of 198 among the cases had analogue subscriptions, only 11 for more than 2 years and only 10 had digital subscriptions, none for more than 2 years. The OR for every having had a mobile phone subscription was 1.5 (95% CI 1.0, 2.4) overall; it was 2.1 (95% CI 1.4, 3.4) for analogue only and 1.0 (95% CI 0.5, 2.0) for digital only. A slight increasing trend was seen with increasing duration of analogue subscription in continuous analyses (OR 1.2 per year ï 95% CI 1.1, 1.5).

Within their case-control study described above, Inskip and collaborators considered specifically the risk of glioma (Table 3) (Inskip et al. 2001). The study included 489 cases of glioma, 85 of which reported regular use of mobile phones (OR 0.8, 95% CI 0.6, 1.2). Only 11 cases had used phones for 5 years or more.

Hardell and collaborators have conducted three case-control studies of malignant brain tumours, mainly glioma, in Sweden (Hardell et al. 1999;Hardell et al. 2002;Hardell et al. 2005b). They have conducted pooled analyses of the results from the later two studies (Hardell et al. 2006a), and only these are shown here as they are the most comprehensive. The combined analyses included

malignant tumours diagnosed between 1997 and 2003 in the regions of Sweden mentioned above (see section on study design above).The analyses included 905 cases and 2,162 controls, respectively 90% and 89% of the cases and controls who were considered eligible for the study. As noted above, unlike most other studies, cases who had died were not considered to be eligible in this study. Results are presented separately for analogue and digital phones and for all malignant tumours, high-grade astrocytoma and low-grade astrocytoma (Table 3). Overall, 178 cases were classified as having used analogue phones and 402 digital phones. The respective ORs were 1.5 (95% CI 1.1, 1.9) and 1.3 (1.1, 1.6) for analogue and digital phones respectively. The ORs appeared to increase with increasing latency ï OR 2.4 (95% CI 1.6, 3.4) and 2.8 (95% CI 1.4, 5.7) for use 10 years or more in the past for analogue and digital phones respectively. The ORs appeared to be higher for high-grade than for low-grade astrocytoma (Table 3). The ORs were also higher for ipsilateral than for contralateral phone use, although an elevated OR was also seen for contralateral use for analogue phones in high-grade astrocytoma patients. For digital phones, the OR for regular use related to having started using mobile phones before the age of 20 appeared to be higher (3.7, 95% CI 1.5, 9.1, based on 16 cases) than for start at later ages. It should be noted that comparisons of results across the three studies show a trend of increasing ORs with time, with statistically significant heterogeneity between studies (Feychting, personal communication 2008). This may in part be related to the fact that the most recent study includes a higher proportion of long term and heavy users than the earlier studies; other methodological differences in the conduct or analysis of the studies may also contribute to this and hence results should be interpreted with caution.

Within INTERPHONE; results have been published of national analyses in Denmark, France, Germany, Japan, Norway, Sweden and the UK, as well as joint analyses of data from Nordic countries and UK-South ((Christensen et al. 2005;Hepworth et al. 2006;Hours et al. 2007a;Klaeboe et al. 2007;Lahkola et al. 2007;Lonn et al. 2005;Schuz et al. 2006a;Takebayashi et al. 2008). Study characteristics and results are summarised in Table 3.

In most studies, the OR related to ever having been a regular mobile phone user was below 1 (Table 3), in some instances statistically significantly so, possibly reflecting participation bias or other methodological limitations.

In analyses by level of use, results by duration of use and time since start of use vary across studies (Table 3). Confidence intervals are wide however, due to the small number of long-term users in individual studies and results are therefore compatible. Pooling of data from Nordic countries and part of the UK yielded the largest number of long term users (143) (Lahkola et al. 2007). Among these, based on 77 cases, a significantly increased risk of glioma was found for reported use of mobile phones for 10 years or more on the side of the head where the tumour developed (OR 1.39, 95% CI 1.01, 1.92). This finding could reflect either a causal association (as the vast majority of the RF energy is absorbed on the side of the head where the phone is held ï see Methodological Issues section above) or an artefact, related to differential recall between cases and controls.

Results of analyses by level of use (total number of calls, total duration of calls) are difficult to compare and to summarise in a tabular form, as most studies have used different cut points. The most comprehensive information comes from the pooling of data from the Nordic and South-UK INTERPHONE studies (Lahkola et al. 2007). Although all of the ORs by level of use, by number of calls and duration of calls are below 1 (Table 4), it is of interest that the magnitude of the ORs appears to increase with increasing amount of use. This increase is in fact statistically significant for number of calls in analyses in which light users are used as the reference group instead of non-users (this type of analysis is conducted to evaluate the possible impact of a selection bias that could be related to use of mobile phones in the study).

In the Japanese INTERPHONE study (Takebayashi et al. 2008), efforts were made to evaluate the maximum amount of RF energy absorbed at the location of the tumour; such analyses, gave an OR of 1.55 (95% CI 0.57, 4.19) related to the highest quartile of cumulative phone time weighted by maxSAR, based on 15 exposed cases; the OR was 5.84 (95% CI 0.96, 35.60) for subjects with cumulative maxSAR-hours of 10 or more W kg^{-1} ï hour; this result, based on few subjects (7 cases and 4 controls) needs to be investigated further.

Meningioma

Within the above mentioned registry based case-control study in Finland (Auvinen et al. 2002), analyses were also conducted for meningioma specifically, based on 129 cases and their matched controls. The number of subscribers was very small: 8 out of 129 among the cases had analogue subscriptions, only 2 for more than 2 years and only 3 had digital subscriptions, none for more than 2 years. The OR for every having had a mobile phone subscription was 1.1 (95% CI 0.5, 2.4) overall; it was 1.5 (95% CI 0.6, 3.5) for analogue only and 0.7 (95% CI 0.2, 2.6) for digital only (Table 5).

Within their case-control study described above, Inskip and collaborators considered specifically the risk of meningioma (Table 4) (Inskip et al. 2001). The study included 197 cases of glioma, 32 of which reported regular use of mobile phones (OR 0.8, 95% CI 0.4, 1.3). Only 6 cases had used phones for 5 years or more (Table 5).

As indicated above, Hardell and collaborators have conducted three case-control studies of benign brain tumours in Sweden (Hardell et al. 1999;Hardell et al. 2002;Hardell et al. 2005a). They have conducted pooled analyses of the results from the later two studies (Hardell et al. 2006b), and only these are shown here as they are the most comprehensive. The combined analyses included 916 meningioma diagnosed between 1997 and 2003 in the regions of Sweden mentioned above (see section on study design above) and 2,162 controls. Results are presented separately for analogue and digital phones (Table 5). Overall, 113 cases were classified as having used analogue phones and 295 digital phones. The respective ORs were 1.3 (95% CI 0.99, 1.7) and 1.1 (0.9, 1.3) for analogue and digital phones respectively. The ORs were slightly higher when use 10 years or more in the past was considered ï OR 1.6 (95% CI 1.02, 2.5) and 1.3 (95% CI 0.5, 3.2) respectively for analogue and digital phones. The ORs were also slightly higher for ipsilateral than for contralateral phone use, although an elevated OR was also seen for contralateral use for analogue phones. .

Within INTERPHONE; results have been published of national analyses in Denmark, France, Germany, Japan, Norway and Sweden, as well as joint analyses of data from Nordic countries and UK-South (Christensen et al. 2005;Hours et al. 2007a;Klaeboe et al. 2007;Lonn et al. 2005;Schuz et al. 2006a;Takebayashi et al. 2008;Lahkola et al. 2008). Study characteristics and results are summarised in Table 5.

The OR related to ever having been a regular mobile phone user was below 1 (Table 5), in all studies, in some instances statistically significantly so, possibly reflecting participation bias or other methodological limitations.

In analyses by level of use, results by time since start of use vary across studies but are generally close to 1 (Table 5). Confidence intervals are wide however, and these results are based on very small numbers of long-term users in individual studies, reflecting the fact that meningioma is more prevalent in women than men and that, in the early years of mobile telephony, most users were ñbusinessmenò. Pooling of data from Nordic countries and part of the UK yielded the largest number of long term users (73) (Lahkola et al. 2008) and an OR of 0.91 (95% CI 0.57, 1.26) related to start of use 10 years or more in the past. As for the glioma results, all of the ORs by number of calls and duration of calls are below 1.

Acoustic neurinoma

As part of the large case-control study in New York, Providence Rhode-Island and Boston mentioned above, Muscat and collaborators also studied the risk of acoustic neurinoma (Muscat et al. 2002). The study included 90 cases (18 years or older and diagnosed between 1997 and 1999) and 86 hospital controls (chosen among inpatients of the same hospital admitted for benign conditions or for cancers excluding leukaemia and lymphoma). Again, use of mobile phones among the study subjects was infrequent 18 cases and 23 controls reported using them (OR 0.9, CI not given) (Table 6). A non-significant increase was seen in subjects who reported using the phone for 3 years or more (OR 1.7, 95% CI 0.5, 5.1), based on 11 cases.

Within their case-control study described above, Inskip and collaborators considered specifically the risk of glioma (Table 6) (Inskip et al. 2001). The study included 96 cases of glioma, 22 of which reported regular use of mobile phones (OR 1.0, 95% CI 0.5, 1.9). Only 5 cases had used phones for 5 years or more and a non-significantly increased risk was seen among them (OR 1.9, 95% CU 0.6, 5.9),

The combined analyses of the two case-control studies of brain tumours conducted by Hardell and collaborators included 243 acoustic neurinoma diagnosed between 1997 and 2003 in the regions of Sweden mentioned above (see section on study design above) and 2,162 controls (Hardell et al. 2006b). Results are presented separately for analogue and digital phones (Table 6). Overall, 68 cases were classified as having used analogue phones and 105 digital phones. The respective ORs were 2.9 (95% CI 2.0, 4.3) and 1.5 (1.1, 2.1) for analogue and digital phones respectively. The ORs was similar higher for analogue phones when use 10 years or more in the past was considered ï OR 3.1 (95% CI 1.02, 2.5), based on 19 cases ï but lower for digital phones 0.6 (95% CI 0.1, 5.0) based on 1 case only. The ORs were also slightly higher for ipsilateral than for contralateral phone use, although elevated ORs was also seen for contralateral use. .

Within INTERPHONE; results have been published of national analyses in Denmark, France, Germany, Japan, Norway and Sweden, as well as joint analyses of data from Nordic countries and UK-South (Christensen et al. 2004;Lonn et al. 2004a;Takebayashi et al. 2006;Klaeboe et al. 2007;Schlehofer et al. 2007;Hours et al. 2007a;Schoemaker et al. 2005). Study characteristics and results are summarised in Table 3.

Again, in most studies, the OR related to ever having been a regular mobile phone user was below 1 (Table 6), possibly reflecting participation bias or other methodological limitations.

In analyses by level of use, results by time since start of use vary across studies (Table 6). Confidence intervals are wide however, due to the very small number of long-term users in individual studies and results are therefore compatible. Pooling of data from Nordic countries and part of the UK yielded the largest number of long term users (47) (Schoemaker et al. 2005). Among these, based on 31 cases, an increased risk of neurinoma was found for reported use of mobile phones for 10 years or more on the side of the head where the tumour developed (OR 1.30, 95% CI 0.8, 2.0) and a significantly increased risk in relation to duration of use of 10 years or more (OR 1.8, 95% CI 1.1, 3.1, based on 23 cases). As for glioma, this finding could reflect either a causal association (as the vast majority of the RF energy is absorbed on the side of the head where the phone is held ï see Methodological Issues section above) or an artefact, related to differential recall between cases and controls.

Other adult tumours

Salivary gland tumours

Within the above mentioned registry based case-control study in Finland (Auvinen et al. 2002), analyses were also conducted for salivary gland tumours specifically, based on 34 cases and their matched controls. The number of subscribers was very small: only 3 cases had analogue subscriptions (1 for more than 2 years) and only 1 had a digital subscription (Table 7)

A case-control study of salivary gland tumours was conducted in Sweden by the group of Hardell and collaborators (Hardell et al. 2004). The study included all cases diagnosed in the whole of Sweden between 1994 and 1999 or 2000, depending on the region. A total of 267 (out of 415 identified) cases and 1,053 (out of 1,152) controls participated in the study. Information about mobile phone use was collected through the same mail questionnaire as used by this group in their brain tumour study described above. The ORs were 0.92 (95% 0.58, 1.44) for use of analogue phones and 1.01 (95% CI 0.68, 1.50) for digital phones, based on 31 and 45 exposed cases respectively. The study included few long term users; only 6 cases had used analogue phones 10 years or more in the past and none had used digital phones for that long. Results for parotid gland tumours specifically were similar (OR for analogue phones 0.73, 95% CI 0.41, 1.29 and for digital phones 0.98, 95% CI 0.62, 1.55, based on 18 and 33 cases respectively) (Table 7).

Within INTERPHONE, results were published of analyses of the parotid gland case-control study in Sweden and Denmark (Lonn et al. 2006) and in Israel (Sadetzki et al. 2007) (Table 7). The analysis of data from Sweden and Denmark (Lonn et al. 2006), included 60 cases of malignant parotid gland tumours, 112 benign (pleomorphic adenoma) and 681 controls. 25 of the malignant cases and 77 of the benign were classified as regular users (ORs 0.7, 95% CI 0.4, 1.3 and 0.9, 95% CI 0.5, 1.5 respectively for malignant and benign tumours). The numbers of long term (2 and 7 respectively among malignant and benign tumour cases) and heavy users was small in this study. For benign tumours, a non-significantly increased OR was observed for reported use of 10 years or more on the side of the head where the phone was held (2.6, 95% CI 0.9, 7.9, based on 6 cases) although a decreased risk was observed when the phone was reported to be held on the other side of the head (OR 0.3, 95% 0, 2.3, based on 1 case). These results are difficult to interpret however as contralateral use is included in the reference group for the ipsilateral analyses and ipsilateral use in the reference group for contralateral analyses, thereby exaggerating any difference between the results of the two analyses.

The Israeli INTERPHONE study (Sadetzki et al. 2007) included 402 benign and 58 malignant cases and 1,266 individually matched controls. For the entire group, the OR related to regular mobile phone use was OR 0.87 (95% CI 0.68, 1.13) (Table 7); this OR, and all of the ORs in relation to level and duration of use were below 1, possibly reflecting selection bias or other methodological limitations. For ipsilateral use, the odds ratios in the highest category of cumulative number of calls and cumulative call time were 1.58 (95% CI 1.11, 2.24) and 1.49 (95% CI 1.05, 2.13), respectively. The risk for contralateral use was reduced, but not significantly so for either of these variables. Analyses restricted to regular users (in which light or recent users were used as the referent category instead of non-users in order to compensate for a possible selection bias related to mobile phone use) and to conditions that may yield higher levels of exposure (e.g., heavy use in rural areas) showed consistently elevated risks, suggesting a possible relation between heavy mobile phone use and risk of parotid gland tumours. Although this study included few long term users (13 cases had used mobile phones for 10 years or more), the Israeli mobile phone users are exceptionally heavy users compared to users in the other INTERPHONE countries. Additional investigations of this association, with longer latency periods and large numbers of heavy users, are needed to confirm these findings.

Intratemporal facial nerve tumours

A case-control study of tumours of the intratemporal facial nerve (IFN) was conducted in the US (Warren et al. 2003) at an academic, tertiary-care referral centre, using a structured telephone survey. METHODS: Patients with IFN tumours (n = 18) were case-matched with patients treated for acoustic neurinoma (n = 51), rhinosinusitis (n = 72), and dysphonia or gastroesophageal reflux disease (n = 69). The OR for IFN tumour was 0.4 (95% CI, 0.1-2.1) with regular cellular telephone use. Results from this study are difficult to interpret given the small number of cases, the inclusion in the control group of acoustic neurinoma (a tumour possibly related to mobile phone use) and the absence of long term heavy users in the study.

Uveal melanoma

Two case-control studies of uveal melanoma were conducted in Germany in the mid to late 1990s to assess the effects of occupational exposures on this type of tumour (Stang et al. 2001). Questions were asked about occupational use mobile phones and of radio sets. Together, the studies included 118 cases and 475 controls; 9 cases and 21 controls reported having used radiosets and 6 cases and 15 controls mobile phones at work. Increased ORs were found both for radioset exposures (OR 3. 95% CI 1.4, 6.3) and for probable and certain exposure to mobile phones (OR 4.2, 95% CI 1.2, 14.5). Information about mobile phone use in this study is very limited, and subjectôs answers were uncertain (with some reporting ñpossibleò exposure to mobile phones at work).

A descriptive epidemiological study in Denmark compared trends in the incidence of ocular malignant melanoma and in mobile phone subscriptions (Johansen et al. 2002). There was little evidence of an increase in incidence of this tumour in the period 1943 to 1996 or of a relation with trends in phone subscriptions in the latter part of the period (1982-1996). The number of subscriptions was relatively low, however, until 1992, and this study therefore provides little information about risk of this tumour.

Lymphoma

A case-control study was conducted in 4 areas of Sweden to evaluate the possible association between mobile phones and risk of non-Hodgkin's lymphoma (NHL) (Hardell et al. 2005c). The study included cases aged 18-74 and diagnosed between 1 December 1999 to 30 April 2002. Controls were frequency matched and selected from the national population registry. Information about mobile telephone use was obtained by questionnaire. A total of 910 (out of 1,129 eligible) cases and 1016 (92%) controls accepted to participate in the study. The vast majority of cases (819) were B-cell lymphomas; there were 53 T-cell lymphoma cases. No association was seen between use of mobile telephones (whether analogue or digital, ever or 10 years or more in the past) and the risk of B-cell lymphoma. Regarding T-cell lymphoma, a non-significantly increased risk was seen for ever use of analogue or digital phones (OR 1.56, 95% CI 0.64, 3.81 and 1.41, 95% CI 0.68, 2.92, based on 14 and 31 exposed cases, respectively). There was no apparent trend with time for analogue phones; for digital phones, the risk appeared to increase with increasing latency but this was based on very small numbers of cases.

Testicular cancer

A case-control study of testicular cancer was also conducted by the same group in Sweden (Hardell et al. 2007). The study included all cases diagnosed in men aged 20-75 in the whole of Sweden between 1993 and 1997. Overall 981 (out of 1,021 eligible) cases participated (542 seminoma and 346 non-seminoma cases) and 870 (89%) controls participated in the study. The

ORs for seminoma were 1.2 (95% 0.9, 1.6) for use of analogue phones and 1.3 (95% CI 0.9, 1.8) for digital phones, based on 125 and 98 exposed cases respectively. The study included few long term users; only 13 cases had used analogue phones 10 years or more in the past (OR 2.1, 95% CI 0.8, 5.1) and none at that time had used digital phones for that long. For non-seminoma, the ORs were 0.7 (95% CI 0.5, 1.1) and 0.9, CI (95% CI 0.6, 1.4), respectively for analogue and digital phones, based on 50 and 66 exposed cases. There was no evidence of an exposure response relationship and no association was found with place where the mobile phone was kept, such as trousers pocket.

Reproductive outcomes

The association between prenatal and postnatal exposure to cell phones and behavioural problems in young children was investigated within the framework of national birth cohort study in Denmark (Divan et al. 2008). Mothers of 13,159 children completed a follow-up questionnaire when their children reached 7 years of age in 2005 and 2006. The questionnaire included questions concerning the current health and behavioural status of their children, as well as past exposure to cell phone use, specifically use of mobile phone during pregnancy (including numbers of times per day and proportion of time the phone was on, use of hands-free equipment and location of the phone when not in use) and for children, current use of cellular and other wireless phones. After adjustment for potential confounders, the odds ratio for a higher overall behavioural problems score was 1.80 (95% CI 1.45, 2.23) in children with both prenatal and postnatal exposure to cell phones. Similar ORs were seen for different types of behavioural problems and ORs tended to be higher for prenatal than for postnatal exposures. Results of this study are difficult to interpret at present. The fact that the questionnaire was administered post-hoc, at age 7, may have led to differential recall bias. Only 65% of eligible mothers returned the questionnaire and this may represent a selected sample of the cohort. Further, confounding by some factors, including behavioural factors that may correlate with maternal phone use, could affect the results. It will be important to examine this association in other similar cohorts and to collect information about mobile phone use in pregnancy rather than at age 7 when the behavioural problems that are being investigated are already manifest.

Summary and conclusions - status of knowledge today

This report reviews and evaluates published epidemiological studies on RF and health. Included in the assessment are scientific studies that have been published primarily in peer reviewed scientific journals.

As outlined in the previous sections, many of the epidemiological studies reviewed here suffer from inadequate assessment of radio frequency exposure and, in particular in the case-control studies, from possible recall errors and selection bias. In addition, many studies had inadequate sample size, incomplete follow-up of subjects, lack of information on potential confounding variables and, in some cases, inadequate comparison groups and methods of analyses.

On the basis of the epidemiological studies reviewed, because of the inconsistencies of results and the limitations of these studies, it is not possible to evaluate at this time whether there exists a health risk from exposure to RF radiation, particularly at the levels of concern for mobile communication. A number of recent large studies of glioma, acoustic neurinoma and possibly parotid gland tumours appear to suggest a possible increased risk related to long term or heavy use of phones. It is unclear, however, whether the observed associations are real, reflecting a causal association, or artefactual, reflecting differential reporting between cases and controls.

In the short term, more information on a possible carcinogenic risk will be provided by the results of the international INTERPHONE analyses, based on larger numbers of long-term and heavy users than the individual studies, taking into account the results of the various methodological sub-studies and detailed localisation of tumours. The results of more detailed analyses, also underway, focusing on more precise localization of tumours using 3-dimensional radiological images, and on the analysis of the effect of RF exposure at the location of the tumour, using a gradient of RF emitted by mobile phones, will also be of great importance.

Research recommendations

INTERPHONE will mainly provide information on effects of exposure to RF in adulthood and only on the risk of brain and CNS tumours and of tumours of the parotid gland.

Studies of other outcomes and of exposures in childhood and adolescence are therefore sorely needed, as are surveillance studies of cohorts of mobile phone users in order to assess possible effects on a variety of cancer and non-cancer endpoints ï see for example research recommendations by a number of international bodies (WHO 2006;SCENIHR 2007;EMF-Net 2006). A number of studies are underway or starting that will address these issues (COSMOS, CEFALO, Mobi-Kids) in the medium and longer term future.

Further studies of occupationally exposed populations will also be important.

For these studies to be informative, however, it will be essential that the above described limitations are overcome and, in particular, that reliable and accurate individual estimates of RF exposure be available for all study subjects.

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Table 1: Rate ratio for cancer: results from epidemiological studies of occupational or recreational RF exposure. ***(Notes: unless otherwise indicated, the reference group is the ñlowò or ñunexposedò group in the study; numbers in italics were calculated from the data presented in the paper) ï adapted from (Kilkenny and Cardis 1999)***

Authors	Exposed group definition	Cancer type	Cases	Rate ratio	95% CI
Cohort studies					
(Lilienfeld et al. 1978)	US embassy personnel	All	17	0.89	0.5-1.4
		Brain	0	0.0	-
		Leukaemia	2	2.50	not available
		Lung	5	0.86	0.3-2.0
		Digestive	3	0.65	0.1-1.9
		Breast	2	4.00	0.5-14.4
(Robinette et al. 1980;Groves et al. 2002)	ñHigh exposure jobsò among Navy technicians	All	1,180	0.80	0.74-0.87
		Brain	51	0.65	0.43-1.01
		All leukaemia	44	1.48	1.01,2.17
(Milham S Jr 1988a)	Amateur radio operator licence holders	All	2485	0.71	0.6-0.7
		Brain	29	1.39	0.9-2.0
		Lymphatic and haematopoietic	89	1.23	1.0-1.5
		- leukaemia	36	1.24	0.9-1.7
(Szmigielski 1996)	Workers in areas with high MW/RF field intensities	All	*~67*[1]	2.07	1.1-3.6
		Brain & CNS	*~2-3*	1.91	1.1-3.5
		Lymphatic and haematopoietic	*~24*	6.31	3.1-14.3
		Oesophageal/stomach	*~8-9*	3.24	1.9-5.1
		Colorectal	*~7*	3.19	1.5-6.2
(Finkelstein 1998)	Police Officers	All	561	0.9	0.8-1.0
		Brain	16	0.8	0.5-1.4
		Leukaemia	12	0.6	0.3-1.0
		Testicular	23	1.3	0.9-1.8
(Tynes et al. 1996)	Female Radio & Telegraph operators	All	140	1.2	1.0-1.4
		Brain	5	1.0	0.3-2.3
		Leukaemia	2	1.1	0.1-4.1
		Rectum	6	1.8	0.7-3.9
		Breast	50	1.5	1.1-2.0
		Uterus	12	1.9	1.0-3.2
		Kidney	3	1.6	0.3-4.8
(Morgan et al. 2000)	Motorola US employees ***ï*** *moderate and high exposure groups combined*	All	na[2]	na	
		Brain and CNS	7	0.86	0.38-1.73
		Lymphatic and haematopoietic	21	0.61	0.39-0.93
		- leukaemia	11	0.74	0.36-1.40
		- non-Hodgkin lymphoma	6	0.41	0.20-0.74
		- Hodgkin´s disease	3	0.87	0.23-2.53
Case-control studies					
(Grayson 1996)	Ever exposed to RF ï based on job title ï time exposure matrix	Brain	94	1.39	1.0-1.9

[1] Although numbers of cancers are not provided in the paper, it was possible to estimate them from the rate data presented.

[2] Not available

Authors	Exposed group definition	Cancer type	Cases	Rate ratio	95% CI
(Thomas et al. 1987)	Ever-exposed to RF/MW - based on occupational history	Brain	69	1.6	1.0-2.4
(Berg et al. 2006)	Highly exposed subjects ï based on occupational history and hygienists	Glioma			
		- overall	22	1.22	0.69-2.15
		- 10 years or more	13	1.39	0.67-2.88
		Meningioma			
		- overall	11	1.34	0.61-2.96
		- 10 years or more	6	1.55	0.52-4.62
(Karipidis et al. 2007)	Highest exposed subjects ï based on occupational history, JEM and hygienists	Glioma	6	0.89	0.28-2.81

Table 2 Distribution of all cases and controls ascertained and proportion interviewed by study centre (reproduced from (Cardis et al. 2007)

Study centre	Glioma		Meningioma		Acoustic neurinoma		Malignant parotid gland tumours		Controls	
	No. ascertained	No. (%) Interviewed	No. ascertained	No. (%) Interviewed	No. ascertained	No. (%) Interviewed	No. ascertained	No. (%) Interviewed	No. from sampling frame	No. (%) Interviewed
Australia	536	301 (56)	413	255 (62)	179	127 (71)	21	7 (33)	1,608	669 (42)
Canada										
Montreal	101	65 (64)	71	48 (68)	41	33 (80)	13	9 (69)	391	234 (60)
Ottawa	38	25 (66)	18	15 (83)	21	17 (81)	6	6 (100)	259	180 (70)
Vancouver	134	80 (61)	45	31 (69)	41	34 (83)	19	13 (68)	680	239 (35)
Denmark	248	181 (73)	155	121 (81)	73	71 (97)	15	15 (100)	1,277	662 (52)
Finland	211	178 (84)	252	231 (92)	87	76 (87)	-[3]	-	1,337	559 (42)
France	155	94 (61)	190	148 (78)	140	111 (79)	-	-	639	472 (74)
Germany	312	256 (82)	275	250 (91)	76	67 (88)	-	-	1,869	1190 (64)
Israel	206	180 (87)	390	350 (90)	78	72 (92)	20	19 (95)	911	599 (66)
Italy	128	118 (92)	124	110 (89)	30	30 (100)	11	11 (100)	486	340 (70)
Japan	90	60 (67)	102	82 (80)	82	69 (84)	-	-	574	287 (50)
New Zealand	132	84 (69)	72	54 (75)	21	20 (95)	-	-	350	172 (49)
Norway	236	180 (76)	191	148 (77)	51	38 (75)	21	11 (52)	404	278 (69)
Sweden	298	227 (76)	205	184 (90)	107	102 (95)	20	18 (90)	617	407 (66)
UK										
North	628	429 (68)	222	180 (81)	116	102 (88)	-	-	1,747	788 (45)
South	848	307 (37)	390	221 (57)	218	152 (70)	-	-	1,211	582 (50)
Total	4,301	2,765 (65)	3,115	2,425 (78)	1,361	1,121 (82)	146	109 (75)	14,360	7,658 (53)

[3] Parotid gland tumours were not included in these centres.

1 **Table 3 ï Summary of published results from studies of mobile phone use and risk of glioma**

Country	Age range	Diagnosis years	Number of cases and controls	OR and 95% CI Ever regular use	OR and 95% CI Start of use 10 years or more in the past	OR and 95% CI Ipsilateral use, start of use 10+ years in past	OR and 95% CI Contralateral use, start of use 10+ years in past
INTERPHONE studies							
Denmark (Christensen et al, 2005)	20-69	2000-2002	Low-grade 81 155 High-grade 171 330	Low-grade 1.08 (0.58, 2.00) 47 High-grade 0.58 (0.37, 0.90) 59	Low-grade 1.64 (0.44, 6.12) 6 High-grade 0.48 (0.19, 1.26) 8	NA	NA
France (Hours et al, 2007)	30-59	2001-2003	96 96	1.15 (0.65, 2.05) 59	*46 months+ 1.96 (0.74, 5.20) 21*	NA	NA
Germany (Schuz et al, 2006)	30-69	2000-2003	366 1,494	0.98 (0.74, 1.29) 138	2.20 (0.94, 5.11) 12	NA	NA
Japan (Takebayashi et al, 2008)	30-69	2000-2004	83 163	1.22 (0.63, 2.37) 56	*6.5 years + 0.60 (0.20, 1.78) 7*	NA	NA
Norway (Klaeboe et al 2007)	19-69	2001-2002	289 358	0.6 (0.4, 0.9) 161	*6+ years 0.8 (0.5, 1.2) 70*	*6+ years 1.3 (0.8, 2.1) 39*	*6+ years 0.8 (0.5, 1.4) 32*
Sweden (Lonn et al, 2005)	20-69	2000-2002	371 674	0.8 (0.6, 1.0) 214	0.9 (0.5, 1.5) 25	1.6 (0.8, 3.4) 15	0.7 (0.3, 1.5) 11
UK (Hepworth et al, 2006)	18-69	2000-2004	966 1,716	0.94 (0.78,1.13) 508	0.90 (0.63,1.28) 66	NA	NA
Nordic combined (Lahkola et al, 2007)		2000-2004	1,522 3,301	0.78 (0.68, 0.91) 867	0.95 (0.74, 1.23) 143	1.39* (1.01, 1.92) 77	0.98 (0.71, 1.37) 67
Others							
Sweden (Hardell et al. 2006a)	20-80	1997-2003	905 2,162 539 124	All malignant tumours Analogue 1.5 (1.1, 1.9) 178 Digital 1.3 (1.1, 1.6) 402 High grade astrocytoma Analogue 1.7 (1.3, 2.3) 115 Digital 1.5 (1.2, 1.9) 244 Low grade astrocytoma Analogue 1.2 (0.6, 2.2) 19 Digital 1.4 (0.9, 2.3) 56	Analogue 2.4 (1.6, 3.4) 82 Digital 2.8 (1.4, 5.7) 19 Analogue 2.7 (1.8, 4.2) 59 Digital 3.8 (1.8, 8.1) 15 Analogue 1.6 (0.6, 4.1) 19 Digital 1.3 (0.2, 11) 1	NA	NA

Country	Age range	Diagnosis years	Number of cases and controls	OR and 95% CI Ever regular use	OR and 95% CI Start of use 10 years or more in the past	OR and 95% CI Ipsilateral use, start of use 10+ years in past	OR and 95% CI Contralateral use, start of use 10+ years in past
Finland (Auvinen et al. 2002)	20-69	1996	198 989	Analogue 2.1 (1.3, 3.4) 26 Digital 1.0 (0.5, 2.0) 10	NA	NA	NA
US (Inskip et al, 2001)	18+	1994-1998	489 799	0.8 (0.6, 1.2) 85	*5+ years* *0.6 (0.3,1.4) 11*	NA	NA
US (Muscat et al, 2000)	18-80	1994-1998	469 422	*All brain cancers* 0.85 (0.6, 1.2) 66	NA	NA	NA

1

2

Table 4 ï Results of analyses by cumulative number of calls and cumulative hours of use ï Pooled analyses of glioma data from Nordic and UK-South Interphone studies. Reproduced from (Lahkola et al. 2007)

,3

	Number of cases	OR	95 % CI
Cumulative number of calls			
Never/nonregular use	626	1.0	
<2,172	352	0.73	(0.62, 0.87)
2,172ï 7,792	205	0.74	(0.60, 0.91)
>7,792	265	0.91	(0.74, 1.12)
P for trend		*P=0.93*	
*P for trend ï users only**		*P=0.05*	
Cumulative hours of use			
Never/nonregular use	626	1.0	
<125	368	0.75	(0.64, 0.89)
125ï 503	193	0.69	(0.55, 0.85)
>503	262	0.90	(0.73, 1.10)
P for trend		*P=0.98*	
P for trend ï users only		*P=0.09*	

* Results of analyses in which light users are used as the reference category ï such analyses are useful to evaluate the impact of a potential selection bias in studies such as this where the overall OR for regular users is below 1 where it is possible that the proportion of users and non-users is not representative of the population from which the subjects are sampled.

1 **Table 5 ï Summary of published results from studies of mobile phone use and risk of meningioma**

Country	Age range	Diagnosis years	Number of cases and controls		OR and 95% CI Ever regular use		OR and 95% CI Start of use 10 years or more in the past		OR and 95% CI Ipsilateral use, start of use 10+ years in past		OR and 95% CI Contralateral use, start of use 10+ years in past	
INTERPHONE studies												
Denmark (Christensen et al, 2005)	20-69	2000-2002	175	316	0.83 (0.54, 1.28)	67	1.02 (0.32, 3.24)	6	NA		NA	
France (Hours et al, 2007)	30-59	2001-2003	145	145	0.74 (0.43, 1.28)	71	46 months+ *0.73 (0.28, 1.91)*	*15*	NA		NA	
Germany (Schuz et al, 2006)	30-69	2000-2003	381	762	0.84 (0.62, 1.13)	104	1.09 (0.35, 3.37)	5	NA		NA	
Japan (Takebayashi et al, 2008)	30-69	2000-2004	128	229	0.70 (0.42, 1.16)	55	*5.2 years +* *1.05 (0.52, 2.11)*	*30*	NA		NA	
Norway (Klaeboe et al 2007)	19-69	2001-2002	207	358	0.8 (0.5, 1.1)	98	*6+ years* *1.0 (0.6, 1.8)*	*36*	*6+ years* *1.1 (0.6, 2.3)*	*17*	*6+ years* *1.2 (0.6, 2.3)*	*18*
Sweden (Lonn et al, 2005)	20-69	2000-2002	273	674	0.7 (0.5, 0.9)	118	0.9 (0.4, 1.9)	8	1.3 (0.5, 3.9)	5	0.5 (0.1, 1.7)	3
Nordic combined (Lahkola et al, 2008)		2000-2004	1,209	3,299	0.76, (0.65, 0.89)	573	0.91 (0.67, 1.25)	73	1.05 (0.67, 1.65)	33	0.62 (0.38, 1.03)	24
Others												
Sweden (Hardell et al. 2006b)	20-80	1997-2003	916	2,162	Analogue 1.3 (0.99, 1.7) Digital 1.1 (0.9, 1.3)	 113 295	Analogue 1.6 (1.02, 2.5) Digital 1.3 (0.5, 3.2)	 34 8	NA		NA	
Finland (Auvinen et al. 2002)	20-69	1996	129	643	Analogue 1.5 (0.6, 3.5) Digital 0.7 (0.2, 2.6)	 8 3	NA		NA		NA	
US (Inskip et al, 2001)	18+	1994-1998	197	799	0.8 (0.4, 1.3)	32	*5+ years* *0.9 (0.3, 2.7)*	*6*	NA		NA	

2

Table 6 ï Summary of published results from studies of mobile phone use and risk of acoustic neurinoma

Country	Age range	Diagnosis years	Number of cases and controls		OR and 95% CI Ever regular use		OR and 95% CI Start of use 10 years or more in the past		OR and 95% CI Ipsilateral use, start of use 10+ years in past		OR and 95% CI Contralateral use, start of use 10+ years in past	
INTERPHONE studies												
Denmark (Christensen et al, 2004)	20-69	2000-2002	106	212	0.90 (0.51, 1.57)	45	0.22 (0.04, 1.11)	2	NA		NA	
France (Hours et al, 2007)	30-59	2001-2003	109	214	0.92 (0.53, 1.59)	58	*46 months+* *0.66 (0.28, 1.57)*	*14*	NA		NA	
Germany (Schlehofer et al, 2007)	30-69	2000-2003	97	194	0.67 (0.38, 1.19)	29	NA	0	NA		NA	
Japan (Takebayashi et al, 2006)	30-69	2000-2004	101	339	0.73 (0.43, 1.23)	51	*8+ years* *0.79 (0.24, 2.65)*	*4*	NA		NA	
Norway (Klaeboe et al 2007)	19-69	2001-2002	45	358	0.5 (0.2, 1.0)	22	*6+ years* *0.5 (0.2, 1.4)*	*8*	*6+ years* *0.9 (0.3, 2.8)*	*5*	*6+ years* *0.8 (0.2, 2.5)*	*4*
Sweden (Lonn et al, 2004)	20-69	1999-2002	148	604	1.0 (0.6, 1.5)	89	1.9 (0.9, 4.1)	14	3.9 (1.6, 9.5)	12	0.8 (0.2, 2.9)	4
Nordic combined (Schoemaker et al, 2005)		1999-2004	678	3,553	0.9 (0.7, 1.1)	360	1.0 (0.7, 1.5)	47	1.3 (0.8, 2.0) *1.8 (1.1-3.1)**	31 *23*	1.0 (0.6, 1.7) *0.9 (0.5, 1.8)**	20 *12*
Others												
Sweden (Hardell et al. 2006b)	20-80	1997-2003	243	2,162	Analogue 2.9 (2.0, 4.3) Digital 1.5 (1.1, 2.1)	 68 105	Analogue 3.1 (1.7, 5.7) Digital 0.6 (0.1, 5.0)	 19 1	NA		NA	
US (Inskip et al, 2001)	18+	1994-1998	96	799	1.0 (0.5, 1.9)	22	*5+ years* *1.9 (0.6, 5.9)*	*5*	*NA*		*NA*	
US (Muscat et al, 2002)	18-80	1997-1999	90	86	0.9	18	*3+ years* *1.7 (0.5, 6.1)*	*11*	*NA*		*NA*	

* Analysis by duration of use instead of time since start of use.

Table 7 ï Summary of published results from studies of mobile phone use and risk of parotid gland tumours

Country	Age range	Diagnosis years	Number of cases and controls	OR and 95% CI Ever regular use	OR and 95% CI Start of use 10 years or more in the past	OR and 95% CI Ipsilateral use, start of use 10+ years in past	OR and 95% CI Contralateral use, start of use 10+ years in past
INTERPHONE studies							
Israel (Sadetzki et al, 2007)	18+	2001-2003	Total 460 1,266 Benign 402 1,072 Malignant 58 294	Total 0.87 (0.68, 1.13) 285 Benign 0.85 (0.64, 1.12) 252 Malignant 1.06 (0.54, 2.10) 33	Total 0.86 (0.42, 1.77) 13 *Total ï regular users only* *1.45 (0.82, 2.57) 13*	Total 1.60 (0.68, 3.72) 10 Benign 1.97 (0.81, 4.85) 10	Total 0.58 (0.15, 2.32) 3
Sweden and Denmark (Lonn et al, 2006)	20-69	2000-2002	Benign 112 321 Malignant 60 681	Benign 0.9 (0.5, 1.5) 77 Malignant 0.7 (0.4, 1.3) 25	Benign 1.4 (0.5, 3.9) 7 Malignant 0.4 (0.1, 2.6) 2	Benign 2.6 (0.9, 7.9) 6 Malignant 0.7 (0.1, 5.7) 1	Benign 0.3 (0.0, 2.3) 1 Malignant NA 0
Others							
Sweden (Hardell et al. 2004)	20-80	1994-2000	199 1,172	Analogue 0.73 (0.41, 1.29) 18 Digital 0.98 (0.62, 1.55) 33	NA	NA	NA
Finland (Auvinen et al. 2002)	20-69	1996	34 170	Analogue 1.0 (0.3, 4.0) 3 Digital 1.7 (0.2, 16) 1	NA	NA	NA

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Evaluation of the Effect of Radiofrequency Radiation Emitted From Wi-Fi Router and Mobile Phone Simulator on the Antibacterial Susceptibility of Pathogenic Bacteria *Listeria monocytogenes* and *Escherichia coli*

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Abstract

Mobile phones and Wi-Fi radiofrequency radiation are among the main sources of the exposure of the general population to radiofrequency electromagnetic fields (RF-EMF). Previous studies have shown that exposure of microorganisms to RF-EMFs can be associated with a wide spectrum of changes ranged from the modified bacterial growth to the alterations of the pattern of antibiotic resistance. Our laboratory at the nonionizing department of the Ionizing and Non-ionizing Radiation Protection Research Center has performed experiments on the health effects of exposure to animal models and humans to different sources of electromagnetic fields such as cellular phones, mobile base stations, mobile phone jammers, laptop computers, radars, dentistry cavitrons, magnetic resonance imaging, and Helmholtz coils. On the other hand, we have previously studied different aspects of the challenging issue of the ionizing or nonionizing radiation-induced alterations in the susceptibility of microorganisms to antibiotics. In this study, we assessed if the exposure to 900 MHz GSM mobile phone radiation and 2.4 GHz radiofrequency radiation emitted from common Wi-Fi routers alters the susceptibility of microorganisms to different antibiotics. The pure cultures of *Listeria monocytogenes* and *Escherichia coli* were exposed to RF-EMFs generated either by a GSM 900 MHz mobile phone simulator and a common 2.4 GHz Wi-Fi router. It is also shown that exposure to RF-EMFs within a narrow level of irradiation (an exposure window) makes microorganisms resistant to antibiotics. This adaptive phenomenon and its potential threats to human health should be further investigated in future experiments. Altogether, the findings of this study showed that exposure to Wi-Fi and RF simulator radiation can significantly alter the inhibition zone diameters and growth rate for *L monocytogenes* and *E coli.* These findings may have implications for the management of serious infectious diseases.

Keywords

radiofrequency radiation, bacteria, Wi-Fi, antibiogram

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Introduction

Antibiotic resistance is one of the most important threats to global health.[1] According to World Health Organization, this problem is rising dangerously to high levels worldwide, which leads to longer hospitalization, higher medical costs, and raised mortality.[2]

Bacteria are becoming resistant to almost all commonly available antibiotics and this is a worldwide problem.[1] Today, greater use of telecommunication technologies like Global System for Mobile communication (GSM), cordless phones, mobile base stations, wireless personal, and local area networks, such as bluetooth, has led to ever increasing exposure to radiofrequency electromagnetic fields (RF-EMF).[3] Therefore, living organisms are now being exposed to microwaves and radiofrequency radiation signals from various sources.[4] The effects of these radiations on the biological functions of living cells shows an emerging area of interest in human health with respect to environmental effects.[5] Several studies were conducted to confirm the effects of electromagnetic radiation on cell functions[6-8]; however, the findings obtained in these studies were controversial. In particular, it was proven that EMF can affect functional parameters (cell growth and antimicrobial susceptibility).[9-12]

Listeria monocytogenes is a gram-positive, facultative anaerobe, nonspore-forming, motile, and rod-shaped bacterium.[13] In 1952, it was recognized as the main cause of neonatal infection, meningitis, and sepsis.[14] Listeria infection in adult patients is related to immunocompromised systems like HIV infection,[15] organ transplants, individuals who have received corticosteroids, and immunosuppressant drugs for their malignancies. *Escherichia coli* known as *E coli*, a gram-negative, rod-shaped, facultatively anaerobic bacterium,[16] is a common cause of life-threatening infections such as bloodstream and urinary tract infections, otitis media, and other complications.[17]

Our laboratory at the nonionizing department of the Ionizing and Non-ionizing Radiation Protection Research Center has performed experiments on the health effects of exposure to animal models and humans to different sources of electromagnetic fields such as cellular phones,[18-20] mobile base stations,[21] mobile phone jammers,[22,23] laptop computers,[24] radars,[25] dentistry cavitrons,[26] magnetic resonance imaging,[27,28] and Helmholtz coils.[29,30] In this study, we assessed whether the exposure to 900 MHz and 2.4 GHz RF-EMF emitted from GSM and a common Wi-Fi router could change the susceptibility of microorganisms to different antibiotics.

Materials and Methods

Antibiotic Susceptibility Test

In the current study, *L monocytogenes* ATCC 19115 was used and *E coli* strain was isolated from patients in Faghihi hospital, Shiraz, Iran. *Escherichia coli* strain was characterized by conventional methods including morphological and biochemical tests and confirmed using API 20 E method. The pure cultures of *L monocytogenes* and *E coli* were diluted in Mueller-Hinton Broth to reach 0.5 McFarland turbidity standards to get 1.5×10^8 CFU/mL as the total count.[31] Bacterial suspensions were spread on plates and cultured with a set of 6 antimicrobial substances; they were tested by disk diffusion method (Kirby-Bauer method) on Mueller-Hinton agar (MHA-Biolife, Italy) plates and *E coli* ATCC 25922 was used as the quality control for antibiotic susceptibility tests, according to the Clinical and Laboratory Standards Institute guidelines (CLSI, 2013). The incubation period was 18 to 24 hours at 35°C, and then inhibition zones for each disk were measured.

Antimicrobial Agents

Antibiotics used for *E coli* tests were imipenem (10 μg), levofloxacin (LEVO 5 μg), aztreonam (30 μg), ciprofloxacin (CIPR 5 μg), cefotaxime (CTX 30 μg), and piperacillin (100 μg). *Listeria monocytogenes* tests were conducted using doxycycline (DOX 30 μg), sulfamethoxazole–trimethoprim (SXT 25 μg), LEVO 5μg, CTX 30 μg, CIPR 5 μg, and ceftriaxone (CTR 30 μg) antibiotics.

All antibiotic disks were purchased from ROSCO Diagnostica (DK-2630 Taastrup, Denmark). Results of antibiotic susceptibility tests before and after exposure to either Wi-Fi or GSM mobile phone radiation were measured and analyzed. The inhibition zone of each plate was recorded as the average of at least 2 different measurements (in millimeters). Three replicate agar plates were used for each regime, according to CLSI guidelines (2013).

Wi-Fi Router

A D-Link Wi-Fi router (D-Link, D-Link Corporation, Taiwan) was used in this study as the exposure source. During the exposure period, data were exchanged between the modem and a laptop computer that was placed in another room (5 m away from the Wi-Fi router).

The Wi-Fi router operated with a power level of 1 W and the specific absorption rate at the distance 14 cm between the bacterial suspension (broth medium) and Wi-Fi router was 0.13 W/kg. During the exposure, bacterial samples were collected in different times 3, 6, 9, and 12 hours after being exposed using sterile swabs.

Radiofrequency Simulator

In this study, all exposures were performed using a GSM 900 MHz mobile simulator operating in the "Talk mode." This mobile phone simulator was developed at the Department of Medical Physics and Biomedical Engineering, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran, by the collaboration of the private sector.

Outgrowth Curve

For the evaluation of radiofrequency exposure effect on the growth rate of bacteria, optical density (OD) was measured.

Table 1. Inhibition Zone Diameters Before and After Exposure to RF and Wi-Fi Radiofrequency Radiation for *Escherichia coli.*

Wi-Fi Exposure		RF Simulator			Wi-Fi Exposure		
Exposure Time	Drug	Control (Mean ± SD)	Exposure (Mean ± SD)	*P* Value	Control (Mean ± SD)	Exposure (Mean ± SD)	*P* Value
3 hours	PIPRA	26.30 ± 0.58	24.67 ± 0.58	.0262[a]	25.67 ± 0.58	25.30 ± 0.58	.5608
	IMI	31.67 ± 0.58	25.30 ± 0.58	.0002[a]	29.67 ± 0.58	25.30 ± 0.58	.0008[a]
	LEVO	34.67 ± 0.58	30.30 ± 0.58	.0008[a]	34.67 ± 0.58	31.67 ± 0.58	.0032[a]
	AZT	35.30 ± 0.58	29.30 ± 0.58	.0002[a]	34.67 ± 0.58	32.30 ± 0.58	.0083[a]
	CIPR	33.67 ± 0.58	28.67 ± 0.58	.0005[a]	33.30 ± 1.20	30.67 ± 0.58	.0247[a]
	CTX	36.67 ± 0.58	31.30 ± 0.58	.0001[a]	34.67 ± 0.58	30.30 ± 0.58	.0008[a]
6 hours	PIPRA	26.30 ± 0.58	22.30 ± 0.58	.0011[a]	25.67 ± 0.58	24.67 ± 0.58	.1023
	IMI	31.67 ± 0.58	23.67 ± 0.58	.0001[a]	29.67 ± 0.58	26.67 ± 0.58	.0032[a]
	LEVO	34.67 ± 0.58	26.30 ± 0.58	.0001[a]	34.67 ± 0.58	30.67 ± 0.58	.0011[a]
	AZT	35.30 ± 0.58	25.67 ± 0.58	<.0001[a]	34.67 ± 0.58	30.67 ± 0.58	.0011[a]
	CIPR	33.67 ± 0.58	26.30 ± 0.58	.0001[a]	33.30 ± 1.20	33.67 ± 0.58	.7165
	CTX	36.67 ± 0.58	28.30 ± 0.58	.0001[a]	34.67 ± 0.58	29.30 ± 0.58	.0004[a]
9 hours	PIPRA	26.30 ± 0.58	22.67 ± 0.58	.0016[a]	25.67 ± 0.58	24.67 ± 0.58	.1023
	IMI	31.67 ± 0.58	25.67 ± 0.58	.0002[a]	29.67 ± 0.58	25.67 ± 0.58	.0011[a]
	LEVO	34.67 ± 0.58	28.30 ± 0.58	.0002[a]	34.67 ± 0.58	29.67 ± 0.58	.0005[a]
	AZT	35.30 ± 0.58	26.67 ± 0.58	.0001[a]	34.67 ± 0.58	28.67 ± 0.58	.0002[a]
	CIPR	33.67 ± 0.58	30.67 ± 0.58	.0032[a]	33.30 ± 1.20	30.30 ± 0.58	.0176[a]
	CTX	36.67 ± 0.58	28.67 ± 0.58	.0001[a]	34.67 ± 0.58	28.67 ± 0.58	.0002[a]
12 hours	PIPRA	26.30 ± 0.58	23.67 ± 0.58	.0051[a]	25.67 ± 0.58	24.30 ± 0.58	.0516
	IMI	31.67 ± 0.58	28.67 ± 0.58	.0032[a]	29.67 ± 0.58	25.67 ± 0.58	.0011[a]
	LEVO	34.67 ± 0.58	30.30 ± 0.58	.0008[a]	34.67 ± 0.58	32.30 ± 0.58	.0083[a]
	AZT	35.30 ± 0.58	27.67 ± 0.58	.0001[a]	34.67 ± 0.58	33.67 ± 0.58	.1023
	CIPR	33.67 ± 0.58	35.30 ± 0.58	.0262[a]	33.30 ± 1.20	34.30 ± 0.58	.2636
	CTX	36.67 ± 0.58	31.67 ± 0.58	.0005[a]	34.67 ± 0.58	35.30 ± 0.58	.2134

Abbreviations: AZT, aztreonam; CIPR, ciprofloxacin; CTX, cefotaxime; IMI, imipenem; LEVO, levofloxacin; PIPRA, piperacillin; RF, radiofrequency.
[a]Statistically significant diffidence.

For each bacterium, a precisely specified concentration of bacterial suspension inoculated in the broth medium and then divided into 2 series as a control and RF simulator exposure groups. For estimating the number of bacterial cells in a broth medium, the turbidity of each group was recorded in 625 nm absorption at different times using a spectrophotometer (UNICO UV-2100 Spectrophotometer, UNICO, USA).

Statistical Analysis

All experiments were replicated 3 times for exposed and nonexposed groups. The means were compared using the nonparametric Mann-Whitney *U* test, and statistical significance of any difference observed among the mean values was determined using SPSS version 15. $P < .05$ was considered significant.

Results and Discussions

In our study, we have evaluated *E coli* and *L monocytogenes* for their in vitro susceptibility to various antibiotics in the presence of radiofrequency radiation. For each antibiotic, inhibition zone was measured and the test was repeated 3 times. Data obtained for exposed and nonexposed (control) bacteria are summarized in Table 1.

According to Table 1, for *E coli*, exposure to Wi-Fi and RF simulator decreased the inhibition zone diameters that show an antibacterial resistance pattern. At first, there was no change in sensitivity, but after increasing the exposure time, a specific range of antibacterial resistance was observed.

After 24 hours of exposure, as it can be seen in Table 1 and Figures 1 and 2, the bacteria that were exposed to radiation showed less resistance compared to early-time exposure. However, they didn't return to time 0 exposure condition.

According to Figures 3 and 4, for *L monocytogenes*, comparison of data obtained from exposed and nonexposed groups did not show any significant changes in their antibacterial activity except for DOX. However, for *E coli*, there was a significant change in antimicrobial activities that suggest exposure condition to radiation could influence the degree of antibiotic susceptibility of *E coli* more than Listeria. In a similar pattern, for *L monocytogenes*, a specific window of response was observed (Figures 3 and 4). *Listeria monocytogenes* response to each antibiotic was different, for DOX, and the window response occurred after 6 hours of exposure to Wi-Fi and RF simulator radiation. However, for other antibiotics, these changes were only observed at the ninth hour of exposure to Wi-Fi while this response could not be observed for RF simulator radiation. After 9 hours of exposure to Wi-Fi for CIPR and SXT antibiotics, bacteria had a tendency to become more resistant. This was in contrast to the pattern observed for LEVO, CTX, and CTR antibiotics, which an increased sensitivity

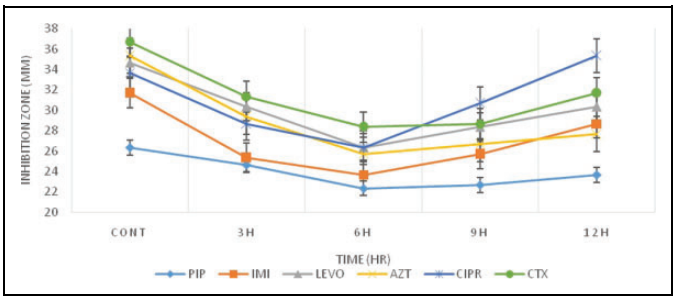

Figure 1. Inhibition zone diameters preexposure and postexposure to radiofrequency (RF) simulator radiation for *Escherichia coli*.

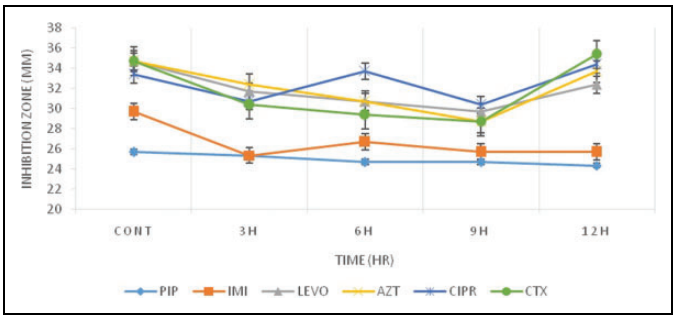

Figure 2. Inhibition zone diameters preexposure and postexposure to Wi-Fi radiation for *Escherichia coli*.

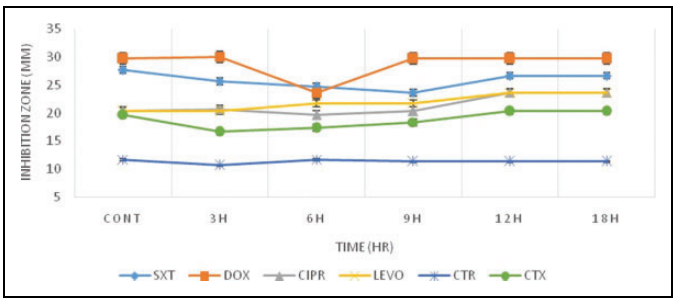

Figure 3. Inhibition zone diameters preexposure and postexposure to radiofrequency (RF) simulator radiation for *Listeria monocytogenes*.

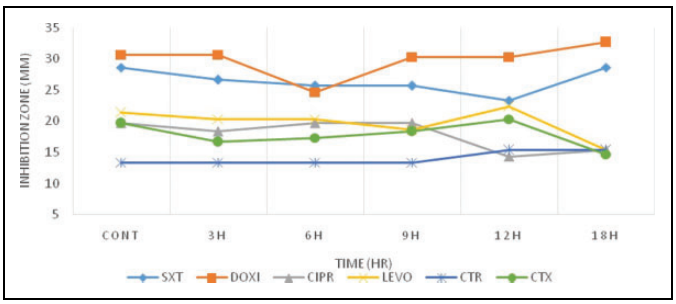

Figure 4. Inhibition zone diameters preexposure and postexposure to Wi-Fi radiation for *Listeria monocytogenes*.

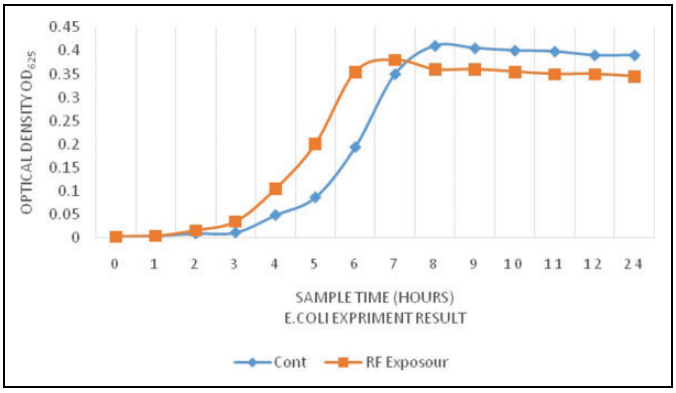

Figure 5. Growth curves in *Escherichia coli* broth medium preexposure and postexposure.

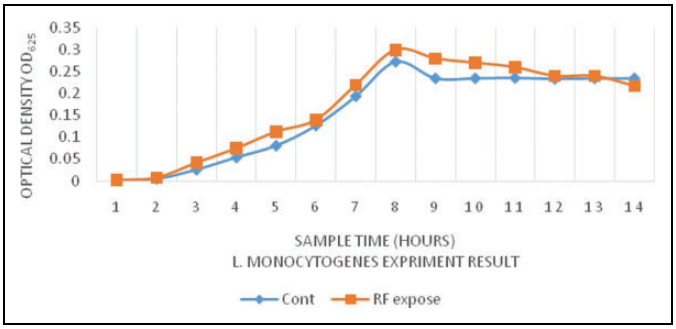

Figure 6. Growth curves *Listeria monocytogenes* in broth medium preexposure and postexposure.

was observed. As mentioned above, for Listeria, limited antibacterial changes were observed for DOX after exposure to Wi-Fi and RF simulator radiation. On the other hand, we have previously addressed the bioeffects of the exposure of bacteria to electromagnetic radiations and investigated different aspects of the challenging issue of the ionizing or nonionizing radiation-induced alterations in the susceptibility of microorganisms to antibiotics.[19,32-34]

In the current study, the pattern of the response of *E coli* to Wi-Fi and RF simulator radiation was identical. The maximum differences in the diameters of inhibition zones were observed between 6 and 9 hours of the bacterial exposure to radiation (Figures 1 and 2). After 12 hours of exposure, the bacterial responses to radiation as a stressor led to returning to the preexposure status. This observation is in line with the previous reports of Mortazavi et al,[18,19,34-36] who showed that the radiation-induced stimulatory/beneficial effects in bacteria can be observed only within a narrow window of radiation dose. Based on this theory, when the radiation level is within the window (between the lower and upper levels of the window), stimulatory effects of ionizing or nonionizing radiation can be detected. Therefore, the response of the bacteria and other microorganisms to any environmental stressors can be determined by some key factors such as the magnitude of the dose and dose rate. This type of response was previously confirmed in *Klebsiella pneumoniae*.[34]

We have also evaluated the effect of radiofrequency radiation on the growth rate of bacteria. As shown in Figures 5 and 6, during each investigated time period, remarkable differences

Table 2. Average Optical Density (OD_{625}) Results for *Escherichia coli* and *Listeria Monocytogenes* Preexposure and Postexposure.

Experimental Results				
	E Coli		*L Monocytogenes*	
	OD_{625}		OD_{625}	
Time	Control	Exposure	Control	Exposure
0 hour	0.003 ± 0.001	0.003 ± 0.006	0.002 ± 0.0011	0.002 ± 0.0006
1 hour	0.009 ± 0.006	0.004 ± 0.001	0.005 ± 0.006	0.008 ± 0.0006
2 hours	0.01 ± 0.001	0.016 ± 0.006	0.026 ± 0.001	0.042 ± 0.0003
3 hours	0.012 ± 0.006	0.035 ± 0.001	0.054 ± 0.001	0.075 ± 0.001
4 hours	0.049 ± 0.001	0.105 ± 0.006	0.081 ± 0.006	0.113 ± 0.001
5 hours	0.087 ± 0.001	0.201 ± 0.001	0.127 ± 0.001	0.14 ± 0.001
6 hours	0.194 ± 0.001	0.355 ± 0.002	0.194 ± 0.001	0.22 ± 0.002
7 hours	0.35 ± 0.01	0.38 ± 0.002	0.273 ± 0.001	0.3 ± 0.001
8 hours	0.41 ± 0.006	0.36 ± 0.002	0.235 ± 0.006	0.28 ± 0.001
9 hours	0.405 ± 0.006	0.36 ± 0.002	0.235 ± 0.001	0.27 ± 0.001
10 hours	0.4 ± 0.01	0.355 ± 0.002	0.236 ± 0.001	0.26 ± 0.002
11 hours	0.398 ± 0.003	0.35 ± 0.002	0.234 ± 0.006	0.24 ± 0.006
12 hours	0.39 ± 0.01	0.35 ± 0.002	0.235 ± 0.001	0.24 ± 0.001
24 hours	0.39 ± 0.01	0.345 ± 0.002	0.235 ± 0.001	0.217 ± 0.006

were observed in the rate of bacterial growth in exposed and nonexposed groups (Table 2). In particular, gram-negative (*E coli*) and gram-positive bacteria (*L monocytogenes*) showed a significant growth after exposure. Moreover, the time to reach the logarithmic phase in the growth curve of the bacteria was faster in exposed groups. However, after 8 hours, based on OD_{625} absorbance, the total count of *E coli* bacteria in the exposed group was less than that of the control group. These observations are in line with the finding of Akbal et al.[37] However, the total counts of *L monocytogenes* after 24 hours of exposure was higher than that of the control group. At a broader view, our data confirm previous studies that showed that radiofrequency radiation could induce changes in cell growth and antibiotic sensitivity in *E coli.*

Some researchers have indicated that organisms acquire resistance through several known factors such as patient noncompliance or in vitro exposure to radiofrequency radiation.[38-40] Nowadays, our world is surrounded by enormous radiofrequency sources such as Wi-Fi routers and laptop computers that can lead to serious health problems. When someone is infected with a microorganism that obtained its resistance from the host environment, it causes a serious problem for health-care systems and treatment failure or receiving a higher dosage of antibiotics will be possible. Therefore, this may lead to more side effects and finally prolonged hospitalization.

In several studies,[10,41] it was shown that antimicrobial sensitivity alterations were affected by the intensity of electromagnetic fields. Antibacterial sensitivity also depends on the physical properties of the electromagnetic fields such as frequency and magnetic flux density, exposure duration, and type of bacteria. Based on this point, evaluation of the effect of radiofrequency radiation on bacteria is not only essential to investigate their environmental effects, but it is also vital for detecting the antibiotic resistance pattern in the clinical laboratories and environment.[42-45]

Since the frequency of Wi-Fi router is 2.4 GHz while it is 900 MHz for the mobile simulator, we can conclude that the difference in response to Wi-Fi and the mobile simulator is possibly due to the frequency of radiation.[46] In several studies on bacteria,[34,47,48] one of the factors that influenced antibacterial sensitivity was the cell wall structure of bacteria and peptidoglycan (PG) nature in gram-positive and gram-negative bacteria. In gram-positive ones like Listeria, cell wall thickness is greater than that of gram negatives. The thicker the PG,[49] the permeability of the cell wall to permit the entrance of molecules to the cells will be decreased. According to these findings, the frequency of radiation can make some changes in PG of cell wall and enhance the permeability of the membrane to antibiotics.[8,50] Torgomyan showed that alteration in the oxidoreduction state of proteins in the bacterial cell membrane can be the major membranous mechanism after exposure to low-intensity electromagnetic field.[51]

Also, the effect of electromagnetic radiation on *E coli* cultures was studied by Justo et al,[52] which found that cell growth could be changed (stimulation or inhibition) under magnetic field. Furthermore, the exposure of *E coli* ATCC 25992 to the magnetic field of 2 mT at the frequency of 50 Hz caused significant alterations in the morphology, growth curves, structural parameters, and the sensitivity to certain antibiotics such as nalidixic acid, amoxicillin, and erythromycin.[9,53] These results were confirmed by the study of Stansell et al,[54] who found that static magnetic fields at moderate intensities are able to decrease the antibiotic sensitivity and make *E coli* WHMC 4202 more resistant.

In our study, we used several antibiotics that act through various mechanisms including protein and DNA synthesis

Table 3. Antibiotics Classification.

Antibiotic Classification	Mechanism	Antimicrobial Agents	Abbreviation
Sulfonamide	DHFRI	Trimethoprim/ sulfametho-xazole	SXT
Penicillin	Inhibits cell wall synthesis	Ceftriaxone	CTR
		Cefotaxime	CTX
		Piperacillin	PIPRA
		Imipenem	IMI
		Aztreonam	AZT
Tetracycline	Protein synthesis inhibition (30 s)	Doxycycline	DOX
Fluoroquinolones	Nucleic acid synthesis inhibition	Ciprofloxacin	CIPR
		Levofloxacin	LEVO
Aminoglycoside	Protein synthesis inhibition (30 s)	Amikacin	AMI

Abbreviation: DHFRI, dihydrofolate reductase inhibitors.

inhibition, cell wall inhibition, and dihydrofolate reductase inhibition (it is summarized in Table 3). Each antibiotic enters the cell via a specific pathway. Some of them enter via efflux pumps in the cell membrane,[34,55,56] and others enter via ion channels through the cell wall.[57] All of these antibiotics may enter the cell via a nonspecific mechanism such as endocytosis. In this mechanism, molecules pass the membrane based on the permeability of the cell wall.[58-60] Considering our results, we believe that Wi-Fi and mobile exposure can serve as physical methods to alter the antibacterial susceptibility of microorganisms. In this light, the permeability of the membrane can be changed by radiofrequency radiation. It seems that the radiation can alter the sensitivity of the efflux pumps or ion channels by permitting the entrance of the molecules through the cell wall. In order to verify these theories, it would be better if this study is replicated with other pathogenic bacteria both gram-positive and gram-negative ones with various forms of antibiotics.

Conclusion

Based on our results, it can be concluded that the bacterial strains used in this study respond differently to EMFs. These bacteria were capable of responding to environmental stresses that act by activating some specific systems such as ion channels, change via the membrane, DNA repair system, and probably ion efflux pumps in the membrane as well as interactions of molecules and antibacterial agents.[61] There are some ambiguities that need further investigations regarding answering questions such as which cellular mechanism is responsible for adaptation? Which factors are involved in alterations of antibacterial sensitivity? And subsequently, what are the differences in the response to radiation in gram-negative and gram-positive bacteria? Moreover, experiments on different bacterial strains with various electromagnetic fields should be performed in the future to better clarify these uncertainties.

Authors' Note

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http://www.norad4u.com/knowledge/studies

EMF/EMR Science, reports and Studies

Contents

Preview

Through the years several governments, committees and international bodies issues warning regarding RF and ELF EMF/EMR. As more science and proof is becoming clear and wide spreed, more and more warning have been issues and more reports have concluded that exposure to RF and ELF fields is not healthy, and can have health effects that are not related to the heat effect.
This is while other governments, committees and international bodies consider EMF radiation is "not dangerous" and while the industry continue to push for more and more wireless technologies world wide.
I think that even today, the ever growing body of science should be enough to except the potential danger of EMF and call for drastic measures to reduce EMF exposure and usage of Radio Frequency emitting devices, both on the government level and specially on the personal level.

Can non ionizing radiation photon cause damage?

The industry, and scientist which follow it, argue that RF and ELF photon does not have enough energy to damage DNA and therefor it is 100% safe. Well that is obviously a simplification of the reality in which other less direct mechanisms effects and damage biological systems when radiated by RF and ELF EMF. SALFORD showed in 2003 that the brain-blade-barrier is damaged when a brain is being radiated with RF radiation. This BBB damage cause other neurological damage to the brain. FRIDMAN showed in 2007 the mechanism in which free radicals are created when a tissue is radiated with RF radiation. Free radicals can lead to DNA breaks. Hanry Lai showed in his research from 1998 that DNA breaks do occur when DNA is being radiated with "safe" levels of RF radiation.

Reports

- 05/2015 - **The "International EMF Appeal -**
  About 190 scientist call on to the UN, WHO and states in order to adopt more protective guidelines that will be based also on biological changes and damages caused by EMF.
  Press here to Read more about it...
- **WHO/IARC** - "IARC CLASSIFIES RADIOFREQUENCY ELECTROMAGNETIC FIELDS AS POSSIBLY CARCINOGENIC TO HUMAN" (06/2011)- http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf .
  It is important to note that this decision was accepted after a conflict of interest was exposed in the committee:
  - http://www.microwavenews.com/Ahlbom.html
  - http://www.monanilsson.se/document/AhlbomConflictsIARCMay23.pdf
- **European Parliament 2009 -**

  Health concerns associated with electromagnetic fields

- COUNCIL OF EUROPE - "The potential dangers of electromagnetic fields and their effect on the environment " by the "COUNCIL OF EUROPE - Parliamentary Assembly" (6/05/2011) - http://www.assembly.coe.int/Mainf.asp?link=/Documents/AdoptedText/ta11/ERES1815.htm
- **Russia** - "The Russian National Committee on Non-Ionizing Radiation Protection (RNCNIRP) has published a new resolution entitled: "Electromagnetic Fields from Mobile Phones: Health Effect on Children and Teenagers" - http://www.scribd.com/doc/55420788/Electromagnetic-Fields-from-Mobile-

Phones-Health-Effect-on-Children-and-Teenagers.

- **INDIA** - "REPORT OF THE INTERNAL MINISTERIAL COMMITTEE ON EMF RADIATION " - "Government of India, Ministry of Communications & Information Technology, Department of Telecommunications" - http://www.dot.gov.in/miscellaneous/IMC%20Report/IMC%20Report.pdf.
- **ISRAEL** - The environmental and health committee in the KNESSET (Israel parliament) called the government to adopt the recommendations of a technical committee to reduce and to prevent exposure to electromagnetic radiation of students in schools to, due to the possible health effect of electromagnetic radiation might have on their health - http://norad4u.blogspot.com/2010/11/article-about-reduction-and-prevention.html.
- The **Bioinitiative** (www.bioinitiative.org) report, which was published in 2007, quotes 2000 studies that show many and diverse health effects of EMR. In 2012 an update of this report was published with additional 1800 studies that show none thermal effect of both Radio Frequency and Extreme Low Frequency Electromagnetic Radiation. The authors of the report warn while the scientific data showing none thermal biological effect of non-ionizing radiation accumulate, and while the damage to public health seems to get bigger and wider, the industry does it's best to continue the deployment of radiation emitting technologies and devices while trying to hold back the information of the possible risk from the public.
  On the Bioinitiative website there is a color table of studies, named "RF Color Charts" , that show a the studies along side the RF levels that biological effects and changes are caused in. The RF Color Charts makes it very easy to understand how very law levels or RF radiation effect Biologic systems. To view the chart, go to the main page and search for the "RF Color Chats".
- **The REFLEX study** - Carried out in 12 institutes, in 7 different countries, found that exposure to ELF (Extreme Low Frequency) EMF, and RF EMF (Radio Frequency emitted from cellphones) caused changes in genes and in their expressions (genotoxic effects) in living cells in-vitro. The team concluded that in-vitro damage is read and that in vivo damage should be studied in humans.
  The REFLEX study
  About the REFLEX study
  About the REFLEX study on BBC
- **ICEMS** (www.icems.eu) - the **International Commission for Electromagnetic Safety** published several resolutions that reviews many health effects of EMR other than heat related effect.
- **WHO/IARC** - "IARC CLASSIFIES EXTREAM LOW FREQUENCY MAGNETIC FIELDS AS POSSIBLY CARCINOGENIC TO HUMAN" (2002)- https://apps.who.int/inf-fs/en/fact263.html
- **Carl Blackman - 2009** - **Cell phone radiation**: Evidence from ELF and RF studies supportingmore inclusive risk identification and assessment
  A review of about 131 studies showing NTE (None Thermal Effect) of EMF radiation.

  "This paper will review some of the salient evidence that demonstrates the existence of NTE and the exposure complexities that must be considered and understood to provide appropriate, more thorough evaluation and guidance for future studies and for assessment of potential health consequences"

Sites with lists of studies

Since I am not a scientist I am not going to bring a list of studies and then explain them. If you need a list of studies, so you can read and decide for yourself, I can recommend the following site that has a list of most studies about health effect of Electromagnetic Radiation that were published: http://www.powerwatch.org.uk/science/studies.asp

In addition you can find more studies on the following pages:

- The studies page on the "EM Watch" site.
- The latest research page on the "EM Radiation Research Trust" site.
- The news and media page on the "Electromagnetic Health" site.
- Dr. Zuri Glazer Review and Summary of ~2000 studies that show effects of Radio frequency radiation. The first addition of this review was printed in 1971 as part of a US Navy Research. The review is now available on Prof. Magda Haves web site.

RF (High frequency) EMR Influence, damage & health effect studies

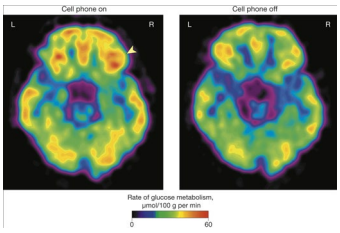
More and more studies show biological damage and health effects of RF EMR, even at very low levels which don't cause any heat effect and were considered to be safe.

Studies about influence of RF EMR in so called "safe" levels (partial list)

Effects of Cell Phone Radiofrequency Signal Exposure on Brain Glucose Metabolism - Nora D. Volkow, MD 2011

"In healthy participants and compared with no exposure, 50-minute cell phone exposure was associated with increased brain glucose metabolism in the region closest to the antenna. This finding is of unknown clinical significance."

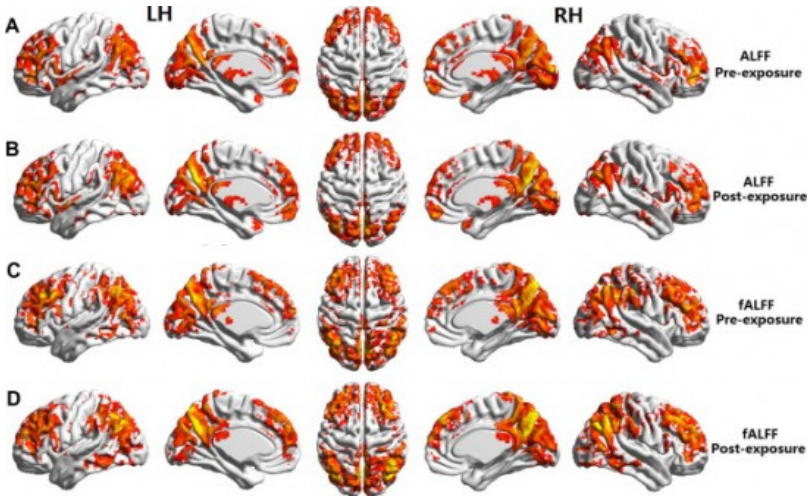
The study - http://jama.jamanetwork.com/article.aspx?articleid=645813



The alteration of spontaneous low frequency oscillations caused by acute electromagnetic fields exposure - 2013

"The study provided the evidences that 30min LTE RF-EMF exposure modulated the spontaneous low frequency fluctuations in some brain regions."

Link - http://www.ncbi.nlm.nih.gov/pubmed/24012322
About the study - http://www.prlog.org/12215083-lte-cell-phone-radiation-affects-brain-activity-in-cell-phone-users.html



picture - brain activity after exposure to LTE RF radiation

Studies about biological damage in so called "safe" levels (partial list)

This is a partial list of the most important studies that show Biological damage and mechanisms of damage caused by RF EMF exposure.

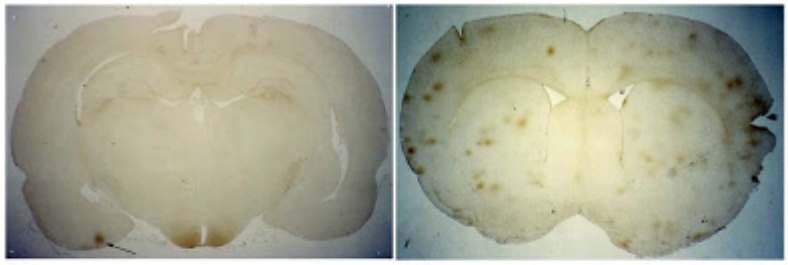
Brain damage after RF-MW exposure - Salford -2003

The picture below is taken from the "**Nerve Cell Damage in Mammalian Brain after Exposure to Microwaves from GSM Mobile Phones**" study by **Leif G. Salford, Arne E. Brun, Jacob L. Eberhardt, Lars Malmgren, Bertil R.R. Persson.** (please see the source link below for full study).
Please notice the red spots on the radiated brain (Right picture), these are "protein leakage from blood vessels" marking the damage to the brain's blood vessels which can cause headaches and other symptoms.

Source: http://www.ncbi.nlm.nih.gov/pubmed/12782486

Full study : http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1241519/pdf/ehp0111-000881.pdf

Video of a lecture with Dr Leif Salford: http://youtu.be/E_WJ_aJPWIA



(a) (b)

Figure 1

Fig. 1 . (a) Slightly enlarged cross section of central parts of the brain of an unexposed control rat, stained for albumin which appears brownish in the central inferior parts of the brain, the hypothalamus, a normal feature. In the left lower corner (arrow) a brown spot representing an occasional focal leakage.
(b) As (a) for an RF exposed rat , stained for albumin , which appears brownish in multiple small foci representing leakage from many vessels.

DNA brakes - Henry Lai and Dr Narendra -1996

The comet trail "dust like" particles in the pictures are DNA breaks. The picture below clearly shows that DNA breaks accusers after exposure to X-ray and Cell phone radiation. The source of the picture is from **Dr Henry Lai and Dr Narendra** research about "**Single- and double-strand DNA breaks in rat brain cells after acute exposure to radio-frequency electromagnetic radiation"**

Source: http://www.ncbi.nlm.nih.gov/pubmed/8627134

Dr. Neil Cherry about Motorola attempt to contradict this study:

Dr. Neil Cherry wrote number of papers regarding the danger of RF radiation. One was specifice about the studies that Motorola founded in order to allegedly contradict Henry Lai studies. The parper used to be availible on this link, but it seems to be removed. The info also appear on other papers of Neil Cherry. click on the links bellow and search for "Motorola":

1. Evidence of Health Effects of Electromagnetic Radiation, To the Australian Senate Inquiry into Electromagnetic Radiation - **Dr. Neil Cherry**
2. Evidence that Electromagnetic Radiation is Genotoxic: The implications for the epidemiology of cancer and cardiac, neurological and reproductive effects - **Dr. Neil Cherry**

Video of a lecture given by Dr Henry Lai about DNA breaks as an outcome of RF exposure: http://youtu.be/JrBjQJhHfzk

Fig.1 Unexposed control. Bundle of DNA (No-Tail)

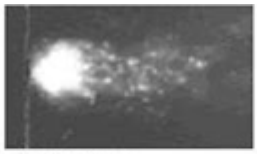


Fig.2 X-ray calibration 25.6 rads. DNA breaks are very obvious

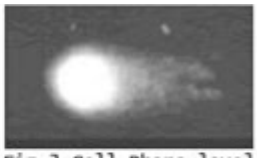


Fig.3 Cell Phone level microwave exposure 2hrs 2.45GHz reaching so called Safe SAR levels

Comet Tail = DNA Damage

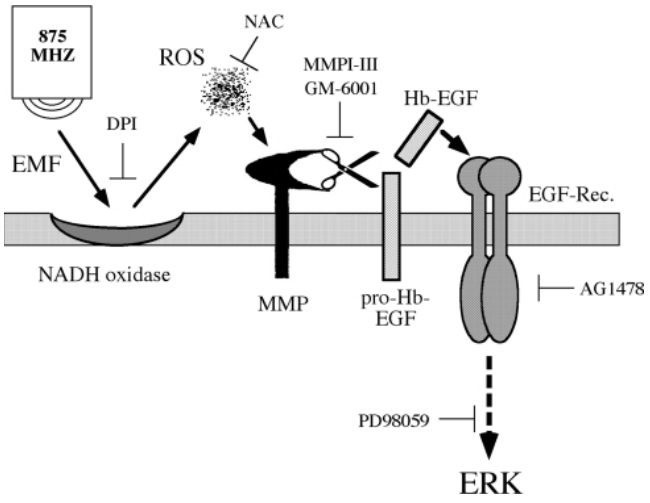
Lymphoma cancer in mice - Repacholi MH -1997

Mike Repacholi exposed mice to RF radiation, similar to that emitted from cellphones, and found that the risk for Lymphoma was found to be significantly higher in the mice that were exposed. Several years after the research was done, Repacholi took back his finding and was appointed to several roles in the WHO and was lately hired as a consultant to the industry.

The research: http://www.ncbi.nlm.nih.gov/pubmed/9146709

Creation of Free radicals as a result of RF radiation exposure - Friedman J- 2007

On their research Mechanism of short-term ERK activation by electromagnetic fields at mobile phone frequencies from 2007, Dr. Joseph Friedman and Prof. Roni Seger, from the Department of Biological Regulation, The Weizmann Institute of Science, found that exposure to RF electromagnetic radiation caused oxygenate stress and for the first time showed a detailed molecular mechanism by which electromagnetic irradiation from mobile phones interacts and changes cell communication and activities.



RF EMF Health effect and epidemiological studies

Cell phone usage by pregnant women and of children causes behavioral difficulties - Divan HA, Kheifets L, Obel C, Olsen J - 2008

"Exposure to cell phones prenatally-and, to a lesser degree, postnatal-was associated with behavioral difficulties such as emotional and hyperactivity problems around the age of school entry"
Link to the study: http://www.ncbi.nlm.nih.gov/pubmed/18467962

27 minutes of cellphone use per day incress brain cancer risk - The interphone study - 2010

The interphone study final result ware published on 17/05/2010, after 5 years of delay. a first look suggests that using a mobile phone actually protect you from brain cancer, how could that be? a second look shows that people who use their mobile phone for more then 27 minutes per day (1640 hours in 10 years) have 40% higher risk of getting a brain tumor. In the study itself there were many issues and problems that cause the results to be moderated. Appendix 2 of the study try to mathematically fix some of the problems in the study resulting with higher risk (please see picture bellow).

Interphone study formal report: http://ije.oxfordjournals.org/content/39/3/675.full.pdf

Appendix 1 -
http://ije.oxfordjournals.org/content/suppl/2010/05/06/dyq079.DC1/Interphone_Appendix1.pdf
Appendix 2 -
http://ije.oxfordjournals.org/content/suppl/2010/05/06/dyq079.DC1/Interphone_Appendix2.pdf

About the interphone study: http://norad4u.blogspot.com/2010/05/what-went-wrong-with-interphone-study.html

Table 2 ORs between mobile phone use and brain tumours (meningioma and glioma separately) by regular use, time since start of use, cumulative call time and cumulative number of calls—excludes use with hands-free devices

	Meningioma			Glioma		
	Cases	Controls	OR[a] (95% CI)	Cases	Controls	OR[a] (95% CI)
Cumulative call time with no hands-free devices (h)[b]						
Never regular user	1147	1174	1.00	1042	1078	1.00
<5 h	160	197	0.90 (0.69–1.18)	141	197	0.70 (0.52–0.94)
5–12.9	142	159	0.82 (0.61–1.10)	145	198	0.71 (0.53–0.94)
13–30.9	144	194	0.69 (0.52–0.91)	189	179	1.05 (0.79–1.38)
31–60.9	122	145	0.69 (0.51–0.94)	144	196	0.74 (0.55–0.98)
61–114.9	129	162	0.75 (0.55–1.00)	171	193	0.81 (0.61–1.08)
115–199.9	96	155	0.69 (0.50–0.96)	160	194	0.73 (0.54–0.98)
200–359.9	108	133	0.71 (0.51–0.98)	158	194	0.76 (0.57–1.01)
360–734.9	123	133	0.90 (0.66–1.23)	189	205	0.82 (0.62–1.08)
735–1639.9	108	103	0.76 (0.54–1.08)	159	184	0.71 (0.53–0.96)
⩾1640	130	107	1.15 (0.81–1.62)	210	154	1.40 (1.03–1.89)

Table 2 (out of the interphone study) - ORs between mobile phone use and brain tumors (meningioma and glioma separately).

Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case-control study – IJE, May 2010

Appendix 2 Table – ORs between mobile phone use and brain tumours (meningioma and glioma separately) by time since start of regular use, cumulative call time and cumulative number of calls, excluding use with hands-free devices; analyses restricted to ever regular-users

	Meningioma					Glioma				
	Cases	Controls	OR	95 % CI		Cases	Controls	OR	95 % CI	
Time since start of regular use (years)										
1-1.9 years	116	112	1.00			93	159	1.00		
2-4	362	367	0.90	0.62	1.31	460	451	1.68	1.16	2.41
5-9	288	308	0.75	0.51	1.10	468	491	1.54	1.06	2.22
10+	76	67	0.86	0.51	1.43	190	150	2.18	1.43	3.31
Cumulative call time with no hands-free devices (hours)[1]										
<5 hours	113	88	1.00			90	114	1.00		
5.0-12.9	83	88	0.79	0.48	1.29	92	124	0.88	0.56	1.39
13-30.9	95	107	0.72	0.45	1.15	127	118	1.37	0.87	2.14
31-60.9	70	87	0.59	0.35	0.99	108	126	1.13	0.72	1.77
61-114.9	74	88	0.58	0.35	0.97	121	135	1.06	0.68	1.67
115-199.9	69	95	0.64	0.39	1.06	129	119	1.13	0.71	1.78
200-359.9	74	81	0.58	0.35	0.96	116	138	1.00	0.63	1.58
360-734.9	83	80	0.85	0.51	1.41	142	139	1.17	0.74	1.84
735-1639.9	85	69	0.81	0.49	1.36	126	125	1.09	0.69	1.72
1640+	96	71	1.10	0.65	1.85	160	113	1.82	1.15	2.89
Cumulative number of calls with no hands-free devices (in hundreds)[1]										
<1.5 x 100 calls	109	81	1.00			92	102	1.00		
1.5-3.4	86	98	0.54	0.32	0.90	91	123	0.95	0.59	1.52
3.5-7.4	92	97	0.76	0.46	1.27	108	148	0.85	0.55	1.32
7.5-13.9	88	91	0.76	0.45	1.26	121	111	1.19	0.74	1.89
14-25.4	75	107	0.56	0.34	0.92	133	134	1.10	0.70	1.73
25.5-41.4	71	72	0.60	0.35	1.02	121	124	1.19	0.75	1.88
41.5-67.9	85	94	0.63	0.38	1.05	126	122	1.02	0.64	1.62
68-127.9	102	89	0.79	0.49	1.29	136	147	1.13	0.73	1.77
128-269.9	79	63	0.76	0.44	1.32	154	120	1.49	0.94	2.36
270+	55	62	0.66	0.37	1.17	129	120	1.31	0.82	2.11

[1] ORs adjusted for sex, age, study centre, ethnicity in Israel, and education.

Table 2 (out of the appendix # 2 of the interphone study) - ORs is higher!

Cellphone and cordless phones use and brain cancer - Lennart Hardell - 2010

"Use of mobile phones gave an increased risk, highest in the >10 years' latency group yielding odds ratio (OR) = 2.4, and 95% confidence interval (CI) = 1.4-4.1. The risk increased with cumulative number of lifetime hours for use, and was highest in the >2,000 h group (OR = 3.4, 95% CI = 1.6-7.1)."
Lennart Hardell is a world known scientist on the field of electromagnetic radiation. His many studies and reviews show constant correlation between RF exposure and health effects.

Link to the study:http://www.ncbi.nlm.nih.gov/pubmed/20551697
Link to other publications by
Hardell: http://www.ncbi.nlm.nih.gov/pubmed?term=%22Hardell%20L%22%5BAuthor%5D

Polish army RF-MW exposure study - Szmigielski S - 1996

"Cancer morbidity in subjects occupationally exposed to high frequency (radiofrequency and microwave) electromagnetic radiation". this study tracked the RF-MW exposure levels and health records of army personal of the polish army for 15 years (both soldiers that were exposed and those who were not). The study shows that personal that was exposed to RF-WM radiation had added risk of 2.07 of cancer, and that their morbidity rate was higher.

Link to the study: http://www.ncbi.nlm.nih.gov/pubmed/8717316
About the study: http://www.microwavenews.com/news/backissues/m-j95issue.pdf

Additional scientific information and tests

However I would like to show you the following video, 2 pictures and a single chart that can maybe tell the all story.

http://www.ncbi.nlm.nih.gov/pubmed/20551697

What happens to your blood when radiated:

Few years ago I came across pictures and articles about live blood cell analysis of human exposed to RF radiation. For years I search for a good, simple, easy to understand video clip that explains the test and shows parts of it.

This video, made by Dr. Magda Havas from the Environmental & Resource Studies, Trent University, Peterborough, ON, Canada, is the best I have ever seen until today. It is short, self explanatory and easy to understand. Dr. Magda Havas explains the test and the outcome while showing pictures and videos from the test itself.

The video show what happens to a human blood when exposed to electromagnetic radiation from a computer and also from a cordless phone. The test outcomes are clearly seen and can explain some of the symptoms of Radiation exposure and of Electromagnetic Hyper sensitive (EHS).

Dr Magda Havas about "Live Blood Analysis"

Does exposure to EMR from DECT phone effect the hart bit?

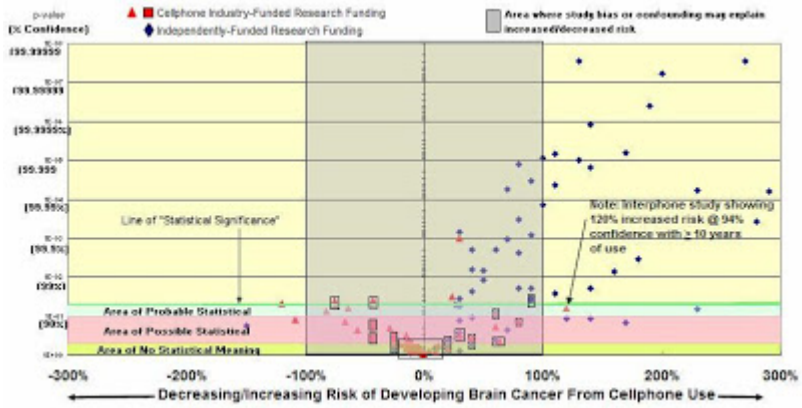
The answer is yes, exposure to electromagnetic radiation from DECT phone does change the hart bit of some people (electro hypersensitive included). The below video summeriest the experiment done by DR. Magda Havas and DR. Jeff Marrongelle that was done in March 2010 and will be published later on in 2010. The experiment tested if exposure to EMR from DECT phones effect people hart rate. The outcomes show that it does, watch the following video for more info.

More about Dr. Magda Havas at http://www.magdahavas.com/ and http://www.magdahavas.org/.

Industry funded resource vs. independent resource

The cart below was done by Lloyd Morgan and it original (fully functional links to all the studies that appear in the chart as dots) can be found on www.powerwatch.org (see link below).
The chart below clearly shows that **industry funded research (in red color)** show none or small increased risk while **independent resource (in blue)** shows that the risk increases a great deal more. In addition some of the industry funded research show improvement or less risk than the control group. This can be cause by faults in the study or it can really represent a change in the functional of the body (that can have good measured aspects but also some hidden bad aspects).

Source: http://www.powerwatch.org.uk/columns/morgan/20060818_viewgraphs.asp



For more info about this article press here...

ELF (Extreme Low frequency) magnetic field health effect studies

Extreme low frequency electromagnetic fields have been calcified by the WHO/IARC as "possibly carcinogenic to humans" in 2002. The classification came after several studies and pool analysis showed that people, and specially children, that lived or studies next or under to high voltage power line had a much larger risk of getting different types of cancer. Some studies did not show a link because of a wrong working premise that the exposure from the power line extends up to 200 meters from the power lines, while in reality the magnetic field reaches only 50 meters from each side of the power line. A pool analysis of the data was done using the 50 meters as the exposure limit and showed the risk and the link to cancer.

The level that is considered to be the risk threshold is 2-3 mG. The ICNIRP, very high, standard of 1000 mG deals with only short term exposure, yet it is being considered by many governance and electrical companies as the only standard that covers also long term exposure. The ICNIRP's standard takes into consideration only one health effect which is muscle tension.

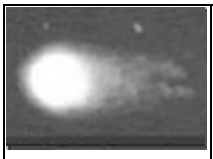
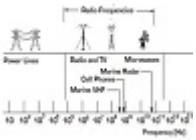
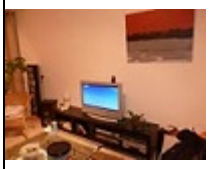
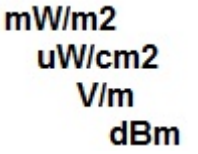
Leading studies about the likes between ELF from power lines to cancer

- **WHO/IARC** - "IARC CLASSIFIES EXTREAM LOW FREQUENCY MAGNETIC FIELDS AS POSSIBLY CARCINOGENIC TO HUMAN" (2002)- http://www.iarc.fr/en/media-centre/pr/2001/pr136.html
- Electrical wiring configurations and childhood cancer - Wertheimer & Leeper in 1979
- Feychting & Ahlbom 1993 - Magnetic fields and cancer in children residing near Swedish high-voltage power lines
- Olsen 1993 - Residence near high voltage facilities and risk of cancer in children
- 2000, 2001 Ahlbom and Schuz & Ahlbom 2008
- Childhood cancer in relation to distance from high voltage power lines in England and Wales - 2005 Draper G, Vincent T, Kroll ME, Swanson J.
- Kabut 2006- Childhood leukemia and magnetic fields in Japan: a case-control study of childhood leukemia and residential power-frequency magnetic fields in Japan.
- Lowenthal 2007 - Residential exposure to electric power transmission lines and risk of lymphoproliferative and myeloproliferative disorders: a case-control study
- Maternal exposure to magnetic fields during pregnancy in relation to the risk of asthma in offspring - 2011

More studies and details about ELF magnetic health risk are available on www.powerwatch.org.uk

: http://www.powerwatch.org.uk/library/downloads/pf-emfs-2-cancer-20110909.pdf

More on EMF/EMR Knowledge on this site:

 EMF/EMR Science, reports and studies	 EMR from cellphone	 Cellphone antennas	 Radiating Smart meters	 Dirty Electricity
 EMF/EMR sources by frequency	 EMF/EMR sources by location	 EMF/EMR sources at home	 EMF/EMR sources at work	 EMF/EMR sources in the great out-door
 WIFI in schools	 RF Units Conversion	 "The cellular, not what you thought"	 EMF/EMR lectures and presentations - soon	Back to EMR knowledge page

Obesity epidemic caused by EMF exposures in the home according to startling new research

Thursday, July 11, 2013 by: Lloyd Burrell
Tags: *obesity epidemic*, *dirty energy*, *electropollution*

(NaturalNews) Two-thirds of the U.S. population is overweight, and about one-quarter to one-third of adults are obese. Fact. Poor diet and a lack of exercise are at fault, the experts say. But what if the cause of this epidemic was something even more insidious? What if that which is considered the lifeblood of our modern day lives, electricity or more precisely dirty electricity, was really to blame?

The answer to these questions is an unequivocal yes. At least according to Samuel Milham, MD, MPH, author of an alarming new study on the link between obesity and exposure to dirty electricity (a form of electromagnetic field pollution).

According to Dr. Milham's study just published in *Electromagnetic Biology and Medicine*, EMFs (in the form of dirty electricity), are contributing not only to obesity, but to a myriad of other health concerns which plague Americans in today's disease-ridden society.

Dr. Milham found evidence of the link between dirty electricity exposures and obesity and diabetes through analyzing worldwide health metric data. He noticed that many small islands known for having the highest BMIs (marker for obesity), worldwide in addition to the highest incidence of diabetes did not draw their energy supply from an electrical grid. An alternative source of energy was commonly used, a diesel generator set, known to be a major source of dirty electricity.

What is dirty electricity?

Dirty electricity, defined as electrical pollution contaminating the electrical grid, stems from the use of many commonplace items found in or around the home but also from the poor design of our electrical distribution system. As Dr. Milham says "the high obesity levels in the US is not surprising, because the U.S. uses the earth as the major conduit for neutral return currents."

Studies show the human body suffers adverse affects at a cellular level from this constant exposure to dirty electricity. Combine this with the fact that there are actually more overweight and obese people living in the United States than people who are living within a healthy weight range and Dr. Milham's conclusions start to make sense.

Electricity and the diseases of civilization

In his book *Dirty Electricity: Electrification and the Diseases of Civilization*, Dr. Milham reveals that as electricity spread throughout the United States in the 20th century, so did other diseases of civilization including:

• ADHD

• Suicide
• Cancer
• Obesity
• Asthma
• Diabetes
• Cardiovascular disease

Affected populations

Is it a coincidence that locations utilizing less electricity have the lowest levels of these exact same diseases? Unlikely.

When comparing the levels of exposure to dirty electricity between the Amish and non-Amish populations the findings cannot be ignored. The Amish people are well-known for their lack of dependency on electrical power. The upshot is a population with half the rate of diabetes and cancer and virtually no obesity or ADHD.

Other recent findings stemming from a reduction of or less exposure to dirty electricity found:

• The number of children requiring albuterol (asthma inhalers) decreased from 37 to only three in one U.S. schoolhouse.
• A lower risk of cancer for California middle-school teachers.

How to reduce exposure

Utility companies should be made to face up to their responsibilities. Supplying consumers with a highly polluted electricity supply which puts populations at considerable risk of harm is not acceptable.

Householders need to act to protect their home and work environment as much as possible. By eliminating certain devices in the home which contribute to this problem, and introducing capacitive filters, many home and work environments can be effectively cleaned up.

Sources for this article include:

http://www.sammilham.com/

http://www.nhlbi.nih.gov/guidelines/obesity/BMI/bmicalc.htm

http://informahealthcare.com/doi/abs/10.3109/15368378.2013.783853

About the author:
Lloyd Burrell is the founder of http://www.electricsense.com/. Since falling prey to a violent reaction to his cell phone in 2002 Lloyd has spent more than 10 years researching the effects of electromagnetic fields (EMFs) on health. He is the author of an eBook entitled "How To Beat Electrical Sensitivity" which offers a solution to the growing number of people whose health is being compromised by exposure to wireless and similar technologies.

http://www.electricsense.com/

Exposure to Electric and Magnetic Fields (EMF) Linked to Neuro-Endocrine Stress Syndrome: Increased Cardiovascular Disease, Diabetes, & Cancer

By Donald Hillman, Ph.D., Professor Emeritus, Michigan State University

Published by Shocking News,[1] No. 8 **Email: donag1@aol.com** **November 2005**

SUMMARY – My heart rate increased 29%, systolic blood pressure increased 10%, diastolic blood pressure increased 48%, and body temperature increased while I was sitting on the sofa with my feet in the 20 to 50 milliGauss (mG) magnetic field corona from the ground wire below the floor. I recorded 228 millivolts and 2.44 amperes (A) of electrical current passing through my body during the 35-minute exposure. Lansing Board of Water and Light utility engineers recorded voltage, 1.5 average to 8.8 A maximum current, 200% Total Harmonic Distortion, and 100-320 mG (10-32 microTesla) magnetic fields for 24-hours at the ground wire in my home. These exceeded IEEE (Institute of Electrical and Electronic Engineers) 519-1992, standards for harmonic distortion (5%), OHSA Directives for hazardous current (1.0 milliampere) and published values related to cancer.

Discovery of EMF in My Home.

A cellular telephone company's request to place additional signal generators-transmitters and antennae on the East Lansing-Okemos Water Tower led to concerns about health risks to citizens in the community and a decision to measure the electrical output from the cellular phone installation. The water tower is located in Patriarche Park across the street from St. Thomas Aquinas School and within 87 to 400 feet of twenty neighborhood homes. Oscilloscope measurements of voltage, frequency, and current on the ground wire from the cell station revealed up to 10 volts (peak-peak), a broad spectrum of harmonic frequencies ranging from 180 hertz to megaHertz radio frequencies (rf) including 1.25 gigaHertz microwaves, with 1.8 amperes (A) of current and 100 or more milliGauss (mG) magnetic fields at the ground wire. Similar readings were on the ground wires and water pipes of at least six homes and the school.The utility mitigated the EMF from the ground wire in my home by installing a dielectric coupling in the water pipe to which the ground wire was attached. These findings were reported to the utility and neighbors in *Shocking News* #7, May, 2005.

EMF - Link to Stress: The present report addresses the physiological connection between the observed increased heart rate and blood pressure, my and neighbors' medical history of cardiovascular disease, diabetes, abdominal aortal aneurysm, diverticulosis, gastro-esophageal acid reflux, and nonHodgkin's lymphoma as evident in an extensive review of literature. The maladies are associated with a broad spectrum of physiological changes involving stimulation of the hypothalamus, pituitary, and adrenal gland secretions mediated through the central nervous system (CNS) which include the brain and spinal cord. Neuro-endocrine reactions comprise the autonomic nervous system which monitors internal and external environmental stimulation through the sympathetic and parasympathetic neuro-endocrine system to achieve homeostasis.

My cardiovascular problems began with irregular heart beat (skipping every 4th beat) and corresponding high blood pressure some years earlier for which I was administered daily diltiazem, a calcium ion channel blocker. I have had two quadruple coronary by-pass surgeries ten years apart, abdominal aortal aneurysm repair, prostate reduction surgery, intestinal diverticulosis, gastro-esophageal acid reflux syndrome, and Type II diabetes diagnosed 4 years ago for which I was prescribed daily endogenous insulin-stimulator drugs. I experienced body temperature rise and perspiration (sweats) which subsided without treatment during the night, and joint-muscle pain. My wife has had difficulty sleeping in the house, has had tumors in the uterus requiring hysterectomy, a gall-bladder ablation, a shrunken kidney, borderline erythrocytic anemia.

A neighbor located 87 feet from the cell tower was suffering from a fibrillating heart, had a heart-valve replaced about five years ago and a pacemaker installed. The pacemaker was replaced after about five years, and a defibrillator was installed to maintain a functional heart rhythm. His wife suffers from multiple sclerosis, a disease associated with scattered demyelination of nerve axons in the central nervous system affecting motor control. Myelin is the insulation coating of nerves that protects them from electrical interference.

The lady next door was currently in the local hospital under chemotherapy and radiation treatment for recurring lymphoma cancer. Her duplex-neighbor lady had surgery for replacement of a knee within the last year and her son, age circa 30 years, is Type-I diabetic using an insulin pump.

Effects of EMF exposure on heart rate and blood pressure were reported by other investigators. Resting blood pressure of ten volunteers increased during exposure to a GSM

[1]***Shocking News*** (dba) is a registered publisher of science-based information dedicated to public awareness of electric and magnetic fields (EMF) in the living environment and their effects on the health and welfare of humans and animals. Editor is Don Hillman, Ph.D.,Professor Emeritus, Department of Animal Science, with help from wife Mary, MS, Michigan State University, East Lansing, MI. Don is a member of the American Society of Agricultural Engineers and The American Dairy Science/Animal Science Association. Telephone: (517) 351-9561.

900 MHz radio-frequency (rf) electromagnetic field for 35 minutes (Braune, S., et al., 1998), and rf fields influenced cardiovascular and hormonal parameters of the autonomic nervous system (Braune et al., 2002). Alteration of diurnal rhythms of blood pressure and heart rate occurred in workers exposed to radio frequency electromagnetic fields in the range 0.738 - 1.503 MHz and 200 - 550 volt/meter (V/m) electric fields, but the changes did not occur in a comparison group at lower exposure levels (Szmigielski et al., 1998). Similar changes in heart rate and heart rate variability occurred in subjects exposed to occupational levels of 50 Hz circular polarized magnetic fields (Sait et al., 1999).

Heart rate and sleep were affected when healthy young men were exposed to 900 MHz spatial peak specific absorption rate (SAR) 1 W/kg simulating exposure to a cellular telephone signal pulsed at a rate of 9 to 14 Hz. While EMF exposure was to the head, workers estimated that exposure of the hypothalamus was 0.1 W/kg, sufficient to affect heart rate and sleep (Huber et al., 2003).

Cardiovascular disease associated with hypertension and ischemia of the heart was 4 to 5 times greater with maximum Odds Ratio 19.1 times higher among men 30 to 39 years of age who were radar trackers in a civil airport compared to co-workers not exposed to EMF (Tikhonova, G. I., 2003). Spectral analysis of heart rate and arterial pressure short-term variability, consists of two major components: low- (LF, 0.04 - 0.15 Hz) and high- (HF, synchronous with respiratory rate). Both heart rate and respiratory rate were modified with sympathetic spinal nerve stimulation (Montano et al., 2001). Modulation of microwave, pulse signals, and continuous wave (CW) magnetic fields affected frog isolated heart pacemaker function and heart rate due to microwave heating of tissues which occurred over a wide range of microwave frequencies (Pakhomov et al., 1995, 2000). Nocturnal 60 Hz exposure affected heart rhythm (Sastre et al., 1998) and brain frequency magnetic fields altered cardiac autonomic control mechanisms (Sastre et al., 1994). Graham et al. (1994) found a dose response slowing of heart rate and alterations in the latency and amplitude of event-related brain measures derived from electroencephalograms (EEG) when human subjects were subjected to 9 kV/m electric fields and 20 microTesla (µT–Tesla is a measure of the flux density or intensity of a magnetic field) exposure compared to 6 kV, 10 µT, and 12 kV, 30 µT dose combinations in blind studies. This study confirmed earlier reports that a combined 9 kV, 20 µT dose resulted in slowing of heart rate, changes in brain wave potentials, and changes in reaction time during challenge testing of humans (Cook et al., 1992). We measured 8 kV/m at head height below a 46 kV transmission line passing through a barnyard where the owner developed high blood pressure and irregular heart beat near Leslie, MI.

Cardiac sympathetic nerve fibers originate in the intermediolateral columns of the upper five or six thoracic and lower one or two cervical segments of the spinal cord. Changes in heart rate usually involve a reciprocal action of the sympathetic and parasympathetic divisions of the autonomic nervous system. Thus, heart rate increases with a decrease in parasympathetic activity (vagus nerves) and an increase in sympathetic activity; and decreases with the opposite effect as described by Berne et al. (1998). The parasympathetic nervous system does not enervate the body wall but only structures in the head and the thoracic, abdominal, and pelvic cavities. Thus, location of exposure to specific frequencies may be important in the heart response to electrical stimulation. However, stimulation of peripheral efferent nerves affects the heart through the neuro-endocrine system and exogenous signals need not penetrate the heart directly. Similarly the heating effect produced by stimulation of the thyroids (TSH) can account for the specific absorption rate (SAR) temperature increase upon electrical stimulation of intact man or animals.

The EMF Cortisol Connection – Cortisol in blood, heart rate, and blood pressure increased; and release of oxytocin was delayed when dairy cows were exposed to 4.0 and 8.0 mA contact current compared to no exposure in controlled experiments (Gorewit et al., 1984). Cortisol is released from the adrenal gland when ACTH (adrenocorticotropic hormone) is released from the pituitary by electrical stimulation of peripheral nerves. Similarly, oxytocin release from the pituitary stimulates excretion of milk (milk release) from the mammary gland upon stimulation of the udder by suckling or massaging of the udder in preparation for machine-milking. Impaired milk let-down, i.e., incomplete milking, was a common complaint of dairy farmers raising the stray voltage issue. Milk retained in the udder can increase incubation of low-level infections in the udder resulting in increased somatic cell count (SCC) according to Mein (1998) which may result in exclusion of milk from the market. Therefore, “uncontrolled electricity” can cause severe economic consequences for dairy farmers, in addition to affecting the health and milk production of the herd and the family. Epinephrine administration significantly reduced milk yield in heifers and cows but did not inhibit oxytocin release in response to milking. Investigators found that as little as 50 µg epinephrine inhibited mammary blood flow to the udder by as much as 90% (Gorewit and Aromando, 1984). ACTH, cortisol, oxytocin, and epinephrine are all involved in the chronic electrical-stress syndrome. These responses are activated by chronic stimulation of the autonomic nervous system as described by Berne et al. (1998).

Cortisol Effects on Connective Tissue – Inhibition of collagen synthesis by cortisol produces thinning of the skin and the walls of capillaries. The resultant fragility of the capillaries leads to intracutaneous hemorrhage (Berne et al., 1998). In this regard, a medical officer for an aircraft manufacturer reported finding between 75 and 100 cases of unexplained bleeding tendency, as well as a significant excess of leukemia and brain tumors among workers exposed to low-strength microwaves (Becker, 1990). Collagen in smooth muscle is an important component of blood vessels, the intestinal tract, bone-joint cushions, cartilage and skeletal muscle connectors to bone. Its integrity is impaired by excessive cortisol and cortisol is increased by EMF exposure. A small step of logic allows the conclusion that EMF affects integrity and elasticity of the aorta and other vessels permitting aneurysm, development of weak smooth muscle, gastrointestinal diverticulosis, ulcers, and gastro-esophageal acid-reflex syndrome. Joint-muscle pain is a common complaint associated with EMF exposure and diabetes, as experienced by the author. Type I personalities are often

associated with a stress syndrome and cardiovascular disease, etc. EMF exposure is clearly another source of neuro-endocrine stress. Which part will give out first under chronic electro-stress environmental conditions is the diagnostic puzzle.

The increased cortisol in blood of cows during short-term electrical stimulation concurs with results obtained when rats were exposed to 0.5 mW/cm^2 for periods of up to 25 months. The exposure was 20 times below the ANSI (American National Standards Institute) and military acceptable standard at the time (A. W. Guy, in Becker, 1990). Blood cortisol of all rats was equal at the beginning, but cortisol of exposed rats increased above controls shortly after the experiment began. By the end of the experimental period, cortisol was lower in exposed rats compared to controls. The cortisol pattern was a typical adrenal response to stress finally resulting in adrenocortical fatigue, as in Addison's disease of humans. While the rats used in the Guy experiments were gnotobiotic (germ and virus free), 18% of the exposed rats had cancers of the pituitary, adrenal, and thyroid glands, and only 5% of the controls had cancer (Becker, 1990; Chou, Guy, et al., 1992). In earlier experiments, serum corticosterone was depressed 31.7 %, while albumen levels increased 28.2%, and body weight was 6.6% lower in rats exposed to150 V/m for 30 days compared to unexposed controls (Marino et al., 1975). Similarly, Imaida et al. (1998) found that mean levels of corticosterone, ACTH, and melatonin were higher for rats exposed to near field TDMA modulated 929.2 MHz RF EMF at 50 pulses/sec, 0.33 duty cycle, than for unexposed controls. The experiment was repeated with rats exposed to TDMA modulated 1.439 GHz RFEMF whole body SARs 0.680-0.453 W/kg for 90 minutes per day, 5 days/wk for 6 weeks. Significant increases were found in the serum levels of corticosterone, ACTH and melatonin in the RFEMF group compared to the sham group. However, no difference was found in the incidence of liver cancer. Cancer of pituitaries and adrenals was not reported (Imaida et al., 1998b, in Heynick et al., 2003).

Note that the level of exposure in each of the above cases was less than the 1.6 W/kg SAR allowed by the FCC and Congressional Telecommunications Act of 1996. The ANSI standard was lowered from 10 mW/cm^2 to the present permissible 1.6 W/kg specific absorption rate (SAR) in 1982 on the basis of "new" information. Apparently, it should be lowered again on the same basis, and technology for controlling exposure needs improvement.

Experimental chronic exposures with intact live animals support the hypothesis that pituitary, adrenal, and pineal glands are affected by modulated, pulsed signals as produced by cell phone signal generators, electronic devices using switch mode power supplies, and by power line 60 Hz, 4 to 8 mA contact current. Current and EMF on the ground wire, water pipes, and kitchen sink 1.68 ± 1.0 A, average of 26 measurements in East Lansing homes was comparable to EMF in the living area and current on the ground wire and bathtub in studies conducted by EPRI, the Electric Power Research Institute (Kavet et al., 2005, 2000, 1999).

The pituitary gland produces hormones and neurotransmitters that affect essentially all functions of the body. In addition to ACTH stimulating the adrenal glands (glucose energy supply) and oxytocin stimulating mammary muscle [and uterine contractions at parturition], the pituitary produces thyroid stimulating hormone (TSH) which controls the release of thyroid hormones and determines metabolic rate and heat production, somatotrophic hormone (growth hormone) which influences body mass, protein and energy utilization (i.e., conversion to milk production, and growth), gonadotrophins: follicle stimulating hormone (FSH) causes growth of the ovarian follicles and stimulates spermatogenesis in the testes; luteinizing hormone (LH) transforms ovarian tissue into corpus luteum which produces progesterone and inhibits the estrus cycle following ovulation. Retained CLs are common in dairy cattle and impair reproduction. Prolactin (PRL) initiates milk synthesis of mammary cells. Antidiuretic hormone (ADH) regulates electrolyte concentrations in the blood and water excretion by the kidneys. The neurotransmitters involved in afferent impulses to the hypothalamus are largely, norepinephrine, acetylcholine, as well as serotonin the most important neurotransmitter in the brain.

Serotonin is also secreted by the pineal gland in the hypothalamus, and serotonin receptors are responsive to EMF exposure (Johnson et al., 2003; Sieren et al., 2004). Dopamine, acetylcholine, γ-aminobutyric acid, and the opioid peptide β-endorphin act as neurotransmitters for efferent impulses to the median eminence of the neurohypophysis. These impulses regulate the discharge of releasing hormones or inhibiting hormones into the adjacent capillaries. Virtually all of the tropic hormones from the adenohypophysis cause changes in the concentrations of either peripheral target gland hormones (thyroid, adrenal, gonadal) or of substrates, such as glucose or free fatty acids.

The enormous influences of chronic cortisol stimulation on body functions are well known in medical circles but the influence of environmental EMF on the neuro-endocrine stress syndrome and human health has been overlooked, perhaps because the pieces to the complex puzzle have not been assembled recently.

Chronic excessive stimulation of either sympathetic or parasympathetic control mechanism causes a stress reaction involving the central nervous system, through stimulation of peripheral nerves and activation of the autonomic nervous system response in the brain and the hypothalamus which contain the pituitary and pineal glands. The pituitary issues hormonal responses in the blood, neurotransmitters, which influence the adrenal glands and the function of virtually all organs in the body (Berne et al., 1998, *Physiology*).

The Diabetes Connection – Cortisol maintains glucose production from protein, *"Although the major impact of cortisol is on liver glycogen, an excess of the hormone eventually increases blood glucose levels. This increase occurs because cortisol powerfully antagonizes the actions of insulin on glucose metabolism. Hence, cortisol inhibits insulin-stimulated glucose uptake in muscle and adipose tissue, and it reverses the insulin suppression of hepatic glucose production.* ***In short, cortisol is an important diabetaogenic, antinsulin hormone. Its primary hyperglycemic and lipolytic and secondary ketonic actions are usually exhibited only when its secretion is greatly stimulated by stress"*** (Berne et al., *Physiology*, 1998).

Insulin secretion of pancreatic islet beta-cells was attenuated by exposure of cells to EMF in three of four laboratory experiments, *in vitro,* (Sakurai, et al., 2004). Exposure of insulin to 0.7 V/m electric field of 50 Hz pulsed frequency EMF produced significant time-dependent differences in the conformation of the insulin molecule, reduced the binding capacity to its receptor, reduced the intracellular tyrosine phosphorlation level, and modified gene expression of insulin-signaling pathways and hepatic cell proliferation (Li et al., 2005). Primary deficiency of insulin as a consequence of selective β-cell destruction is known as Type I or insulin-dependent diabetes mellitus. The disease usually results from a genetically conferred vulnerability to an environmental insult that initiates a destructive autoimmune process. Electricity in the environment may be that insult.

An estimated 18 million people in the United States have Type II diabetes. Because a major cause of this form of diabetes is resistance to insulin, the EMF observations by Li et al. (above) offer promising suggestions for mitigating diabetes by following a specific electron diet or reducing electron exposure to specific frequencies and time periods.

The above factors help explain how EMF, millivolts of high frequency Graham/Stetzer Units (Graham, M., 2003) during environmental exposure in the home was related to increased blood glucose of diabetics ($R^2 = 0.83$) and decreased blood glucose and insulin requirements of diabetics when frequency filters were installed in wall outlets to reduce EMF exposure (Havas and Stetzer, 2004). Similarly, the incidence of Type II diabetes was higher among persons living near high power transmission lines and was positively related to an EMF index (mG x time) daily exposure in Australia (Beale et al., 2001). Milk and milk-fat of cows decreased when exposed to 10 kV/m electrical field and 30 μT magnetic fields (Burchard et al., 2004). Similarly, milk fat was lower from cows exposed to 1-5 and 8-12 mA contact current during milking (Aneshansley et al., 1992). Because insulin is necessary for absorption of glucose into mammary cells, and glucose is essential for milk-fat synthesis, cows exposed to EMF and contact current may have been diabetic.

Cortisol facilitates fat metabolism, supports responsiveness of the vascular tree, modulates central nervous system function, and profoundly affects the immune system. In addition to its effect on glucose and fat metabolism, Berne et al. highlighted the following specific effects of cortisol: **Effects on muscle.** Cortisol maintains the contractility and work performance of skeletal and cardiac muscle. [Remember that short-term stress increases cortisol and long-term EMF stress results in adrenocortical fatigue]. **Effects on bone**. Cortisol inhibits bone formation by several mechanisms: reduces Type I collagen formation; decreases the rate of differentiation of osteoprogenitor cells to active osteoblasts; decreases the absorption of calcium from the intestinal tract by antagonizing vitamin D_3. The result of these actions is a reduction in the availability of calcium for bone mineralization. Thus, one major consequence of excess cortisol production is an overall reduction in bone mass (osteoporosis). **Effects on the vascular system.** *Cortisol is required for the maintenance of normal blood pressure.* [However electrical stress increased cortisol, blood pressure and heart rate of cows and humans as noted above.] **Effects on the kidney.** *Cortisol influences the rate of glomerular filtration. The hormone is also essential for rapid excretion of a water load.* In the absence of cortisol, the synthesis and secretion of antidiuretic hormone (ADH) are increased and its action on renal tubules is enhanced; free-water clearance is diminished and dilution of the urine is limited. Diabetes insipidus, the inability to produce concentrated urine and frequent urination (Gotta-Go syndrome) is the hallmark of ADH deficiency. **Effects on the central nervous system**. Cortisol modulates excitability, behavior, and mood of individuals; the electrical activity of neurons is influenced. Both Type I and Type II glucocorticoid receptors (GRs) are present in various areas of the brain, particularly in the limbic system and the hippocampus. Cortisol decreases rapid eye movement (REM) sleep but increases both slow-wave sleep and time spent awake. In excess, cortisol can cause insomnia, strikingly elevate or depress moods, decrease memory and hippocampal volume and memory function. EMF affected sleep in experimental trials (Akerstedt et al., 1999; Huber et al., 2003, 2004) and student behavior in the classroom (Havas & Stetzer, 2004) and electro-hypersensitive persons had higher heart rate and heart rate variability (Lyskov, 2001). Cortisol also specifically decreases the ability to detect a salty taste and dampens acuity to gustatory, olfactory, auditory, and visual stimuli. On the other hand, cortisol improves the ability to integrate those sensations that are perceived and to organize appropriate responses. **Effects on the fetus.** *Cortisol facilitates in utero maturation of the central nervous system, retina, skin, gastrointestinal tract, and lungs.* (See Berne et al. for details). However, in a study of 1583 pregnant women, those using computers more than 20 hours per week had 40% more miscarriages compared with female workers who did not use computers (Goldhaber et al., 1988). Prenatal development of the central nervous system is a particularly sensitive marker of heat-induced developmental abnormalities and can be correlated with heat-induced behavioral deficits (Saunders and McCaig, 2005). Body heat increased during EMF electrical exposure. Extensive reviews of EMF effects on reproduction, embryonic and fetal development were published by Brent 1999; Heynick et al., 2003; and Levin 2003). **Effects on inflammatory and immune response.** *Cortisol has a profound influence on the complex set of reactions evoked by tissue trauma, chemical irritants, infection, or foreign proteins.*

The EMF Cancer Link – Cortisol inhibits recruitment of circulating leukocytes to trauma or infection sites, decreases phagocytic and antibacterial activity of circulating neutrophils, i.e., increases neutrophils release from bone marrow but decreases their effectiveness for controlling disease, and (EMF decreases AMP to ATP energy transfer in neutrophils), decreases number of circulating eosinophils, decreases number of thymus derived T-lymphocytes, and depresses the immune system response to invading organisms or substances such as viruses.

Melatonin a hormone secreted from the pineal gland is associated with the function of the circadian clock which regulates sleeping, and many related functions of the body.

Leukemia and lymphomas (tumors) are characterized by the abnormal proliferation and reduced differentiation of developing lymphocytes and other blood cells in peripheral blood, bone marrow, and tumor tissues. The diagnostic report for the lymphoma patient revealed: “cytogenetics tests of bone marrow

cells were abnormal in culture cells stimulated by lymphoid mitogens. Two of the metaphases were abnormal due to multiple structural and numerical aberrations characterized by additional material on the short arm of one chromosome 2, trisomy 3 with one being abnormal, rearrangements of 6q, 8p and trisomy for chromosomes 7 and 18 and 2 markers. The spectrum of abnormalities are most consistent with the presence of a lymphoma or other lymphoid disorder. Skin biopsies of both lower left leg lateral and medial section morphological features were consistent with diffuse large B cell lymphoma. Otherwise, the patient was a chromosomally normal female, Karyotype 46,XX ."

Cytotoxicity of a T-lymphocyte line against lymphoma target cells was inhibited by exposure of the lymphocytes to 450 MHz field sinusoidally amplitude-modulated at frequencies between 3 and 100 Hz (Lyle et al., 1983). Exposure of the effector cells to the field prior to adding them to the target cells in the cytolytic assay resulted in a similar inhibition, suggesting a direct interaction of the field with the cytolytic T lymphocytes (Lyle et al., 1993). This corresponds to changes in immunological response of B- and T-lymphocytes to mitogens after long term chronic exposures reported by Guy et al. (1985) and was similar to the failed lymphoblast response to staphyloccus *aureus* antigens in cows exposed to low-level intermittent electricity for two-weeks in a report to Advisors to the Minnesota Public Utilities Commission (Reinemann et al., 1999).

Secondly, changes in the absolute numbers and ratios of CD4+/CD8+ lymphocytes in favor of CD8+ cells of cows at Farm A housed under a 380 kV transmission line exposed to 1.98 to 3.28 μT magnetic fields compared to cows at a distant Farm B considered zero exposed, except in brief periods (3 min × 4 times/day) during which 0.2 to 0.7 μT were present while a feed distributor was running. Investigators found that the mean values of CD8+ and CD6+ leucocyte sub-populations were significantly higher in cows from the exposed farm. Two typologies of CD8+, called Dim and Bright in function of the cytofluorescence analysis, are evident in the exposed farm whereas the population remained single in the not-exposed farm.

Melatonin concentrations are higher during darkness and decrease during daylight. Melatonin is believed to produce strong oncostatic, immunological, and antioxidant functions in the blood. EMF exposure has decreased melatonin concentrations in blood, or urinary excretion of its metabolite, in humans sleeping under an electric blanket (Wilson et al., 1990), electrical workers exposed to 60 Hz magnetic fields while working in substations or on 3-phase conductors (Burch et al., 2003), women exposed to visual display units (computer monitors) during office work (Arnetz and Berg, 1996), in dairy cattle exposed to overhead EMF (Burchard, 2003), and in laboratory animals (Reiter, 1994).

A study conducted in Denmark (Olson et al., 1993) investigated 1707 cases of leukemia, brain tumors, and malignant lymphomas recorded in the Danish cancer registry and were restricted to children of less than 15 years at diagnosis. Controls were selected at random from the central population registry. The study revealed that exposure to magnetic fields (in the order of 0.4 μT, (4 mG) increased cancer. The risk for lymphoma was already increased for fields above 0.1 μT (1 mG). In a study by Robinette et al., (1980) on naval personnel and radio operators it was shown that workers in this occupation had a higher than normal risk for brain cancer. Mortality from cancer was increased close to air force bases compared with other places. It was concluded that this was due to the proximity of radar installations. Similarly, the rate of brain tumors was higher among navy radar operators than among other appropriate controls following the Korean War (Lin, 1985, in Becker, 1990).

EMF-Cancer (Direct Evidence) – Electrical currents had been traced from utility down-ground wires to water pipes where 180 Hertz current combined with 3rd, 5th, and 7th harmonics in the living areas of homes were positively associated with cases of leukemia, lymphoma, and brain tumors where victims had died in Denver, Colorado (Kuane et al., 2002). Positive associations between power line EMF and leukemia, lymphoma, brain tumors, spontaneous miscarriages, alzheimer, and suicide of electrical workers, etc. were reported by California Department of Health Services. For access to some 400 references see (Neutra et al., 2002) at the website listed below or address in the references at the end of this article. Many articles have appeared since 2001 when the California reference list was compiled. Childhood and adult leukemia, lymphoma, and brain tumors have been associated with odds ratios 2 to 4 times greater risk among persons exposed to 4 mG or higher EMF (Kaune et al., 2002; Neutra et al., 2001; Ahlbom et al., 2000; Villeneuve et al., 2000; Robinson et al., 1999; Coghill, 1996; Verschaeve, 1995; Fechting and Ahlbom, 1993; London et al., 1991; Loomis et al., 1990; Thomas et al., 1987; Savitz et al., 1988; and Wertheimer and Leeper, 1979, 1982, 1995). Furthermore, efforts were made to identify possible confounders, that could bias the results of these studies (e.g., air pollution, socio-economic conditions, water quality, traffic patterns, static magnetic fields and resonance models, but no evidence of such confounders has been identified.

Horst et al. (2004) found that persons living within 400 meters of a cellular phone tower had 3 times more cancer than those living more than 400 meters from the tower. Our evidence showing the high frequency EMF typical of the rf and microwaves produced by the cell phone signal generator transmitter measured from the ground wire, and measured on the ground wires and water pipes of a neighbor lady with nonHodgkin's lymphoma, concurs with the results of Ontario, Canada Hydro Electric employees. Incidence of nonHodgkin's lymphoma was 3 to 4 times higher in the top thirty percent exposure-time index of electrical employees based on measured electric fields (thresholds 10 and 40 V/m) compared to administrative and office employees with low exposure (Villeneuve et al., 2001).

Electro-Sensitivity of people is now recognized as a physical impairment by government health authorities in the United Kingdom and Sweden. The UK Health Protection Agency (HPA) recognized that people can suffer nausea, headaches, and muscle pains when exposed to electromagnetic fields from mobile phones, electricity pylons and computer screens. They recognize that general practitioners (GPs) are not generally aware of the electro-sensitivity syndrome and HPA will provide guidelines for GPs to follow in diagnosing the disease.

Doctors may need to examine EMF in the home, and perhaps in their own office to identify the sources and will need to add EMF meters to their instrument bag to confirm a diagnosis.

Development of cardiovascular disease, diabetes, and nonHodgkin's lymphoma of the immediate occupants in this study is consistent with recognition of health authorities that chronic disease "Cancer, Cardiovascular, and Diabetes" account for two-thirds of the $1.55 billion spent on health care in this country and are increasing, according to the Center for Disease Control (Lansing State Journal, 10/02/05). Secondly, our finding supports the likelihood of increased risk of other major diseases caused by excessive exposure to EMF.

National Institutes of Environmental Health mentioned possible EMF associations with sudden cardiac death, dementia, suicide (NIEHS, Portier and Wolf, 1998), and spontaneous abortion (Li et al., 2002, and Lee et al., 2002) as reported by California Department of Health Services (Neutra et al., 2002, p. 10) on website:
http://www.dhs.ca.gov/ehib/emf/RiskEvaluation/riskeval.html

Some of the California EMF findings and Michigan's 51,000 new cancer cases per year were in Shocking News #2, May, 2004, and are on the website www.electricalpollution.com

Sources of EMF – The Ground Wire in Homes, Schools and Workplaces – Our electrical data concur with studies by EPRI (Electric Power Research Institute), the research arm of the power industry. Kavet el al. (2000) found strong correlations with the average magnetic field in the living area and the 24-hour average net current on the service drop (the ground wire) and the number of service drops on the same transformer. Similarly, Kavet (2005) found that EMF in living areas was correlated with volts on water pipes, and volts on the bath tub. Excessive voltage and current was on water pipes, the kitchen sink, bathtub, sheet metal air ducts, chair springs, and bed springs in our home (Shocking News #7).

Modern Household Appliances and Office Equipment with electronic controls, i.e., heating and air conditioning units, television, VDUs (computer monitors), printers, copy machines, MRI, digital clocks, microwave ovens, TV, radio, refrigerators, stoves, etc., produce harmonics and emit large amounts of EMF to distances of 1 to 6 feet from the appliance in our home.

- G/S meter readings from wall outlets in Kellogg Center, MSU were 700 to 1760 G/S Units, while in my home they now read 15 to 20 G/S Units, down from 120-200 (units of high frequency current) in wall outlets.

Mitigation of EMF has been achieved by:

1. Installing a dielectric union (rubber insulated connector) in the water pipe to which the ground wire is connected. Some homes may already have this isolation. You need to know if yours does. If it was built before 1975, it may not have a dielectric connection and magnetic fields on the ground wire and water pipes could be very high.
2. Installation of high frequency filters in the wall outlets of homes can dramatically reduce the EMF from the outlets and the EMF environment in living areas. Contact dave@stetzerelectric.com
3. Installation of a shielded neutral isolation transformer between the utility (source) and the customer (end-user) service connection will prevent the high frequency signals from passing from the utility wires to your home or business circuits. This should be required of all businesses that produce a large amount of high frequency residue (dirty electricity) on the ground wire.
4. Improved maintenance of utility (primary) and/or customer (secondary) wiring to reduce resistance on circuits by installing adequately sized transformers, and neutral to the substation wire conductors serving customers. Most utility engineers know what to do, but executive $ objectives often take precedence over risks to human health and life.

CONCLUSIONS

Excessive electrical current and high frequency rf and microwave magnetic fields were tracked via oscilloscope measurements from the cellular telephone station at the water tower in Patriarche Park. Signals were on the utility ground wire and radiating into the living areas of homes and a school in East Lansing. Heart rate, heart rhythm, and blood pressure were affected during exposure to electromagnetic fields (EMF) in a home. Similarly, occupational exposure and controlled laboratory studies confirm these findings. Diabetes, NonHodgkin's lymphoma, and other health impairments that occurred to residents near the park, plus leukemia, and brain tumors have been associated with EMF in other studies. Cardiovascular disease, diabetes mellitus and impaired immunity are typical physiological responses to neuroendocrine stress. Pituitary and adrenal gland responses to both contact current and electromagnetic current have been demonstrated in humans and animals. Excessive current and mG of magnetic fields were observed at ten homes in the area. Recorded measurements were outside of IEEE stands for power quality and OSHA standards for electrical hazards. Methods for mitigation of environmental contamination are known and should be encouraged by utilities and government agencies responsible for electrical safety and human health.

Michigan Public Service Commission promulgated Rules R460.2701 to RR460.2708, etc. would not require utilities to identify any electrical problem other than 60 Hertz, steady state voltage or current, and would not require using appropriate instruments to detect the problems in the East Lansing community or elsewhere in the state. Further, the MPSC proposed rules will have the effect of using the power of the state to allow utilities to avoid their responsibility to protect citizens and residents from unhealthy and unwanted electrical damage.

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Review Article

Health Implications of Electromagnetic Fields, Mechanisms of Action, and Research Needs

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Abstract

Electromagnetic fields (EMF) have been implicated to influence a range of bodily functions. Given their ubiquitous nature, widespread applications, and capability to produce deleterious effects, conclusive investigations of the health risks are critical. Accordingly, this paper has been constructed to weigh the bioeffects, possible biointeraction mechanisms, and research areas in bioelectromagnetics seeking immediate attention. The several gaps in the existing knowledge do not permit one to reach a concrete conclusion but possibility for harmful effects cannot be underestimated in absence of consistent findings and causal mechanisms. Several studies with appropriate methodologies reflect the capacity of electromagnetic radiations to cause adverse health effects and there are several credible mechanisms that can account for the observed effects. Hence, need of the hour is to activate comprehensive well-coordinated blind scientific investigations, overcoming all limitations and demerits of previous investigations especially replication studies to concretize the earlier findings. Furthermore, appropriate exposure assessment is crucial for identification of dose-response relation if any, and the elucidation of biological interaction mechanism. For the time being, the public should follow the precautionary principle and limit their exposure as much as possible.

1. Introduction

The terrestrial electromagnetic environment has been and is being rapidly altered by humans as a result of technological advancements. This was well recognised very early in the seventies by Dr. Robert O. Becker (twice nominated for Nobel Prize) who said “I have no doubt in my mind that, at the present time, the greatest polluting element in the earth’s environment is the proliferation of electromagnetic fields (EMFs).” On one hand, these electromagnetic waves (EMW) provide immeasurable benefits; on the other hand, they may also create potential hazards through uncontrolled and excessive radiation emissions. There are various types of electromagnetic radiations (EMRs) and

depending upon their frequency and wavelength they are categorized into different types. Broadly the EMFs are categorized into two groups, namely, extremely low frequency (ELF) EMF (>3 Hz–3 kHz) and radiofrequency radiation (RFR) EMF (3 kHz–300 GHz). Scientific investigations concerning the interaction of EMF with living systems, especially its health effects, are increasing in number. There are arguments for both positive [1–3] and negative bioeffects [4–8]. However, the lack of sufficient knowledge on biological effects of the vast majority of frequencies even below the safety limit leads to several apprehensions [9–11]. The discussion is still ongoing especially regarding the contentious nonthermal effects. It is considered that the energy absorbed calculated in terms of specific absorption rate (SAR) [12] is too low to produce biological effects [13]. At the same time, several studies have demonstrated the influence of EMF by energies that are much lower than those capable of producing temperature changes in living tissues [10, 14]. The cell physiology either in vitro [14] or in vivo [15] can be affected by these temperature-insensitive reactions. Whether this could result in pathological alterations in higher life forms is a matter of debate [16]. Despite the documentation of temperature-insensitive biological effects, they have not been considered in the existing EMF safety standard; rather it is principally based on heating effect of EMF [17]. The current SAR values for general and occupational groups are presented in Table 1. As a result, current recommendations are established on the lowest exposure known to induce acute observable effects due to heating [7].

tab1

Table 1: Showing the SAR values for general public and occupational groups laid by ICNIRP [18], International Commission on Nonionising Radiation Protection; SAR stands for specific absorption rate expressed in Watts per kilogram (W/kg).

In the past, when much of the attention was centered on certain EMW called ionizing radiation, the others called nonionizing radiation (NIR) were generally assumed to be harmless. However, after World War II, this assumption has been reconsidered. The overwhelming scientific investigations concerning health effects of NIR have highlighted their potential to affect the well-being of biological organism. Several researchers have raised questions regarding adequacy of current safety limits [17] and asserted for their revival so that the new biologically based exposure limits will be capable of eliminating the possibility of bioeffects [19].

Some of the documented bioeffects include changes in melatonin levels [20–25], induction of heat shock protein (hsp) [26], effects on spatial memory [27, 28], alteration of intracellular calcium concentration [29], changes in blood-brain-barrier permeability (BBB) [30], enzyme activity [31], genotoxicity [32, 33], nonspecific disabilities, and subjective symptoms [34–37] to name a few. Also, radiation exposure from mobile phones (MPs) has been linked with tinnitus, brain tumours, and acoustic neuroma [38–41]. Additionally, studies at cellular/molecular level are important in illuminating the actual primary injury produced by EMFs [17, 27].

The field of bioelectromagnetics is surrounded with controversies because some studies are contradictory [11, 42] and not always corroborated by independent researchers [35]. The lack of any accepted causal mechanism further adds to the controversy. As a result, important details are simply not comprehended and generate confusion in the general public. As uses expand, the new situations are likely to further increase the environmental EMF levels. To cope with these situations and to promote life of biological organisms more comfortably and efficiently achieving a scientific understanding of the biointeractions of these fields and evaluation of health risks is highly desirable. This paper, therefore, has been constructed to weigh carefully the bioeffects, biointeraction mechanisms and lacunae in EMF research areas seeking immediate attention so that the public is not excessively exposed nor the technological advancements suffer a setback by unjust fears that may or may not exist. In this review, we shall restrict our discussion to the health relevant effects of ELF-EMF and RFR-EMF.

ELF and RFR-EMF related studies were identified by peer-reviewed literature and data searched in electronic database (PubMed) using a number of key words and their combinations (electromagnetic field, health effects, electric, magnetic, reproductive outcome, and biointeraction mechanisms as examples) in order to find English-language reports related to electromagnetic field health effects and their probable modes of action. A number of papers were retrieved by hand searching several journals and few were obtained through direct correspondence with the authors. Unlike other review papers, no strict inclusion criteria were set. However, a rational explanation of the experimental design, use of control/sham population, exposure conditions, blinding of the research, statistical assessment of the data, and role of artifacts could be reached for most, but not all investigations.

2. Health Effects of Electromagnetic Fields

2.1. Electromagnetic Hypersensitivity (EHS)

EHS is a recent phenomenon of occurrence of subjective signs and symptoms in some sensitive individuals with EMF experience from varied electronic sources. Despite lower levels of exposures, symptoms of ill health have been observed among the subjects [34]. According to WHO [43], about 1–3% of the world's population are affected by this EHS syndrome. The exposure to EMFs especially at lower levels and for long duration was originally reported among the East European radar workers and linked with a number of subjective and objective (skin and mucosa-related) symptoms. Sufferers often label EHS as loner's disease because of the consequent social isolation [9]. Epidemiological investigations have been conducted on people complaining about unpleasant symptoms (Table 2). Complainants have related their symptoms most frequently to exposure to MP base stations (74%) followed by MPs (36%), cordless phones (29%), and power lines (27%) [36]. Objective skin symptoms of EHS have been related to increase in mast cell counts and their degranulation, thereby causing the release of inflammatory substances such as histamine responsible for allergic hypersensitivity, sensation of itch and pain, edema, local erythema, and many kinds of dermatoses [19]. With reference to effects of ELF-EMF, Barsam et al. [44] studied the effect of occupational exposure on sleep quality in high voltage substation workers. In their case-control study, they found poor sleep quality among 90.5% of cases and 85.3% of controls. Despite, the increased prevalence of poor sleep quality in exposed group, no statistically significant difference was reached. Similar occupational studies conducted in substation units of a petroleum complex also revealed higher percentage of poor sleep quality in addition to poor health condition in exposed population when compared to control population [45]. However, the researchers in this group also could not reach any statistically significant correlation between the ELF-EMF exposure level and poor quality of sleep and health status. Another case-control study undertaken on the occupational group of electric utility workers highlighted the increased rate of suicide attempts in exposed group as compared to controls [46]. The authors also suggested that the occurrence of depression in the exposed workers might be the plausible reason. A study by Beale et al. [47] demonstrated the occurrence of psychological symptoms like suicide, depression, and unmanageable emotional condition amongst the residents exposed to chronic 50 Hz MF exposure as a result of their residence in the vicinity of high-voltage substations and power transmission lines. Case studies and anecdotal reports in this regard indicate that people's health problems like diabetes, multiple sclerosis, asthma, and so forth could have some association with biologically active dirty electricity which has been found to improve when levels are reduced [48]. Dirty electricity present in the surroundings has been shown to affect the well-being of teachers and pupils. Use of filters ameliorated the effects, thereby protecting sensitive individuals [49].

tab2

Table 2: Subjective signs and symptoms of electromagnetic hypersensitivity (EHS) [34, 36].

As regards RFR-EMF, Navarro et al. [37] carried out a health survey in the vicinity of a cellular phone base station, working in DCS-1800 MHz frequency range with exposition time greater than 6

hours/day, 7 days/week, in 95% of the subjects. Exposure assessment was done by measuring microwave power densities at residence of respondents. Statistical analysis revealed a significant correlation between the declared severity of symptoms and measured power density. The study also showed an increase in the declared severity in groups with higher exposures. Comparable studies have also been performed reporting significant relation of some symptoms to the measured exposures [34]. Epidemiological studies suggest that frequency and severity of symptoms tend to increase with duration of exposure and are reversible if exposure is discontinued temporarily or permanently with symptomatic and general supportive treatment and also severity weakens for those residing far away from exposure source. For instance, in one of the health surveys among self-declared EHS individuals, 90% of subjects reported occurrence of health symptoms when present in the exposure area and disappearance of the same after leaving the exposure area [36]. Studies have also highlighted the significant link between longer duration of daily MP use and health effects [31, 50, 51]. The MP use by children in this regard can be deleterious as their nervous system is under development and greater amount of energy is absorbed because of their thinner skull bones as compared to adults; additionally longer exposure duration increases their vulnerability to a greater extent [52]. However, to date, quality double-blind studies have not shown any correlation between subjective health complaints and RF exposure [43]. At the same time, epidemiological studies of EMF well-being are difficult to conduct because of imprecision in exposure assessment [53–56] and lack of objectivity in measuring health effects or complaints [35]. In addition, the symptoms are nonspecific and subjective, based on self-reporting, and hence difficult to prove clinically in absence of clear diagnostic criteria for the condition [57]. The subjective complaints of well-being also vary from individual to individual and are a function of several variables like age, sex, social status, anxiety, current health status and accompanying disease, and personality traits [35] as well as the fear generated due to awareness of adverse effects from EMF exposures [34]. Psychological stress may be one of the consequences of EHS in patients and incomplete understanding of pathophysiology of these complex symptoms in absence of any single biomarker so far recognized unique to EHS makes the diagnosis and medical treatment a complicate endeavour [9, 35]. It has also been suggested that subjective symptoms could be the consequence of already prevailing psychiatric condition or stress response resulting from EMF health concerns instead of the exposure itself [43]. In today's modern world, when we cannot part away from electronic gadgets, the EMF experiences are real and practically unavoidable, resulting in disturbances, which could be devastating for a few afflicted individuals. In dearth of any visible causal mechanism and pathophysiological biomarker, its etiology is quite incomprehensible. The pain of EHS patients aggravates further, when the majority of population do not experience any symptom with EMF exposures. The increasing number of reports on EHS however warns us to take this research promptly and locate the biomarkers that could give some clue in ameliorating the problems of such individuals. More investigations are hence needed to completely delineate the pathophysiology of EHS along with the generation of clear diagnostic criteria to identify the problem and develop strategies to limit the suffering of afflicted individuals. Besides, investigations dissecting the relation between EHS manifestation in elderly, children, and diseased persons (like neurodegenerative diseases, mentally and genetically unstable conditions) with EMF experiences are crucial. The lacunae in human studies, with regard to exposure assessment, inclusion of suitable controls, and data collection, and so forth, need to be eliminated to reach fruitful insights. For the time being, individuals with EHS need to be supported by the family, society, and the government to lead a normal and respectable life.

2.2. Cytotoxic and Genotoxic Effects

DNA alteration is considered to instigate carcinogenesis [8, 58] and change in DNA or micronuclei (MN) generation is an accepted indication for genotoxicity [59]. Different cell types and organisms have been reported to react differently to differing exposure characteristics [26, 32, 60]. Concerning this, Ivancsits and coworkers [61] have identified three responders (fibroblast and melanocytes from human, granulosa cells from rat) and three nonresponder cell types (lymphocytes, monocytes, and

skeletal muscle cells from human) when exposed to intermittent ELF-EMF using alkaline and neutral comet assays. Delimaris et al. [62] examined the effect of pulsed 50 Hz EF on human lymphocytes and showed significant DNA damage in exposed group in comparison to controls. However, Scarfì et al. [58] could not detect any statistically significant genotoxic difference in human fibroblasts exposed to intermittent 50 Hz EMFs. A number of studies have demonstrated the potential of ELF-EMF to cause DNA damage [33, 63–66].

As regards RFR-EMF, d'Ambrosio and coworkers [67] have documented significant micronuclei occurrence with phase modulated RFR as against no effect by continuous wave (CW). Phillips et al. [68] observed reduced and increased SSB, at least in some experiments at low and high SARs, respectively, with RF-EMF exposures as opposed to sham controls. Increased DNA damage was reported in human lens epithelial cells exposed to 1.8 GHz at 3 W/kg [69]. Similar findings were reached by Sun et al. [70] on the same cell types after two-hour exposure to 1.8 GHz at SARs of 3 and 4 W/kg. DNA damage at 4 W/kg was found to be irreversible. Studies on marine radar operators also registered significant increase in MN frequency and comet parameters of % of DNA in tail and tail moment after EMF exposures [1]. A detailed summary of various studies have been tabulated (Table 3). The occurrence of aneuploidy is well acknowledged to enhance the risk of tumour. In this context, linear and SAR dependent aneuploidy rise for chromosome 17 detected by fluorescence in situ hybridization post RFR exposure further substantiates their carcinogenic potential [67]. Significant DNA damage occurred after EMF exposure [71], which decreased with free radical scavenger treatment suggesting free radical involvement in inducing damage [3, 33]. Ferreira et al. [72] found a significant increase in erythrocyte MN frequency in newborn pups from irradiated pregnant rats suggesting the genotoxic potential of EMF exposure. Some investigations have shown the genotoxic potential of EMFs only when coupled with some mutagen or carcinogenic or physical agents indicating their synergistic effect [13, 64]. Cell-culture studies by Luukkonen and coworkers [73] conducted on human SH-SY5Y neuroblastoma cells to study the combined effect of CW-RF (872 MHz) and global system for mobile communication (GSM) with menadione suggested that 872 MHz CW-RF radiations at 5 W/kg might enhance chemically induced reactive oxygen species (ROS) production and thus cause secondary DNA damage. At the same time, enhancement of chemically induced DNA damage observed in this study was associated only with the CW-RF; no effects were seen with GSM signal. Amid these positive effects, Lagroye and coworkers [8] did not find any alkali-labile DNA damage, DNA-DNA cross-links, and DNA-protein cross-links in mouse fibroblast cells exposed to continuous 2450 MHz at 1.9 W/kg for two hours implying their inability to produce genotoxic effects directly by damaging the DNA. Proteomic study on endothelial cell-lines showed the manifestation and phosphorylation of various, chiefly unidentified proteins with RF-EMF exposure [14]. Amid these proteins is Hsp 27, a biomarker for cellular stress. Variation in the expression of cellular stress marker Hsp 90 postirradiation suggests the complex cell defense mechanism and cell response to EMF [26]. EMF interaction with biological system is a very complex process and is a function of several biological, physical, and environmental factors. The exquisite sensitivity of biological systems to EMF experiences leads to intriguing results and regardless of scientific evidences accumulated so far, it is difficult to conclude about EMF toxic effects as the contradictory findings tangle the results confounding the true findings. The differences in experimental protocols in terms of frequency applied, modulation, intensity, investigated endpoints, cell type used, sample size, and so forth have also added to the controversy [5, 10, 60]. Evaluation of present data also becomes difficult due to relatively small number of replication studies because of want for funding. However, possibility of genetic hazard cannot be eliminated in view of conflicting scientific outcomes and lack of accepted causal mechanisms, as the confusion has been generated by some commercial groups in their own interest. Therefore, the need of the hour is to critically analyse the differences and similarities in study variables with greater emphasis with regard to biological systems used, exposure characteristics, study protocol used, findings, data interpretation, and conclusions

drawn along with recognising the source of funding, rather than giving weight to the number of studies either observing or not observing an effect. Addition of statistically sound scientific investigations dissecting EMF biointeraction with respect to field direction, orientation, polarization, duration and time of exposure, and so forth needs to be elucidated to gain fruitful insights into cellular behaviours and their responses. However, this province seems of least interest in bioelectromagnetics research. Further investigations investigating the link between EMF exposures and the blue print, that is, the DNA of children, aged, and sick (neurodegenerative, genetic, or mental disease), are needed and will further substantiate the earlier findings. Given the inconspicuous nature of EMF health effects, even slight deviations in experimental protocols can head towards intriguing outcomes. Therefore, sound experimental designs with appropriate methodologies are critical in order to reach firm grounds. In light of the researches done so far, we conclude that the bulk of literature on EMF and cytogenetic endpoints reflect both positive as well as negative effects. Hence, for now, precautions should be taken to limit the exposures as much as possible.

tab3

Table 3: Studies on the cytotoxic and genotoxic effects of electromagnetic fields.

2.3. EMF and Cancer

Epidemiological investigations have focused attention towards association between ELF-EMF exposures and incidence of tumours [6, 40, 41, 77]. Investigations concerning military personnel also indicate the development of tumours [17]. Amongst all cancer endpoints weighed in epidemiological investigations, childhood leukemia in connection to postnatal exposure exceeding 0.4 μT gets the maximum support for an association [54]. Recently, a formal assessment for suggestion of carcinogenesis from exposure to static and ELF fields by the International Agency for Research on Cancer [78] concluded that ELF-MFs are possibly carcinogenic to humans and grouped them in 2B category.

With regard to RFR-EMF, Hardell et al. [38] in their study suggested that occurrence of vestibular schwannoma has increased in the decades after introduction of cell phones in Sweden, the country with the highest use of mobile technology [17]. Hardell et al. [38] conducted a cross-sectional study in order to find the association between cell phone usage and vestibular schwannoma. Self-administered questionnaire was used for exposure and symptom assessment. Cases were identified from the Swedish cancer registries with age, sex, and geographical area matched control. Histopathological and anatomical tumour localization was done by CT and MRI scans. The authors reported risks for vestibular schwannoma among cell phone users. Significant rise in risk was reached for analogue phone users. Elevated risks were also calculated for cordless and digital phones but these results could not reach statistical significance. The researchers also reported cases of unilateral tinnitus in some persons using cell phone on ipsilateral side; however, a causal relation could not be established on the basis of case report. With regard to association between vestibular schwannoma and cordless and cellular phones, another interesting finding was observed. The highest rising incidence was obtained for men and the age group of 50–59 years. MP use has also been associated with ipsilateral cerebral brain tumours [77, 79], astrocytoma and acoustic neuroma [40, 41], and contralateral temporal tumours [79]. Muscat et al. [79] evaluated the risk of brain tumour in relation to handheld cellular phone use. They included the malignant brain tumour patients as cases (469) and hospital patients as controls (422) after matching for gender, age, race, hospital, and month of admission. Structured interview was employed to gain information related to MP use. The mean duration of MP usage for cases and controls was found to be 2.8 years and 2.7 years, respectively. Out of the 41 measurable tumours, 26 appeared on the ipsilateral side while 15 appeared on the contralateral side. The authors did not find any association between short-term handheld cellular phone use and cerebral brain tumour risk. Another study by the same group [80] based on hospital derived acoustic neuroma patients as cases (90) and patients with nonmalignant diseases as controls (86) reported an average cell phone use

of 4.1 and 2.2 years, respectively. Odds ratio was found to increase from 0.5 for 1-2 years cell phone use to 1.7 for 3–6 years group; however, the relative risk did not differ significantly with regard to the frequency, duration, and lifetime hours of use. The study by Muscat group was surrounded with limitations like lack of data on long-term users especially with regard to under-estimation of risks for slow growing tumours. Hepworth et al. [81] found no association between increased glioma risk and MP use along with absence of any relation with time since first use, years of use, total hours of use, or number of phone calls. The positive association observed between glioma risk and ipsilateral MP use in conjunction with the negative association as regards contralateral MP use was attributed to recall bias as the glioma patients tend to overreport the use on the same side of the tumour while under mentioning the same on the opposed side. This large case-control study was carried out with cases identified from hospital records and cancer registries whereas controls were selected randomly from the general practitioner's list after matching and personal contact. The details regarding the tumour site and laterality and tumour grade were judged from the pathology reports and scans. Computer assisted personal interviews were used to extract the details pertaining to MP use, number of calls made and received, start and stop year, side of use, model and make of MP used, network operator, use of handsfree, usage in rural/urban area, and so forth. On the basis of two case-control studies on brain tumours with regard to MP and cordless phone use, the Hardell group found an elevated risk for ipsilateral exposure with >10 years latency period and subjects started using MP and cordless phone below 20 years of age as regards both astrocytoma and acoustic neuroma [41]. Questionnaire method was employed to evaluate the exposures and cases were identified from the cancer registries. The tumour was assessed with regard to the anatomical region in the brain and was associated with the head side used during phone calls with ipsilateral use defined as greater than 50% and contralateral as less than 50% of the calling time. A review was undertaken with an aim to assess the brain tumour risk in relation to long-term use of mobile phones greater than 10 years and ipsilateral exposure [40]. The reviewers based their findings on the basis of 18 studies (2 cohort and 16 case-control) and found an increased risk for acoustic neuroma and glioma. In addition, the chance of tumour was found to be the highest for ipsilateral exposure in all the studies as reflected by the increased odds ratio. Another review by Levis et al. [82] concluded that the risk for head tumours doubles with long-term MP use. They also observed that methodological flaws with regard to nonblinding of experiments produce negative results and underestimate the risk for tumour development, whereas those studies, which are free from errors, biases, and financial interests, therefore, employing blind protocols, yield positive results indicating a cause-effect link between log-term use of MPs and statistically significant rise in head tumour risk. With increasing number of dynamic MP users worldwide, scientists consider this as the "largest biophysical human experimentation" ever conducted in the past history [17]. An interesting finding was reached in which incidence of brain tumour was found to be higher in populations of cell phone users in rural areas as compared to urban [39]. Also, average exposures have been observed to be slightly higher in rural areas compared to urban areas from MP base stations [34]. In this regard, the connection between exposures and geographic area, ethnicity, nutritional status, economic status, and so forth may provide some remarkable insights and further enhance our understanding. However, association between brain cancer incidence and MP use remains unclear due to inconsistent findings. Short-term and long-term cellular telephone use also did not reflect any connection with cancer risk [6]. As far as cancer risk in animals is concerned, lymphoma risk was found to be significantly higher in experimental groups of mice exposed to pulsed RFR 900 MHz coming from cellular phone than in controls [83].

Study by Cho and Chung [59] suggested the role of low density ELF-EMF as an enhancer in initiation process of Benzopyrene rather than as an initiator of mutagenic effects in human lymphocytes. Most reviews, however, do not support EMF exposures to be carcinogenic. Lack of supportive animal data for carcinogenic potential of EMF also makes the understanding of epidemiological outcomes a difficult enterprise along with faults in human experiments especially with respect to exposure

assessment. Majority of the reviews have indicated lack of evidence for cancer initiation by magnetic field (MF) alone; however, accumulating evidence suggests that they could act as cocarcinogens if given in combination with known genotoxic or nongenotoxic carcinogens showing their synergistic effect. Additionally, the DNA damaging potential of EMFs by free radical generation and also by increasing their lifespan coupled with alterations in DNA repair mechanisms is of concern. However, considering the information in hand on carcinogenesis, cocarcinogenesis with tangling results in the absence of established mechanisms, strict limitations to exposures are suggested till the time any firm conclusion is reached.

2.4. Effects on Endocrine System

Among the several hormones secreted by the body, melatonin gained the focus of most of the EMF investigations. Melatonin, essentially a tryptophan derivative produced chiefly from the pineal gland has been documented to be affected by EMF in animals [25, 84, 85] as well as in humans [21, 22, 24]. In addition, the enzyme machinery involved in melatonin biosynthesis has also been reported to be affected by EMF action [86, 87]. Recently, Bellieni et al. [88] investigated the effect of ELF-EMFs from incubators on melatonin production in newborns who had been kept in the incubators for at least 48 hours. In their study, they found a transitory rise in melatonin secretion almost immediately after the babies were taken out from the incubators, highlighting the EMF potential to influence newborn melatonin production. Significant melatonin depression was registered in an occupational cluster of electronic equipment repairers exposed to ELF-EMFs due to their work in comparison to controls [89]. Epidemiological studies performed on Swiss railway workers exposed to 16.7 Hz MFs exhibited statistically significant reductions in mean evening 6-OHMS (6-hydroxymelatonin sulphate) concentrations after first and fifth days of exposure [24]. The result of yet another occupational study conducted among male electric utility workers exposed to 60 Hz yielded a decrease in postwork shift 6-OHMS/creatinine excretion with temporally stable MF exposures [21]. However, the reduction was found on second and third days of exposure whereas no change was observed on the very first day as opposed to that by Pfluger and Minder [24] indicating the role of exposure duration and that exposure effect may be delayed by several days. Anyway, the experiment of Wood et al. [22] suggested that exposure of humans to 50 Hz circularly polarized 20 μT MF result in a delay in the onset of rise of plasma melatonin concentrations. As regards animal studies, Kumlin et al. [20] found an interesting augmenting effect on the circadian rhythm of melatonin synthesis in female mice strain (CD2F1) exposed to 50 Hz MF having no or very low natural melatonin rhythm in contrast to previous researches using rodents showing chiefly diminishing effects. The findings do not corroborate the registered melatonin diminution in MF-exposed animals but do imply MF effects on pineal gland. Another experiment showed striking reduction in night-time melatonin concentrations as a result of exposure to rapid on/off mode MFs during the day for several days [25]. The authors pointed that rapidly changing exposure conditions create difficulties in acclimatization as opposed to stable exposure characteristics. The inadequacy in exposure characterization and the conduct of investigation at different times, for different exposure durations and at different locations, render the comparison among studies complicated [87]. Melatonin is highly accepted for its antioxidant and tumour inhibiting properties; hence, if oxidative stress (OS) is accompanied by suppression of melatonin levels, it may produce deleterious effects [87]. Given the importance of melatonin for organisms, further studies with better EMF characterization and standardization are crucial. Hormone serotonin, a tryptophan derivative produced chiefly from the pineal gland, has also been documented to be affected by EMF [85, 90]. However, there are very few studies investigating serotonin and EMF connection. Serum cortisol and ACTH concentrations were found to rise significantly in male guinea pigs exposed to 50 Hz EMF reflecting the capacity to cause stress regardless of being a low frequency [91]. Noticeable depression in melatonin and corticosterone levels were reached in a study investigating the effect of continuous EMF emission from video display units in exposed embryos and young chickens [92]. In addition, significant rise in fetal loss was also registered indicating the adverse effects of these EMF

emissions. Occupational studies focused on the effect of EMFs released from magnetostrictive cavitrons used by dentists showed serum cortisol diminution [93]. In the midst of all these studies reporting either an increase or decrease in cortisol concentration, another group of researchers reported no significant change [94] reflecting the inconsistency in this field. With regard to adrenaline and noradrenaline level, significant suppression was registered in electric utility workers exposed occupationally to 50/60 Hz EMFs [95].

As regards RFR, 900 MHz with 217 Hz pulse frequency from digital wireless communication was reported to have no significant effect on salivary melatonin in healthy male students [96]. Cortisol which is a steroid hormone and one of the key stress biomarkers released from adrenal glands has been shown to be affected by RFR-EMF experience [96–99]. It is assumed that RFR-EMF may act as a stressor evident from the increased cortisol concentration documented in previous investigations with animals [100, 101] and humans [102–104]. However, the reports of cortisol increase are contradicted by the results of cortisol diminution [97, 98] and investigations reflecting no effect on adrenal cortisol secretion [96, 105] highlighting the disagreement in this field of investigation. Given the relevance of cortisol, any imbalance can lead to health impairments in due course [103]. More studies therefore in this connection are required to assess the course of action of the biological system in response to EMF stress. ACTH levels were reported to decrease [98] as well as not being affected [97] by RFR exposure. Significantly, higher levels of the stress biomarkers adrenaline and noradrenaline have been reported in physiotherapists [103]. Buchner and Eger [106] also assessed the catecholamines in subjects exposed to cell phone base station. They examined the acute as well as chronic effects of EMF exposure and found a significant increase in adrenaline and noradrenaline levels after EMF exposure, following a drop, but the normal levels were not restored even at the end of the study (about one and a half year). They also observed significant diminution in dopamine levels. Given the role of these catecholamines in controlling B.P., heart rate (HR), and other biological functions, the shift from baseline values due to stress has immense significance for health and well-being and, hence, their continual alteration may prove harmful in due course. Decreases in testosterone concentration with EMF exposure have been stated by some research groups [98, 105, 107] with no effect as well in some reports [97]. FSH levels have also been found to reduce with EMF exposure at MP frequency [105]. So far as, effect on female reproductive hormones is concerned, there is limited number of studies. The few investigations on RFR from MPs and base stations have shown to mutate prolactin but not progesterone levels indicating the consequent effects on menstruation and pregnancy [98]. Significant rise in serum progesterone concentration has also been reported in pregnant rats after microwave exposure [108]. In addition, parallel studies investigating prolactin levels have documented normal levels even after exposure to radio-cellular phones [97, 109]. As far as thyroid hormones are concerned, decrease in T3 [98, 100] and T4 [98, 110] and increase in T4 [100] in parallel to no effect or retention of normal T3 levels [110] have all been documented with EMF contact. These findings when taken together reflect the variation in EMF research and puzzle the understanding about EMF biointeraction and therefore urge for more studies. In light of the above evidences, it seems that EMF acts as a stressor and has the potential to affect the various endocrine secretions posing a significant health threat.

2.5. Effects on Cardiovascular System

An experiment on human head exposure to 37 Hz EMF at a flux density of 80 μT suggested that EMF could alter nociception and may be associated with cardiovascular abnormalities [111]. Håkansson et al. [112] indicated a low level rise in AMI risk in the highest exposure group and observed by means of the synergy index of 2.7 in monozygotic twins that the genetically predisposed subjects have an increased EMF influence for AMI, possibly induced by reduced heart rate variability (HRV). A cohort study on electric utility workers pointed towards an association between occupational 50 Hz ELF-EMF exposure and arrhythmia related heart disorders [113]. On the contrary, a cohort study of railway

workers exposed to 16.7 Hz intermittent MF indicated no association with fatality from arrhythmia related heart diseases or acute myocardial infarction (AMI) [4]. Because of the electric character, the circulatory and the nervous system particularly the autonomic nervous system is vulnerable to EMF effects [114]. More explicit damage of neurovegetative regulation, especially a decreased parasympathetic function, may result with high-intensity EMFs leading to cardiovascular malfunctioning [115]. ELF-EMFs have been also implicated to affect the HRV in newborns [116] and interfere with electronic medical equipment like implanted pace makers, but only when kept close to chest [117]. The detailed summary of various investigations concerning cardiovascular system effects have been listed (Table 4). Ali et al. [118] has attributed the alterations in rat heart functions as a result of decreased RBC membrane elasticity, permeability, and changes in molecular structure of haemoglobin exposed to 50 Hz, 0.2 mT MFs. Yet another study on rats linked the observed histopathological alterations like unclear cytoplasm, polymorphic nucleus, disrupted fibrous tissue, necrosis, and bleeding in heart epithelial tissue with 50 Hz EMF exposure [119].
tab4
Table 4: Studies concerning the effects of electromagnetic fields on the cardiovascular system.

As regards RFR-EMF, Bortkiewicz et al. [115] found more impairment in 24-hour and resting ECG in AM (amplitude modulation) broadcast station workers when compared to radio-link station workers who are supposed to have less exposure. A significantly higher frequency of irregularity identified as conduction, rhythm, or repolarization disturbances in resting and 24-hour ECG (electrocardiography) was noticed among subjects exposed to medium frequency when compared to control [120]. Stress is considered to increase B.P. (blood pressure) and exposure to EMFs has been implicated to cause stress [103, 111]. Vangelova and colleagues [121] found significantly higher systolic and diastolic B.P., total cholesterol, and low-density lipoprotein cholesterol levels in radio operators exposed to RFR and confirmed stronger association between RFR-EMF exposure and the likelihood of becoming hypertensive and dyslipidemic. The researchers, however, noted that the results could be influenced by the extended shifts and monotonous work as well. The study also revealed that majority of the hypertensives who were under medication reached their normal B.P. only when stayed away from the station. Earlier findings have also reported increased hypertension with RFR exposures [115]. Significantly higher levels of stress biomarkers like adrenaline, noradrenaline, and cortisol have been documented in medical staffs with RFR-EMF exposures, which could also influence B.P., heart rate (HR), and so forth, [103]. Recent findings have highlighted the possibility of small short-term and medium-term effects on HR and cerebral blood flow to intermittent universal mobile telecommunication system (UMTS) exposures [122]. Andrzejak and coworkers [123] reported an increased parasympathetic tone and decreased sympathetic tone during MP use measured by HRV analysis and indicated the potential of MPs in affecting the autonomic balance in healthy individuals. However, the confounding effect of talking during measurement of the parameters cannot be neglected. Similar results of sympathetic domination and parasympathetic suppression were reached by Kodavanji et al. [124] pointing towards the link between long-term MP use and adverse effects on HRV, thereby affecting the autonomic balance in healthy individuals. However, since the study was undertaken on a small population without randomization, the results need further confirmation. To add, a recent investigation with the intent to find the effect of RFR-EMF from MP on the electrocardiographic parameters in ischemic heart disease patients taking into account the gender aspect reached some interesting results. They observed prolongation of QT interval in male subjects with or without ischemic heart disease in addition to interference with voltage property of ECG records in myocardial ischemia patients excluding the female counterparts from these effects [125]. In the midst of studies reporting positive findings, parallel studies reporting absence of effects [126–128] create confusion and hampers our understanding. Further long-term studies with better exposure characterization and health assessment are essential to depict the true picture in light of the prevailing

controversy with the employment of the latest techniques. In this connection, EMF effect on newborns and patients with electronic implants or on life supporting systems needs immediate attention.

2.6. Effects on Nervous System

The inability of neuronal cells to divide and repair once damaged makes the organism susceptible to develop several neurodegenerative diseases. The occurrence of Parkinson's disease, and so forth, has been linked to cumulative DNA damage in brain tissues [60]. The increased prevalence of Alzheimer's disease reported among workers of textile factories exposed to ELF-MFs [129] could be one such instance. Ahlbom and coworkers [54] in their review also indicated towards a possible relation between amyotrophic lateral sclerosis (ALS) and occupational ELF-EMF exposure. However, effect of confounders cannot be ruled out. Cognitive performances like attention, perception, and memory have been reported to diminish instantly by 50 Hz, 1 mT ELF-EMF exposure in human subjects [130]. In concert, authors have found significant alterations in learning and information acquisition in passive avoidance learning task in both male and female mice exposed to 8 mT, 50 Hz ELF-EMF [131]. Authors have also found association between occupational ELF-EMF exposures and problems like dementia and depression [132, 133]. Results from animal studies in mice have also established the induction of depression at ELF-EMF exposures due to increased nitric oxide levels in cortex, hippocampus, and hypothalamus [134]. Studies have indicated that short-term ELF-EMF exposure may cause small alterations in neurotransmitter metabolism and in circulating amino acids [90] as well as influencing monoamine metabolism when exposure is in the same direction as the mouse position [42]. In connection, Rajeswari et al. [135] highlighted the importance of orientation of the field exposure with respect to the subject in human experiments. They found the subjects to be restless and aggressive when exposed to pulsations in north orientation, and cholinesterase levels in serum were significantly increased. In east, west, and south orientations, the subjects appeared to be calm and serum cholinesterase levels were normal, which suggested the increase of cholinesterase due to MF stress. Prato and colleagues [136] have reported significant inhibitory effects of a variety of ELF-MFs on endogenous opioid and exogenous opiate induced analgesia in snail Cepacea. Zecca et al. [137] found that higher field strength exposure may raise norepinephrine levels in pineal gland of rats accompanied with key changes in brain involving opioid system in frontal cortex, parietal cortex, and hippocampus. Pertaining to this, the documented calcium ion efflux from brain tissue at RFR exposure can be an important neurochemical effect as their significance in routine nervous system operation is well known, for example, neurotransmitter release for cellular interaction [138].

With reference to RFR-EMF, authors have reported that RFR-EMFs interact with cognitive functions like shortening of reaction times, particularly during tasks that require attention or manipulation of information in the working memory [27, 143]. In yet another study, shorter latency in passive avoidance task was registered in MP RF-EMF exposed rats reflecting significant impairments in memory retention and retrieval [144]. The authors suggested that the RFR-EMF exposure induced damage might lead to alterations in neuronal functioning of both hippocampus and amygdala resulting in changed behaviour during task performance. A cross-sectional study meant to detect neurobehavioural deficits among residents living close to base stations found the prevalence of neuropsychiatric complaints such as memory changes, headache, sleep disturbance, depressive symptoms, dizziness, and tremors to be significantly higher among exposed inhabitants than controls [145]. The study outcomes were based on a questionnaire survey, clinical examination, neurobehavioural test battery (NBTB), and environmental measures with age, sex, education level, smoking habit, occupation, and MP use matching. The NBTB indicated that the exposed inhabitants exhibited a significantly lower performance than controls in one of the tests of attention and short-term auditory memory. The inhabitants opposite the station showed a major reduction in performance in problem-solving test than those under the station. However, in the tests of visuomotor speed and one test of attention the exposed individuals performed significantly well as compared to controls. A cross-

sectional community based study conducted among hand-held cellular telephone users in Singapore found headache to be the most prevalent central nervous system symptom as compared to nonusers and the prevalence increased significantly with increased duration of usage per day [146]. The findings were further substantiated by reduced prevalence by more than 20% among those who used handsfree equipment as opposed to those who never used them. The reduced exposure as a result of using handsfree equipment could be possible because the antenna is kept farther away from the head. Studies have proved the sensitivity of brain cells towards RFR-EMF exposures [139, 140]. Significant increases in brain glucose metabolism in regions closest to MP antenna have been observed with acute exposures [147]. GSM-MP radiations have been demonstrated to induce seizures in rats made seizure prone by subconvulsive picrotoxin doses and to alter the cerebral activity reflected by significantly higher c-Fos levels in some brain regions, which raises question for persons with epileptic disorders [15]. MP-EMFs have been suggested to affect the normal neurophysiology through alterations in cortical excitability as a result of demodulation or direct interference with membrane ionic changes, which results in depolarisation and excitation of nerve cells [53]. However, no histopathological changes have been observed with long-term MP exposures [148]. Increased BBB permeability has also been documented not only immediately but also after seven days of exposure to MPs [30]. So far, the most reliable findings have been reached regarding the brain electrical activity [10]. Impairment in spatial learning and memory functions has been demonstrated in animal studies [27, 143]. Details of investigations with exposure characteristics have been tabulated (Table 5). Lai et al. [28] pointed towards 2450 MHz MW induced short-term memory deficits in rats by the stimulation of endogenous opioids in brain resulting in depressed cholinergic activity responsible for memory functions. The results of Xu et al. [149] pointed towards the connection between extended low intensity GSM 1800 MHz (2.4 W/kg) exposure and synaptic activity evident by decreased excitatory synaptic activity and excitatory synapse number in cultured rat hippocampal neurons. A study investigated the effect of GSM modulated 900 MHz RF-EMF at 1 W/kg on neuron development in two different cell systems by the assessment of morphological parameters and mRNA expression for β-thymosin and stress-related proteins [150]. The authors found a diminution in neurite generation from the soma without any effect on branching and neurite length in both the cellular systems, which was also found to be associated with β-thymosin mRNA overexpression. Yuasa et al. [151] conducted an investigation in order to study the acute effects of pulsed high frequency MP-EMF emissions used for 30 min on somatosensory evoked potentials (SEPs) in healthy individuals. They demonstrated negative effects on SEPs as well as their recovery function indicating the absence of immediate effects on the sensory cortex. EMRs from MP base stations may expose residents to risk of developing neuropsychiatric difficulties and alterations in performance of neurobehavioural functions either by inhibition or facilitation [145]. The comparative analysis of studies relating cognitive and nervous system performance with EMF experience gets complicated due to different assessment tools employed and exposure situations and despite the bulk of scientific evidence, the results turn into conflicting and unconvincing outcomes. At present, the precise mechanism of EMF ill effects on neurons lacks sound understanding; however, some investigations have indicated the role of lipid peroxidation and free radical generation [2, 152]. To add, the nervous system is chiefly helpless to ROS insults because of its high metabolic rate, inadequate oxidant protection, and reduced cellular turnover [152].

tab5

Table 5: Studies concerning the health effects of electromagnetic fields on the nervous system.

2.7. Effects on Reproductive Functions

Rising male infertility cases in recent times have led to scientific investigations, which indicate the involvement of EMRs as one of the possible environmental factors [153]. Understanding of EMF effect on reproductive functioning is also clouded by contradictory findings [154] despite several decades of research. MPs rather than being a status symbol nowadays have become a part and parcel of everyone’s life since the past decade and a half [155]. As it is often carried in pockets in very close

proximity to body and the reproductive system, effect of the same on male infertility is an important issue, which seeks immediate attention. Various studies have been undertaken to investigate the potential of ELF field characteristics in inducing damage to the reproductive system [156–160]. In this regard, intermittent 50 Hz low frequency horizontal EF exposure has been reported to cause significant histopathological alterations like focal tubular atrophy, necrosis, and seminiferous epithelial erosion in rat testis [156]. The serum testosterone levels, however, did not differ significantly between exposed and control groups. Toxic effects of 60 Hz, 1 mT ELF-EMF were also reported in male rat offspring exposed from gestation day 13 to postnatal day 21 [159]. The study found a reduction in the count, diameter, area, and volume of seminiferous tubules and height of seminiferous epithelium along with leydig cell count indicative of the harmful effects on testis development. On the contrary, 60 Hz, 500 μT exposure for 21 hours/day from gestation day 6 to postnatal day 21 in pregnant rats did not elicit any significant difference between the exposed and the controls with regard to spermatogenesis and fertility in male offspring [160]. With reference to investigations in mice, 60 Hz EMF was found to raise significantly the germ cell death and defects in seminiferous tubules without any effect on the body or testes weights. At the same time, the same frequency of EMF at 0.5 mT was shown to induce DNA breakage though cell survival was not significantly impaired [157]. Another study at 60 Hz, 14 μT, and 200 μT reported the induction of apoptosis in mice testicular germ cells [158].

As regards RF-EMF exposure, animal studies undertaken so far document higher levels of sperm head abnormalities, positively correlated to RF-EMF exposures suggesting a dose-response effect [165]. Aitken et al. [166] reported alterations in genome of epididymal spermatozoa in mice exposed to 900 MHz RF-EMW, 12 h/day for 7 days. Parallel studies in rats have documented lower spermatocyte counts along with leydig cell hyperplasia and elevated testosterone levels at 2.45 GHz frequency [154]. Significant decline in protein kinase C and total sperm count together with increased apoptosis was reported in male rats exposed to RF-EMF (2 hours/days, 35 days, 0.9 W/kg) from MPs [167]. The investigators indicated the possible role of ROS behind these findings. Previous study on rats found major impairments in OS equilibrium in reproductive tissues along with modified semen parameters reflecting the fundamental connection between RF-EMR exposures and mutations in semen quality [168]. In contradiction, no difference in testicular function was found at GSM-RF exposure from cellular phone in rats [169]. An in vitro study assessing the effect of 900 MHz MP radiation at a SAR of 2.0 W/kg on human sperm's fertilizing potential found no harmful effects on acrosome reaction [170]. However, the researchers did reach significant findings with regard to sperm morphometry and a measurable decline in sperm binding to hemizona was found thus indicating a significant effect of RF-EMF on male fertilizing potential. Interesting findings were reached in a study evaluating the effects of RFR released from GSM multiband MP (900/1900 MHz at a SAR of 1.4 W/kg) in Drosophila melanogaster exposed during the 10-day developmental period from egg laying through pupation [171]. The authors reported elevation in offspring count, stress protein hsp70 concentration, and binding activity of serum response element (SRE) in conjunction with phosphorylation of nuclear transcription factor, ELK-1 indicative of cellular stress, which could further lead to critical alterations in the organism. Observational studies conducted in connection to RFR-EMF exposure reported diminution in semen quality by reduced sperm count, motility, viability, and normal morphology which were also found to be a function of duration of MP use [163]. Wdowiak et al. [172] also demonstrated an increase in the proportion of sperm cells with abnormal morphology and a decrease in the proportion of rapid progressive sperms with the frequency of exposure from GSM-MPs. Davoudi et al. [161] also reported a decrease in rapid progressive motile sperm due to GSM-MPs. The details of investigations have been summarised in Table 6. Extended MP uses have been reported to elicit harmful effects on sperm motility in previous researches as well [162, 173]. Studies show a possible relationship between occupational exposure to radiofrequency equipment including radar and reduced fertility and sperm quality [164, 174]. Epidemiological investigations have indicated a link between male infertility and MP use, but the mechanism of action is unclear. The role of hyperthermia in

causing infertility is apparent but the nonthermal effects are debatable [154]. However, it has been speculated that the effect could be specific to EMR effect, a thermal effect, or due to the combination of both [168]. So far, motility or sperm movement is the only factor observed to be affected significantly [155]. Reproductive functions like meiosis, fertilization, and so forth are particularly vulnerable to toxic insults [154]. De Iuliis et al. [153] have highlighted the occurrence of ROS and DNA fragmentation after RF-EMR exposure putting a question mark on the safety of MP use especially in the context of fertility and children's health. Until now, the malfunctioning porous cell membrane and disrupted calcium homeostasis along with OS can be accounted for the damaging effects on testicular cells [12]. Conclusive outcomes have not yet been reached despite extensive researches. So far, long-term studies concerning EMF effects on male reproductive functions are lacking to substantiate the findings and give any clue regarding the biointeraction mechanisms. As far as effect on female reproductive system is concerned, there is limited number of studies. RFR from MPs and base stations have been shown to mutate prolactin but not progesterone levels indicating the consequent effects on menstruation and pregnancy [98]. Miscarriage risks have been shown to be higher in pregnant physiotherapists due to their occupation [175]. Han et al. [176] found significant rise in risk of embryo growth cessation in the first pregnancy trimester of pregnant women especially with the medical history of embryo growth termination with regard to increased exposures from television and MPs. Animal investigations also support the toxic effects of RFR. In this connection, Gul et al. [177] registered a fall in follicles count in rat ovaries submitted to intrauterine RF exposures whereas Xu et al. [178] demonstrated toxic alterations in the reproductive organs. Further studies in females are wanted with special relevance for pregnant women, who are also carrying the future generation. Children form yet another group of prime importance since their reproductive systems are immature and exposures are prolonged; hence, they can be the worst sufferers.
tab6
Table 6: Studies concerning the health effects of electromagnetic fields on the reproductive system.

2.8. Auditory and Ocular Effects

A recent study [179] concluded that higher ELF-EMF exposure at 50 Hz, 10.182 kV/m coupled to 4.45 pT MF may give rise to adverse auditory effects especially to the organ of Corti and outer hair cells as a result of decreased distortion product auto acoustic emission amplitudes in higher frequency region localized in basal turn of cochlea in rabbits which have also resemblance with human's frequency spectra. As regards RFR-EMF, MP use has been associated with tinnitus and acoustic neuroma [38, 41]. Ear is the first biological structure to be hit by EMFs from MP. In addition, relatively greater vulnerability of cochlear outer hair cells to injuries from a diversity of exogenous and endogenous agents makes the system a victim of radiation emissions [179, 180]. These days, about 50% of world's population possesses a MP [30] and even greater than that are experiencing EMF emissions through "passive mobile phoning" [181]. Hearing problems reported in few observational studies [50] have also been investigated to occur in animals [179] with parallel contradictions [180, 182]. Studies with ten minutes acute MP radiation exposures have resulted in no immediate effect on hearing threshold level of pure tone audiometry, transient evoked otoacoustic emissions [183], auditory brain stem response [184], and any depreciation in hearing in young human volunteers. However, regular long-term MP use has been linked to increased relative risk of acoustic schwannoma [39]. Despite the interests in EMF effects due to MP, there is lack of solid evidence regarding the ill effects on auditory system and, hence, we are far from any conclusion and not able to develop safe and sound communication devices necessary for safeguarding one of the senses [11].

Heat-related skin injury and lens defects reported in eyes of man are the only undisputed harmful effects of MW exposure [56]. Carpenter [185] in late seventies reported that microwaves have the capability to induce cataracts and affect the eyes by reducing the ascorbic acid content of the lens coupled with the inhibition of DNA synthesis and mitosis in lens epithelium thereby slowing down the

recovery process. In addition, the lens becomes more vulnerable to EMF threats because of decreased water content and absence of vasculature [12, 56, 186]. Spector [187] suggested the role of OS in cataract development due to extensive oxidation of lens protein and lipid at older age. Nevertheless, the database is yet deficient to decide regarding ocular defects including cataracts in human subjects exposed for extended durations.

2.9. Effects on Sleep Parameters

Sleep insufficiency was observed to be more common in the occupational group of electronic equipment repairers exposed to ELF-EMF though not statistically significant when compared to controls [89]. Earlier studies have also documented diminished sleep and sleep efficiency with 60 Hz MF experience [188]. So far, studies evaluating sleep quality in the context of ELF-EMF exposure in humans have not reached any statistical significance [44, 45, 89].

In connection to RFR-EMF, Abelin et al. [189] reported the prevalence of difficulties of falling asleep and, in particular, maintaining sleep, which increased with increasing RF-EMF exposure in the vicinity of short-wave broadcast transmitter. In addition, sleep quality was found to improve after interruption of the exposure. A similar study found an association of EMF exposure with sleep quality and melatonin excretion but only in poor sleepers suggesting the sensitivity of a group of people [190]. The authors highlighted that the absence of blinding in their investigation could lead to such results. Another study by Wiholm et al. [191] indicated the negative influence on sleep component during laboratory exposure to 884 MHz wireless signals. Besides, volunteers with no self-reported symptoms related to MP use appear to have more headaches during actual RF exposure as compared to sham exposure. Several studies evaluating RF exposure effects on sleep parameters and sleep EEG are surrounded with contradictory outcomes owing to methodological limitations like small sample sizes and lack of replications of the previous findings. According to a clinical review [192], sleep disturbances do not seem to be a predominant complaint under exposure to high frequency EMF and with the present level of knowledge no final conclusion can be drawn concerning any potential health hazard. Hutter et al. [34] also reported no significant effect on sleep quality and pointed that it could be dominated by the fear of negative health effects of EMF radiations as well as age. Sleep is an important component of the biological species to overcome the daily wear and tear. Studies relating EMF exposures to sleep do suggest some biological effects; however, these do not provide evidence for any adverse health consequences. Further research with well-designed protocols is required with lessons from past experiments so that valuable information is updated in bioelectromagnetics field.

3. Mechanisms of Action

3.1. Thermal and Nonthermal Interactions

Due to lack of sufficient energy required to break the molecular bonds in cells by EMFs, the elicited effects are assumed to be indirect and secondary to other induced biochemical modifications [60, 76]. Ruediger [32] suggested the indirect role of microthermal processes, OS and altered DNA repair mechanisms behind the observed effects. However, studies have also pointed towards the involvement of resonance-like sensing mechanisms working only at specific combinations of frequency and amplitude suggestive of a direct EMF effect [136]. It is proposed that low frequency time varying electric fields (EFs) interact with the body by the induction of electric currents, formation of electric dipoles, and reorientation of existing dipoles whereas interaction of time-varying MFs leads to induced EFs and circulating electric currents. Higher current densities and EFs have been shown to be induced when the direction of external EF is parallel to the longer vertical axis of body (from head to feet) and the MFs are from front to back, respectively, due to better coupling with human body compared to other configurations [193]. Additionally, EMF effects are dependent on a number of physical (frequency, modulation, polarization, wave characteristics, near or far field configuration, duration and orientation of EF and MF exposure, dielectric properties, conductivity and water content of tissues,

and environmental factors like humidity, temperature, etc.) and biological variables (species, shape and size of the body, weight, geometry of the body, and nutritional and health status).

The possible effect of EMF irradiation is either thermal or nonthermal depending on frequency and strength. The elicited effects are assumed to be noticeable when not shrouded by thermal noise also termed as Brownian motion which is a virtue of all objects/materials above absolute zero temperature. The thermal effects are induced as a consequence of heat gained by water contained in body tissues. Hence, body tissues or organs like lens of eye and testes with less vasculature or deficient in water content are the most vulnerable to even small rise in temperature. Usually, body parts with the smallest cross-section like hand, feet, fingers, and toes gain the maximum values of current densities and EFs [193].

3.2. Oxidative Stress

OS resulting from imbalance of reactive oxygen species (ROS) and antioxidants, leading to disruption of cell functions, has been proposed as one of the probable modes of EMF action [2, 5, 60, 71, 196]. EMFs have also been implicated to lengthen life of free radicals particularly by Fenton reaction [33], affect enzyme activity [31], and change protein levels indicative of induction of cellular stress response pathways [14]. Fenton reaction is a process in which hydroxy free radicals are generated from hydrogen peroxide produced during mitochondrial oxidative respiration in presence of transition metals like iron [60, 64]. EMF interaction with free radicals and transitional metals has also been linked to the observed genotoxic effects [33, 64]. In this regard, cells, which are metabolically active, or have higher cellular concentrations of free iron and superparamagnetic iron particles (magnetites) in body tissues like brain cells, are more vulnerable to EMFs [60]. Several studies have demonstrated OS inducing ability of EMF including MP-RFR in different animal models [31, 152, 196–198] or in cell cultures [64, 73] paralleled with negative findings as well [5, 7]. Studies demonstrating EMF's ability to cause OS are summarised in Table 7. Given the credence of free radicals in signal transduction and EMF in boosting the free radical lifetime, there are chances of EMF influencing signalling [194].

tab7

Table 7: Studies showing the oxidative stress inducing ability of electromagnetic fields.

3.3. Melatonin Diminution

Several human and animal studies conducted thus far have suggested decrease in melatonin after EMF exposure [21, 23, 24, 87]. Like all other EMF effects, melatonin diminution is also surrounded with conflicting results [87]; however, the effects have been suggested to be somewhat constant, at least in rodents [199]. Some studies have also supported the protective effect of melatonin against oxidative damage induced by EMFs [2, 3, 64, 152, 195] pointing towards the OS mechanism involved in generating negative health outcomes and melatonin's beneficial properties. The hypothesised mechanism of EMF action on melatonin concentration is through the imitation of light rays to the retina [22]. To add, Yaga et al. [86] found significant suppression of N-acetyltransferase (NAT) activity, a rate-limiting enzyme in melatonin synthesis due to MF exposure. The melatonin forming enzyme hydroxyindole O-methyl transferase has also been documented to be affected [87]. Melatonin's shielding actions counter to EMF ill effects are supposed to shoot from its direct free radical foraging and indirect antioxidant property of inhibiting free radical production at the power house of the cell and, hence, diminution of pineal melatonin secretion could be proposed as a possible mechanism of EMF interaction with living organisms.

3.4. Calcium Flux

Calcium ion efflux/influx has also been proposed as the biological mechanism [200] and is dependent on ambient temperature, geomagnetic field intensity, direction, and signal strength [201–203].

Calcium ions are crucial for cAMP pathway as well as serotonin/melatonin conversion and their efflux from pinealocytes is supposed to cause melatonin suppression. Besides, calcium dependent signal transduction systems also have been implicated in the mediation of immune cell effects by low frequency EMF [29]. However, authors have indicated the occurrence of calcium efflux/influx at some specific exposure combinations but not at other relatively closer exposure characteristics mainly due to the "window" effect or nonlinear nature of modulation frequency and intensity effect.

3.5. Molecular Mechanisms

Similar to physiological stress response at the organ system level, there are also cellular stress responses at the cell level to impart protection to the cell from external and internal stressors. The cellular stress response is characterized by an elevation in stress protein concentration [204] in response to a stress causing damage to biomolecules like DNA and proteins [205]. EMFs at ELF, RF, and amplitude modulated RF have been demonstrated to stimulate the same stress response [204, 206, 207]. Unlike the past assumption of absence of DNA-EMF interaction plausibility, recent investigations indicate the potential of EMF both ELF and RF to stimulate DNA and induce protein expression [14, 171, 208, 209]. Various studies have highlighted the genotoxic ability of EMF at both ELF and RF range as evidenced from DNA strand break reports post-EMF experience [33, 63–65, 68]. Recent investigations have further revealed the presence of an EMF reactive sequence in DNA [210] which acts particularly in response to EMF stimulus. These EMF reactive DNA sequences code for the production of the chief stress protein hsp70, in response to the binding of transcription factor, heat shock factor 1 (HSE-1) to heat shock element (HSE) in the promoter region [210–213]. Friedman et al. [209] delineated the molecular mechanism behind the stimulation of the ERKs in response to RFR exposure at MP frequencies. The RF-EMF through its interaction with NADH oxidase in the plasma membrane causes the formation of ROS, which further activate the MMPs (matrix metalloproteinases). Because of activation, the MMPs break into Hb-EGF [heparin-binding EGF (epidermal growth factor)] and stimulate the EGF receptor, which sequentially triggers the ERK cascade. The ERK cascade is one of the four mitogen-activated protein kinase (MAPK) signaling cascades that controls transcription and associated cellular processes like replication, cell-cycle progression, apoptosis, differentiation, metabolism, and so forth, in reaction to extracellular stimuli. The MP radiation induced overexpressed protein transcription factors have been found to regulate the cellular processes such as apoptosis [214] and replication and cell cycle progression [14, 215]. The reported findings with regard to cellular stress response post-EMF experience give critical insights into connection to harmful health-relevant potential of ELFs and RFRs in addition to their role as cellular biomarkers.

In light of several credible biointeraction processes, the OS mechanism appears to gain the maximum support. The hypothesised EMF biointeraction path may involve ROS generation, leading to diminished antioxidant capacity, affecting the antioxidant/prooxidant equilibrium and causing OS, thereby instigating adverse health effects. This sequence may be paralleled by calcium efflux, which alters serotonin conversion into melatonin thus triggering melatonin diminution, which further substantiates OS. At the same time, ROS may lead to the activation of signal transduction pathway trigging the ERK cascade. The cellular stress response mediated by hsp70 overexpression can also be considered but this effect is limited to certain group of cells while other cell types are being nonresponsive [216]. The exact mode of biointeraction mechanism still needs to be elucidated.

4. Research Needs

The limited quality of research works in bioelectromagnetics and methodological problems is an important concern [57, 155]. Until now, epidemiological investigations have failed to get the SAR value which is the most direct dosimetric measure of an individual's exposure at the tissue or organ level under study [217]. Moreover, lack of an appropriate exposure assessment method [55] and

reliable equipment for calculation of energy absorbed in the body and the intricate relation with species, frequency, power, EMF source, and modulation dosimetry has inhibited the utilization of laboratory results to human conditions [53] and the conduct of epidemiological studies [56]. Hutter et al. [34] suggested the usage of personal "exposimeter" or long-term exposure monitoring as the best way for exposure assessment. So far, errors in exposure assessment due to lack of long-term exposure monitoring by EMF dosimeters, exposure has been assessed by crude methods in most studies, such as wiring codes, occupation or residence in relation to proximity to a source, spot measurements, time-weighted average and self-reports, and hence results in underestimation of actual risk and clouds the true relationship. Absence of suitable control population for comparison as all of us are exposed to EMFs every day coming from varied sources with different degrees further complicates the understanding of literature on human EMF exposure [52, 55].

Furthermore, clear understanding is hampered by the multipart interactions of different EMF exposure factors [12, 53] and shape, size, mass, orientation, and electrical characteristics of body and individual characteristics like age, gender, activity level, incapacitation, or illness [218]. Environmental parameters like ambient temperature, wind velocity, humidity, and body insulation also affect the communication between body and the EMF vector. Anatomical differences among humans and animal models as regards size, shape, reproductive tract variations, and so forth further complicate the understanding of observed results [12].

As far as studies investigating exposure of humans to MP radiations are concerned, they have followed the standard method of EMF exposure assessment by retrospective interviews or obtaining information or self-reports of subjects on total duration of use or number of calls, number of years of use, side of use ipsilateral, or contralateral along with exposure duration estimates and billing records from service providers [52, 79]. However, these parameters have been questioned for recall bias [52]. Animal experimentation especially using primates or species closely related to humans would eliminate the chances of recall bias regarding MP use and give meaningful directions. Besides, the duration based exposure assessment is built on the postulation of equivalent power emissions per minute from all phones which may not be correct with expanding use of GSM based phones with variable power outputs ending in miscalculation of true exposure in spite of recall accuracy [217]. Besides, geographic area, physical environment, user location rural or urban, distance between user and base station antenna, handsfree use, individual characteristics of phone handset, and its use as well as technical features of provider network all have some effect on EMF emissions and consequent exposure to the individuals [12, 34, 52, 219].

A research carried out by Erdreich et al. [217] to increase the accuracy of exposure estimation in epidemiological studies of GSM-MPs found that the average power output rate in GSM phones varies with several characteristics of phone use, the largest being the site of investigation, followed by user movement and location (indoor or outdoor), use of handsfree device, and urbanicity. The understanding is complicated further by factors like distance to the phone, holding position, position of antenna, pinna size, elasticity of ear, thickness of skull bone, type of tissue, tissue type distribution, and so forth, governing the actual amount of power absorbed [220]. In addition, lack of long-term studies also restricts our understanding. Apart from this, role of media finds significance in focusing the attention on the potential adverse health effects caused by MP radiations. This may give rise to fear or awareness forcing MP users to report more symptoms than nonusers even if the prevalence of symptoms were equal [146].

Animal and cell culture studies are surrounded with conflicting results as a consequence of the heterogeneous exposure conditions (type of EMF-RF, MW, CW, Pulsed, and so forth, SAR value, exposure duration) [5, 7] and differing assay protocols [53]. At the same time, vested interests of

sponsors also influence the study outcome with quality studies having mixed funding and, hence, sponsorship should be taken into consideration while interpreting the findings [221]. We strongly advocate that with mere swelling number of studies no fruitful conclusions can be reached. If we do not address the limitations of past investigations, we may not be able to truly contribute to the domain of bioelectromagnetics. Therefore, need of the hour is to do innovative research with sound designs and appropriate methodologies rising above the demerits of past researches.

5. Conclusion

Given the ubiquitous nature of EMFs, their widespread applications, and their capability to produce deleterious effects, conclusive investigations of the health risks are critical. With the published literature on EMF, it is still not sufficient enough to reach a concrete conclusion. But the possibility of negative consequences cannot be excluded. Several studies with appropriate methodologies reflect the capacity of EMFs to cause adverse health effects. However, the absence of any established biointeraction mechanism does not diminish the reliability of these studies as there are several credible mechanisms like OS that can account for the observed effects.

Therefore, need of the hour is to restrict the swelling numbers of scientific investigations and in place activate comprehensive well-coordinated blind scientific investigations especially long-term studies overcoming all limitations and demerits of previous findings with suitable replication studies and follow-up. There is a need for standardized research methodology along with the inclusion of appropriate exposure assessment technique which is crucial for identification of dose response relation if any and the elucidation of mechanism for biological interaction. If we do not work upon the demerits of previous findings, we may remain far from any concrete conclusion. At the same time, it is critical to analyse the EMF investigations giving more weight to the similarities and dissimilarities rather than giving more importance to the endpoints reached.

For the time being, since it is difficult to protect oneself from EMFs, the only practical way to check exposures is to distance oneself from the source. Together, the precautionary approach and ALARA (as low as reasonably achievable) principle can also be applied to save us from substantial exposures and the possible ill effects if any. The objective is to minimize EMF exposures to the greatest degree possible without significant economic cost and disturbance.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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http://www.dailymail.co.uk/sciencetech/article-1346285/Mr-Fox-fantastic-sense-direction-uses-magnetic-field-hunt.html

Mr Fox has a fantastic sense of direction as he uses the magnetic field to hunt

By David Derbyshire for MailOnline
Updated: 03:11 EST, 12 January 2011

Foxes aren't just cunning - they also have a fantastic sense of direction, scientists have shown.
A new study has found that the creatures are able to detect the Earth's magnetic field and use their navigational skills to hunt mice, rabbits and voles.
In tests, animal behaviour experts discovered that foxes tend to face north east when jumping on prey, no matter their location or the time of day.

Researchers believe they combine their acute hearing with their uncanny sense of direction to time jumps perfectly.
The discovery means foxes join other migratory animals - including pigeons, turtles and whales - in being able to sense the points of the compass.
The same team of scientists has previously shown that cattle and deer tend to align themselves with the Earth's magnetic field when resting so that herds end up pointing in the same direction.
Prof Hynek Burda, of the University of Duisburg-Essen in Germany, studied the behaviour of 84 wild red foxes at 65 locations across the Czech Republic as they pounced on food.

Foxy loxy: The predators combine their acute hearing with their uncanny sense of direction to time jumps perfectly

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Safety Advice for Electromagnetic Fields

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Potential Wireless Health Effects

The following sections discuss the scientific and epidemiological studies.

- Infertility
- Cancer
- Sleep Disruption/Insomnia
- Calcium Efflux
- Arrhythmia and other Cardiac Problems
- Neurological Problems
- ADHD
- Immune System Changes
- Allergy, Asthma
- Autism
- Mercury
- Plants
- Animals

For more on the mechanisms that may explain the biological/health effects, refer to the Science Overview.

Infertility

Wireless technologies may increase the risk of infertility, by impacting human sperm count, motility, and normal morphology.[1] Five countries have now shown that cell phone use among men had negative effects upon sperm. Relevant studies were done in Ohio, Wisconsin, as well as Australia, Hungary, Poland, and Turkey.[2] Occupational exposure of Danish personnel to radar may also have resulted in lower sperm counts.[3] In animals, microwaves also affect rat sperm motility,[4]reduce the average number of fruit fly offspring (Drosophila melanogaster),[5] result in irreversible infertility in mice [6]. Female rats' ovaries are affected as well,[7] which is alarming because females, unlike males, have only one set of eggs from birth, and the genetic damage that accumulates before they give birth may affect posterity.

Power line frequencies, in addition to microwave frequencies, have similarly been linked to infertility or miscarriage, suggesting that this is not necessarily a thermal effect, and that power line and microwave frequencies may be working under similar mechanisms. Read more on powerline magnetic fields here.

Genotoxic Effects and Cancer

Genetic changes resulting from microwaves, including DNA strand breaks, double-

stranded breaks, and effects on gene expression, is another interesting area of research. There is both scientific evidence for this as well as epidemiological evidence for the increase of cancer as a result of wireless exposure.

Scientific Evidence

One of the first studies to show DNA breaks from microwaves was conducted by Henry Lai and Narendra Singh of the University of Washington.[8] Despite the industry's attempts to attack this study, this finding was later confirmed by the 7-nation European REFLEX project and a study by the University of Vienna. There are now in total at least 11 studies showing DNA breaks.[9] In addition to studies on DNA breaks, there are also now studies showing effects upon gene expression.[10] Not all studies found significant increases in DNA damage, but it's important to note that not all cell types may be equally sensitive. A paper by Phillips, Singh, and Lai further notes that the comet assay method is very sensitive and that some researchers with little prior experience made specific methodological errors, or developed versions with different detection sensitivities.[11]

The exact mechanism behind DNA breaks is under speculation. The following have been raised as possibilities:

- ***Direct Interaction with Electrons:*** Local charging of DNA caused by displacement of electrons in DNA can result in its disaggregation, and thereby impact protein synthesis.[12]
- ***Free Radicals:*** Radiation-induced increase in oxidative and nitrosative free radicals may result in DNA damage as well as hinder the repair process. There are at least 24 papers on increased free radical activity from microwaves since 1997. Researchers found that antioxidants could reduce the EMF-induced DNA damage.[13]
- ***Electrical:*** DNA happens to be a good conductor of electricity, and electrical charge transfer may be linked to DNA breaks.[14] For example, Swiss scientists at University of Basel found that DNA conducts electricity like a semiconductor. An electrical charge added to the DNA may cause a charge transfer to travel the DNA until it encounters guanine, which it oxidizes, causing strand breaks that may lead to genetic mutations.
- ***DNA as an antenna:*** Since DNA is a good conductor of electricity, it can act like an antenna, with different coil sizes responding to many EMF frequencies, according to Martin Blank, Columbia University.
- ***Calcium Efflux:*** Another mechanism proposed for DNA damage is related to the leakage of DNAase through the membranes of lysosomes, due to the calcium efflux effect (see section on calcium efflux below).[15]
- To read more about these and other potential mechanisms, see theScience Overview

Note that genotoxic effects were found for both power line (alternating current) 50/60Hz frequencies in addition to radio/microwave frequencies. Because power lines and microwaves may have different power/frequency levels, it suggests that it is not related to the thermal effect.[16]

When the rate of repair cannot keep up with the rate of DNA breaks, then there is greater likelihood of retaining mutations, which may lead to cancer. If the mutation is too great, cell death may occur, which is a partially protective mechanism, because it prevents the propagation of errors. However, at the same time, it can be dangerous for cells in the

brain, heart, and ova which are less likely to be regenerated through mitotic activity, and where cell death can possibly lead to conditions like Alzheimer's, Parkinson's, and infertility.

Corresponding Epidemiological Evidence

Given that microwaves cause damage to DNA, we might expect to see cancer increases in epidemiological studies. Indeed, cancer has been potentially linked not only to mobile phones, but also to cordless phones [17], radio towers, and TV towers (Australia, Great Britain, Rome, and San Francisco, and Lookout Mountain, Colorado).[18] Some have argued that radio and TV towers have been around for a long time and are safe, and therefore the same should be true about mobile phone masts. Nevertheless, the premise itself appears false, given the many epidemiological studies on radio and TV towers, which indicate a correlation with cancer. Although the Radio and TV transmitters are more powerful, they are also tightly regulated and so are likely to be spaced further apart than cell towers.

Cell towers and mobile phone masts, as well as cordless phones, in contrast, are now quite ubiquitous, and a lot of people are now exposed to high levels. Sometimes these masts are placed right on residential buildings, right outside of people's apartments. There appear to be multiple cancer clusters in close proximity to mobile phone masts, for example, in Israel, in Naila, Germany, in the UK, in Perez, Spain, in Taman Subang in Kelana Jaya, Malaysia, in Taiwan, and Bayville, NY (see footnotes for more information).[19] Eileen O' Connor, of the EM Radiation Research Trust, is one example of a **breast cancer** survivor who was in a cancer cluster near a mobile phone mast.[20] The high breast cancer rates of Marin County, California, were also suspected by some to be related to wireless radiation.[21] In Canada, telecommunications workers had increased rates of**melanomas (skin cancer)** [22], a cancer which is increasing in several countries.[23]**Leukemia** is another form of cancer that has been noticed with nonthermal microwave radiation, e.g., as a result of the Russian's secretly irradiating the U.S. Embassy in Moscow.

In the large Interphone multinational study on mobile phones and **brain cancer**, a link between mobile phones and cancer was found for multiple nations. The correlation was found despite poor study design that would actually grossly underestimate the risk of mobile phones. For more information on Interphone's weaknesses, including its definition of "regular user," the exclusion of children and business users, and more, see Cellphones and Brain Tumors: 15 Reasons for Concern: Science, Spin and the Truth Behind Interphone.

In the US Congressional hearing in 2008, one of the debated issues was whether the evidence points to a causal relation between wireless technologies such as mobile phones and cancer. The wireless industry representative claimed that the overall cancer statistics have not been getting worse.

> Looking at the overall statistics is not completely appropriate in this case, without considering the individual trends that are a part of this overall statistics. For example, the overall statistics includes statistics for lung cancer, one of the most prevalent cancers, whose incidence has been decreasing due to increased awareness of the dangers of smoking.[24] Instead of looking at overall statistics, it may be more instructive to look at a particular type of cancer. For example, brain

cancer has been on the rise for young adults, e.g., 20-29 year olds.[25]It is also instructive to look at salivary gland tumors among younger users.

There is approximately a ***20-year time lag***between the rise of smoking and the consequent rise of lung cancer deaths and between the decrease in smoking and the consequent decrease in lung cancer deaths. The population that began using cell phones 20 years ago is much smaller than the population using cell phones today, and these users were generally not as heavy users as today. It is possible that we will see a similar or even shorter time lag between wireless technology use and its long-term consequences. Personal home and office wireless technologies have only been around for a few decades, starting around the 1980s, with the newer and possibly more dangerous technologies like Wi-Fi and digital (as opposed to analog) cordless phone systems getting greater adoption and popularity in the ***late 1990s***. They have not been studied for long enough to establish their safety. Also, we have the difficulty of factoring in "second-hand"radiation, especially since people are not fully aware of their level of exposure, unlike with smoke.

Furthermore, the cancer statistics also suffer from omissions, e.g., the omissions of Veterans Administration cancer statistics from state registries since late 2004.[26] In some studies, business users and children have been excluded. In other studies, only short-term studies not exceeding 1 decade were performed.

- Further reading: http://www.nzine.co.nz/features/emr_cancer.html and related chapters

Sleep Disorders

Research Studies

There is some research confirming that microwaves can impact sleep. Researchers at the University of Zurich, Switzerland found that 15 minutes of exposure affected brain waves during sleep in young male volunteers.[27] In one study, the components of sleep thought to be important for daily recovery, have been found to be adversely impacted by wireless technologies as well. A 3-hour exposure prolonged the latency to reach the first cycle of deep sleep, and decreased stage 4 sleep.[28] Studies have shown that ELF *pulse-modulated* microwaves have effects upon sleep. Furthermore, *pulse-modulated* microwaves may increase regional cerebral blood flow and enhanced EEG power. In contrast, non-pulse-modulated microwaves did not enhance EEG power. [29] Concerning the EEG effects, it has also been found that the EEG alpha band are especially affected.[30]

Corresponding Anecdotal and Epidemiological Evidence

One of the symptoms associated with microwave sickness is sleep issues, such as insomnia or frequent waking.[31] In the 1990s, an experiment was performed with a short-wave radio broadcast transmitter in Schwarzenburg, Switzerland. This study found that microwaves may result in more difficulty falling asleep as well as maintaining sleep. Sleep quality improved when the transmitter was shut down. This was not a double-blind study, however, and so does not rule out the possibility of placebo-like effect.[32] Another study by Citizens Initiative Kempten West (Germany) found that mobile phone masts resulted in a large decrease in serotonin in a majority of the participants. In any case, it is interesting to note that the use of prescription sleep aids has nearly tripled in young adults between 1998 and 2006.[33] In 1998 and 1999, were introduced cordless phones of the 2.4

GHz spectrum as well as Wi-Fi (see Appendix 1C).
In K. Crofton's book, *Radiation Rescue*, the first testimony is from someone who heeded the wireless wake-up call, following which her insomnia of 3 years disappeared, and she was sleeping well for a couple of weeks.

Calcium Efflux

Wireless radiation has been shown to remove calcium ions from membrane surfaces.[34] An experiment (Blackman et al) found calcium ion efflux from chick-brain tissue at certain field intensities.[35] This calcium efflux phenomenon may have impacts in multiple systems including the neurological and cardiovascular system. For example, contractions in the heart are influenced by calcium. Neurotransmitters in the brain are also influenced by calcium.[36] Some relevant research on cardiac and neurological effects will be discussed in the following sections.
We can further gather some insight into the importance of calcium, and the disruption that calcium efflux might have, by studying the delicate balance between Magnesium and Calcium in the body. Magnesium helps dissolve calcium and maintain calcium levels in the blood, the excess of which could effect calcification and disrupt cell function. Additionally, magnesium allows just enough calcium for electrical transmission along the nerves. Magnesium and calcium also work in opposite roles in the relaxation vs. contraction of muscles. Magnesium plays an important role as well as co-factor in chemical reactions, in the synthesis of proteins, and the the production of energy. Finally, Magnesium is also important in the detoxification process. According to *The Magnesium Miracle,* magnesium deficiency and calcium excess is potentially related to multiple conditions, including neurological, heart, infertility, osteoporosis, kidney stones, bowel disease, chronic fatigue syndrome, asthma, cramping, depression, and more. [37] Perhaps some of the symptoms of microwave sickness are related to the calcium efflux effect.

Cardiac Effects like Arrhythmia

Scientific Research

As mentioned previously, Calcium and Magnesium play an important role in the contraction and relaxation of the heart. Neuroscientist Allan Frey, who came up with a theory for microwave hearing, found that microwaves could trigger heart arrhythmia in laboratory animals or even stop hearts with the right modulations.[38] A study on frogs' hearts found a greater release of calcium ions within two intensity regions in response to electromagnetic waves.[39] Similarly, the calcium concentration in guinea pigs' heart muscle cells is also affected by low levels of microwave radiation.[40] Problems with heart rate have furthermore been observed in exposed chick embryos.[41] Chick embryos exposed to GSM mobile phone radiation during development actually had higher mortality rates.[42] With regards to humans, a study exposing ten healthy individuals to a digital cell phone for 35 minute periods in double-blind experiments found an average rise in systolic and diastolic blood pressure of 5-10 mm Hg as well as a slowing of heart rate.[43] Magda Havas has also performed a double-blind study which shows some volunteers' heart rate responding to DECT cordless phone stations without knowing whether the DECT station was plugged into a live or dead outlet.[44]

Corresponding Anecdotal and Epidemiological Evidence

People living near radio towers or mobile phone masts appear to have increased cardiac symptoms such as arrhythmia. In Switzerland, when examining adults before and after turning on a cell tower for arrhythmia, it was found that there was a significant increase in arrhythmia.[45] The example of Ouruhia, New Zealand, previously given, also included cardiac symptoms near the radio tower. Since the heart involves electrical signals, this may not be a complete surprise.

Cardiac problems have also been observed in the young. The usage of wireless technologies by pregnant women has been correlated to higher fetal and neonatal heart rate and decreased cardiac output, according to one study.[46] Since electrical disturbances in the heart may be responsible for some cases of Sudden Infant Death Syndrome (SIDS), we should also be concerned about a potential link between microwaves and SIDS.[47] The frightening thing is that people worried about SIDS often employ wireless baby monitors to check on their babies, not realizing that the monitor itself may cause electrical disturbances. There are anecdotes in which wireless DECT baby monitors gave babies more problems than the older analog wireless baby monitors.[48]

Neurological Effects

Scientific Research

Other examples of leakage across barriers include the increased permeability of the blood-brain barrier (BBB) to various substances like albumin, which could damage neurons. Neuronal damage was found in rat brains 50 days after a 2 hour exposure to a level as low as 2mW per kg.[49] This increased permeability of the BBB in rats was also found after 7 and 14 days after the exposure.[50] Other studies have suggested that other substances besides albumin can also penetrate this barrier when exposed to microwaves.[51] This BBB permeability may partly explain why some people have headaches around wireless technology.[52]

Research has also found calcium efflux in brain tissue in response to microwaves. Blackman discovered two power density windows in which calcium would be removed from brain tissue.[53] As a possible mechanism, Andrew Goldsworthy suggests that if the voltage is just right, it will selectively remove the more strongly charged ions, such as divalent ions like calcium.

Since calcium plays an important role at the inter-neuron synapse in the release of neurotransmitters, this might further explain effects related to neurotransmitters. Changes in neurotransmitter functions have been found after low intensity exposures.[54] Dopamine, norepinephrine, acetycholine levels, and 5-HT, a precursor to serotonin, and melatonin, for example, may be affected.[55] Low levels of norepinephrine may help explain feelings of **stress**. Low levels of serotonin may help explain symptoms of **depression**around mobile phone masts. Chronic exposure to GSM cell phone radiation was found to reduce synaptic activity in the hippocampus neurons, which may also help to explain **memory loss** in wireless phone use.[56] Impaired memory was also found in rats as a result of wireless exposure and is another symptom of microwave sickness.[57]

Neuron death is another concern. BBC News reports that Swedish researchers studied rats whose brains are in the same development stage of a teenager. 50 days after a 2-hour exposure to radiation equivalent to mobile phones, they found an abundance of dead brain cells.[58] Exposed brain neurons may die more rapidly because of a lower capacity

for DNA repair in brain cells. Neuron death could contribute to **Alzheimer's** disease or **Parkinson's**disease. Changes in protein folding resulting from microwaves could cause formations of long strands of proteins called fibrils which trigger heat shock proteins. Protein fibrils are likewise found in diseases like Alzheimer's and Parkinson's.[59]

ADHD and Emotional Disorders

Mobile phone usage by pregnant mothers was recently correlated to the risk of having children with greater hyperactivity and emotional problems, even to the surprise of some of the researchers who expected to find otherwise.[60] This phenomenon might explain the rise of modern day disorders such as ADHD (attention deficit hyperactivity disorder). In Switzerland, when examining school children before and after turning on a cell tower for concentration problems, academic performance, and ADD, it was found that there was a significant increase in problems.[61]A study in Latvia of children near an early warning radar station in the early 1990s, found decreased attention, memory, and learning ability in the children living closes to the radar.[62]The Skrunda radar station operated from 1971 to 1998. Scientists were invited to conduct studies due to reports of ill health. Among the many effects they found included impaired memory and attention in school children.[63]

Immune System Dysfunctions and Chronic Diseases

Unlike other particles and pathogens, microwaves can penetrate directly into the body. This is a problem for the immune system which relies a lot on skin as a barrier against pathogens. Some of the possible consequences found from microwave radiation include:

- Morphological alterations of immune cells
- Changes in lymphocytes dependent on the carrier frequency,
- Reduced T lymphocyte count, and
- Hypersensitivity manifesting as autoimmunity.[64],[65]

Johansson observed that electrohypersensitive individuals had higher densities of dendritic cells in their skin, which are reactors to ionizing radiation like X-rays and UV. Hence, electrohypersensitivity is postulated as being the result of irradiation due to effects similar to those documented of ionizing radiation like UV light. The increased numbers of mast cells could release histamines resulting in itch and pain. Mast cells are found to occur in many places, including the brain and heart. Chronic exposure to EMF was postulated to lead to chronic allergic responses and inflammatory responses.

Chronic Fatigue Immune Deficiency Syndrome (CFIDS or CFS)

The immune system dysfunctions caused by wireless technologies, may also be related to Chronic Fatigue Syndrome (CFS or CFIDS) as noted by Olle Johansson. Whereas wireless technologies may initially stimulate the immune system, they can eventually exhaust it. The depressed immune system may then make one more susceptible to ordinary bacterias/viruses. CFS was a symptom mentioned found in Ouruhia, New Zealand, correlated to a radio tower. One individual claims to have recovered from Chronic Fatigue Syndrome, by escaping from wireless technologies.[66]

Increased Asthma, Allergies and Rashes

Dr. Peter Finch discovered mobile phone frequencies increased the production of histamines, which are involved in allergic reactions and bronchial spasms. Consequently,

Dr. Finch predicted an increase in allergies and asthma.[70] It is therefore interesting that asthma, along with headaches and impaired concentration, was one of the strongest connections found in users of wireless telephones, according to a study in Örebro University, Sweden.[71] Asthma was also one of the symptoms found near the AM/FM radio towers in Ouruhia, New Zealand.
Even power frequencies may increase risk for asthma. Asthma of offspring is also being linked to the power line magnetic field exposure of mothers during pregnancy (De-Kun Li et al, 2011). Filters for dirty electricity, high frequency radiation on wires, have also reportedly reduced a number of symptoms, including headache, skin irritation, and asthma.[72]

Possible Mechanisms for Asthma:

- Impacts on the autonomic parasympathetic vs. sympathetic system by wireless technologies. The parasympathetic system results in constriction of bronchial tubes, whereas the sympathetic system results in dilation. This system is mediated by neurotransmitters like acetycholine which may be affected by wireless technologies. (Adams, The Asthma Sourcebook, p.4)
- As mentioned previously, the calcium efflux of microwaves affect might result in an imbalance of Calcium and Magnesium, which might have an impact on asthma. Calcium tends towards constriction of muscles vs. relaxation by Magnesium.
- Impacts on the immune system: Mobile phone frequencies result in an increase in histamines. Asthma may also be related to an increase in the number of mast cells, which store and release irritating chemicals. Wireless technologies may increase the number of mast cells.

Possible Mechanisms for Allergies, Rashes, Gut permeability:

One Japanese study found that microwave radiation can increase allergic responses to dust and pollen in adults with eczema, in comparison to the control group.[69] This may also be related to mast cells. Mast cells may cause other problems depending upon where they occur-- asthma related to bronchial tubes, hay fever related to the nose, conjunctivitis related to the eye, and eczema/hives related to the skin (Adams, pp8-9).
The other hypothesis for the mechanism behind allergies is that it is the result of cell membrane weakening due to the calcium efflux effect. Andrew Goldsworthy explains that when calcium ions are replaced with monovalent ions, it weakens the cell membrane, increasing the likelihood of pores.[67] This membrane weakening can affect “tight junction barriers,”such as nasal mucosa, lungs, and gut linings. Leakage through pores may allow increased amounts of toxins to enter in and damage the cell, resulting in increased allergies, multiple chemical sensitivities, asthma, skin rashes, bowel cancer, and gut permeability. Gut permeability might in turn contribute to many health conditions such as type-1 diabetes, Crohns disease, celiac disease, multiple sclerosis, and irritable bowel syndrome. [68]

The Autism Hypothesis and Other Developmental Problems

Autism arose in the 1980s and 1990s around the time that wireless technologies started becoming popular.[73] Autism has been thought to be a “geek syndrome”, rising amongst places like Silicon Valley, where a greater proportion of people are likely to be

technology lovers, and hence, wireless users.[74] According to one source, it nearly tripled between 1987 and 1998 in California. Brick, NJ, also had autism, at the rate of 8 children per 1000 between ages 3 and 5. Investigators could not find a chemical contaminant to explain it, but 10 miles away was a Doppler weather radar transmitting at an extremely high power of 750,000 watts since late 1994. [75]

Are there any studies which suggest a possible correlation between wireless technologies and autism?[76] One pilot study by **Dietrich Klinghardt** checked the body voltage and microwave power density that a person would have in the sleeping location of the pregnant mother. These numbers were compared for the sleeping location of women who later gave birth to healthy children versus the sleeping location of those who gave birth to autistic children. The study found significantly higher body voltages and microwave power density for the mothers who gave birth to the autistic child.[77]

Suggestions for the cause of autism range from mercury toxicity from vaccines to problems with neurotransmitters to genetic damage to GMO's and food allergy problems, all of which can be exacerbated by wireless technologies. Klinghardt believes that electro-smog (wireless radiation) is one of three interconnected causes of autism. This electrosmog may contribute to the growth of molds and other bio-toxins, which may also be working in autism. [78] Another study in 2007 suggested that wireless technologies could make it more difficult for autistic children to excrete heavy metals, such as mercury.[79]With regards to synergy, it is possible that EMF worsens the effects of a toxin (e.g., by opening the blood-brain barrier, letting more of the toxin in) or stands in the way of the body's natural protective mechanism against the toxin (e.g., by reducing glutathione levels). Andrew Goldsworthy also hypothesizes that microwaves can interrupt the pruning process in neuron connections, and thereby contribute to autism.[80].

The latest Bioinitiative Report (2012) notes additional clues that might link microwaves to an increased risk for autism. For example, some of these factorsinclude increased oxidative stress, reduced glutathione levels, interference with calcium signaling, cell membrane peroxidation, impacts to gap junctions like the blood-brain barrier, genotoxicity, mitochondrial dysfunction, melatonin dysregulation, disturbed immune function, and brain cell damage. The report concludes that even if these links cannot be proven, that EMF can increase the risk by worsening challenging biological problems.

An increase of**Down's syndrome** was also found amongst the children of radar operators, and amongst residents near satellite uplinks in the microwave bands in Vernon, NJ (radar and satellite also fall within the microwave band).[81] Note that radar has also been linked to "internal bleeding, leukemia, cataracts, headaches, brain tumors, heart conditions, and liver involvement with jaundice" at certain power densities.[82]

Effects on Mercury

Mercury also seems to be tied into Electromagnetic radiation. The Swedish book of testimonies of electromagnetic hypersensitivity, Black on White, includes many individuals who reported their sensitivity to microwaves following a dental appointment that impacted mercury levels.[83] Another anecdote has been provided of an otherwise normal patient who developed trigeminal neuralgia. It was suspected to be a result of this man's root canal with 2 metals and amalgam fillings in combination with the cell tower. The individual had the filling for 15-20 years before the neuralgia, but he did not become sick until after the cell tower came up. It is suggested that the amalgam fillings may act as

an antenna[84]Note that mercury also increases excretion of magnesium and calcium from kidneys. Magnesium levels are important as they can help in the excretion of certain heavy metals.[85] There is also a possibility that radiation increases mercury release, which can be dangerous since mercury is a toxic chemical.

Effects on Plants

Even plants seem to be affected by microwaves, including tomato plants, pine trees, aquatic plants, poplars, willows, and more. In Latvia, pines exposed to radar, experienced a decline in growth in comparison to surrounding trees, coinciding with the start of the emissions. Exposed pine trees were also found in other studies to have increased resin production (a possible stress response) and low seed germination. Trees near phone masts have similarly experienced deterioration.[86]

Dr. Wolfgang Volkrodt, a retired Siemens physicist and engineer, studied deforestation in the German and Swiss Alps. He noticed areas of damage that occurred even where there was no acid rain. He hypothesized the cause was the massive communication between NATO countries and the soviet block. The theory was that the pine needles absorbed electrical current, and channeled this into the soil, which was destroyed. Indeed, U.S. satellites found deforestation in areas with massive communication. Some students built a Faraday cage around whole areas of forest, and those were the areas where the forests started to regenerate[87].

Effects on Animals

Effects can be seen not only in humans, but also in animals-- including horses, cows, pigs, birds, bird eggs, rats, monkeys, amphibians, bees, worms, drosophila (fruit flies), yeast, algae, and bacteria, some of which were mentioned earlier due to laboratory studies on animals.[88]Our mobile phone standard of 1.6 W/kg was itself based on a behavioral disturbance in monkeys in response to microwaves.

One possible explanation for some of these effects is related to magnetite, which is used in many animals as a navigational tool. Bees, butterflies, birds, fish, dolphins, and magnetobacteria have magnetite. In 1992, it was even discovered that the blood brain barrier and meninges covering the human brain (Joseph Kirschvink at California Institute of Technology) also has magnetite. The sinus region was also found to have magnetic material.[89] The pineal gland, which produces melatonin, has also been found to be contain calcite microcrystals with piezoelectric properties, which might operate with a similar mechanism as the magnetite crystals in the brain.[90]

Mammals

It is interesting to consider a few case studies regarding livestock exposed to mobile phone masts or radio towers, which involve pigs, cows, and horses.

In Casaveieja, Spain, farmers blamed mobile phone base stations for **pigs'** miscarriages. Upon the disassembly of the antennae, the problems stopped.[91]

In Bavaria, Germany, a farmer started noticing problems beginning in 1992, and could not find a reason other than the radio frequency broadcasts. The **cows'** problems included conjunctivitis, itching, reproductive problems, decreased milk production, dancing or weaving in stalls, and pointing heads away from the transmission tower. When one cow was moved to a neighbor's farm 20 kilometers away, this strange behavior disappeared in

5 days. Not to mention also, this farmer's family also experienced many health issues, including headaches, non-malignant growth, aching joints, pains in bladder, head, and heart. Other animals, including birds, cats, and chickens and dogs, upon entering the farm, appeared to be strangely and negatively affected.[92]

In New Zealand, well-known horse trainer Penny Hargreaves had a small farm near a radio tower. She had some **cows** which became nervous and disoriented. All 90 of her **horses** were also affected and became nervous and jumpy. Symptoms included loss of balance, volatile behavior, more infections than ever before, and walking as if their feet hurt. Penny and her daughter also suffered health problems including abdominal pain, joint pains, heart palpitations, ringing in the ears, mental confusion, and asthma, until they moved away.[93]

Birds

Previously, negative effects were mentioned regarding exposed chick embryos. In scientific research, cell cultures of avian brain tissue subjected to cell phone frequency also had abnormal neuronal firing in over half of the cell samples, or else an abnormal shut down. In practice, around cell towers, we do see abandonment of nest sites, fewer eggs, chick deformities, a decrease of population,[94] as well as lower productivity in nests, plumage deterioration, and partial albinism.[95] The decrease in population may be in part due to cell tower collisions, but also in part due to interference with magnetic navigation.[96]

Bees, Insects, & Worms

A serious problem has afflicted bee colonies *worldwide*, called colony collapse disorder. Beekeepers have been surprised to find many beehives unusually abandoned. 25 to 50% of American bee keepers reported loss, e.g., 50% to 90% of their bees disappeared within a 6 month period .[97]While herbicides, pesticides, and GMO's may be suspected for problems with bee colonies, some also postulate that the increase of mobile phone masts (e.g., cell towers) could be related to colony collapse disorder by interfering with their navigational skills.[98]

A limited study at Landau University put DECT wireless stations at the bottom of bee hives. The ones with greater exposure to the DECT stations had greater incidence of colony breakdown. Fewer bees returned to the hive, and the exposed hives had lower honeycomb weights.[99] A study in 2009 by Pattazhy from Kerala also found that mobile phone towers could damage the navigational skills of worker bees.[100]

Another hypothesized mechanism is through the interference of the Nitrogen Monoxide (NO) system, which would disrupt not only learning capability and olfactory orientation but also the immune system. The mechanism by which this happens might be related to the sensitivity of NADH oxidase enzyme to magnetic and electromagnetic fields. As a result, not only would this interfere with bees' orientation, but also with their susceptibility to virus, fungi, and other microorganisms.[101]

Non-thermal microwave fields like that of cell phones were also found to induce heat-shock responses in the soil nematode Caenorhabditis elegans[102]as well as fruit flies.[103]

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Brenda Peterson
Novelist and nature writer

Killing With Sound: What Happens When the Whales Stop Singing?

Posted: 02/22/2013 6:26 pm EST Updated: 04/24/2013 5:12 am EDT

Close your eyes. Your world is now only sound -- the rain, the traffic, that far-off siren. In this acoustic world, how you navigate, find food, your children, or mate, all depends upon how well you hear. Imagine that as you search in the darkness for a crying child, a horrifying drone, loud as a rocket, suddenly blasts sound pulses like shockwaves through your home.

There are no noise-cancelling headphones to stop the U.S. Navy's 235-decibel pressure waves of unbearable pinging and metallic shrieking. At 200 Db, the vibrations can rupture your lungs, and above 210 Db, the lethal noise can bore straight through your brain until it hemorrhages that delicate tissue. If you're not deaf after this devastating sonar blast, you're dead.

This is the real life of marine mammals destroyed by the U.S. Navy's all-out acoustic war on the world's oceans. The collateral damage of this high-intensity military sonar is shocking. But because all these millions of dying whales or dolphins are too often out of human sight, they're also out of mind. Only when cetaceans strand on land do we witness what orca researcher, Ken Balcomb, calls, this "acoustic holocaust." Military sonar so panics cetaceans that as they try to escape the sonic violence, they rise too quickly to the surface and die of "the bends."

Ken Balcomb has researched multi-generations of the resident orca pods in the Pacific Northwest. In March, 2000, Balcomb documented a mass stranding of predominantly deep-diving beaked whales off the Bahamas that the Navy later finally admitted was a result of their LFA (Low-frequency Active sonar) tests. Balcomb told the *Los Angeles Times*, "sonar waves at certain frequencies might have resonated around the whale's ears, causing tissues to tear much as a wineglass will shatter at a particular pitch."

Scientific American calls military sonar, "rolling walls of noise." For the dolphins, whom researchers have documented as "self-aware," noting that they "call each other by name," this is a brutal and inhumane death sentence. For whales, such as the great blue, who can communicate over thousands of miles, such sonic stress affects reproduction and communication so much that some whales simply stop vocalizing. What happens to our oceans when the whales stop singing?

In the Navy's latest environmental impact statement draft, they admit that the sonar exercises planned for 2014-2018 may unintentionally "harm marine mammals 2.8 million times over five years." This estimate is up about 150,000 instances a year from their EIS statement of 2009-2013. Included in this estimate are two million incidents of "temporary hearing loss," and 2,000 are targeted for permanent hearing loss.

A deaf whale is a dead whale. Dr. Lindy Weilgart, sperm whale researcher at Dalhousie University in Halifax, Nova Scotia warns us "There are some technologies that simply should never be used. As a scientist -- and as a mother and fellow inhabitant of this fragile planet -- I am alarmed at this new threat to our oceans. The ocean gives us our air, our water, our food, and regulates our climate. The ocean literally enables human life."

Criticism of the Navy's sonar has intensified, even as the military has intensified their sonar

tests.The main concern of scientists and environmentalists is that the Navy has not done enough environmental impact research and knows much too little about the devastation they're unleashing on our marine environment to proceed with such expanded target ranges.

The Navy has paid little heed to the scientists, the lawsuits, the public outcry, and the many media storms all protesting this risky technology. Even while sometimes admitting sonar's role in mass strandings -- like those in the Bahamas, Canary Islands, Pacific Northwest, Greece, and North Carolina -- the Navy has proceeded to garner federal permits to expand their sonar tests. NMFS (National Marine Fisheries Service) just gave the Navy the go-ahead for their proposed 2014-2018 sonar exercises, targeting those two million whales and dolphins. In response, the NRDC (Natural resources Defense Council) and Earth Justice, along with several tribes have brought a lawsuit claiming that NMFS was "wrong to approve the Navy's expanded training plan," which would affect Washington, Oregon and California coasts.

The Navy has agreed only to post look-outs onboard ships to spot whales. "Visual detection can miss anywhere from 25 to 95 percent of the marine mammals in an area," says Heather Trim, Director of Policy for People for Puget Sound. The Navy should at least use common-sense precautions: declare whale sanctuaries, birthing nurseries, and whale migration paths off-limits to sonar testing. The Navy could employ their sophisticated listening devices to make sure no cetaceans are in the path of their lethal sonar. Finally, the Navy could engage in a serious and thoughtful dialogue with scientists and environmentalists about how to assure our military readiness while not destroying the very ocean they supposedly serve.

Our seas are not just a backdrop or stage upon which to practice our war games. As a recent *New Yorker* blogger wryly points out, "The cat-and-mouse games played by submarines may have made a certain kind of sense during the Cold War, but what is the point of them now? Russia is annoying, but it is no longer our mortal enemy. The Chinese have no desire to bury us, except under piles of sneakers and kitchen appliances... The terrorists have no submarines."

As we now ponder cuts to the defense budget, why not stop this military sonar's expansion until we have enough sound science and environmental research to use it judiciously and with much greater concern for all life? In this time of collapsing fisheries and disastrous marine pollution, when our oceans are more fragile and endangered than ever before, why let the Navy blast its expensive and fatal sonar through our seas?

We must not let our fear of some supposed enemy destroy our foresight. The tragedy is that in our zeal to protect ourselves, we are destroying the same life support system that we need for our own survival -- our oceans. Because when you save the whales, you also save the humans.

http://www.cellphonetaskforce.org/?page_id=585

THE WORK OF OLLE JOHANSSON

 In the 1970s the newspaper industry was one of the first to supply its employees with computers. Complaints of visual problems and headaches, as well as clusters of miscarriages and birth defects in children born to female editors and other newspaper employees, generated some publicity. In the United States, then-Representative Al Gore held Congressional hearings in 1981 on the health effects of computer screens. In Sweden, a union activist brought the problem to the attention of Dr. Olle Johansson, a neuroscientist at the world-renowned Karolinska Institute. Johansson was the head of the Experimental Dermatology Unit at the Institute.

“For me,” said Johansson, “it was immediately clear that persons claiming skin reactions after having been exposed to computer screens very well could be reacting in a highly specific way and with a completely correct avoidance reaction, especially if the provocative agent was radiation and/or chemical emissions — just as you would do if you had been exposed to e.g. sun rays, X-rays, radioactivity or chemical odours.”

Johansson began to study the skin of these patients, and proved that they had a real skin condition that was provoked by sitting in front of a computer screen. The damage was similar to that caused by ultraviolet radiation from the sun. He also showed that the radiation from computers causes measurable changes even in the skin of “normal” people,” and also in the skin of laboratory animals.

He named the new disease “screen dermatitis.” However, since such individuals also usually complained of other symptoms, such as chest pain, memory loss, fatigue, insomnia, dizziness, nausea, and headache, the more general term “electromagnetic hypersensitivity” came into use.

Many people who worked in the electronics industry in Sweden, including an estimated 12% of the electrical engineers in that industry, became electrically sensitive, and helped form an organization called Föreningen för el-och bildskärmsskadade (Association for the Electrosensitive), or FEB. Due in part to the work of FEB and the research of Dr. Johansson, electrosensitivity is a fully recognized disability in Sweden.

 More recently, Johansson and his colleagues have conducted important epidemiological studies showing that wireless communication networks are causing significant illness throughout society. They have also shown that increased rates of asthma as well as certain types of cancer were strongly correlated with exposure to radio broadcasting during the twentieth century.

"The world may be moving inexorably," Johansson warns, "toward one of those tragic moments that will lead historians to ask: Why did they not act in time?"

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https://defyingdisaster.com/health-effects-research/

EMF Research

Peer-reviewed studies from scientists over more than five decades have shown a consistent correlation between exposure to electromagnetic fields (EMFs) and negative impacts to living beings.

Biological effects from EMF exposures include damage to DNA, higher risks of cancer, Alzheimer's disease, Lou Gehrig's disease, heart disease, autoimmune diseases such as MS and diabetes, lowered sperm counts and many others.

Troubling and disabling symptoms affect a wide range of body functions. EMF exposure affects all of nature, interrupting the ability of birds and bees to navigate, causing cows to be agitated and to produce less milk, and leading to (bee) colony collapse disorder.

Importantly, many of these effects on health and nature occur at levels that are thousands of times lower than the limits set by regulatory agencies like the FCC as safe. It is now clear that safety limits are no longer sufficiently protective of public health, particularly more susceptible individuals (infants, children, pregnant women and the elderly.

EMF sources associated with adverse health effects include:

- Cellular (long-range transmission) towers and antennas in schools, neighborhoods, churches, light standards, power poles, highways and towns
- Wireless (short-range transmission) systems and devices including cellphones, cordless phones, baby monitors, computers, tablets
- Electrical production facilities, transmission lines, structure wiring, all electrically powered items and electronics
- Radar
- Radio and TV broadcasting facilities
- Smart meters, appliances and transmission systems
- Microwave ovens
- Satellites

Modern technology has stoked an unparalleled degree of innovation and improvement in our quality of life. At the same time, both wired and wireless infrastructures and the buildings, equipment and gadgets connected to them now bring electromagnetic fields (EMFs), a form of radiation, into virtually every space we inhabit, whether at work, home or play, inside or outside, in cities or rural areas.

Relatively few people in the U.S. are aware EMFs cause harm. Unfortunately, industry forces have successfully discredited a very large body of research that strongly supports significant and growing harm from EMFs.

We've seen industry oppose strong scientific evidence of harm before – with tobacco, asbestos, chemicals, fracking and other industries that have paid scientists to generate "evidence" that falsely supported their claims of product safety.

The research, articles and reports found here are arranged in the following manner:

1. Collections of EMF studies

2. EMF studies in chronological order

3. Articles, Commentaries and reports about EMF health effects

4. Effects of EMFs on plants and animals

Research studies, articles and reports on EMF health effects

1. COLLECTIONS of EMF STUDIES

1972: 2,300 studies published by the US Navy showing biological impacts of EMF: Naval Medical Research Institute 2300 Studies on EMF Health Effects.
http://www.radiationresearch.org/pdfs/20091016_naval_studies.pdf

2012 BioInitiative Report – References 1,900 new studies showing biological impacts from non-thermal EMF. Prepared by 29 authors from ten countries, ten holding medical degrees (MDs), 21 PhDs, and three MsC, MA or MPHs. Among the authors are three former presidents of the Bioelectromagnetics Society, and five full members of BEMS.: http://www.bioinitiative.org/

Comprehensive German data bank of global EMF research showing biological effects of RF/EMF. Includes summaries of over 5700 studies: http://www.emf-portal.de

WiFi in Schools. Refers to numerous studies. Includes chart showing numerous health effects from laptop and iPad radiation: http://www.wifiinschools.com/science.html

Comprehensive collection of studies, papers and commentary of how EMF pollution affects body systems and disease. Studies arranged by disease: http://emractionday.org/science

Thousands of studies showing links between EMF pollution and adverse biological effects:
http://www.powerwatch.org.uk/science/studies.asp

Collection of over 5,000 studies showing biological impacts from EMF pollution: http://justproveit.net/studies

Graph with 67 studies that show adverse health effects occur well below the limit set by the U.S. government EMF limits and the corresponding effects of smart meters – See the following PDF, as well as the graphic:

10 of 14 studies of significant biological effects from living near a cell phone tower: Click here for studies. Peer reviewed, double-blind studies showing that electro-sensitivity is associated with wireless technologies:
http://www.magdahavas.com/microwave-radiation-affects-the-heart-are-the-results-real-or-are-they-due-to-interference/ & http://electromagnetichealth.org/electromagnetic-health-blog/cordless-heart/

Research on the health effects of cell phone masts/towers from a group in Portland, Oregon:
http://www.respectpdx.org/index.php?option=com_content&view=category&layout=blog&id=5&Itemid=6

2. EMF STUDIES IN CHRONOLOGICAL ORDER

2016 NTP study preliminary results showing that cell phone radiation causes cancer in rats. This $25 million study is the gold standard of EMF research and makes it clear that our current wireless safety standards do not adequately protect the public.

2016 Study demonstrating the Nocebo (placebo) response does not explain EHS.
http://www.ncbi.nlm.nih.gov/pubmed/26369906 Read full study here.

2015 study showing 2.4 GHz WiFi decreases sperm function. Researchers conclude that "there should be major concern regarding the exposure to Wi-Fi networks existing in the vicinity of our living places."
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4503846/

2015 study showing that 2.4 GHz WiFi may be accepted as one of the major risk factors for brain tumors and neurodegenerative diseases such as Alzheimers. Effects of 2.4 GHz WiFi on microRNA Brain Tissue

2015 paper showing that polarized EMF (man-made) is much more biologically active than non-polarized EMF (natural sources such as infrared, ultraviolet and visible light from the sun):
http://www.nature.com/articles/srep14914

2015 Study by leading industry RF scientist shows that 3G GSM cell phone technology causes cancer in animals:
http://www.microwavenews.com/news-center/rf-animal-cancer-promotion

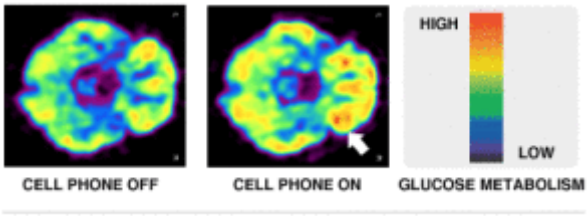
2014 Long-term study from Swedish scientist Lennart Hardell on glioma and acoustic neuroma brain tumors showing that RF (radiofrequency radiation) is carcinogenic. The scientist calls for RF to be labeled an IARC Class 1 Carcinogen (meaning *definitely* carcinogenic to humans) and recommends urgent revision to safety guidelines. http://www.pathophysiologyjournal.com/article/S0928-4680(14)00064-9/fulltext

Swedish brain cancer rates have increased 30% since 2008 but cases are not reflected in the cancer registry:
http://www.stralskyddsstiftelsen.se/2014/10/increase-brain-tumors/

2014 Japanese study showing significant decrease in clinical symptoms of residents of a nearby building once a cell tower was removed. Significant Decrease of Clinical Symptoms after Mobile Phone Base Station Removal–An Intervention Study Tetsuharu Shinjyo and Akemi Shinjyo.
https://elettrosensibili.wordpress.com/2015/10/14/significant-decrease-of-clinical-symptoms-after-mobile-phone-base-station-removal-signifikanter-ruckgang-klinischer-symptome-nach-senderabbau/

2011 Dr. Leif Salford and his colleagues at Lund University Hospital in Sweden exposed over 1,600 experimental animals to low-level microwave radiation. They then repeated the experiment in another 32 animals but waited 8 weeks before examining their brains. They found that up to two percent of the neurons in all areas of the brain were shrunken and degenerated. *Silent Wireless Spring. ArthurFirstenberg*
http://www.cellphonetaskforce.org/wp-content/uploads/2011/10/silentwirelesspring.pdf

2011 study by Nora Volkow showing that cell phone radiation increases brain glucose metabolism in areas next to antenna. Increased glucose metabolism is associated with cancer. Study shows that biological changes occur at levels lower than FCC guidelines. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3184892/



Journal of Neuroscience highly controlled double-blind study showing evidence of electro-hypersensitivity (EHS) symptoms of headache, skipped heartbeats, temporal pain and muscle twitching from EMF that was repeatedly turned off and on, in a female physician. The subject could not detect when the EMF was off or on but her symptoms began within 100 seconds after initiation of EMF exposure: http://www.ncbi.nlm.nih.gov/pubmed/21793784

2009 YouTube: "Suppressing the science on cellphones". Prominent researcher Franz Adlokofer's study funded by the European Commission found that high frequency electro-magnetic fields damage genes and gene function. He describes the attempts made by the telecommunications industry to discredit him and his research. https://www.youtube.com/watch?v=B9ycyWd8GMs

2009 Research article by Dr. Carl Blackman showing that non-thermal effects of electromagnetic radiation should be included in national and international exposure standards, which should have been lowered, not raised as they were recently: http://www.pathophysiologyjournal.com/article/S0928-4680(09)00004-2/pdf

2001 Dr. Neil Cherry discusses evidence available in 2001 that showed a causal link with EMFs and brain tumors. http://www.pathophysiologyjournal.com/article/S0928-4680(09)00004-2/pdfrozpotter@defyingdisaster.com

1995 Electrical distribution lines constitute both inside and outside homes is one of the major sources of the public's time-weighted average exposure to magnetic fields. This report provides insight into representative data on magnetic field levels inside residences and in proximity to distribution lines. EPRI *Handbook for the Assessment and Management of Magnetic Fields Caused by Distribution Lines*. Author(s): Enertech Consultants. http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=TR-106003

1994 U.S. Air Force study confirming existence of non-thermal EMF effects, including alterations to the central nervous system and cardiovascular system: Air Force Study showing non-thermal effects

1981 NASA paper showing numerous health affects from non-thermal electromagnetic fields. NASA report on EMF effects on human body

1965 Ford Motor Company commissioned this study which shows the numerous damaging biological effects of microwave radiation. It notes in particular how damaging microwave radiation is to the central nervous system.

3. ARTICLES, COMMENTARIES AND REPORTS ON THE EFFECTS OF EMF RADIATION

2002 Dr. Gro Harlem Brundtland, Director of the World Health Organization and former Prime Minister of Norway, admits that cell phones and computers make her ill. http://emrabc.ca/wp-content/uploads/2010/01/SUMMERLAND.pdf

52 Medical Doctors and Researchers respond to industry PR that "smart" meters are safe: https://maisonsaine.ca/sante-et-securite/electrosmog/smart-meters-correcting-gross-misinformation.html

Italian Supreme Court rules that brain tumor is caused by cell phone: http://www.telegraph.co.uk/health/9619514/Mobile-phones-can-cause-brain-tumours-court-rules..html

World Health Organization and IARC classifies microwave radiation as a "possible carcinogen", Class 2B, the same classification as lead and DDT– May 31, 2011: http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf

"Captured Agency" report on how the FCC is completely dominated by the wireless industry that it supposedly regulates. Published June 2015 by investigative journalist Norm Alster and the Harvard University Center for Ethics. Mr. Alster also wrote about the Dot Com Crash and the 2008 Financial Crisis before they happened. Click for free PDF or Kindle versions.

2001 Cellphone manufacturers own patents that would cut radiation risks but do not use their own technology http://www.rcrwireless.com/20010604/carriers/manufacturers-own-patents-to-cut-radiation

2014 Former Nokia technology chief says cellphones wrecked his health. Nokia has held patents since 1998 that would reduce the irradiation of cell phone users – but did not utilize the technology: http://betweenrockandhardplace.wordpress.com/2014/10/20/former-nokia-ctos-multiple-sclerosis-and-nokias-patents-to-prevent-it/

Declassified 1976 Defense Intelligence Agency report showing that military personnel exposed to non-thermal microwave radiation experienced "headaches, fatigue, dizziness, irritability, sleeplessness, depression, anxiety, forgetfulness and lack of concentration." Defense Intelligence Agency 1976 Report on Biological Effects of EMF

Internal FDA memo from 1993 states that data "strongly suggests" that microwave radiation promotes cancer: http://www.goaegis.com/fda0203.html

A discussion of industry, military and other influences on RF–DNA research, "Radiation Research" and The Cult of Negative Results. http://microwavenews.com/news-center/%E2%80%9Cradiation-research%E2%80%9D-and-cult-negative-results

Article describing the efforts to discredit the work of a prominent research scientist whose findings link cellphones to cancer as a result of DNA breaks. http://www.seattlemag.com/article/nerd-report/nerd-report

Swisscom admits elevated risk of cancer and genetic damage from Wi-Fi: http://www.safeschool.ca/Swisscom__WiFi_Harms.html

Motorola has "war-gamed" the science since 1994: http://www.huffingtonpost.com/devra-davis-phd/cell-phones-brain-cancer_b_3232534.html

Nokia has held patents since 1998 that would reduce the irradiation of cell phone users – but did not utilize the technology: http://betweenrockandhardplace.wordpress.com/2014/10/20/former-nokia-ctos-multiple-sclerosis-and-nokias-patents-to-prevent-it/

Research article by Dr. Carl Blackman showing that frequency modulation (not the carrier wave) is the primary reason for non-thermal biological effects: Dr. Carl Blackman Modulation 2009 Paper

Harvard Pediatric Neurologist states dangers of Wi-Fi in classrooms and potential autism link: Harvard Pediatrician EMF Dangers for Children

2002 letter from EPA confirms that FCC guidelines only relate to damage from heating (thermal) effects but do not consider long-term, chronic, non-thermal microwave radiation exposures, the type we are exposed to every day by consumer wireless devices). It EPA Letter Stating FCC Guideliness are only based on Thermal Effects

Report warning about Smart Meters by Santa Cruz Public Health Advisor, Poki Namkung, MD: http://emfsafetynetwork.org/wp-content/uploads/2009/11/Health-Risks-Associated-With-SmartMeters.pdf

Sufficient evidence exists for microwave radiation to be labeled a definite carcinogen (presentation by Dr. Anthony Miller): http://smartgridawareness.org/2013/12/04/rf-fields-possibly-probably-or-definitely-carcinogenic/

Survey of 210 respondents whose health was harmed by smart meters: http://www.mainecoalitiontostopsmartmeters.org/wp-content/uploads/2013/01/Exhibit-10-Smart-Meter-Health-Effects-Report-Survey2.pdf

Use of fluorescent lighting leading to an increase in eye disease in developed countries: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3222423/

Governments and organizations that ban or warn against wireless technology: http://www.cellphonetaskforce.org/?page_id=128

High school students in Denmark show how Wi-Fi affects biology: http://mastsanity.org/health-52/research/324-experiments-with-cress-in-9th-grade-attracts-international-attention-denmark-16th

Smart Meters – Separating Fact from Fiction: http://www.es-uk.info/news/2012-02-10-fact-from-fiction.pdf

American Society of Environmental Medicine warns of health effects from EMF and RF radiation: http://aaemonline.org/emf_rf_position.html

4. EMF EFFECTS ON PLANTS AND ANIMALS

Papers by Dr. Donald Hillman, Professor Emeritus, Department of Animal Science, Michigan State University demonstrating _____: http://www.msu.edu/user/hillman/elecshok.htm and http://www.msu.edu/user/hillman/ABSRTACT.htm

Farm and human health effects, Chris Hardie, Editor, LaCrosse Tribune Newspaper, funded by The Pew Center: http://www.strayvoltage.org

Bee Colony Collapse Disorder (CCD) can be partially explained by the increased microwave radiation in our environment from wireless technologies the past decade – a new study out of Switzerland: http://www.cellphonetaskforce.org/?page_id=672

2015 paper showing that rabbits experience heart arrhythmia and increased blood pressure when exposed with 2.4 GHz WiFi: http://www.sciencedirect.com/science/article/pii/S1382668915300594

2004 Electric and magnetic fields affect milk production and the behavior of cows. Donald Hillman, Ph.D. http://emf.homestead.com/files/ShockingNewsv3-072004.pdf

Open Letter to Parents, Teachers, & School Boards Regarding Wireless Utility Meters (AMR, AMI, ERT, and Smart Meters), Smart Boards, Smart Phones, 3G/4G Cell Towers and Wifi:

There has been an alarming increase in illness, disease, aggressive behavior, crime, and death since the introduction of the above mentioned technologies into our society.

Bullying and inappropriate behaviors in school districts as well as businesses and homes have been increasing steadily.

Health problems caused by continual exposure to wireless frequencies from Wifi and Smart Phones were already on the rise when the school districts started allowing installations of wireless utility meters and smart boards in their schools.

It was after these installations that we saw a sudden increase of bizarre behaviors in students and staff as well as a steady increase in illnesses and disease processes which were being continually misdiagnosed by the Medical Community.

The continual EMF/ELF/Radiation emitted by these devices has an accumulative effect on the body and disrupts its ability to heal and maintain health. The body is Electrical and these frequencies interfere with it's own electrical system causing it to break down and become vulnerable to disease.

When students are sitting in classrooms surrounded by this "soup of radiation" their entire body is being damaged! (Brain, Immune System, Heart, Lungs, etc…)

The World Health Organization has labeled this technology as a **Class 2b carcinogen** and thousands of studies have proven the EMF/ELF/Radiation to be a contributing cause to ADD, ADHD, Aggressive Behavior, Dementia, Parkinsons, MS, Heart Palpitations, Heart Attacks, Strokes, Nose Bleeds, Headaches, Flu-like symptoms, chronic coughs, unexplained rashes, severe depression, suicidal tendancies, and many, many more!

Schools are reporting severe outbreaks of Flu, Mumps, Meningitis, etc… as well as unprovoked shootings, bullying, and criminal behavior of students.

Anyone who takes the time to research the long-term effects of EMF/ELF/Radiation from the above mentioned devices and equipment will find that the sudden increase of these problems is directly related to the accumulative exposure to this "soup of radiation."

The companies that make these devices would have you believe they are safe and the media has been told to remain silent on their dangers.

The vast majority of Medical Doctors are making a fortune "mis-diagnosing" and "mis-informing" parents and students of what is truly wrong because they either refuse to pay attention to the research or they don't want to give up the financial windfall they have received due to the invention, sales, and installation of these devices and equipment.

Documentation and 1000's of Research Studies have been turned into the AMA, Kentucky Attorney General, and the Kentucky Public Service Commission under Case File 2012-00428. They may be reviewed at their website online!

The documentation is being ignored and the entire population is being "duped" into believing this technology is safe as well as believing that all the health problems and outbreaks are due to something other than the chronic exposure to this EMF/ELF/Radiation.

It is one thing to be able to turn your phone, laptop, or wifi off and on, but the above mentioned technology is not "hard-wired" nor is it analog! Everyone is being exposed constantly and the body has no recovery period from the exposure!

Parents, Teachers, Students, and the Entire Population need to stand-up and speak-out against this technology being used in the schools, businesses, and homes!

It is one thing to choose to use this technology in your home, but to expose everyone to it chronically because they have no choice for a EMF/ELF/Radiation FREE School or Work Environment, is a crime!

Children and young adults are more vulnerable to this technology because their bodies have not fully developed. (Especially their Brains and Immune Systems!)

Take a stand and tell your school board to "Hard Wire" all technology! Do not allow wireless devices such as the AMR/AMI/ERT/Smart Meters to be installed on Homes, Businesses, Schools, Hospitals, etc…

Instead of Wifi and Smart Boards, tell the School Boards that all laptops and smartboards must be hardwired.

Say "No" to the smart phones! You and your family can function just fine with the old style cell phones that use the CDMA Networks. Those phones still gave off EMF/ELF and Radiation, but the levels were half of what the smart phones put out!

It's a choice! Health or eventual illness and disease! You must control your environment and get informed before you or your children become a statistic!

There are so many more dangers associated with this technology, but there is just not enough room to list it here.

Please go to Kentucky Public Service Commission Case File 2012-00428 and see for yourself the documentation filed against wireless utility meters and the damages they are causing to property by killing trees, wildlife and making residents sick!

We are a community of Traditional Natural Medicine Doctors who have researched and understand the symptoms and illnesses caused by exposures to EMF/ELF/Radiation created by the above mentioned devices.

Our Nation is in crisis, and the most important issue at hand is not being addressed!

Increases in Cost of Healthcare, Crime, Illness and disease, is directly proportional to these exposures to EMF/ELF/Radiation. The exposure can not be controlled unless we are the ones who can individually turn it off and on! This is not an option if it is not "Hard Wired." (Our privacy is also being violated by the utilization of these devices!)

Research and Learn! Visit http://safeschool.ca/Health_Warnings.html

Research and Learn! Visit http://emfsafetynetwork.org/wp-content/uploads/2010/08/Symptoms-after-Exposure-to-Smart-Meter-Radiation.pdf

Research and Learn! Visit http://www.activistpost.com/2013/10/34-scientific-studies-showing-adverse.html

Research and Learn! Visit http://www.ijsgce.com/uploadfile/2012/1011/20121011122317256.pdf

http://www.powerwatch.org.uk/science/studies.asp?pf=1

Peer-reviewed scientific studies on EMF related subjects

When it comes to EMF issues, one of the most frequently heard phrases is "There is no evidence to support EMFs having health effects" or simply "There is no conclusive evidence".

This is completely wrong; there is an enormous body of evidence out there, but public and even academic awareness seems to be very poor. Therefore, we will be presenting a list of papers and odds ratios which either show serious effects or are considered important papers on the subject which we have collected over the years. This page will be updated regularly.

P This study has found effects from the exposure or radiation category

N This study has found no effects from the exposure or radiation category

- This study has offered important insights or findings but is neither a positive or null finding

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EMR Health Alliance of BC

Electromagnetic Radiation in Western Canada

WI-FI Studies

EFFECTS OF 2.4 GHz RADIOFREQUENCY RADIATION EMITTED FROM WI-FI EQUIPMENT ON microRNA EXPRESSION IN BRAIN TISSUE.

Int J Radiat Biol. **2015 Mar 16**
http://www.ncbi.nlm.nih.gov/pubmed/25775055?dopt=Abstract

The results revealed that long term exposure of 2.4 GHz Wi-Fi radiation can alter expression of some of the miRNAs such as miR-106b-5p (adjP* = 0,010) and miR-107 (adjP* = 0,005). We observed that mir 107 expression is 3.3 times and miR-106b-5p expression is 3.65 times lower in the exposure group than in the control group. However, miR-9-5p, miR-29a-3p and miR-125a-3p levels in brain were not altered.

CONCLUSION:

Long term exposure of 2.4 GHz RF may lead to adverse effects such as neurodegenerative diseases originated from the alteration of some miRNAs expression and more studies should be devoted to the effects of RF radiation on miRNAs expression levels.

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34 Studies on Wi-Fi Radiation

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Study Suggests Wi-Fi Exposure More Dangerous To Kids Than Previously Thought

Most parents would be concerned if their children had significant exposure to lead, chloroform, gasoline fumes, or the pesticide DDT. The International Agency for Research on Cancer (IRIC), part of the United Nations' World Health Organization (WHO), classifies these and more than 250 other agents as Class 2B Carcinogens – possibly carcinogenic to humans. Another entry on that same list is radiofrequency electromagnetic fields (RF/EMF). The main sources of RF/EMF are radios, televisions, microwave ovens, cell phones, and Wi-Fi devices.

Uh-oh. Not another diatribe about the dangers of our modern communication systems? Obviously, these devices and the resulting fields are extremely (and increasingly) common in modern society. Even if we want to, we can't eliminate our exposure, or our children's, to RF/EMF. But, we may need to limit that exposure, when possible.

That was among the conclusions of a survey article published in the *Journal of Microscopy and Ultrastructure* entitled "Why children absorb more microwave radiation than adults: The consequences." From an analysis of others studies, the authors argue that children and adolescents are at considerable risk from devices that radiate microwaves (and that adults are at a lower, but still significant, risk). The following points were offered for consideration:

- Children absorb a greater amount of microwave radiation than adults.
- Fetuses are even more vulnerable than children. Therefore pregnant women should avoid exposing their fetus to microwave radiation.
- Adolescent girls and women should not place cellphones in their bras or in hijabs (headscarf).
- Cellphone manual warnings make clear an overexposure problem exists.
- Government warnings have been issued but most of the public are unaware of such warnings.
- Current exposure limits are inadequate and should be revised.
- Wireless devices are radio transmitters, not toys. Selling toys that use them should be monitored more closely.

Children and fetuses absorb more microwave radiation, according to the authors, because their bodies are relatively smaller, their skulls are thinner, and their brain tissue is more absorbent.

Do the benefits of immersive learning applications outweigh the dangers of increased cellular and Wi-Fi exposure for children?

More generally, the studies cited in the paper seek to link RF/EMF exposure to different types of cancer, low sperm count, and other disorders. However, it is important to note that survey articles such as these need to be taken in their proper context. This particular article is one group's perspective. It was published in a relatively new and minor journal with limited data sets. They also note that the average time between exposure to a carcinogen and a resultant tumor is three or more decades, thus making it difficult to arrive at definitive conclusions.

This is not a call to throw out all electronic devices. However, at the very least, it should open up the discussion about different safety levels for adults versus children. Hopefully more longitudinal studies will be done to verify or contradict the assumptions so far. In the meantime, are the government's current regulations adequate? The exposure levels they warn against haven't seem to have been updated for more than 19 years.

In a Network World opinion article ominously titled "Is Wi-Fi killing us…slowly?" columnist Mark Gibbs makes the point that "… laws and warnings are all very well but it's pretty much certain that all restrictions on products that use microwave technology will err on the safe side; that is, the side that's safe for industry, not the side of what's safe for society." Gibbs then added this ominous closing question, "Will we look back (sadly) in fifty or a hundred years and marvel at how Wi-Fi and cellphones were responsible for the biggest health crisis in human history?"

But, short of that worst-case scenario, the topic certainly merits more scrutiny, and perhaps some common sense limits on what devices our children use, and for how long.

http://www.forbes.com/sites/robertszczerba/2015/01/13/study-suggests-wi-fi-exposure-more-dangerous-to-kids-than-previously-thought/

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Wi-Fi Makes Trees Sick, Study Says

By René Schoemaker, IDG News Service - Nov 19, 2010 1:09 PM
Editorial note: A Dutch agency that looks into the health effects of electromagnetic radiation issued a statement that the results of the research described in this story were unconfirmed. "Based on the information now available [it] can not be concluded that the Wi-Fi radio signals leads to damage to trees or other plants," it said, according to a Google translation. Radiation from **Wi-Fi networks** is harmful to trees, causing significant variations in growth, as well as bleeding and fissures in the bark, according to a recent study in the Netherlands. All deciduous trees in the Western world are affected, according to the study by Wageningen University. The city of Alphen aan den Rijn ordered the study five years ago after officials found unexplained abnormalities on trees that couldn't be ascribed to a virus or bacterial infection. Additional testing found the disease to occur throughout the Western world. In the Netherlands, about 70 percent of all trees in urban areas show the same symptoms, compared with only 10 percent five years ago. Trees in densely forested areas are hardly affected. Besides the electromagnetic fields created by mobile-phone networks and wireless LANs, ultrafine particles emitted by cars and trucks may also be to blame. These particles are so small they are able to enter the organisms. The study exposed 20 ash trees to various radiation sources for a period of three months. Trees placed closest to the Wi-Fi radio demonstrated a "lead-like shine" on their leaves that was caused by the dying of the upper and lower epidermis of the leaves. This would eventually result in the death of parts of the leaves. The study also found that **Wi-Fi radiation** could inhibit the growth of corn cobs.The researchers urged that further studies were needed to confirm the current results and determine long-term effects of wireless radiation on trees.
http://www.pcworld.com/article/211219/study_says_wifi_makes_trees_sick.html
http://www.dailymail.co.uk/sciencetech/article-1332310/Is-Wi-Fi-killing-trees-Dutch-study-shows-leaves-dying-exposure-Wi-Fi-radiation.html
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Plants won't grow near Wi-Fi routers, experiment finds

Friday, December 13, 2013 by: Michael Ravensthorpe

Tags: Wi-Fi routers, radiation, plant growth

(NaturalNews) It's not difficult to understand the appeal of Wi-Fi. This revolutionary technology, which has been commercially available since 1999, eliminates cabling and wiring for computers, reduces cellular usage charges and allows us to connect to the

Internet from anywhere with a signal. Despite these benefits, however, studies continue to show that the radiation generated by wireless routers is negatively affecting our health. In fact, the British activist website *Stop Smart Meters* recently published a list of 34 scientific studies demonstrating the adverse biological effects of Wi-Fi exposure, including studies linking it to headaches, reduced sperm count and oxidative stress.

The latest research into the dangers of Wi-Fi, though, comes from a surprisingly humble source: Five ninth grade female students from Denmark, whose science experiment revealed that wireless radiation is equally as devastating to plants.

Undeniable results

The experiment began when the five students realized that they had difficulty concentrating in school if they slept near their mobile phones the previous night. Intrigued by this phenomenon, the students endeavored to study the effects of cellphone radiation on humans. Unfortunately, their school prevented them from pursuing this experiment due to a lack of resources, so the students decided to test the effects of Wi-Fi radiation (comparable in strength to cellphone radiation) on a plant instead.

The girls placed six trays of *Lepidium sativum* seeds (a garden cress grown commercially throughout Europe) in a room without radiation, and an equal amount in a room next to two Wi-Fi routers. Over a 12-day period, they observed, measured, weighed and photographed the results. Even before the 12th day arrived, however, the end results were obvious: The cress seeds placed near the routers either hadn't grown or were completely dead, while the seeds placed in the radiation-free room had blossomed into healthy plants.

The experiment earned the five students top honors in a regional science competition. Moreover, according to a teacher at their school, Kim Horsevad, a professor of neuroscience at the Karolinska Institute in Sweden was so impressed with the experiment that he is interested in repeating it in a controlled scientific environment.

You can help reduce your exposure to Wi-Fi radiation by following the advice in this article.

Sources for this article include:

http://www.globalresearch.ca

http://www.safespaceprotection.com

http://www.naturalnews.com

http://science.naturalnews.com

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Michael Ravensthorpe is an independent writer whose research interests include nutrition, alternative medicine, and bushcraft. He is the creator of the website, Spiritfoods, through which he promotes the world's healthiest foods.

Learn more: http://www.naturalnews.com/043238_Wi-Fi_routers_radiation_plant_growth.html#ixzz3UmGuCfVK

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Radiation from WiFi connections can reduce sperm activity in up to a quarter of men, study finds

By DAILY MAIL REPORTER
UPDATED: 09:50 GMT, 1 December 2011

Working on a laptop wirelessly may hamper a man's chances of fatherhood.

In a study, sperm placed under a laptop connected to the internet through wi-fi suffered more damage than that kept at the same temperature but away from the wireless signal.

The finding is important because previous worries about laptops causing infertility have focused on the heat generated by the machines.

Radiation: It may be convenient, but using a laptop on your lap could be harming your sperm, say researchers (file picture)

In the latest study, researchers took sperm from 29 men aged 26 to 45 and placed them either under a wi-fi connected laptop or away from the computer.

The laptop then uploaded and downloaded information from the internet for four hours.

At the end of the experiment, 25 per cent of the sperm under the laptop had stopped moving and 9 per cent showed DNA damage.

By comparison, just 14 per cent of samples kept away from the wi-fi stopped moving. And just 3 per cent suffered DNA damage, the journal Fertility and Sterility reports.

The wireless connection creates electromagnetic radiation that damages semen, the scientists, from the United States and Argentina, believe.

Lead researcher Conrado Avendano, of Nascentis Medicina Reproductiva in Cordoba, said: 'Our data suggest that the use of a laptop computer wirelessly connected to the internet and positioned near the male reproductive organs may decrease human sperm quality.

'At present we do not know whether this effect is induced by all laptop computers connected by WiFi to the internet or what use conditions heighten this effect.'

A separate test with a laptop that was on, but not wirelessly connected, found negligible EM radiation from the machine alone.

The findings fuel concerns raised by a few other research teams.

Some have found that radiation from mobile phones creates feeble sperm in the lab, for example.

And last year urologists described how a man sitting with a laptop balanced on his knees can crank up the temperature of his scrotum to levels that aren't good for sperm.

So between the heat and the radiation from today's electronic devices, testicles would seem to be hard-pressed.

Concern: A quarter of sperm exposed to WiFi radiation in the study were no longer swimming around after four hours

However, Dr Robert Oates, the president of the Society for Male Reproduction and Urology, has managed to father two kids despite having both a laptop and an iPad.

He told Reuters Health he doesn't believe laptops are a significant threat to male reproductive health.

Remarking on the new study, he said: 'This is not real-life biology, this is a completely artificial setting.

'It is scientifically interesting, but to me it doesn't have any human biological relevance.'

He added that so far, no study has ever looked at whether laptop use has any influence on fertility or pregnancy outcomes.

'Suddenly all of this angst is created for real-life actual persons that doesn't have to be,' said Oates, also of Boston Medical Center.

He added: ‘I don’t know how many people use laptops on their laps anyway.’

According to the American Urological Association, nearly one in six couples in the U.S. have trouble conceiving a baby, and about half the time the man is at the root of the problem.

While the impact of modern technology is still murky, lifestyle does matter, researchers say.

Earlier this month, a report in Fertility And Sterility showed that men who eat a diet rich in fruit and grains and low in red meat, alcohol and coffee have a better shot at getting their partner pregnant during fertility treatment.

Read more: http://www.dailymail.co.uk/sciencetech/article-2067515/Using-Wi-Fi-laptop-damages-sperm-reduce-activity-study-finds.html#ixzz3UmHrMcTm

http://survincity.com/2010/07/the-effects-of-electromagnetic-waves-on-human/

The effects of electromagnetic waves on human health

There are many ways to classify the effects of electromagnetic radiation on health. Here we have to distinguish between biological changes (which are proved by experimental observations at the cellular level) and pathological effects (causing or worsening of disease) proved by epidemiological studies.

Effects of radiation on the list of health, presented here is actually just a small sample of large studies, reported in the present time in the scientific literature.

Pay attention!Links to articles, reports, studies, video reports on this topic can be found in the text material, and at the end.

Biological effects of electromagnetic radiation

Here are some of the biological changes according to research vyzvannyhelektromagnitnym radiation (first — the most recent data):

Protein changes in the skin.

Ten women volunteered to participate in the proposed study in which they were EMP (900 mH) via GSM mobile phones for one hour. After the experiment, scientists seized for investigation of skin cells in order to find any stress reactions. They investigated 580 different proteins and found two that were significantly affected. (He has been increased by 89%, while the other is reduced by 32%). Source — «NewScientist» on February 23, 2008.

Anomalies of development and quality of sperm.

Researchers at the Cleveland Clinic studied 361 male sperm quality, tested in the clinic issledoaniya fertility. On average, those who have spent many hours talking on the cell phone, showed a low sperm count, and increased rates of sperm abnormality. Source — «New Zealand Herald».

Irritation of brain cells.

Researchers from Fatebenefratelli Hospital in Isola Tiberina, found that elektromagnitnoepole emitted by cell phones can cause some cells in the cerebral cortex (adjacent to the side of the head where the phone is used) is strongly excited by the hour, while others become depressed. Source — «Health24» — June 27, 2006

DNA damage.

German research group Verum studied the effect of radiation on human and animal cells. After the cells were placed in the electromagnetic field of a cell phone — they showed an increase in the gap in their DNA that are not always able to be recovered. This damage can be passed on to future cells which, in turn, could develop into malignant tumors. Source — «USA Today», December 21, 2004

Damage to brain cells.

Study the effects of cell phone frequencies (applied at non-thermal intensity) on rat brain showed damage to neurons (brain cells) in different parts of the brain, including the cortex, hippocampus and the main ganglia. Source — Newsletter "Environmental Health Perspectives", June 2003

Aggressive growth of leukemia cells.

Researchers at the National Research Council in Bologna, Italy showed that leukemia

cells exposed to cell phone frequencies (900 mH) for 48 hours, have become more active breed. Source — «NewScientist» October 24, 2002

High blood pressure.
Researchers in Germany have found that a one-time use of a cell phone for 35 minutes could cause an increase in the normal blood pressure by 5-10 mm. Source — "Lancet", June 20, 1998

The adverse effects of electromagnetic radiation.
Here are some of the pathological (bolezneobrazuyuschih) effects vyzvannyeelektromagnitnym radiation, published in the media (in reverse chronological order):

Cancer of the salivary gland.
Israeli researchers report that people who used cell phones for 22 hours a month or more, up to 50 percent more likely to develop cancer slyunnoyzhelezy than those who used cell phones rarely or never used them. Source — «Health24», February 19, 2008

Brain Tumor.
The analysis of several previous studies led to the conclusion that the use of a cell phone for more than 10 years with an increased risk of acquisition of certain types of brain tumors (2.4 times for acoustic neuroma and 2 times for gliomas). Source — «News24», October 3, 2007

Lymphatic cancer and cancer of the bone marrow.
Researchers from the University of Tasmania and the University of Bristol studied the records of 850 patients who were diagnosed with cancers of the bone marrow and lymphatic system. They found that people living within 300 meters of high voltage power lines over a long period (especially a child), 5 times more at risk of developing these diseases later in life. Sources — "Journal of Internal Medicine", in September 2007, «Physorg.com», August 24, 2007

Miscarriage.
Researchers in California have found that electromagnetic radiation from electrical appliances (such as vacuum cleaners, hair dryers and mixers) can significantly increase the risk of miscarriage in women. Source — "Journal of Epidemiology", January 2002

Suicide.
American researchers have found that the growth rate of suicide among 5000 workers operating the technical facilities related to electricity, which had been exposed to very low frequencies, doubled compared to the results of the control group of the same size. The effect was particularly expressive of young workers. "Journal of Occupational and Environmental Medicine", March 15, 2000

In addition to the above — produced a lot of other studies, but not all of them got the attention of the media.

The list of diseases caused by exposure to electromagnetic radiation on health

Life-threatening Diseases
- Alzheimer disease
- Brain cancer (adult and child)
- Breast cancer (male and female)
- Depression (suicidal)
- Heart disease

- Leukemia (adult and child)
- Miscarriages

Other conditions:

- Allergies
- Autism
- Elevated blood pressure
- Electro-sensitivity
- Headaches
- Hormonal changes
- Damage to the immune system
- Damage to the nervous system
- Sleep Disorders
- Sperm abnormalities

How Does Amy?

Some scientists previously believed that the only way by which izlucheniemoglo produce harmful effects in its intensity was sufficient to cause the effect of heating tissue. (Previously, it was reported that talking on a cell phone for half an hour can raise the temperature in that part of the brain where the head came in contact with her staff). Subsequently, this theory has been roundly condemned by many studies, which proved that the intensity of the electromagnetic radiation is not enough to harm.

The mechanisms by which electromagnetic radiation can trigger the disease, is not yet fully understood, but actively conducting experiments on the subject.

DNA damage.

Our cells have mechanisms to partially compensate the damage caused to DNA, but, apparently, the EMR may violate these mechanisms. DNA damage is involved directly in the development of several diseases, including various types of cancer.

Protective antiviral mechanism of the host cell (interference) with the production of melatonin.

Electromagnetic radiation is introduced into the process of the production of melatonin, a hormone produced in the human body. We have already proved that low melatonin levels are associated with several diseases, including cancer. (Recent research indicates that the production of seratonin can also be affected by EMI).

The effect on cell-cell communication.

Our body cells communicate internally and externally through electric signals. These signals can be changed by electromagnetic radiation through the production of electrical currents within the body, causing changes in cellular activity and cell structures.

The harmful effects of electromagnetic radiation on health may depend on …

At this stage we do not have all the answers, but the tips of various studies indicate that the health effects of EMF may depend on:

The intensity of the radiation.

Getting into the zone of strong electromagnetic waves can be harmful, even if briefly. In one study of pregnant volunteers were asked to wear a device that measures the intensity of the highest (peak) for EMI day period. The results indicated that higher peak levels of RF correlated with higher rates of damage to health (miscarriage).

Cumulative effect of radiation.

During the day the person is exposed to electromagnetic radiation of different

frequencies. For example, they may come from electric shavers and hair dryers, the equipment of cars, buses or trains, household items such as heaters, ovens and microwaves, neon lamps, home wiring, power lines, carrying and using a cell phone. These are the most common sources.
The combination of these effects can overwhelm the body's defenses and defense mechanisms.

The duration of the EMP.

Numerous studies indicate that damage to health is beginning to be noticeable only after many years of exposure EMR, such as from power lines of high voltage, or cell phones.

Transience of EMF.

More biological stress from exposure to electromagnetic radiation the body is under the instruments, with volatile, fluctuating cycle (photocopier, printer, etc.), rather than in regular employment.

Frequency EMF.

So far, not known for certain what type of electromagnetic waves cause adverse health effects, but it seems to have different frequencies cause a variety of negative effects.

Signal interference.

To produce an analog or digital signal — electromagnetic wave can be modulated in various ways. Where waves are used for communication (eg, radio, television, mobile phone, etc.), the signal is applied to the frequency of the carrier. There is evidence that, in some cases, a component of the signal can be more harmful than the EMR support.

Medical EMR danger is real.

The danger to our health caused by high levels of man-made electromagnetic fields, is real. Such a general conclusion, many of the growing number of senior scientists and professional health care workers.
Fortunately, there are many ways to protect ourselves and our loved ones, before our health will be affected.
Now absolutely certain that electromagnetic fields can exert a negative influence on your health.
If you are still skeptical — please learn on this article (effects of EM radiation on human health).
Aware — is forearmed. If you know the risks and EMI protection strategies, then you can make the best choice for the health of you and your family.
If you can not follow all the recommendations below — make at least what you can.
In this case — it helps everything.

General Rule protection from EMI # 1

Reduce exposure to electromagnetic radiation, increasing your distance from the radiation.

This — the most important rule for EMP protection, and often the easiest to use.
How much to move away from the source of radiation — depending on its intensity. For example, to reduce the intensity of the field, you may have to move to a distance:
25 meters for power lines and cell phone towers.
30 see on your computer monitor
5 cm from the electric clock next to your pillow
2.5 cm from the cell phone

Many people realize that they can increase their level of security from EMI went away for a hundred meters away from power lines or cell phone towers, but few people think that in life, you can further protect themselves by placing the computer on the floor or move a TV yet away from themselves and their children.
To understand the safety distance for different kinds of devices, study**Now this document**, but keep in mind that your EMR devices may differ from those in this list. If you have the opportunity to use fluxmeter — better to take advantage of this opportunity.

General Rule Protection EMI number 2

If you can not avoid exposure to electromagnetic radiation, try to limit it.
For many may have long been commonplace — to watch a technician at work, go by and chat with colleagues around the office printers and copiers, or stand next to the oven while cooking dinner.
In all these cases, as in many others, for your health it would be better to apply Rule # 2.

General Rule EMP protection # 3

If there is no real need to include the device — turn it off (or on).
EMP is based on the many devices that people working unreasonable to leave, for example chargers (for batteries, cell phones, laptops, etc.), as well as computers in sleep mode, and printers.
Off devices also contributes to the health of the planet and your wallet.
You also have to know and remember all sources of electromagnetic radiation in their environment, at home or in the office. This might sound strange to the background of the general behavior, but this is the only responsible approach mature and well-informed person.
Explore and all major sources of EMR in your house or apartment.
Note the location of the building in which you live. Power lines at a distance greater than 400 meters — are unlikely to have seriously impact on your health. If this distance — less — we recommend you use flowmeters.
Local power lines (supply your home with electricity) can also cause significant electromagnetic radiation.
Note the distance from your home to the transformer substation buildings or engineering. Electromagnetic radiation from the local substation can come to a distance of 5-10 meters. Do not allow children to play in this area.
400 meters — the optimal distance to be safe from the effects of cell phone towers, you know that they are there in your area.
As long as you look around the area, pay attention to how far you are from the TV and radio antennas. They may have a much stronger radiation than cell towers.
Several studies have linked increased rates of cancer and leukemia with proximity to the TV antenna, especially a very large and powerful, which increases cancer, being located at a distance of 3-5 kilometers.
Unfortunately, there is no better protection than to apply Rule # 1
Protecting your home from EMI
The house / apartment, sources of EMR is the internal wiring of appliances and all kinds. Internal wiring is essential and one of the major sources of electromagnetic radiation, but

it is rarely people think. Some companies offer expertise in the presence of electromagnetic radiation in the apartments.

Radiation protection appliances

As for appliances, some very common types of household appliances rather high level of radiation. Put them on a long distance from the people, and remember that your communication with them should not be long.

For frequent or prolonged use any device — be it makes sense to find an alternative with lower EMI (such as a laptop or phone).

For example, portable hair dryers often have high levels of electromagnetic radiation, but if you use it for just 1 minute a day, then you are unlikely to be exposed to some seriously affected.

However, if you — a hairdresser, using a portable hair dryer for a total of about 60 minutes a day, then you should consider buying a dryer with low EMI. The same applies to the sewing machine.

Technique in the bedroom — or protection from EMI in the bedroom

Try to identify your personal exposure to electromagnetic radiation. Pay particular attention to the instruments and equipment that you encounter most often during the day. Start with your bedroom, because here you spend about 8 hours a day, so even a small level of EMR in your bedroom can significantly damage your health.

Turn off the electric blanket, if they do not need or use the lowest level of the adjustment. Keep electric clock / radio as far away from a sleeping person, preferably at a distance of 60 cm or more network devices. Even hours on batteries and a clock radio does not have to be next to your head.

Pay attention to the place where electricity is opened opened in your home and on the position of the main distribution box.

If it's in the bedroom, put the bed at a distance of not less than 1.5 meters from it. Magnetic part of the electromagnetic radiation easily penetrates through walls, so also think about what is on the other side of the wall.

Radiation protection cell phones.

Cell phones are becoming a major biological threat, almost weapon possibly as harmful as smoking. In order to reduce the negative impact — use alternative means of communication (land line) when a every opportunity.

Do not use cell phones for long conversations and think about others — do not keep them on the tube more than necessary.

We recommend using a headset, or a simple tool like a speakerphone. We do not notice, but we have is really enough situations where it is convenient to use.

The children, for their own health should be protected from cell phone use, because their developing brains are particularly vulnerable to EMP cell phones, and their skulls are thinner.

Experts recommend that children under 10 years do not use cell phones. Older children also need to be subject to strict guidelines on the use of phones.

Protection from electromagnetic radiation in the workplace.

If you spend a lot of time working in the office or at work, try to be at least 1.5 meters from any electrical equipment such as heaters and air conditioners, file servers or printers. Stick to the same distance from the neon wiring connections or nodes.

If you have been working on a computer — place it as far away from you (especially the

head) shall, if the cables. If possible, give preference to the LCD monitor instead of a CRT monitor. Also stay away as far as possible, and at a distance that allows the length of the cables.
If you have installed UPS — remember elektromagnitnoeobluchenie them much higher than the computer itself. Try putting these devices at a distance of 1.5 meters from you and other people.
It should take some effort once to optimize their living space, if you spend many hours every day in this environment.
Try to avoid the location or work in an environment that uses wireless devices — networks, Wi-Fi, cordless phones and modems. Do not flatter their supposed "security". Radio and microwave radiation is more dangerous than the low frequency.
Calculate your personal exposure to low-frequency waves.
Once you have implemented the above recommendations, it is necessary to check the level of daily low-frequency radiation to which you are exposed. This will help you understand where there is a big part of the EMP.
Tolerances for EMI, in our opinion, applies only to low-frequency radiation, but not to the radio and microwave EMF (which probably are dangerous at much lower levels.)
Constant exposure to ELF (ultra-low frequency, ie, <100 Hz) and VLF (very low frequency, ie, 100 Hz-10 kHz) waves at 1.0 milligaus considered safe. This would be equivalent to 24 milligaus / h (1.0 × 24) a day.
Our recommendation for an acceptable level of EMR slightly lower — 20 mg / hour.
To correctly perform this calculation, you have to add all the calculations EMR level from all sources.
For example, if you use a hair dryer (EMP force 100 milligausov obektaizlucheniya at distances of 30 cm) for 1 minute every morning — it's 100 milligausov / minute, or 1.67 milligausov / hour (100/60).
If you sleep for 8 hours next to the electric clock, the power of EMP effects on your head is 4 milligausa, you have accumulated 32 milligausa per hour (4 × 8) and have exhausted your allowable limit EMI before you got out of bed!
To calculate the impact of EMR in milligausah per hour (mg / hours):
Make a list of all devices that you use every day, along with the duration of exposure (in minutes).
Then calculate the value for each of these items on our chart by selecting the appropriate distance for each device.
Multiply the value in milligausahna number of minutes for each item. Summarize mg / min for all the items. Then divide the total by 60 to get the value milligaus / h.
Adapt the resulting overall result to the general factors, such as proximity to the lines elektoperedach**(See table)**, the trip, and any other known sources of ELF / VLF.
This method — somewhat crude tool in order to completely and correctly determine your level of exposure to low-frequency waves. But it helps you to see how much of the proceeds of electromagnetic radiation, and the final figure helps you evaluate your risks.
By calculating your total daily dose, try to make adjustments to your lifestyle, which can help minimize exposure. Start simple. (Remove the electric clock away from your pillow!)
In short, set attainable directly to you limit the resulting exposure, say 30 milligaus per hour. When you reach it, ask to split into two your exposure. Then you can figure out

what else can be done to further reduce this level.

Table EMP effect appliances
This table shows the approximate tlko for very low-frequency waves and the sub radiation. Devices such as mobile phones and microwave ovens are included in this tablitsutolko for the reason that they produce a significant low-frequency radiation as well as radio and micro wave izluenie (the latter not shown in table). This is about values. Your equipment may have several different values.

Electrical Equipment / Appliances	The strength of the electromagnetic field in the distance millig ausah			
	15 cm	30 cm	60 cm	1.2 m
Air-conditioner	3	1	0	0
Baby Monitor	6	1	0	0
Charger	30	3	0	0
Blender	70	10	2	0
Electric can opener for konsevrov	600	150	20	2
Mobile telephone (very low frequency) In contact: 20mG	5	2	0	0
Analog Clock	15	2	0	0
Digital Clock	6	1	0	0
A device for cleaning clothes	3	2	0	0
Coffee machine	7	0	0	0
Monitor to the computer (ray)	14	5	2	0
Monitor to the computer (LCD)	1	0	0	0
Desktop computer	3	1	0	0
Laptop In contact: 20mG	5	1	0	0
Stove / oven	30	8	2	0
Medlennovarka	6	1	0	0

Dishwasher	20	10	4	0
Electric blanket within 2.5 cm: 20mG				
Stationary dryer	3	1	0	0
Fax	6	0	0	0
Fluorescent lamp	40	6	2	0
Mixer	100	10	1	0
Food processor	30	6	2	0
Disposal facilities	80	10	2	0
Hairdryer	300	1	0	0
Heater	100	20	4	0
Hi Fi / CD player / tuner, etc.	1	0	0	0
Iron	8	1	0	0
Microwave (only LF)	200	40	10	2
Oven	9	4	0	0
Power drill	150	30	4	0
Eletropila	200	40	5	0
Power supply (UPS)	90	25	3	1
Desktop printer	3	1	0	0
Big office printer, copier	90	20	7	1
Refrigerator	2	2	1	0
Electric shaver	100	20	0	0
Toaster	10	3	0	0
Ray tube TV	30	7	2	0
Vacuum cleaner	300	60	10	1
Washing machine	20	7	1	0

http://www.sciencedirect.com/science/article/pii/S0048969715002296

Anthropogenic radiofrequency electromagnetic fields as an emerging threat to wildlife orientation

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Highlights

•The growth of wireless telecommunication technologies causes increased electrosmog.

•Radio frequency fields in the MHz range disrupt insect and bird orientation.

•Radio frequency noise interferes with the primary process of magnetoreception.

•Existing guidelines do not adequately protect wildlife.

•Further research in this area is urgent.

Abstract

The rate of scientific activity regarding the effects of anthropogenic electromagnetic radiation in the radiofrequency (RF) range on animals and plants has been small despite the fact that this topic is relevant to the fields of experimental biology, ecology and conservation due to its remarkable expansion over the past 20 years. Current evidence indicates that exposure at levels that are found in the environment (in urban areas and near base stations) may particularly alter the receptor organs to orient in the magnetic field of the earth. These results could have important implications for migratory birds and insects, especially in urban areas, but could also apply to birds and insects in natural and protected areas where there are powerful base station emitters of radiofrequencies. Therefore, more research on the effects of electromagnetic radiation in nature is needed to investigate this emerging threat.

American Academy of Environmental Medicine

Electromagnetic and Radiofrequency Fields Effect on Human Health

For over 50 years, the American Academy of Environmental Medicine (AAEM) has been studying and treating the effects of the environment on human health. In the last 20 years, our physicians began seeing patients who reported that electric power lines, televisions and other electrical devices caused a wide variety of symptoms. By the mid 1990's, it became clear that patients were adversely affected by electromagnetic fields and becoming more electrically sensitive. In the last five years with the advent of wireless devices, there has been a massive increase in radiofrequency (RF) exposure from wireless devices as well as reports of hypersensitivity and diseases related to electromagnetic field and RF exposure. Multiple studies correlate RF exposure with diseases such as cancer, neurological disease, reproductive disorders, immune dysfunction, and electromagnetic hypersensitivity.

The electromagnetic wave spectrum is divided into ionizing radiation such as ultraviolet and X-rays and non-ionizing radiation such as radiofrequency (RF), which includes WiFi, cell phones, and Smart Meter wireless communication. It has long been recognized that ionizing radiation can have a negative impact on health. However, the effects of non-ionizing radiation on human health recently have been seen. Discussions and research of non-ionizing radiation effects centers around thermal and non-thermal effects. According to the FCC and other regulatory agencies, only thermal effects are relevant regarding health implications and consequently, exposure limits are based on thermal effects only.[1]

While it was practical to regulate thermal bioeffects, it was also stated that non-thermal effects are not well understood and no conclusive scientific evidence points to non-thermal based negative health effects.[1] Further arguments are made with respect to RF exposure from WiFi, cell towers and smart meters that due to distance, exposure to these wavelengths are negligible.[2] However, many *in vitro*, *in vivo* and epidemiological studies demonstrate that significant harmful biological effects occur from non-thermal RF exposure and satisfy Hill's criteria of causality.[3] Genetic damage, reproductive defects, cancer, neurological degeneration and nervous system dysfunction, immune system

dysfunction, cognitive effects, protein and peptide damage, kidney damage, and developmental effects have all been reported in the peer-reviewed scientific literature.

Genotoxic effects from RF exposure, including studies of non-thermal levels of exposure, consistently and specifically show chromosomal instability, altered gene expression, gene mutations, DNA fragmentation and DNA structural breaks.[4-11] A statistically significant dose response effect was demonstrated by Maschevich *et al*. , who reported a linear increase in aneuploidy as a function of the Specific Absorption Rate(SAR) of RF exposure.[11] Genotoxic effects are documented to occur in neurons, blood lymphocytes, sperm, red blood cells, epithelial cells, hematopoietic tissue, lung cells and bone marrow. Adverse developmental effects due to non-thermal RF exposure have been shown with decreased litter size in mice from RF exposure well below safety standards.[12] The World Health Organization has classified RF emissions as a group 2 B carcinogen.[13] Cellular telephone use in rural areas was also shown to be associated with an increased risk for malignant brain tumors. [14]

The fact that RF exposure causes neurological damage has been documented repeatedly. Increased blood-brain barrier permeability and oxidative damage, which are associated with brain cancer and neurodegenerative diseases, have been found.[4,7,15-17] Nittby *et al.* demonstrated a statistically significant dose-response effect between non-thermal RF exposure and occurrence of albumin leak across the blood-brain barrier.[15] Changes associated with degenerative neurological diseases such as Alzheimer's, Parkinson's and Amyotrophic Lateral Sclerosis (ALS) have been reported.[4,10] Other neurological and cognitive disorders such as headaches, dizziness, tremors, decreased memory and attention, autonomic nervous system dysfunction, decreased reaction times, sleep disturbances and visual disruption have been reported to be statistically significant in multiple epidemiological studies with RF exposure occurring non-locally.[18-21]

Nephrotoxic effects from RF exposure also have been reported. A dose response effect was observed by Ingole and Ghosh in which RF exposure resulted in mild to extensive degenerative changes in chick embryo kidneys based on duration of RF exposure.[24] RF emissions have also been shown to cause isomeric changes in amino acids that can result in nephrotoxicity as well as hepatotoxicity.[25]

Electromagnetic field (EMF) hypersensitivity has been documented in controlled and double blind studies with exposure to various EMF frequencies. Rea *et al*. demonstrated that under double blind placebo controlled conditions, 100% of subjects showed reproducible reactions to that frequency

to which they were most sensitive.[22] Pulsed electromagnetic frequencies were shown to consistently provoke neurological symptoms in a blinded subject while exposure to continuous frequencies did not.[23]

Although these studies clearly show causality and disprove the claim that health effects from RF exposure are uncertain, there is another mechanism that proves electromagnetic frequencies, including radiofrequencies, can negatively impact human health. Government agencies and industry set safety standards based on the narrow scope of Newtonian or "classical" physics reasoning that the effects of atoms and molecules are confined in space and time. This model supports the theory that a mechanical force acts on a physical object and thus, long-range exposure to EMF and RF cannot have an impact on health if no significant heating occurs. However, this is an incomplete model. A quantum physics model is necessary to fully understand and appreciate how and why EMF and RF fields are harmful to humans.[26,27] In quantum physics and quantum field theory, matter can behave as a particle or as a wave with wave-like properties. Matter and electromagnetic fields encompass quantum fields that fluctuate in space and time. These interactions can have long-range effects which cannot be shielded, are non-linear and by their quantum nature have uncertainty. Living systems, including the human body, interact with the magnetic vector potential component of an electromagnetic field such as the field near a toroidal coil.[26,28,29] The magnetic vector potential is the coupling pathway between biological systems and electromagnetic fields.[26,27] Once a patient's specific threshold of intensity has been exceeded, it is the frequency which triggers the patient's reactions.

Long range EMF or RF forces can act over large distances setting a biological system oscillating in phase with the frequency of the electromagnetic field so it adapts with consequences to other body systems. This also may produce an electromagnetic frequency imprint into the living system that can be long lasting.[26,27,30] Research using objective instrumentation has shown that even passive resonant circuits can imprint a frequency into water and biological systems.[31] These quantum electrodynamic effects do exist and may explain the adverse health effects seen with EMF and RF exposure. These EMF and RF quantum field effects have not been adequately studied and are not fully understood regarding human health.

Because of the well documented studies showing adverse effects on health and the not fully understood quantum field effect, AAEM calls for exercising precaution with regard to EMF, RF and general frequency exposure. In an era when all society relies on the benefits of electronics, we must find ideas and technologies that do not disturb bodily function. It is clear that the human body uses electricity from the chemical bond to the nerve impulse and obviously this orderly sequence can be

disturbed by an individual-specific electromagnetic frequency environment. Neighbors and whole communities are already exercising precaution, demanding abstention from wireless in their homes and businesses.

Furthermore, the AAEM asks for:

- An immediate caution on Smart Meter installation due to potentially harmful RF exposure.
- Accommodation for health considerations regarding EMF and RF exposure, including exposure to wireless Smart Meter technology.
- Independent studies to further understand the health effects from EMF and RF exposure.
- Recognition that electromagnetic hypersensitivity is a growing problem worldwide.
- Understanding and control of this electrical environmental bombardment for the protection of society.
- Consideration and independent research regarding the quantum effects of EMF and RF on human health.
- Use of safer technology, including for Smart Meters, such as hard-wiring, fiber optics or other non-harmful methods of data transmission.

Submitted by: Amy L. Dean, DO, William J. Rea, MD, Cyril W. Smith, PhD, Alvis L. Barrier, MD

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http://www.smartmetereducationnetwork.com/smart-meter-environmental-effects.php

Environmental Effects

I haven't seen two bees at any time on a flower since smart meters were installed in my city.

An ever-increasing number of studies, as well as much anecdotal evidence, points to the harm that wireless frequencies are causing to our environment. The combined effects of wireless radiation on pollinators (including bees and butterflies) and food plants, along with the degradation of our food supply caused by GMOs, are creating a perfect storm for the collapse of the food supply and of the world's ecosystems.

Since the installation of smart meters in Ann Arbor in 2012, I have seen almost no bees. The numbers were already dropping precipitously, and this seems to have been their death knell. That same year, almost no toads. Every year since, the numbers have been minimal. Starting in the summer of 2012, I found that the bugs that are tiny enough to fly through the holes in your window screens were no longer a problem. *Where did they all go?* I wondered, then realized it must be the smart meters. When I go walking Bird Hills Nature Area, I see thousands of flowers but only 0–7 insects during my half-hour walk. This was *not* the case prior to smart meter installation. This year, some of the plants are bearing almost no fruit—likely because the pollinators they require are gone.

Radiofrequency affects the ability of insects to navigate. Navigation systems are critical to the survival of birds, insects, and earthworms, to name just a few.

Here we present a *few* of the scientific studies. First, a word about the environmental community and smart meters.

The earth, bathed in the smart grid.
Nothing can escape it unless we act.

Environmentalists Speak Out

Whitney North Seymour, Jr.

Sadly, most of the environmental community is unaware of the harm caused by smart meters and other forms of wireless radiation. Nonetheless, a few environmentalists both groups and individuals, have taken a stand. The co-founder of the National Resources Defense Council, Whitney North Seymour, attorney, environmentalist, and former state senator, is one of them. Sadly, the organization he co-founded, the NRDC, has jumped on the false "smart meters are green" bandwagon.

See a video of Seymour speaking about smart meters.

Jonathan Libber

Former EPA attorney Jonathan Libber has taken a strong stand against the meters as president of Maryland Smart Meter Awareness. He points out our country's spotty record of figuring out environmental hazards before they're widespread. Libber was a skeptic at first. When a concerned neighbor approached him about the meters, Libber's response was, "Ah, some kind of stuff from California. Whatever. I initially was not that impressed." That would have been the end of it for Libber, except that a friend kept pressing him on the issue, eventually getting him to read about 150 pages of documents. That convinced him, and he joins the ranks of others, like Dr. Martin Blank of Columbia University and former Microsoft Canada president Frank Clegg in opposing the meters because of the harm they cause humans and the environment. Read more at the Baltimore Sun.

Linda Kurtz

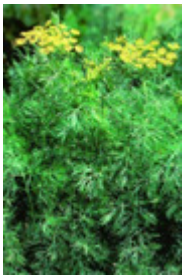
Says Linda Kurtz, head of the Smart Meter Education Network: “The larger environmental community likely has not come out against smart meters for a number of reasons. First, these meters—and all the other wireless devices—have been touted as ‘green’ and energy-saving. Nothing could be further from the truth, as we discuss on our page, “Do Smart Meters Really Save Energy? Secondly, the environmental community has not heard about the negative health and environmental impacts of wireless and digital technologies, mainly because information about these meters has largely been disseminated by conservative and libertarian groups that, in general, do not support the goals of and are not in communication with environmentalists. I feel very fortunate that I, as an environmentalist, have had the opportunity to learn about the negative consequences of these meters on our environment. Third, like most people, so many environmentalists are in love with these technologies and don’t want to give them up, no matter what harm they are causing to the environment. Therefore, they dismiss any reports they do receive about the meters. I have contacted a variety of environmental organizations about these meters. They have not even bothered to acknowledge my emails or phone calls. Finally, guess who sits on the boards of some of the largest environmental organizations? The very people who stand to make the most money from this technology. For instance, Wendy Schmidt, wife of the Google CEO, sits on the board of the NRDC. Ann Doerr, wife of venture capitalist John Doerr (who sits on Google’s board), serves on the board of the Environmental Defense Fund. I don't doubt these people’s commitment on one level, but it is a commitment that ends once their own personal pleasure or wealth is impacted.”

One of the few environmental groups that has taken a stand against smart meters is the San Francisco Sierra Club.

Plants

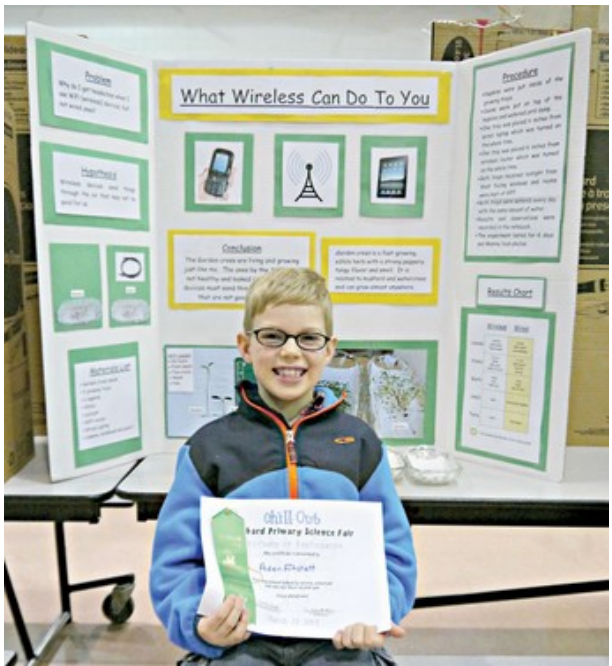
Scientific and Lay Studies on Effect of Microwave Frequencies on Plants

The first studies were by high school students and grade-schoolers. Now, scientists are weighing in.



Food Plants Affected by Microwave Radiation from Wireless Devices
A study published in the Journal of Plant Physiology finds that microwave irradiation of food plants results in thinner cell walls, smaller mitochondria and chloroplasts (both produce energy for plants), and enhanced emissions of volatile compounds. The frequencies studied are those emitted by smart meters, cell phones, wireless routers, and other devices. There was a direct relationship between microwave-induced structural and chemical modifications of the three plant species studied. Volatile compounds function as hormones, to repel predators, and to attract beneficial organisms. Read more...

An Extensive List of Studies Shows Effects. Click here for a list of additional studies showing effects on plants, from tomatoes to barley, from gene expression to perturbation of natural rhythms.



Science Experiment by Grade-Schooler Shows That W-Fi Is Causing His Headaches and Deforms Growing Seeds

An eight-year-old boy in Almont, Michigan was getting severe headaches when seated near the wireless projector in his classroom. They were so severe, he would come home crying from the pain. When he was seated away from the projector, his headaches stopped. For many people, who are even more sensitive than he is, increased distance from wireless device

does not help, because the radiation is permeating the environment around them. See this series of pictures and explanations for more information.

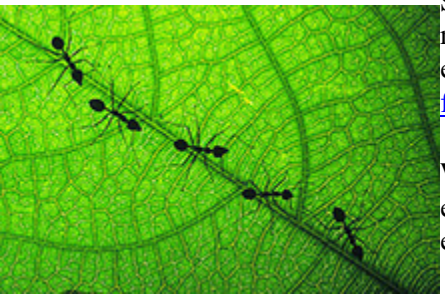
"I want to know why I get headaches when I'm around wireless devices but not the wires," Aiden Fitch says. "We use a laptop at home, and we have a television set, and it's only around wireless that I get the headaches." So Aiden did the same experiment a group of Danish high school students did last year. The Danes began the experiment with Read more...

Bees, Butterflies, and Other Insects

Bees

Study Links Bee Decline to Cell Phones. CNN Report - "Animals, including insects, use cryptochrome for navigation," Goldsworthy told CNN. "They use it to sense the direction of the earth's magnetic field and their ability to do this is compromised by radiation from [cell] phones and their base stations. So basically bees do not find their way back to the hive." Also look at this PDF file.

Honeybees' Behavior Changes When Exposed to RF.



Safe Land for Bees. Barrie Trower, retired British military intelligence officer and microwave warfare expert, asks, "Will the Communications Industry be the final straw for Our Planet's Ecosystems?"

Warning by Dr. Ulrich Warnke. The bioscientist Dr. Ulrich Warnke of Germany knows the electromagnetic workings of nature better than most. Dr. Warnke says: "Today, unprecedented exposure levels and intensities Read more...

Calcium Ions, Cytochrome P450, and the Relationships Between Wireless Radiation, Round-Up, the Decline of Bees and Other Insects, and Human Illness As you know from reading our Health page, calcium plays a critical role in neurotransmission. Studies are showing that glysophate, the main chemical in Round-up (widely used in GMO planting as well as by homeowners on their lawns), and wireless frequencies have the same effects on calcium ions, thus giving humans and bees a double whammy. Many people have reported a decline in insect populations Read more...

Ants

This study on ants regarding food collection and pheromones response showed that electromagnetic radiation causes ants to become confused and unable to collect food. Under the influence of electromagnetic radiation, ants followed trails for only short distances, no longer arrived at marked areas, no longer orientated themselves to a source of alarm pheromone, became unable to return to their nest and recruit congeners. Therefore, the number of ants collecting food increases only slightly and slowly. After 180 h of exposure, their colonies deteriorated.

Earthworms

Oxidative and genotoxic effects of 900 MHz electromagnetic fields in the earthworm. Significant DNA-damaging capacity of 900 MHz electromagnetic radiation. Results indicated the induction of antioxidant stress response in

terms of enhanced catalase and glutathione reductase activity as a result of the RF-EMF exposure, and demonstrated the generation of lipid and protein oxidative damage**.**

Birds

Department of the Interior: Cell Tower Microwave Radiation Has Negative Impact on Birds. Cell tower radiation has had negative impacts on the health of migratory birds and other wildlife, said the Department of the Interior, in a strongly worded letter dated February 7, 2014. "The electromagnetic radiation standards used by the Federal Communications Commission (FCC) continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today."

The department noted that there is a growing level of anecdotal evidence showing harm to nesting and roosting wild birds and other wildlife from non-thermal, non-ionizing electromagnetic radiation from cell phone communication towers. Cell tower radiation is the same radiation as that emitted by smart meters. Read more...

Other Animals

Department of the Interior: Cell Tower Microwave Radiation Has Negative Impact on Animals. Cell tower radiation has had negative impacts on the health of migratory birds and other wildlife, said the Department of the Interior, in a strongly worded letter dated February 7, 2014. "The electromagnetic radiation standards used by the Federal Communications Commission (FCC) continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today."

The department noted that there is a growing level of anecdotal evidence showing harm to nesting and roosting wild birds and other wildlife from non-thermal, non-ionizing electromagnetic radiation from cell phone communication towers. Cell tower radiation is the same radiation as that emitted by smart meters. The Interior Department criticized the federal government's proposed procedures for placement and operation of communication towers, and called for "independent, third-party peer-reviewed studies" in the U.S. to examine the effects of cell tower radiation on "migratory birds and other trust species." It said the FCC standards are no longer appropriate because they control only for overheating and do not protect organisms from the adverse effects of exposure to the low-intensity radiation produced by cell phones and cell towers.

The Interior Department's avers that the 30-year-old FCC standards are outmoded because it does not take into account the effects of lower levels of radiation output from microwave-powered communication devices such as cellular telephones and other sources of point-to-point communications (such as smart meters, which communicate point to point). It says that "very low levels of non-ionizing electromagnetic radiation" are a problem.

The letter from the Department of the Interior states in part: "There is a growing level of anecdotal evidence linking effects of non-thermal, non-ionizing electromagnetic radiation from communication towers on nesting and roosting wild birds and other wildlife in the U.S. Independent, third-party studies have yet to be conducted in the U.S. or Canada, although a peer-reviewed research protocol developed for the U.S. Forest Service by the Service's Division of Migratory Bird Management is available to study both collision and radiation impacts (Manville 2002). As previously mentioned, Balmori (2005) found strong negative correlations between levels of tower-emitted microwave radiation and bird breeding, nesting, and roosting in the vicinity of electromagnetic fields in Spain. He documented nest and site abandonment, plumage deterioration, locomotion problems, reduced survivorship, and death in House Sparrows, White Storks, Rock Doves, Magpies, Collared Doves, and other species.

Though these species had historically been documented to roost and nest in these areas, Balmori (2005) did not observe these symptoms prior to construction and operation of the cellular phone towers. Balmori and Hallberg (2007) and Everaert and Bauwens (2007) found similar strong negative correlations among male House Sparrows. Under laboratory 'conditions, DiCarlo et al. (2002) raised troubling concerns about impacts of low-level, non-thermal electromagnetic radiation from the standard 915 MHz cell phone frequency on domestic chicken embryos-with some lethal results (Manville 2009). Given the findings of the studies mentioned above, field studies should be conducted in North America to validate potential impacts of communication tower radiation—both direct and indirect —to migratory birds and other trust wildlife species."

The full text of the letter, the addendum, and citations are available at: http://1.usa.gov/1jn3CZg

A summarized version can be found at Electromagnetic Radiation Safety.

The press release is found here.

For more information, contact Joel M. Moskowitz, Ph.D., School of Public Health,
University of California, Berkeley.Read less..

http://www.washingtonsblog.com/2012/11/meta-review-of-42-studies-even-the-lowest-level-radiation-is-damaging-to-human-health.html

Meta-Review of 46 Studies: Even the Lowest-Level Radiation Is Damaging to Human Health

Posted on November 19, 2012 by WashingtonsBlog

Even *Miniscule* Amounts of Radiation Can Be Dangerous

A major new scientific study proves that low-level radiation can cause huge health problems.

Science Daily reports:

> Even the very lowest levels of radiation are harmful to life, scientists have concluded in the Cambridge Philosophical Society's journal Biological Reviews. Reporting the results of a wide-ranging analysis of 46 peer-reviewed studies published over the past 40 years, researchers from the University of South Carolina and the University of Paris-Sud found that variation in low-level, natural background radiation was found to have small, but highly statistically significant, negative effects on DNA as well as several measures of health.
>
> The review is a meta-analysis of studies of locations around the globe ….
>
> "Pooling across multiple studies, in multiple areas, and in a rigorous statistical manner provides a tool to really get at these questions about low-level radiation."
>
> Mousseau and co-author Anders Møller of the University of Paris-Sud combed the scientific literature, examining more than 5,000 papers involving natural background radiation that were narrowed to 46 for quantitative comparison. The selected studies all examined both a control group and a more highly irradiated population and quantified the size of the radiation levels for each. Each paper also reported test statistics that allowed direct comparison between the studies.
>
> The organisms studied included plants and animals, but had a large preponderance of human subjects. Each study examined one or more possible effects of radiation, such as DNA damage measured in the lab, prevalence of a disease such as Down's Syndrome, or the sex ratio produced in offspring. For each effect, a statistical algorithm was used to generate a single value, the effect size, which could be compared across all the studies.
>
> The scientists reported **significant negative effects in a range of categories, including immunology, physiology, mutation and disease occurrence**. The frequency of negative effects was beyond that of random chance.
>
> ***
>
> When you do the meta-analysis, you do see significant negative effects."
>
> "It also provides evidence that **there is no threshold below which there are no effects of radiation**," he added. "A theory that has been batted around a lot over the last couple of decades is the idea that is there a threshold of exposure below which there are no negative consequences. These data provide fairly strong evidence that there is no threshold — radiation effects are measurable as far down as you can go, given the statistical power you have at hand."

> Mousseau hopes their results, which are consistent with the "linear-no-threshold" model for radiation effects, will better inform the debate about exposure risks.
> "With the levels of contamination that we have seen as a result of nuclear power plants, especially in the past, and even as a result of Chernobyl and Fukushima and related accidents, there's an attempt in the industry to downplay the doses that the populations are getting, because maybe it's only one or two times beyond what is thought to be the natural background level," he said. "But they're assuming the natural background levels are fine."
> "And the truth is, if we see effects at these low levels, then we have to be thinking differently about how we develop regulations for exposures, and especially intentional exposures to populations, like the emissions from nuclear power plants, medical procedures, and even some x-ray machines at airports."

(We will address below the question as to how most of us can remain healthy if even small doses of background radiation may be harmful.)

Numerous Other Studies Show the Danger of Low-Level Radiation

Indeed, the *overwhelming* consensus among radiation experts is that repeated exposure to low doses of radiation can cause cancer, genetic mutations, heart disease, stroke and other serious illness (and see this.)

The top government radiation experts – like Karl Morgan, John Goffman and Arthur Tamplin – and scientific luminaries such as Ernest Sternglass and Alice Stewart, concluded that low level radiation can cause serious health effects.

A 20-year study involving 110,000 workers who engaged in cleanup work related to the Chernobyl nuclear plant disaster in 1986 found that even low-level radiation causes a significant increase in the risk of leukemia.

A military briefing written by the U.S. Army for commanders in Iraq states:

> Hazards from low level radiation are long-term, not acute effects… Every exposure increases risk of cancer.

(Military briefings for commanders often contain less propaganda than literature aimed at civilians, as the commanders have to know the basic facts to be able to assess risk to their soldiers.)

The briefing states that doses are cumulative, citing the following military studies and reports:

- ACE Directive 80-63, ACE Policy for Defensive Measures against Low Level Radiological Hazards during Military Operations, 2 AUG 96
- AR 11-9, The Army Radiation Program, 28 MAY 99
- FM 4-02.283, Treatment of Nuclear and Radiological Casualties, 20 DEC 01
- JP 3-11, Joint Doctrine for Operations in NBC Environments, 11 JUL 00
- NATO STANAG 2473, Command Guidance on Low Level Radiation Exposure in Military Operations, 3 MAY 00
- USACHPPM TG 244, The NBC Battle Book, AUG 02

Many studies have shown that repeated exposures to low levels of ionizing radiation from CT scans and x-rays can cause cancer. See this, this, this. this, this, this, this, this, this and this.

Research from the University of Iowa concluded:

> Cumulative radon exposure is a significant risk factor for lung cancer in women.

And see these studies on the health effects cumulative doses of radioactive cesium.
As the European Committee on Radiation Risk notes:

> Cumulative impacts of chronic irradiation in low doses are … important for the comprehension, assessment and prognosis of the late effects of irradiation on human beings ….

And see this.
The New York Times' Matthew Wald reported in May:

> The Bulletin of the Atomic Scientists['] May-June issue carries seven articles and an editorial on the subject of low-dose radiation, a problem that has thus far defied scientific consensus but has assumed renewed importance since the meltdown of the Fukushima Daiichi reactors in Japan in March 2011.
> ***
> This month a guest editor, Jan Beyea [who received a PhD in nuclear physics from Columbia and has served on a number of committees at the National Research Council of the National Academies of Science] and worked on epidemiological studies at Three Mile Island, takes a hard look at the power industry.
> The bulletin's Web site is generally subscription-only, but this issue can be read at no charge.
> Dr. Beyea challenges a concept adopted by American safety regulators about small doses of radiation. The prevailing theory is that the relationship between dose and effect is linear – that is, that if a big dose is bad for you, half that dose is half that bad, and a quarter of that dose is one-quarter as bad, and a millionth of that dose is one-millionth as bad, with no level being harmless.
> The idea is known as the "linear no-threshold hypothesis,'' and while most scientists say there is no way to measure its validity at the lower end, applying it constitutes a conservative approach to public safety.
> Some radiation professionals disagree, arguing that there is no reason to protect against supposed effects that cannot be measured. But **Dr. Beyea contends that small doses could actually be disproportionately worse.**
> Radiation experts have formed a consensus that if a given dose of radiation delivered over a short period poses a given hazard, that hazard will be smaller if the dose is spread out. To use an imprecise analogy, if swallowing an entire bottle of aspirin at one sitting could kill you, consuming it over a few days might merely make you sick.
> In radiation studies, this is called a dose rate effectiveness factor. Generally, a spread-out dose is judged to be half as harmful as a dose given all at once.
> ***
> **Dr. Beyea, however, proposes that doses spread out over time might be more dangerous than doses given all at once. [Background] He suggests two reasons: first, some effects may result from genetic damage that manifests itself only after several generations of cells have been exposed, and, second, a "bystander effect," in which a cell absorbs radiation and seems unhurt but communicates damage to a neighboring cell, which can lead to cancer.**
> One problem in the radiation field is that **little of the data on hand addresses the problem of protracted exposure**. Most of the health data used to estimate the

health effects of radiation exposure comes from survivors of the Hiroshima and Nagasaki bombings of 1945. That was mostly a one-time exposure.

Scientists who say that this data leads to the underestimation of radiation risks cite another problem: **it does not include some people who died from radiation exposure immediately after the bombings.** The notion here is that the people studied in ensuing decades to learn about the dose effect may have been stronger and healthier, which could have played a role in their survival.

Still, the idea that the bomb survivor data is biased, or that stretched-out doses are more dangerous than instant ones, is a minority position among radiation scientists.

Dr. Beyea writes:

Three recent epidemiologic studies suggest that the risk from protracted exposure is no lower, and in fact may be higher, than from single exposures.

***

Conventional wisdom was upset in 2005, when an international study, which focused on a large population of exposed nuclear workers, presented results that shocked the radiation protection community—and foreshadowed a sequence of research results over the following years.

***

It all started when epidemiologist Elaine Cardis and 46 colleagues surveyed some 400,000 nuclear workers from 15 countries in North America, Europe, and Asia—workers who had experienced chronic exposures, with doses measured on radiation badges (Cardis et al., 2005).

***

This study revealed a higher incidence for protracted exposure than found in the atomic-bomb data, representing a dramatic contradiction to expectations based on expert opinion.

***

A second major occupational study appeared a few years later, delivering another blow to the theory that protracted doses were not so bad. This 2009 report looked at 175,000 radiation workers in the United Kingdom ….

After the UK update was published, scientists combined results from 12 post-2002 occupational studies, including the two mentioned above, concluding that protracted radiation was **20 percent more effective in increasing cancer rates than acute exposures** (Jacob et al., 2009). The study's authors saw this result as a challenge to the cancer-risk values currently assumed for occupational radiation exposures. That is, they wrote that the radiation risk values used for workers should be increased over the atomic-bomb-derived values, not lowered by a factor of two or more.

***

In 2007, **one study—the first of its size—looked at low-dose radiation risk in a large, chronically exposed civilian population**; among the epidemiological community, this data set is known as the "Techa River cohort." From 1949 to 1956 in the Soviet Union, while the Mayak weapons complex dumped some 76 million cubic meters of radioactive waste water into the river, approximately 30,000 of the off-site population—from some 40 villages along the river—were

> exposed to chronic releases of radiation; residual contamination on riverbanks still produced doses for years after 1956.
> ***
> Here was a study of citizens exposed to radiation much like that which would be experienced following a reactor accident. About 17,000 members of the cohort have been studied in an international effort (Krestinina et al., 2007), largely funded by the US Energy Department; and to many in the department, this study was meant to definitively prove that protracted exposures were low in risk. **The results were unexpected**. The slope of the LNT fit turned out to be higher than predicted by the atomic-bomb data, providing additional evidence that protracted exposure does not reduce risk.
> ***
> In a 2012 study on atomic-bomb survivor mortality data (Ozasa et al., 2012), l**ow-dose analysis revealed unexpectedly strong evidence for the applicability of the supralinear theory**. From 1950 to 2003, more than 80,000 people studied revealed high risks per unit dose in the low-dose range, from 0.01 to 0.1 Sv.

A major new study of atomic bomb data by the official joint U.S.-Japanese government study of the Hiroshima and Nagasaki survivors found that low dose radiation causes cancer and genetic damage:

And Dr. Peter Karamoskos notes:

> The most comprehensive study of nuclear workers by the IARC, involving **600,000 workers** exposed to an average cumulative dose of 19mSv, showed a cancer risk consistent with that of the A-bomb survivors.

It's not just humans: scientists have found that animals receiving low doses of radiation from Chernobyl are sick as well.

Ignore the Voodoo Science Pushers

If radiation is so dangerous, why do government and nuclear energy officials pretend that radiation is harmless?

Because governments have been covering up the danger of radiation for 67 years in order to protect the nuclear arms and nuclear energy industries.

But If Naturally-Occurring Radiation Is Bad For Us, Why Are Most of Us Healthy?

If background radiation is harmful, how have so many people remained healthy?

Initially – as we have previously pointed out – there was *no* background radioactive cesium or iodine before above-ground nuclear testing and nuclear accidents started.

Wikipedia provides some details on the distribution of cesium-137 due to human activities:

> Small amounts of caesium-134 and caesium-137 were released into the environment during nearly all nuclear weapon tests and some nuclear accidents, most notably the Chernobyl disaster.
> ***
> **Caesium-137 is unique in that it is totally anthropogenic**. Unlike most other radioisotopes, caesium-137 is not produced from its non-radioactive isotope, but from uranium. **It did not occur in nature before nuclear weapons testing began**. By observing the characteristic gamma rays emitted by this isotope, it is possible to determine whether the contents of a given sealed container were made

> before or after the advent of atomic bomb explosions. This procedure has been used by researchers to check the authenticity of certain rare wines, most notably the purported "Jefferson bottles".

As the EPA notes:

> Cesium-133 is the only naturally occurring isotope and is non-radioactive; all other isotopes, including cesium-137, are produced by human activity.

Likewise, iodine-131 is not a naturally occurring isotope. As the Encyclopedia Britannica notes:

> The only naturally occurring isotope of iodine is stable iodine-127. An exceptionally useful radioactive isotope is iodine-131…

(Fukushima has spewed much more radioactive cesium and iodine than Chernobyl. Fukushima is still spewing radiation into the environment, and the amount of radioactive fuel at Fukushima dwarfs Chernobyl.)

As such, the concept of "background radiation" is largely a misnomer. Most of the radiation we encounter today – especially the most dangerous types – did not even exist in nature before we started tinkering with nuclear weapons and reactors. In a sense, we are all guinea pigs.

Moreover, internal emitters – radioactive particles which end up inside of our lungs or gastrointestinal track, as opposed to radiation which comes to us from outside of our skin – are *much* more dangerous than general exposures to radiation. See this, this, this and this.

For example, the head of a Tokyo-area medical clinic – Dr. Junro Fuse, Internist and head of Kosugi Medical Clinic – said recently:

> Risk from internal exposure is **200-600 times greater** than risk from external exposure.

There are few *natural* high-dose internal emitters. Bananas, brazil nuts and some other foods contain radioactive potassium-40, but in *extremely low* doses.

True, some parts of the country are at higher risk of exposure to naturally-occurring radium than others.

But the cesium which was scattered all over the place by above-ground nuclear tests and the Chernobyl and Fukushima accidents has a much longer half life, and can easily contaminate food and water supplies. As the New York Times noted recently:

> Over the long term, the big threat to human health is cesium-137, which has a half-life of 30 years.
>
> At that rate of disintegration, John Emsley wrote in "Nature's Building Blocks" (Oxford, 2001), "it takes over 200 years to reduce it to 1 percent of its former level."
>
> It is cesium-137 that still contaminates much of the land in Ukraine around the Chernobyl reactor.
>
> ***
>
> Cesium-137 mixes easily with water and is chemically similar to potassium. It thus mimics how potassium gets metabolized in the body and can enter through many foods, including milk.

As the EPA notes in a discussion entitled " What can I do to protect myself and my family from cesium-137?":

> Cesium-137 that is dispersed in the environment, like that from atmospheric

testing, is impossible to avoid.

Radioactive iodine can also become a potent internal emitter. As the Times notes:

> Iodine-131 has a half-life of eight days and is quite dangerous to human health. If absorbed through contaminated food, especially milk and milk products, it will accumulate in the thyroid and cause cancer.

The bottom line is that there is some naturally-occurring background radiation, which can – at times – pose a health hazard (especially in parts of the country with high levels of radioactive radon or radium).

But cesium-137 and radioactive iodine – the two main radioactive substances being spewed by the leaking Japanese nuclear plants – are not naturally-occurring substances, and can become powerful internal emitters which can cause tremendous damage to the health of people who are unfortunate enough to breathe in even a particle of the substances, or ingest them in food or water.

Unlike low-levels of radioactive potassium found in bananas – which our bodies have adapted to over many years – cesium-137 and iodine 131 are brand new, extremely dangerous substances.

And unlike naturally-occurring internal emitters like radon and radium – whose distribution is largely concentrated in certain areas of the country – radioactive cesium and iodine are being distributed globally through weapons testing and nuclear accidents.

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PLoS one

The Aversive Effect of Electromagnetic Radiation on Foraging Bats—A Possible Means of Discouraging Bats from Approaching Wind Turbines

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Abstract

Large numbers of bats are killed by collisions with wind turbines and there is at present no accepted method of reducing or preventing this mortality. Following our demonstration that bat activity is reduced in the vicinity of large air traffic control and weather radars, we tested the hypothesis that an electromagnetic signal from a small portable radar can act as a deterrent to foraging bats. From June to September 2007 bat activity was compared at 20 foraging sites in northeast Scotland during experimental trials (radar switched on) and control trials (no radar signal). Starting 45 minutes after sunset, bat activity was recorded for a period of 30 minutes during each trial and the order of trials were alternated between nights. From July to September 2008 aerial insects at 16 of these sites were sampled using two miniature light-suction traps. At each site one of the traps was exposed to a radar signal and the other functioned as a control. Bat activity and foraging effort per unit time were significantly reduced during experimental trials when the radar antenna was fixed to produce a unidirectional signal therefore maximising exposure of foraging bats to the radar beam. However, although bat activity was significantly reduced during such trials, the radar had no significant effect on the abundance of insects captured by the traps.

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Introduction

The UK government is committed to ensure that 10% of the country's electricity will be generated from renewable sources by 2010 with an aspiration to double this figure by 2020. Unfortunately the drive to ameliorate the indirect impact of energy production on the environment has led to a more immediate impact on local fauna. The exploitation of wind as a renewable and pollution-free source of energy has led to the proliferation of wind farms across the UK where 206 are currently operational, comprising 2381 turbines and with an estimated 444 sites proposed for future development [1]. Several studies have highlighted the problem of birds colliding with turbines placed along traditional migratory routes [2–6] but until recently the impact of wind turbines on bats has received little attention.

The scale of the problem became apparent in 2004 when, during a six-week period, an estimated 1,764 and 2,900 bat fatalities were recorded at two wind farms in Pennsylvania and West Virginia respectively [7]. The number of collision mortalities reported in America are greater than in Europe, where surveys have begun more recently. However, 15 of the 35 species of European bat have been recorded as regular victims of turbine collisions, and an Intersessional Working Group of Eurobats listed 20 species thought to be at risk of collision due to their foraging and commuting behaviour [8]. Currently, research in Europe is concentrated on arriving at scientifically credible mortality estimates to assess the extent of the problem. Although this is clearly important, the rapid proliferation of wind turbines requires a more urgent response. Research has to be focussed on the underlying reasons behind these collisions and potential methods of mitigation to prevent what is undoubtedly an increasing threat to bat populations.

Attempts at mitigating bird collisions with wind turbines have typically involved the application of visual stimuli to increase the conspicuousness of the turbine blades [9,10], but for bats, where audition is the primary sensory modality, this is clearly not appropriate. The design of an acoustic deterrent for bats, as used to mitigate cetacean entanglement in drift nets [11–13], is complicated by the intrinsic properties of ultrasound, which attenuates rapidly in air [14]. Despite this inherent problem, a recent study [15] revealed a significant aversive response by big brown bats (*Eptesicus fuscus*) following exposure to broadband white noise in a laboratory. However, when an acoustic deterrent was deployed at a wind farm in New York State, USA, results were more equivocal, and researchers concluded that the acoustic envelope of the deterrent system was probably not large enough to consistently deter the activity of bats within the large volume of the rotor-swept zone [16].

A more promising solution is offered by curtailing the operations of wind turbines during high-risk periods. A substantial portion of bat fatalities at operating wind farms occurs during relatively low-wind conditions during the bat migration period

[17]. Some curtailment of turbine operations during these conditions, and during this period, has been proposed as a possible means of reducing impacts to bats [17,18]. Recent results from studies in Canada [19] and North America [20] indicate that changing turbine "cut-in speed" (i.e., the wind speed at which wind generated electricity enters the power grid) from the customary 3.5–4.0 m/s, on modern turbines, to 5.5 m/s, resulted in at least a 50% reduction in bat fatalities. This requires considerable cooperation on behalf of the project operators as curtailing turbine operations, even on a limited basis, clearly poses operational and economic restrictions resulting in some loss of revenue. This method does however offer a promising solution, particularly in areas where it has been proven that bat mortalities occur over a clearly defined and restricted time period. It is not yet clear whether this method of mitigation will prove sufficiently feasible and effective at reducing impacts to bats at costs that are acceptable to companies that operate wind energy facilities. Therefore, given the problems associated with the existing proposed methods of mitigation it is essential to investigate all other alternatives.

It has been suggested that the radio frequency (RF) radiation associated with radar installations could potentially exert an aversive behavioural response in foraging bats [21]. In 2006 Nicholls and Racey recorded bat activity along an electromagnetic gradient at ten radar installations throughout Scotland. Their results revealed that bat activity and foraging effort per unit time were significantly reduced in habitats exposed to an electromagnetic field (EMF) strength of greater than 2v/m when compared to matched sites registering EMF levels of zero. Even at sites with lower levels of EMF exposure ($<$2v/m), bat activity and foraging effort was significantly reduced in comparison to control sites.

Ahlén *et al.* [22] also reported anecdotal evidence that bats foraging offshore in Sweden avoided an area around Utgrunden lighthouse where a powerful radar was in permanent operation. However, although it has been demonstrated that large air traffic control and weather radars appear to exert an aversive response on foraging bats [21], this has little practical application in preventing bats from colliding with turbine blades. It is therefore necessary to establish whether a deterrent effect can be replicated with a small, portable radar system. It is also possible that the electromagnetic radiation from the radar may not be affecting bats directly but rather the insects upon which they feed. Bat activity within an area is strongly correlated with insect density [23,24] therefore any reduction in insect density would result in a concurrent reduction in bat activity. In order to provide an efficient deterrent it is necessary to determine whether any observed reduction in bat activity is a direct result of exposure to electromagnetic radiation or an indirect result of a localised reduction in insect density.

Therefore the aims of the present study were to test the following hypotheses:

(1) Bat activity will be reduced following exposure to a pulsed electromagnetic signal from a small portable radar unit.

(2) The abundance of aerial insects will be reduced following exposure to a pulsed electromagnetic signal from a small portable radar unit.

Materials and Methods

Study sites and sampling protocol

In Britain, foraging bats are predominantly associated with areas where insect density is high: broadleaved woodland, particularly woodland edge, linear vegetation (tree lines and hedgerows) and riparian habitat. More open and intensively managed areas are avoided. In order to assess the impact of radar on foraging bats it was important to locate foraging sites with a high level of bat activity. Using existing knowledge obtained from detailed radio telemetry projects [25] in conjunction with extensive acoustic surveys, 20 foraging sites, with a high and consistent level of bat activity, were selected. All foraging sites were located within a 100 km radius of Aberdeen in northeast Scotland (latitude 57°23' N, longitude 02°45' W) and were separated by a minimum straight-line distance of $>$1 km to ensure independence. Twelve of these sites were located within riparian habitats (small ponds, rivers and streams) and the remainder along the edge of woodland where the radar signal would not be attenuated by any obstruction.

The radar used throughout the study was a Furuno FR - 7062 X-band marine radar (peak power 6 kW, beamwidth: horizontal $-1.9°$, vertical $-22°$, rotation 24 rpm or 48 rpm) with a slotted waveguide array antenna (1.2 m) capable of transmitting at pulse lengths of 0.08 μs–0.8 μs depending on the range selected. At each site the radar antenna was placed on a platform 2 m above ground level, such that the core area of bat activity was directly in line with the radar beam. At each foraging site a control (no radar signal) and experimental trial (radar switched on) were carried out. Starting 45 minutes after sunset, bat activity was recorded for a period of 30 minutes during each trial and the order of trials were alternated between nights. To avoid pseudoreplication, recordings were carried out only once at each of the 20 sites.

As in most radar systems, the antenna of the radar usually swept through 360 degrees. For the current experiment this would reduce the extent of exposure along any radius. Therefore the experiment was repeated with the antenna of the radar fixed such that the radar signal was orientated directly towards the area of highest bat activity. Similarly the duration of exposure to the radar signal is dependent on the duty cycle of the radar transmitter (pulse length×pulse repetition frequency). Therefore the experiment was repeated at each site using two different pulse length/pulse repetition rates (0.08 μs/2100 Hz, 0.3 μs/1200 Hz,) with the radar antenna fixed to maximise exposure. A portable electromagnetic field meter (PMM 8053-Accelonix Ltd.) and isotropic field probe (EP-330 Isotropic E-Field probe-Accelonix Ltd.) were used to measure the maximum value (peak hold) of the electromagnetic field strength (EMF) of the radar in volts per metre (v/m) at three distances from the radar antenna (10, 20, 30 m) for each of the two radar settings implemented throughout the study.

Bat activity recording

At each foraging site bat activity was recorded at three distances from the radar antenna (10, 20, 30 m) using automatic bat-recording stations [26]. Each automatic station consisted of a Batbox III heterodyne bat detector (Stag Electronics, Sussex, UK) linked to a count data logger (Gemini Data Loggers, UK Ltd, Chichester, UK) via an analogue to digital signal converter (Skye instruments, Ltd). The signal converter converts analogue signals from the bat detector into digital signals that can be recorded by the data logger. Every 0.5 seconds a positive or negative signal is sent to the data logger indicating the presence or absence of ultrasound respectively. Therefore the recorded number of bat active half seconds referred to as 'bat counts' over a thirty-minute trial provides a quantitative index of bat activity during that period. Most narrowband detectors will detect a range of frequencies centred on the value shown on the tuning dial. For the Batbox III this window is$\pm$8 kHz of the tuned frequency, therefore the frequency was set to 50 khz in order to effectively

detect each of the 5 breeding species of bat in Scotland (*Pipistrellus pipistrellus*, *Pipistrellus pygmaeus*, *Myotis daubentonii*, *Myotis nattereri* and *Plecotus auritus*). The component parts of the system were housed in large plastic boxes with a hole cut for the bat detector microphones. Automatic recording stations were positioned on platforms 1.5 m above the ground and orientated perpendicular to the radar signal (Fig. 1).

In conjunction with the automatic recording stations bat activity was recorded continuously during each trial using a frequency division bat detector (S-25, Ultrasound Advice, London). This method of ultrasound transformation allows calls to be recorded in real time on audiocassettes and the number of recorded passes provides a quantitative assessment of bat activity Bat detectors were linked to a tape recorder (Sony Professional Walkman, Tokyo, WMD6C) containing metal-tape cassettes. At each site the bat detector was placed at a distance of 20 m from the radar antenna and the height and direction remained constant at 70 cm. The 60 minutes recording at each site were analysed using BatSound software (BatSound Pro, Pettersson Elektronic AB, Uppsala Sweden). In addition to the total number of bat passes, terminal feeding buzzes at each site were counted. These characteristic sounds are produced by aerial hunting and trawling vespertilionid bats when prey capture is attempted [27] and can be used to quantify foraging activity within a site. Foraging rate is expressed as the ratio of terminal buzzes to bat passes; this feeding buzz ratio (FBR) provides a measure of foraging intensity per unit of flight activity [28]. The use of frequency division detectors also allowed accurate species identification at each site.

Insect Abundance

From July to September 2008 aerial insects were sampled using two identical Pirbright-Miniature light-suction traps (PMLT) [29] equipped with 8 W UV light bulbs. Each trap operated at 220 V transformed to 12 V to run from a car battery. At the base of each trap was a water-filled collecting vessel containing 2–3 drops of detergent. Most large insects were excluded by a large-mesh screen immediately above the fan and below the light bulb. The traps were deployed at 16 of the 20 foraging sites described above and were switched on for one hour prior to sunset. At each site the traps were positioned approximately 40 m apart with their trap inlets 2 m above ground level. On each sampling night the radar antenna was positioned on a platform 2 m above ground level and 10 m from one of the traps such that the antenna was orientated directly towards the trap inlet and fixed to produce a unidirectional signal. The second trap was positioned perpendicular to the radar beam to prevent any potential exposure to electromagnetic radiation and left to function as a control. To avoid any potential bias the selection of traps used as the control was alternated each night. The parameters of the radar tested were identical to those described above (Pulse length/pulse repetition rate: 0.08 μs/2100 Hz; 0.3 μs/1200 Hz,) no test was carried out with the antenna rotating.

Immediately following sampling, the insect catch was transferred from the collecting column into a 70% ethanol in water solution using a fine brush. Insects were then counted using a dissecting microscope (×30). Any insects with wingspans exceeding 20 mm were removed from the catch, as they would exceed the range of insect sizes captured by the species recorded throughout the study [30]. Following counting and sorting, the dry mass of insects was recorded by drying the samples in an oven until a constant mass was achieved (21 h).

Statistical analysis

Differences in bat activity (bat counts and bat passes), bat foraging activity (feeding buzz ratios) and insect abundance between experimental and control trials were analysed using paired t tests. To account for multiple comparisons in paired t tests, we applied a manual Bonferroni correction (*P*-values×number of comparisons). However since the application of the Bonferroni correction increases the risk of making more type II errors, i.e. not recognising

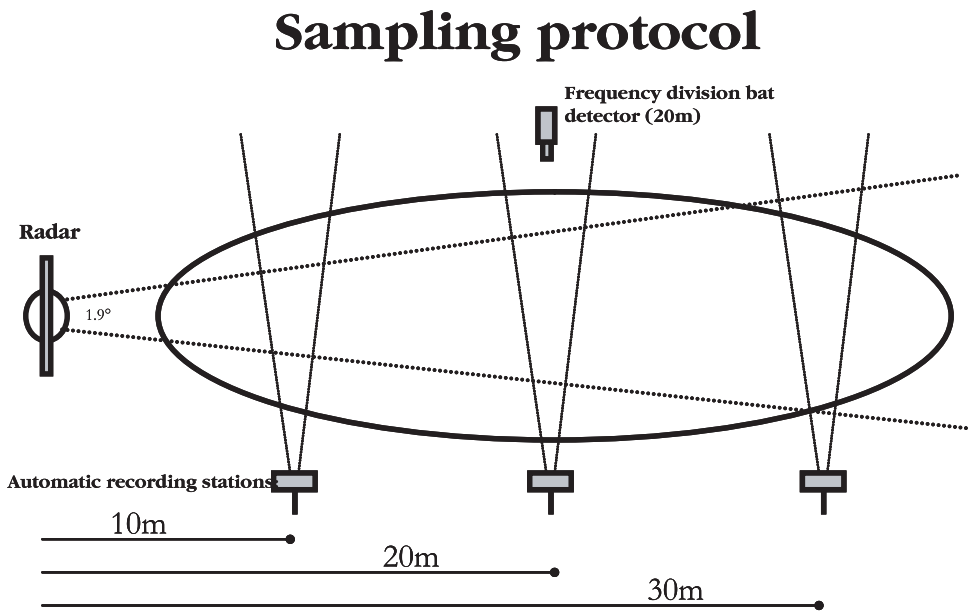

Figure 1. Sampling protocol of experimental trials carried out at 20 independent sites from July to September 2007. At each site bat activity was recorded for 1 h at three distances from the radar antenna (10,20,30 m) using three automatic bat recording stations orientated perpendicular to the radar beam. A frequency division bat detector was positioned 20 m from the radar antenna to provide further information on bat foraging activity during this period.
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Table 1. The maximum value (peak hold) of the electromagnetic field strength (v/m) at three distances from the radar antenna.

Antenna position	Pulse length (μs)	Pulse Repetition rate (Hz)	Duty Cycle (%)	EMF (v/m) Peak hold (10 m)	EMF (v/m) Peak hold (20 m)	EMF (v/m) Peak hold (30 m)
Rotating	0.08	2100	0.0168	5.58	5.11	3.79
Fixed	0.08	2100	0.0168	26.24	22.99	20.25
Fixed	0.3	1200	0.036	25.52	18.68	17.67

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a true effect as significant [31] we report both corrected $P_{\text{Bonferroni}}$ and uncorrected *P*-values. The effect of distance from the radar antenna was analysed using one-way ANOVA. Analyses were carried out using Minitab version 14 [32].

Ethics statement

The authors' work on bats is licensed by the statutory nature conservation organisation in Scotland (Scottish Natural Heritage).

Results

Bat activity

Experimental trials were carried out during 58 nights from July 2007 till September 2007 representing a total of 58 hours of recording data within the following parameters:

1. Rotating antenna – pulse length/pulse repetition rate (0.08 μs/2100 Hz) – 20 h
2. Fixed antenna – pulse length/pulse repetition rate (0.08 μs/2100 Hz) – 20 h
3. Fixed antenna – pulse length/pulse repetition rate (0.3 μs/1200 Hz) – 18 h

The maximum value (peak hold) of the electromagnetic field strength within these parameters is shown in Table 1. Field strength diminished slightly with increasing distance from the antenna under all radar parameters. However when the radar antenna was fixed to emit a unidirectional signal a fourfold increase in field strength was observed at all distances (Table 1).

The three automatic stations recorded a total of 102,810 bat counts during 58 h of recording (Table 2). No significant difference was observed in the number of bat counts recorded between automatic stations positioned at 10, 20 and 30 m from the radar antenna (ANOVA, rotating antenna with pulse length 0.08 μs: $P = 0.57$; fixed antenna with pulse length 0.08 μs: $P = 0.64$; fixed antenna with pulse length 0.3 μs $P = 0.68$) therefore all further tests were carried out on the average of these three values. A further 53,731 bat passes were recorded with the frequency division detector (Table 2). As expected, the majority of passes (84%) were attributed to the two cryptic pipistrelle species: *Pipistrellus pygmaeus* and *P. pipistrellus* (51% and 33% respectively) which are the most common and abundant bats in Scotland. A further 16% of bat passes were attributed to *Myotis daubentonii*.

Total bat activity was invariably higher during the control trials when compared to experimental trials (Table 2). However paired t tests carried out on all indices of bat activity (bat counts, bat passes, feeding buzz ratios) revealed no significant difference in bat activity between control and experimental trials when exposed to a short pulse length (0.08 μs) radar signal from a rotating antenna (bat counts: $t = 1.50$; $P = 0.151$; $P_{\text{Bonferroni}} = 0.453$; Fig. 2a. Bat passes: $t = 1.89$; $P = 0.074$; $P_{\text{Bonferroni}} = 0.222$; Fig. 3a. FBR: $t = 1.80$; $P = 0.088$; $P_{\text{Bonferroni}} = 0.264$; Fig. 4a). Paired t tests carried out on all indices of bat activity (bat counts, bat passes, feeding buzz ratios) showed that bats were significantly less active during experimental trials than during control trials when exposed to a short pulse length (0.08 μs) radar signal from a fixed antenna (bat counts: $t = 2.87$; $P = 0.010$; $P_{\text{Bonferroni}} = 0.030$; Fig. 2b. Bat passes: $t = 2.54$; $P = 0.020$; $P_{\text{Bonferroni}} = 0.060$; Fig. 3b. FBR: $t = 3.82$; $P = 0.001$; $P_{\text{Bonferroni}} = 0.003$; Fig. 4b). However, following Bonferroni correction the difference in the number of bat passes between experimental and control trials was no longer significant. Bats were also significantly less active during experimental trials than during control trials when exposed to a medium pulse length (0.3 μs) radar signal from a fixed antenna (bat counts: $t = 3.95$; $P = 0.001$; $P_{\text{Bonferroni}} = 0.003$; Fig. 2c. Bat passes: $t = 3.69$; $P = 0.002$; $P_{\text{Bonferroni}} = 0.006$; Fig. 3c. FBR: $t = 6.78$; $P < 0.001$; $P_{\text{Bonferroni}} = 0.003$; Fig. 4c). A summary of these results is presented in Table 3.

Insect Abundance

Experimental trials were carried out during 32 nights from July 2008 till September 2008 representing a total of 32 hours of recording data within the following parameters:

Table 2. Total numbers of bat counts, bat passes and feeding buzzes recorded within treatment and control trials during 58 h of recording.

Index of bat activity	Rotating antenna (0.08 μs/2100 Hz)		Fixed antenna (0.08 μs/2100 Hz)		Fixed antenna (0.3 μs/1200 Hz)	
	Treatment	Control	Treatment	Control	Treatment	Control
Bat passes	11160	11599	8065	9305	5367	8235
Feeding buzzes	3711	4015	2386	3300	1563	2720
Bat counts (10 m)	6052	6275	4998	5974	3241	5517
Bat counts (20 m)	6364	6820	5261	6183	3494	5525
Bat counts (30 m)	7066	7386	5744	6792	3879	6239

doi:10.1371/journal.pone.0006246.t002

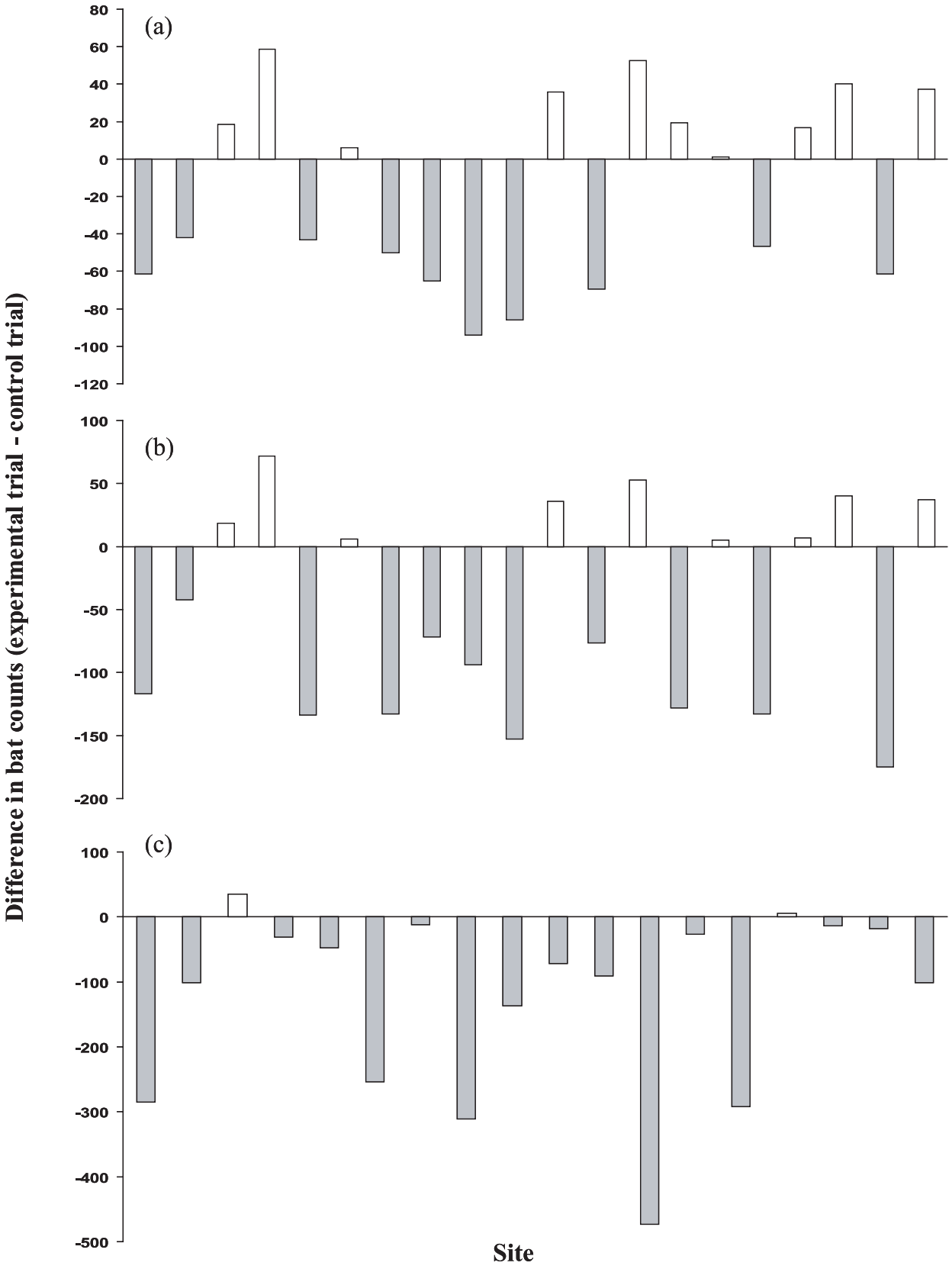

Figure 2. The response of bats to: (a) short pulse length (0.08 μs) radar signal from a rotating antenna. (b) short pulse length (0.08 μs) signal from a fixed antenna. (c) medium pulse length (0.3 μs) signal from a fixed antenna. Each bar represents the difference in bat counts (the number of times that ultrasound was detected by the automatic bat recording stations) between control and experimental trials. A negative value indicates that bat activity was higher during the control trial than during the experimental trial when the radar was switched on.
doi:10.1371/journal.pone.0006246.g002

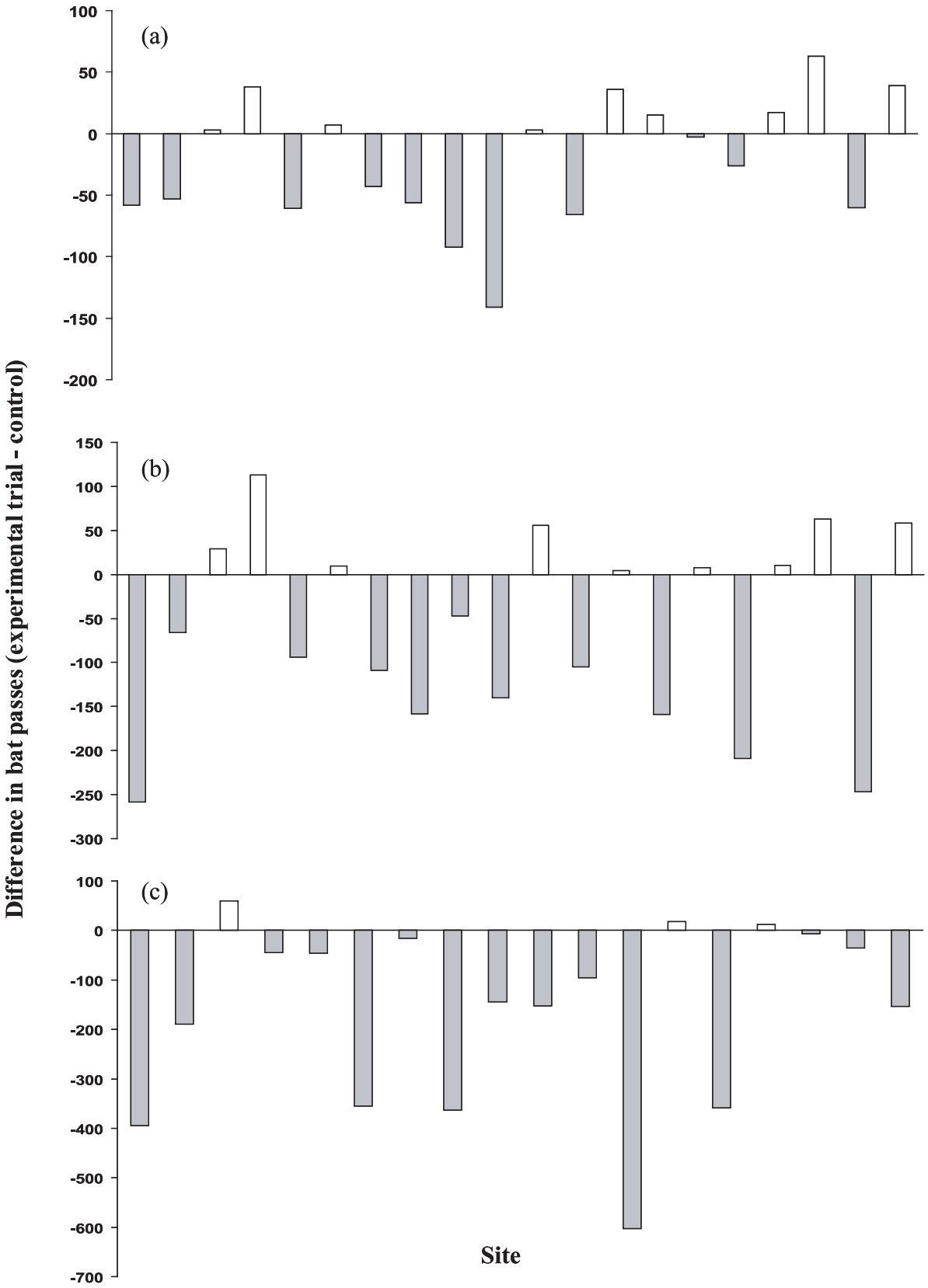

Figure 3. The response of bats to: (a) short pulse length (0.08 μs) radar signal from a rotating antenna. (b) short pulse length (0.08 μs) signal from a fixed antenna. (c) medium pulse length (0.3 μs) signal from a fixed antenna. Each bar represents the difference in bat passes (recorded using a frequency division bat detector) between control and experimental trials. A negative value indicates that bat activity was higher during the control trial than during the experimental trial when the radar was switched on.
doi:10.1371/journal.pone.0006246.g003

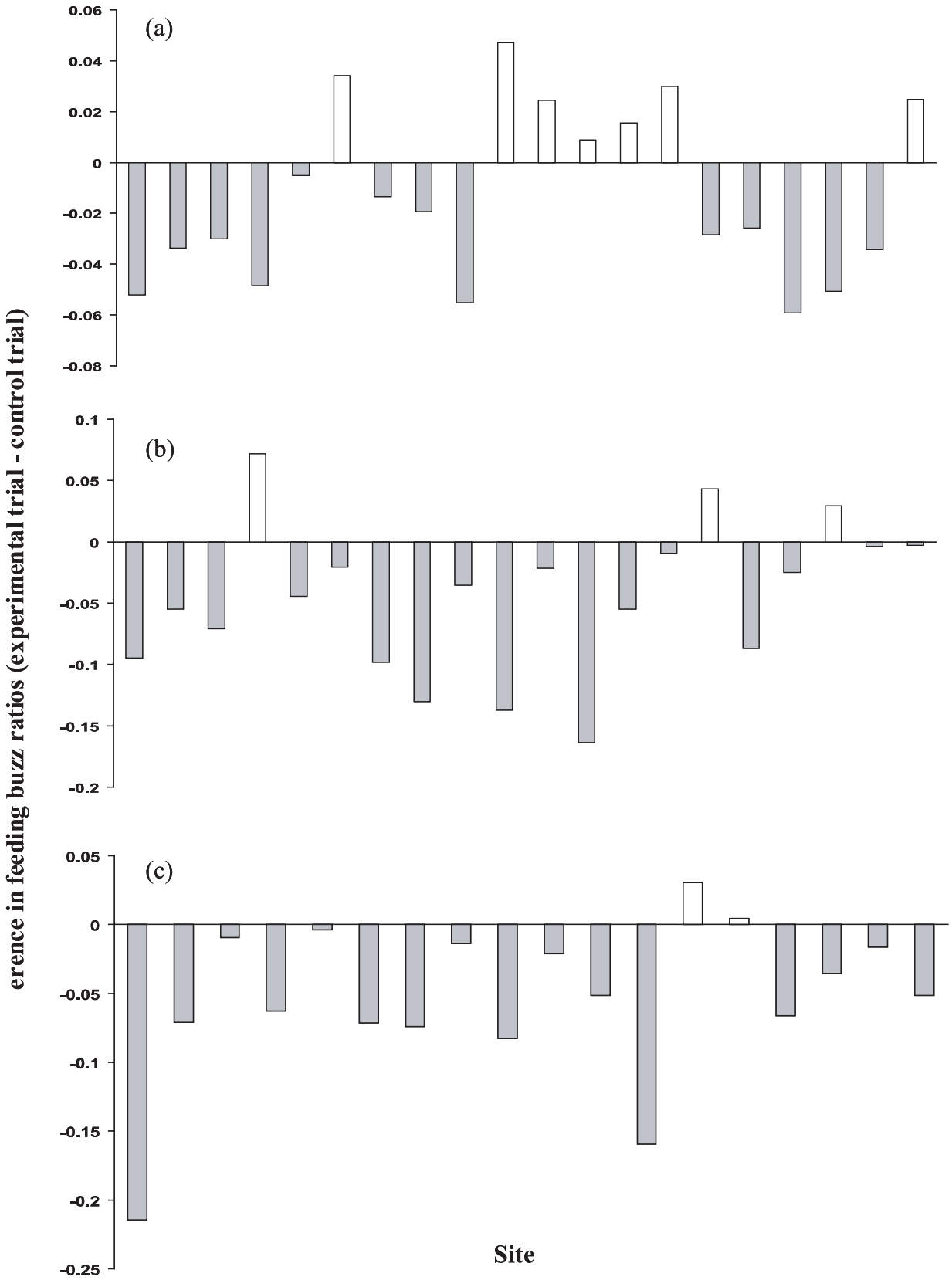

Figure 4. The response of bats to: (a) short pulse length (0.08 μs) radar signal from a rotating antenna. (b) short pulse length (0.08 μs) signal from a fixed antenna. (c) medium pulse length (0.3 μs) signal from a fixed antenna. Each bar represents the difference in foraging rate per unit time as reflected by the difference in feeding buzz ratios (FBR) between control and experimental trials. A negative value indicates that bat activity was higher during the control trial than during the experimental trial when the radar was switched on.
doi:10.1371/journal.pone.0006246.g004

Table 3. Statistical significance of differences in bat activity between control and experimental trials (*) denotes a significant result for both corrected $P_{Bonferroni}$ (P values×number of comparisons) and uncorrected P-values.

Antenna position	Index of activity	Pulse length (μs)	Pulse repetition rate (Hz)	Duty cycle (%)	n	t	P	$P_{Bonferroni}$
Rotating	Bat passes	0.08	2100	0.0168	20	1.89	0.07	0.22
	Bat counts	0.08	2100	0.0168	20	1.50	0.15	0.45
	FBR	0.08	2100	0.0168	20	1.80	0.08	0.26
Fixed	Bat passes	0.08	2100	0.0168	20	2.54	0.02*	0.06
	Bat counts	0.08	2100	0.0168	20	2.87	0.01*	0.03*
	FBR	0.08	2100	0.0168	20	3.82	0.001*	0.003*
Fixed	Bat passes	0.3	1200	0.036	18	3.69	0.002*	0.006*
	Bat counts	0.3	1200	0.036	18	3.95	0.001*	0.003*
	FBR	0.3	1200	0.036	18	6.78	<0.001*	0.003*

doi:10.1371/journal.pone.0006246.t003

1. Fixed antenna – pulse length/pulse repetition rate (0.08 μs/ 2100 Hz) – 16 h
2. Fixed antenna – pulse length/pulse repetition rate (0.3 μs/ 1200 Hz) – 16 h

A total of 10 430 insects were caught during 32 hours of sampling per trap. Ninety five percent of the insects caught had wingspans <20 mm and were dried and included in further analyses. Paired t tests revealed no significant difference in insect abundance between control and experimental traps when exposed to either a short (0.08 μs) or medium pulse length (0.3 μs) radar signal (short pulse: n = 16, t = 1.50; $P = 0.151$; $P_{Bonferroni} = 0.453$; long pulse: n = 16, t = 1.89; $P = 0.074$; $P_{Bonferroni} = 0.222$).

Discussion

Currently there is no accepted method of successfully mitigating bat collisions with wind turbines and attempts at deterring bats by the use of ultrasound have, as yet, been unsuccessful. Therefore the identification of alternative methods capable of inducing an aversive response in bats approaching turbine blades is of paramount importance. Very few field experiments have been carried out to ascertain the possible effects of high frequency electromagnetic radiation on populations of wild animals. However studies have shown that electromagnetic radiation can influence the development, reproduction, and physiology of insects [33], mammals [34], and birds [35]. Our results demonstrate that an electromagnetic signal from a small radar unit with a fixed antenna invariably reduced the foraging activity of bats within 30 m of the unit. However no significant decrease in activity was observed when the radar antenna was rotating. This is not surprising; the length of time a bat would be exposed to the radar signal is a function of the duty cycle of the radar signal (pulse length×pulse repetition rate) and the dwell time (the duration of time that a target remains in the radar beam during each rotation). The rotation of the radar antenna would reduce the time that bats were exposed to pulse-modulated microwave radiation and would therefore attenuate any potential deterrent effect. When the radar antenna was fixed to emit a unidirectional signal a fourfold increase in field strength was observed at all distances.

When foraging sites were exposed to a short pulse length signal from a fixed antenna there was a significant reduction in bat activity during experimental trials (bat counts and bat passes dropped by 15.5% and 13.3% respectively). Although once the Bonferroni correction had been applied, the difference in bat passes between control and experimental trials was no longer significant. An even greater level of significance was however observed when foraging sites were exposed to a medium pulse length signal from a fixed antenna (bat counts and bat passes dropped by 38.6% and 30.8% respectively). Clearly this represents a substantial reduction in bat activity. However, bats continued to forage at each site during experimental trials, and on no occasion were bats observed behaving abnormally or actively avoiding the beam of the radar. However, temporal and spatial fluctuations in bat foraging behaviour are common [23.24] and therefore results have to be treated with caution. Despite this caveat the significant reduction in bat activity during all experimental trials with a fixed antenna supports our hypothesis that electromagnetic radiation exerts a deterrent effect on foraging bats. This raises questions regarding the mechanisms through which bats could perceive electromagnetic fields and why they would seek to avoid them.

Nicholls and Racey [21] suggest that the aversive behavioural response of foraging bats to electromagnetic radiation may be a result of thermal induction. Studies investigating the behavioural response of laboratory animals to the presence of electromagnetic fields have shown that even short-term exposure can produce a thermal burden in an organism that can result in significant behavioural and physiological changes, some of which may be harmful [36]. Behavioural effects of such exposure include perception, aversion, work perturbation, work stoppage and convulsions [37]. The wing membranes of bats present a large surface area over which radiation might be absorbed, increasing heat load on the animal. This, combined with the heat energy produced during flight, makes bats particularly susceptible to overheating [38,39]. Furthermore, observations of captive bats have noted their aversion to even a moderate infra-red heat source [40].

However the pulsed microwave radiation characteristic of radars is a rather inefficient source of energy. The energy produced by a radar signal can reach very high values of peak power density, at relatively low levels of power density averaged over time. This is because the pulse length of the radar signal is hundreds of times shorter than the pulse repetition rate, therefore the average value of power density is hundreds of times lower than the peak value of the radiation. Therefore it would seem unlikely that the energy in the radar signal would be sufficient to induce a thermal burden in bats foraging within the beam. However several studies have reported significant behavioural and physiological effects resulting from exposure to pulsed microwave radiation even

when the average power density of the signal was relatively low [41–43]. The mechanism through which pulsed microwave radiation could affect behaviour in this manner is unclear although one possibility is an auditory response commonly referred to as the auditory microwave hypothesis.

The auditory perception of pulsed microwaves is now widely accepted. The effect is generally attributed to the thermoelastic expansion of brain tissue following the small but rapid increase in temperature due to the absorption of the incident energy. This generates a sound wave in the head that subsequently stimulates the cochlea. Repeated or prolonged exposure to these auditory effects is considered stressful [44].

Laboratory experiments have shown that the frequency of the induced sound is a function of head size and of the acoustic properties of the brain tissue. The estimated fundamental frequency of vibration in guinea pigs, cats and adult humans are 45, 38, and 13 kHz respectively [45,46]. It is therefore not only plausible but probable that bats exposed to an RF pulse of sufficient power would effectively hear this pulse and the frequency detected would lie within the range of frequencies used for orientation, prey detection and capture for the majority of bat species. It is possible that, as reported in other studies, exposure to these auditory effects may be stressful for bats or indeed it may interfere with their echolocation, inhibiting prey detection or capture. During the present study, foraging rate per unit time was significantly reduced during experimental trials indicating that bats foraging within the exposed area were feeding at a reduced rate in comparison to those foraging during the control trials. This is particularly surprising given that exposure to the radar had no significant impact on the abundance of aerial insects, and the observed reduction in foraging rate is therefore unlikely to be linked to a decline in insect abundance. It is therefore possible that the auditory perception of the radar signal during experimental trials could have interfered with the bats ability to detect or capture prey. However further experimentation would be required to accurately identify the causal relationship between exposure to electromagnetic radiation and the observed reduction in both bat activity and foraging rate.

Although we have demonstrated a clear biological effect, one of the limitations of the present study was the use of a commercial marine radar that was not specifically designed for the task. With only a limited control over the parameters of the radar signal, it is difficult to determine which parameters are most effective in deterring bats. To better understand the response of bats to electromagnetic radiation, and to identify an optimum signal capable of deterring bats, will require radar engineers to work with bat biologists to develop a portable radar which can be manipulated to produce a wider range of electromagnetic outputs. The parameters most likely to be important are the frequency, pulse length/pulse repetition rate and power output of the signal. Similarly, the radar used in the present study was only effective when the antenna was fixed to produce a unidirectional signal with a horizontal beamwidth of 1.9°. A narrow unidirectional signal is clearly not appropriate to deter bats from approaching wind turbines. In order to provide an effective deterrent it would be necessary to emit a multidirectional electromagnetic signal capable of encapsulating the large volume of the rotor-swept zone.

Conclusion

We have demonstrated that pulsed electromagnetic radiation from a small, affordable and portable radar system can reduce bat activity within a given area. Results were most effective when the radar antenna was fixed to produce a unidirectional signal therefore maximising dwell time within the beam of the radar. However although bat activity was significantly reduced during experimental trials substantial numbers of bats continued to forage within the beam. It is possible that only a particular combination of wavelength, pulse repetition rate, power output and target size or orientation may provoke a reaction and further work is necessary to elucidate this relationship further.

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Author Contributions

Conceived and designed the experiments: PAR. Performed the experiments: BN. Analyzed the data: BN. Wrote the paper: BN.

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BEES, BIRDS AND MANKIND

Destroying Nature by 'Electrosmog'

Ulrich Warnke

Effects of Wireless Communication Technologies
A Brochure Series by the
Competence Initiative for the Protection of Humanity,
Environment and Democracy

Brochure 1

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Published by Prof. Dr. med. Karl Hecht, Dr. med. Markus Kern, Prof. Dr. phil. Karl Richter, and Dr. med. Hans-Christoph Scheiner

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BEES, BIRDS AND MANKIND
Destroying Nature by 'Electrosmog'

Translation by Marlies von Lüttichau*

Ulrich Warnke

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* Kentum Translators, South Africa, www.kentum.co.za <http://www.kentum.co.za>

For different protection of mankind, environment and democracy

Preamble by the publishers at the launch of the series of papers: *Effects of Wireless Communication Technologies*

The bio-scientist Ulrich Warnke is more familiar with nature's electromagnetic housekeeping than most. In this paper, he shows how wise and sensitive nature was about using electrical and magnetic fields in the creation of life. But he can for this reason also convincingly criticise the present foolish and irresponsible interference in nature's house-keeping. It is clear from his paper that the powers that be in politics, the economy and science are in the process of destroying what nature has built up over millions of years. The traces of this destruction have long been evident in our living environment. The paper shows, however, how short-sightedly we are treating not only our health and the economy, but especially also future generations' right to life.[1] All of the above is documented not as probabilities but based on reproducible effects. This should give pause also to those who regularly justify their actions with the argument that they are unaware of any proof of damage.

Under the term "radio communication", we combine all wireless communication technology, increasingly flooding our residential zones and the environment with electromagnetic fields. A recent, comprehensive research report by the BioInitiative Working Group, a consortium of renowned international scientists, shows how many of the damaging effects of such fields have already been proven (www.bioinitiative.org). The report evaluates the present limiting values as a useless edifice, protecting nobody. Based on this, the European Environment Agency (EEA), the top scientific environment authority of the EU, has warned of the possibility of looming environmental disasters following the increasing density of electromagnetic fields. And the coordinator of the European Reflex project, Prof. Franz Adlkofer, has informed the public on the new research results, proving the high degree of gene-toxicity of UMTS radiation.

The public is little aware of these risks because they are hardly addressed in the "enlightenment" provided by officialdom and industry. The public is given the assurance that they are well-protected by the limits and the compliance-assuring measurements and that UMTS radiation is as harmless as GSM radiation – more antennae in residential areas are recommended in principle.[2] And whilst Ulrich Warnke demonstrates how vulnerable man and environment are, we are told that we are more robustly organised than our machines.[3] The original "radiation protection" has deteriorated to the protection of commercial interests.

The involvement of government in industry and the high percentage of industry-financed research and industry-beholden panels and consultants, have spawned a questionable system of environment and consumer protection. Only that which does not seriously endanger common commercial interests is noted and supported. The rights of the citizen to protection and the suffering of the people are flatly ignored. Those with political responsibility have apparently still not realised that their negligent handling of the obligation to take precautions has long since been proven to be one of the main causes of past environmental disasters and scandals.[4]

As a result of their quarrel with politics of carelessness, an interdisciplinary association of scientists and physicians founded the Competence Initiative for the Protection of Mankind, Environment and Democracy in May 2007 (www.kompetenzinitiative.de). This paper is the first in a new scientific series. The reported results are intended as a correction to trivialising "enlightenment" that does not protect, but endangers. The series intends to maintain a high level of technical information, without being unreadable to the interested layman.

Placing economic interests above culture and morality has contributed significantly to turning Germany into a country of declining education. As the journalist Hans Leyendecker so tellingly describes in his book Die große Gier[5], it started Germany too on a new career on the ladder of corruption. There is nothing that the business lo-

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[1] On injury to the health of children and the youth refer also to the collection published by Heike-Solweig Bleuel "Generation Handy... grenzenlos im Netz verführt", St. Ingbert 2007.

[2] Quoting scientists of the Jacobs University Bremen-Grohn under Prof. Alexander Lerchl: "UMTS doch nicht schädlicher als GSM", www.pcmagazin.de, 2.7.2007, and A. Lerchl at a presentation in Ritterhude acc. to a newspaper report of the Osterholzer Kreisblatt dated 16.6.2007: "More radio masts in the centre of town". Professor Lerchl appeals to all communities not to spend further tax money on mobile radio studies

cation Germany needs more, he concludes, than "new ethics". But this also requires a different perception of progress. Whether we can watch TV via our mobile telephone, is irrelevant to our future. Our future will depend on whether we can return to more human, social and ethical values again in the shaping of our lives and our relationship with nature.

Everyone who thinks beyond today and who inquires about what it means to be human is, in our opinion, called upon to contribute to this future: politicians guided by values rather than economical and tactical election issues; scientists and doctors more often remembering their obligation to the wellbeing of society and mankind; companies understanding, also in Germany, that profit and morality must be in harmony if they wish to remain successful in the long term.

But what we need above all is critical citizens, who can spot the difference between technical progress and consumer foolishness: Citizens who, in both their roles as voters and consumers, remember that democracy once meant rule of the people, not ruling the people.

The dramatic escalation of recorded degradation challenges those with political responsibility to take to heart the protection directives of the constitution and the European Convention on Human Rights. To base your actions affecting millions of your protégés on a half truth, at best, appears to us a political crime affecting health and the future – considering the state of our knowledge.
Religious and ethical cultures still profess to the mandate of conserving creation. But its actual treatment is guided by the pseudo culture of a new class of masters who ruthlessly exploit and manipulate the organisation, finally destroying it.

We thank the E. Oppenheimer & Son (South Africa) and the Diamond Route for having financed this translation.

Prof. Dr. Karl Hecht
Dr. med. Markus Kern
Prof. Dr. Karl Richter
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[3] Statement at the end of a brochure: Mobilfunk und Funkwellen: Information, Fakten, Antworten; published by the Saarland Department of Justice, Health and Social matters, Saarbrucken 2005 (copy of a brochure of the LfU Baden-Wurtemberg).

[4] Compare the paper published by the European Environmental Agency and its German translation published by the Federal environmental office: "Späte Lehren aus frühen Warnungen: Das Vorsorgeprinzip 1896-2000", Copenhagen and Berlin 2004.

[5] "Die große Gier. Korruption, Kartelle, Lustreisen: Warum unsere Wirtschaft eine neue Moral braucht"; Berlin 2007.

Electromagnetic fields as prerequisite and hazard to life

Author´s introduction to this paper

The question of causal effects and biological relevance of electrical and magnetic parameters is generally posed without simultaneous reference to their relevance to life's organisation. These questions cannot, however, be considered in isolation of each other. What role have the electrical and magnetic fields played in the evolution of life on earth? What role are they playing in the individual development and physiological capacities of an organism? Whoever investigates these questions must sooner or later conclude: Not only did the electrical and magnetic fields of our planet exist before all life, but they have had a decisive hand in the evolution of the species – in water, on land and in the near-earth atmosphere. Living creatures adapted to it in the development of their kind.

Biological experience teaches us that life will use the energy pool in which it finds itself to its best advantage. Advantageous not only because the absorbed energy is a carrier of information, useful for orientation in the environment (see glossary; hereinafter GL). But advantageous also because the organism developed to make use of gravitational and electromagnetic interactions, creating decisive functionalities of life. The biological system expresses itself just as the environment does and unity and coordination with its environment is its guiding principle.

But if bees and other insects disappear, if birds are no longer present in their traditional territories and humans suffer from inexplicable functional deficiencies, then each on its own may appear puzzling at first. The apparently unrelated and puzzling phenomena actually have a common trigger, however. Man-made technology created magnetic, electrical and electromagnetic transmitters which fundamentally changed the natural electromagnetic energies and forces on earth's surface – radically changing million-year-old pivotal controlling factors in biological evolution.

This destruction of the foundations of life has already wiped out many species for ever. Since this extinction of species mostly affected ecological niches and hardly ever own life, most of us were not interested. But now, the endangerment of animals is also threatening the survival of man in a new and unexpected way.

Animals that depend on the natural electrical, magnetic and electromagnetic fields for their orientation and navigation through earth's atmosphere are confused by the much stronger and constantly changing artificial fields created by technology and fail to navigate back to their home environments. Most people would probably shrug this off, but it affects among other one of the most important insect species: the honeybee.
Because the bee happens to be the indispensable prerequisite for fructification: without bees, the fruit, vegetable and agricultural crops will fall short.

We are, however, not only affected by the economic consequences of our actions. It can also be proven that the mechanisms evidently affecting birds and bees are also affecting the human organism. An all-round unnatural radiation with an unprecedented power density (GL) is also harming human health in a novel way.

But, unless mankind reminds itself of the basics of its existence and unless the politicians in charge put a stop to the present development, the damage to health and economic fundamentals is predictable and will fully manifest itself not now, but in the next generation.

The reasons for this are explained in this paper. It endeavours to quantify natural electrical and magnetic signals provided to men and animals as guiding signals throughout evolution. The paper, however, places particular emphasis on what happens when these natural signal amplitudes are suppressed, changed and distorted on an unprecedented scale by technically generated artificial fields. Mankind can only take successful countermeasures if the damage mechanisms are understood.

The following analyses are intended to remain readable also for interested laymen. This approach has its limits where experimental fundamentals or specific technical descriptions must be included. The following text therefore offers three options for reading. In its totality, it is intended for readers with a scientific background. It has, however, also the interested layman in mind, by allowing him to skip identified parts containing specific technical justification and arguments. And the parts against a coloured background are intended as a first overview.

I thank Prof. Dr. Karl Richter for the editorial supervision of the paper and Dipl.-Met. Walter Sönning, medical meteorologist, for his technical comments on the sferics question and the compilation of a glossary for the interested layman.

If all the functions bees perform for natural life and its preservation are observed holistically, their importance cannot be overstated. Without the bees, we humans will also suffer major deficiencies.

1. The organisation of life underlying its vulnerability

1.1 We should have known long ago

The relationship between life and the physical parameters of earth's surface and atmosphere have been known for many decades. Those responsible therefore had the opportunity long ago to question to what extent the excesses of technically created electrical and magnetic fields might have the potential to destroy nature's housekeeping.

There are only two types of energy capable of transmitting information over great distances: electromagnetic and gravitational energy. Any forces acting beyond the boundaries of an atom can be traced back to these two energies; ultimately they have an infinite reach. Both energies are universally present and can be modulated in many ways (GL). This is true, for instance for light, the earth's magnetic field, cloud charges, atmospheric electric fields and changes in atmospheric pressure. Together with atmospheric moisture and olfactory particles, they are recognised as orientation aids to mobile organisms.

In the natural environment, there are "oscillating" electromagnetic fields of many orders of magnitude and with frequencies ranging over a virtually unlimited spectrum covering many frequency decades. They manifest themselves as a continuous and enormous "hiss" – like an unlimited ocean, the surface of which is agitated by waves of any imaginable amplitude and extent. Nature has created senses that filter out very specific frequencies and intensities from this ocean of waves, analyse them and convert them to forces. These filtered frequencies identify a specific sphere of life for specific life forms.
Only those energies that are important to the life of an animal are transformed. The forces generated from these energies control nerve cell membranes and protein structures such as enzymes – creating patterns, images and impressions that we call experience. Sensory organs are organs functioning as frequency analysers (GL), information amplifiers (GL) with gains up to a million, sometimes including contrast enhancement and noise suppression. Eyes, ears, sense of smell, taste, sensitivity of touch, light, warmth, chemical, electrical, magnetic and pain receptors. The living world perceives stimuli such as light (including ultraviolet and infrared), sound (including ultrasound and infrasound), electrical fields and currents, magnetic fields and also smells and water currents. And the sensory performance of animals is often comparable to our technical measurement apparatus, sometimes even far superior. Physiologists can prove this by some astounding numbers: Snakes, for instance, can sense temperature variations of a thousandth of a degree centigrade; long-horned grasshoppers and cockroaches can register mechanical surface vibrations with amplitudes (GL) down to 1/25th of the diameter of a hydrogen atom.

The high "intelligence of the systems" is particularly obvious, however, with orientation, navigation and early warning systems. In this regard, the earth's magnetic field has an important role to play. The local geographic position and time of day can be established from the density, direction and inclination of the field lines and their temporal variation.
Every location, together with other physical information, has a specific identifiable pattern. The sensitive reception apparatus of animals use the magnetic field information for orientation and navigation, among other (WARNKE, 2006).

1.1.1 Magnetic fields as global parameter for space and time orientation of all life

To the best of our present knowledge, biological organisms depend less on static magnetic fields than on the very important intensity variations of sufficiently high frequency. If we take a closer look at such variations, the earth's magnetic field cannot be considered in isolation. Other magnetic fields must also be included in the analysis: such as the ionospheric field, for instance, and the field of the Van Allen belt – a radiation belt of very high intensity with rotational symmetry around the magnetic axis and mirror symmetry around the magnetic equator around the earth. Both the ionosphere and the Van Allen belt are held together by earth's magnetic field. The protons and electrons captured from the cosmic radiation or the solar wind (= stream of ionised particles emanating from the sun) by earth's magnetic field, create a protective shield for all life on earth – the Van Allen radiation belt.

The external magnetic fields act as moderators (GL) on the earth's magnetic field. They exhibit both a pronounced solar and also a lunar (moon-dependent) diurnal variation. The reason for the solar-induced variation lies in the diurnal warming of the atmosphere through solar radiation. This is

accompanied by horizontal eddy currents with amplitudes up to 90 000 Ampere in the ionosphere, that generate magnetic fields again. These daily variations also have a pronounced annual cycle.

The moon-dependent variations are furthermore only evident during the day. These are also generated by electrical currents at about 100 km altitude, but they have current amplitudes of "only" 10 000 Ampere. These eddy currents cannot be explained by temperature gradients as with the solar effects, but they are influenced by the gravitational remote action of the moon. The earth's atmosphere is rocked to and fro inside the earth's magnetic field in the rhythm of the tides, inducing electrical currents in the ionised layers of the upper atmosphere where the conductivity is high through the presence of the negatively and positively charged particles (ions). It appears that the conductivity of the ionosphere is too low at night to maintain induction processes (GL) – due to reduced ion densities (WARNKE 1993).

Within the realm of the conventional variations of the magnetic field that have been explained so far, electromagnetic oscillations that occur in mainly two frequency bands also deserve to be mentioned: 10 Hz and 10-25 kHz. On the one hand, there is a resonating electromagnetic oscillation between earth and ionosphere in the 10 Hz region (Schumann resonance, 7.83 Hz) and on the other, thunderstorm activities on earth constantly reinforce certain electro-magnetic oscillations. The dominant frequency of approximately 10 kHz generated by vertical lightning flashes corresponds to a transmitter dipole of cloud-to-earth length, whilst horizontal cloud-to-cloud lighting generates about 20 kHz.

These characteristics may be exploited for the design of thunderstorm warning apparatus. Our device measures the thunderstorm activity in a range of at least 800 km and simultaneously also the activity within a range of 200 km. Under favourable conditions, we can therefore register thunderstorms over the Mediterranean from our location in Saarbrücken.

Lightning also simultaneously generates very low frequency electromagnetic oscillations. Under certain conditions, these oscillations are all guided through the ionosphere along the magnetic filed lines, travel far into space and return to earth along the opposite magnetic field lines. They are reflected at the ground and the waves travel the same way again and again until their energy is dissipated. The higher frequencies are propagated somewhat faster than the lower ones. If this process is made audible through an amplifier, a whistling noise is heard, continuously decreasing in frequency down to a hum, as in a switched-off siren, but much faster, typically for approx. 1/3 of a second. This phenomenon was therefore called "Whistler".

The so-called earth-magnetic storms (magnetic induction B~1μT) are triggered by the magnetic shock waves escaping from the solar flare region at 2000 km/sec and still have a speed of 100 km/sec as they reach earth. This induces unusually high currents in the earth's magnetic field, which in turn change the earth's magnetic field and generate secondary currents. Such currents manifest themselves in long conductive paths such as pipelines, transmission lines etc. and routinely cause technical headaches.

The most important parameters, constant over millions of years, are: earth's static magnetic field: 31 μT (geomagnetic equator); resultant diurnal variation of the earth's field: 60 nT; magnetic storms: 500 nT; sferics field strengths: 0.25 – 3.6 pT per $\sqrt{Hz}$.

The natural high frequency radiation sources have far less energy than the technically generated transmission powers and energies. This is a precondition for transmission of news and communication.

The integrated power density over all frequencies up to 300 GHz is 600-800 $\mu W/m^2$ at the earth's surface. The power density of the microwave solar radiation is about 0.1 $\mu W/m^2$, escalating to several 100 $\mu W/m^2$ during solar flares.

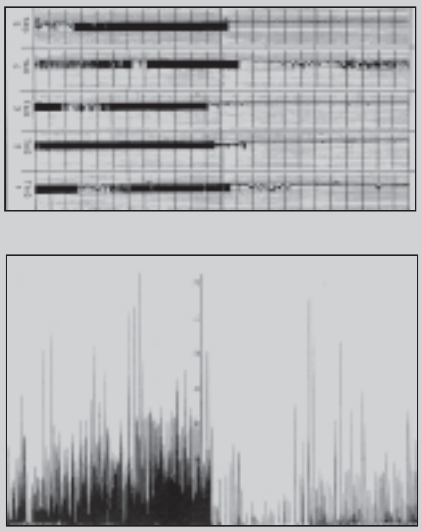

Fig. 1 *Top: The "midnight phenomenon". The activity of the electromagnetic impulses (shown on 5 different days) abruptly ends at midnight.*
Ref. Hans Baumer: (1987) Sferics. Die Entdeckung der Wetterstrahlung. Rowohlt, Hamburg

Bottom: Our original recorded activity cycles of 20 caged bees in a laboratory experiment. The vertical axis (ordinate) shows the total electrical field arising from the electrostatic charging of the wings. It is clear that the bees suddenly all come to rest at midnight.
Acc. to Warnke (1982), published in Baumer's book (1987)

1.1.2 Examples of the utilisation of earth's magnetic field parameters

For a period of millions to a billion years, life on earth had the time in the evolution of the species to adapt to the magnetic and electromagnetic conditions of their environment. They learned to use the natural magnetic field parameters also as conveyors or carriers of a diversity of information:

- The geographic location can be established by the density of the field lines, their direction and variation in time.
- Time of day and annual seasons can be deciphered in the daily, lunar and solar periodic magnetic signals.
- Frontal weather systems and air mass movements transmit characteristic electromagnetic signals, the so-called sferics. These are short oscillations comprising just a few cycles (= impulses) in the range between approx. 3 kHz and 60 kHz (= very low frequency) with a repetition frequency of up to 100/sec or more, depending on the intensity and type of atmospheric processes.

The biosphere at the earth's surface is in contact with the electromagnetic fields of the universe via two narrow frequency windows through the atmosphere. One of these windows is in the narrow medium to long wavelength UV radiation region, including the visible light spectrum and the near (short wave) infrared radiation (average 1milliwatt/m^2); another window is in the high frequency radiation region at wavelengths of 0.1 to 100 m (average 1 nanowatt/m^2 up to 1 milliwatt/m^2 (GL) during solar flares).

Effects of the earth's field and of its compensation or effects of weak artificial fields have been detected in life at all levels of development: with bacteria, single and multi-cellular algae, higher plants, protozoa, flatworms, insects, snails and vertebrates:

- Magneto bacteria (Aquaspirillum magnetotacticum) in the bottom sludge of the oceans utilise the intensity of the earth's magnetic field for orientation. Magnetite crystals (Fe_3O_4) in their bodies form a chain of "compass needles" creating a magnetic moment that the bacteria align against the thermal movement of the water molecules. (The earth's magnetic field applies an energy of 1.4 x 10^{-18} J (GL) to the bacteria – 200 times greater than the energy of the thermal movement at 22°C).
- Fish navigate in the earth's magnetic field. When sharks and stingrays, for instance, move in earth's magnetic field, they experience induced electrical fields of varying strength. The field strength is a function of the direction of movement relative to the direction of the magnetic field. Local physical water currents also generate direction-dependent electrical fields that can be detected. The sensory organ for electrical fields is highly sensitive. (So-called Lorenzian ampoules responding to voltage gradients of less than 0.1 microvolt/m).
- Compass termites (Amitermes) build their metre-high mounds in a north-south direction. With other termites and the woodlouse, the feeding activity is subject to natural magnetic alternating fields (sferics) and the earth's magnetic field.
- Bees make use of the earth's magnetic field and its daily fluctuations for their orientation and communication. They also gain information on weather developments through the natural impulse signals in the atmosphere, i.e. the sferics already mentioned above.
- Whales can sense the magnetic field of the earth.
- Carrier pigeons are affected by variations in the earth's magnetic field down to flux densities in the nano-Tesla region.
- Migratory birds have a mechanism acting like a compass.
- Humans react to atmospheric alternating electromagnetic fields between 10 and 50 kHz through various symptoms of the central nervous system. There are also correlations between activities in earth's magnetic field and sleep-affecting factors, circadian rhythms (HECHT 2005, 2006, 2007), enzyme conversion and hormone production in the central nervous system, the vitamin level in the blood serum, the average skin temperature, vision in half-light and iron content in the blood serum.

All the examples support the existence and the vital control functions of biologically active magnetic and electromagnetic fields with a specific frequency structure and corresponding information content, "arranged" to suit biological systems.

They are characterised by, among other:

- *specific flux densities and gradients ("amplitude windows"), i.e. weak fields may have a greater effect than strong fields,*
- *specific impulse frequencies and impulse sequences ("frequency window"),*
- *specific impulse shapes and a certain complexity of the impulse spectrum,*
- *specific vector characteristics with respect to the body,*
- *minimum effective duration of coherency and specific co-factors, e.g. light.*

Life forms, even of the same species, may be quite differently organised, but coordinated in a collective or social group (fish shoals and flocks of birds). In an isolated form of life, the instantaneous interaction with its environment is therefore exceedingly varied. Reproducible magneto experiments in or between individuals are therefore unlikely in the case of complex organisms, including humans; the specific metabolism parameters are, for instance, also too varied. None of these parameters can be kept as constant as required for reproducibility. "Proof", in the sense of classical scientific criteria, is therefore illusory.

1.1.3 Technical wireless communication is only possible because the transmission is stronger than the natural high-frequency radiation

Technical wireless communication such as mobile radio, radio, TV and satellite

communication is only possible because the power density of the utilised technical high frequency spectrum far exceeds that of natural radiation. Natural radiation at the surface of the earth in the 300 MHz to 300 GHz range is approximately 0.001 microwatt/m² (=0.001 µW/m²); today's typical technically created radiation level in cities is 10 000 µW/m². And the legal German limits even allow values up to 4.5 million µW/m² for the D-grid, up to 9 million µW/m² for the E-grid and up to 9.8 million µW/m² for UMTS.

As we evolved, we were of course also exposed at times to strong static and low-frequency electrical fields (typical voltages: cloud electricity up to 10 000 V, volcano electricity up to 20 000 V, lightning 500 000 V, sferics 10 V), in addition to constant static and low-frequency magnetic fields (earth's field, lonospheric field, cosmic field, lightning). But there were never fields as constant and with as many superpositions of different frequencies from different sources as we are now generating with our technology.

1.1.4 Radiation by organisms themselves could be established in the evolution, because there was no interference by continuously changing external radiation

The same high frequency radiation that technology utilises for communication is also copiously generated inside our bodies. The body also requires it for communication purposes: for biological communication through functional oscillation of our molecules.
Provided there is no interfering external radiation, the body can utilise its built-in frequencies for its internal organisation.

The body internally radiates frequencies in the 1 to 1 000 gigahertz (GHz) range at power densities of about 0.1 µW/m², i.e. lower than those of average solar radiation. If we add up the total range of high frequencies (HF and VHF) present within our organism, we arrive at natural power densities of about 10 000 µW/m². The power generated by our internal electromagnetic oscillations, that we describe as heat (wavelengths around 3 – 10 µm), corresponds approximately to that of a 100 Watt globe.

To understand the natural oscillation of our functional molecules (enzymes and other proteins, nucleic acids, hormones and many more) it is important to realise that what we generally describe as "chemistry" is actually pure physics. All the bonds and their modulations (changes) between atoms on the one hand and molecules on the other are based on physical phenomena. In this context, the electrostatic Coulomb forces (= force between different electrical charges) and the electromagnetic force (e.g. van der Waal force = force between dipoles with different moments and fast oscillations) are prominent. DNA and all the enzymes, for instance, can only carry out their functions through their natural electromagnetic oscillations.

Resonances are of particular importance here. Chain molecules, for instance, can be excited to so-called wring-resonances by high-frequency electromagnetic fields. Proteins exhibit such natural resonances in the range of 1 – 10 GHz; DNA resonates at 10 MHz to 10 GHz. Both of these therefore fall into the spectrum of common mobile radio frequencies.
Wring frequencies (modes) cause wringing of the molecular chains that directly affect the structure of the individual molecules. The structure of the molecules (conformance and configuration) is essential, however, for their specific functionality. Even minor displacements render the molecule useless. The chains may even break apart under energetic external influences.

Biological systems are obviously very sensitive in their reaction to microwave fields. For instance, Belyaev et al, 1996, reported resonance effects on the DNA structure at extremely low power densities of 0.000001 µW/m² in the 40 – 50 GHz frequency range. This surprising result must still be confirmed by other working groups. Nevertheless, it must be stated that: The ultra-weak, but biologically very effective natural electromagnetic fields are contrasting strangely with the technical radiation fields permitted in Germany. On recommendation by the ICNIRP association (Munich), technical radiation fields up to power densities of 10 000 000 µW/m² were legalised – still considered as harmless by the experts. The population, animals and plants may therefore be legally subjected to radiation in the critical frequency spectrum that is more than 10 orders of magnitude higher than the natural fields.

But organisms are not only sensitive to high frequencies; the following examples show that very high sensitivities evolved also in the low frequency ranges.

2. About the disappearing bees and birds

2.1 The bees as evolutionary force and indispensable economic factor

Honeybees existed on earth from about 40 million years ago; a "primal" honeybee encased in amber was found on the coast of the Baltic Sea. Man soon realised the usefulness of animals. And we know today that the enormous development of earth's vegetation, comprising about 200 000 species of a variety of flowering plants, is based on animals. Because about 85% of these flowers are pollinated mainly by bees and propagate through the formation of fruit and seeds.

Since also fruit trees (such as cherry, apple, pear and plum) and agricultural crops (such as rap, sunflower, red clover, lucerne, horse bean as well as vegetables such as tomato, cucumber, pumpkin) fall under these, it is not difficult to understand that bees are one of mankind's most important production animals.

In central Europe the commercial benefit of bees is estimated at 4 billion euros per annum, in the US it is estimated at over 15 billion dollars. These figures are from the New York Times. It quotes estimates by Cornell University, New York State. This included the pollination of fruit and vegetable plants, almond trees and fodder such as clover. That said, however, even the global honey production of 25 000 tons per annum is an important economic factor already.

But if we aggregate all the functions the bees are performing for nature's life and the preservation thereof, their significance can hardly be overestimated. Their industry cannot be substituted either by other insects or by technical measures. If the bees should disappear, we humans will also suffer major deficiencies.

2.2 No chance of survival: ‚Colony Collapse Disorder' CCD

In some countries there are reports of mysteriously dying bees. It appears as if the losses are at their worst in the northern American states and in neighbouring Canada. 25% to 50% of the American bee-keepers report losses through "Colony Collapse Disorder" (New Scientist, 2007). They reported 50% to 90% of their bees to have disappeared within the previous 6 months, and the remaining bee colonies were said to be so weak they can produce hardly any honey (CNN, 2007).

But unusual losses are also reported in Germany, Switzerland, Austria, South Tyrol, Spain, Poland and New Zealand. In Germany, for instance, the beekeeper associations last winter recorded a loss of about 13% in over 7 000 bee colonies - double the previous year's figure (http://orf.at/070416-11296/-index.html). In accordance with a report in the Stern magazine edition 34/2007, German bee monitoring did not confirm this number, only acknowledging an average loss of just on 8%. A 10% loss over the winter months is not regarded as unusual. What is completely unusual, however, is the statement by the president of the DBIB (German Federation of Occupational and Purchasing Beekeepers), Manfred Hederer, in the Deutschlandradio Kultur, on the Federal territory: "The beehives are empty." He paints a picture of bee colonies reduced by 25% - in some cases even 80% (Spiegel 12/2007).

In 2006, the Swiss federal research institute for production animals and dairy farming, Agroscope, (Federal office for agriculture), reported that also all of Switzerland was affected by bee deaths, to a regionally more or less severe degree (Zürichseezeitung, 5. May 2006). Roughly 30 percent of the bees were lost without a trace after winter – about half a billion animals in this year alone (http://www.heute-online.ch/wissen/play/artikel 60601).

Beekeepers from Styria are also reporting a mysterious disappearance of bees. Beekeepers in Vienna estimate a 30% loss. They agree on the following: "The bees are not developing properly anymore. They do survive the winter, but in spring they disappear as if by magic. The hives are simply empty." (This according to beekeeper Hermann Elsasser of Fladnitz in the Raab valley; http://oesterreich.orf.at/steiermark/stories/184609/). Only the brood remains in the hives, and without the care of the older bees, they will die.

Ferdinand Ruzicka, scientist and beekeeper himself, reports: "I observed a pronounced restlessness in my bee colonies (initially about 40) and a greatly increased urge to swarm. As a frame-hive beekeeper, I use a so-called high floor, the bees did not build their combs in this space in the manner prescribed by the frames, but in random fashion. In the summer, bee colonies collapsed without obvious cause. In the winter, I

observed that the bees went foraging despite snow and temperatures below zero and died of cold next to the hive. Colonies that exhibited this behaviour collapsed, even though they were strong, healthy colonies with active queens before winter. They were provided with adequate additional food and the available pollen was more than adequate in autumn. The problems only materialised from the time that several transmitters were erected in the immediate vicinity of my beehives" (RUZICKA, 2003).

Ruzicka organised a survey through the magazine Der Bienenvater (2003/9):

- Is there a mobile radio antenna within 300 m of your beehives? - This was confirmed in 20 replies (100%).
- Are you observing increased aggressiveness of the bees compared to the time before the transmitters were in operation? – 37.5% confirmed this.
- Is there a greater tendency to swarm? – 25% confirmed.
- Are colonies inexplicably collapsing? - 65% confirmed.

Such colony collapses, heralded by "angry" swarming of the bees, were also reported in New Zealand (FIRSTENBERG, 2007).

Other reasons possibly explaining the disappearance of the bees are also under discussion: Monocultures, pesticides, the Varroa mite, migratory beekeeping, dressed seed, winters too severe, genetically modified plants. There is no doubt that some problems can be attributed to this. But the fairly sudden and country-spanning appearance two to three years ago of the dying bees phenomenon cannot be convincingly explained by any of the aforementioned causes. Should the bees simply be too weak or ill, they should also die in or near the hive. But no ill bees were found in the research into this phenomenon.

About 85% of these flowers are pollinated mainly by bees and propagate through the formation of fruit and seeds. We have the utility of animals to thank for the enormous development of earth's vegetation, comprising about 200 000 species of a variety of flowering plants.

2.3 Some bird species are disappearing

But not only are bees and other insects disappearing – birds as well. The house sparrow, for instance, has become clearly scarcer in England and some western European countries. An investigation carried out between October 2002 and May 2006 in Valladolid in Spain, was launched to examine whether this decline in the sparrow population was related to electromagnetic radiation by mobile base stations. The result showed with a high decree of statistical confidence that the number of sparrows was reduced when the electrical field strengths of the antennae exceeded certain values. (BALMORI, HALLBERG, 2007).

A similar investigation was carried out in Belgium. The numbers of house sparrows were counted in the vicinity of several mobile radio base stations, during their breeding season. This confirmed a significant relationship between the electrical field strength in the 900 and 1 800 MHz bands and the diminishing numbers of birds (EVERAERT, BAUWENS, 2007).

It was noticed even earlier that storks that built their nests within a 200 metre radius of base stations could not rear any chicks, remaining without offspring. The results improved at distances of 200 to 300 metres. From a distance exceeding 300 m, the storks bred with a success rate of 96.7%. The electrical field strength at a distance of 200 metres averaged 2.36 $\pm$ 0.82 V/m, and only 0.53 $\pm$ 0.82 V/m at 300 metres. From their results, the authors concluded that the electrical fields of base stations are damaging to the reproduction of the white stork (BALMORI, 2005).

3. Mechanisms of disorientation and damage

3.1 Magnetic field sensitivity in the animal world

Birds, insects, fish and snails are assumed to have a specific organ for sensing magnetic forces. It is questionable, however, whether it is always necessary to assume such a specific magnetic sense. Electrical fields do not penetrate deep into living organisms and currents follow only certain paths. A magnetic field, however, fully penetrates the organism, without major changes. It is too short-sighted to conclude from this that such fields have no effect because they are not absorbed. To start off with, even weak magnetic fields in the body are more energetic than strong electrical fields. As such, the energy in earth's magnetic field inside us is 10 000 times stronger than the strongest possible electrical field in the atmosphere (3 Megavolt/m; WEISS, 1991). Such penetrating forces as the quasi-static magnetic field and the low-frequency electromagnetic field do not theoretically need an own amplifying reception organ. Inside the organism, they can also directly couple into aggregates of orderly paramagnetic molecules or into the electro-mechanical (photon-phonon) code of the endogenous information transmission and storage.

Magnetite was found in all animals that can navigate using their own compass, sometimes in the form of ferritin-proteins (KIRSCHVINK et al. 1981). But it is also present in our brains (KIRSCHVINK et al. 1992). And it reinforces the external magnetic fields in both cases. In the tissue of birds, bees, fish and whales (WALKER et al. 1992), the magnetite concentration exceeds that in the human brain. Most areas of our brain nevertheless contain about 5 million magnetite crystals per gram and even 100 million in the brain membrane.

Because magnetite reacts about 10 000 000 times stronger to external magnetic fields than normal dia- and para-magnetic tissue, the transmission of information separate from the neurons must be considered. Oscillating magnetite excited by ELF fields could, for instance, play a role in transport channels or cell-interconnection channels, raising the possibility of interference by communication and other negative effects of technically created electro-/magneto-smog.

It is easy to prove mechanically acting forces in insects subjected to relatively strong magnets. Own experiments with bees and flies yielded the following results (WARNKE, not published):

- *A newly captured swarm of bees is exceptionally sensitive to magnetic forces. If a magnet with only a few mT field strengths is brought close to the swarm in a dark wooden hive, the entire swarm becomes excited.*
- *Captive bees assume a horizontal rest position at night, aligned to an artificial magnetic field of several mT in the environment.*
- *Dead bees, flies and a range of other insects can be made to float on an electrostatically neutral water surface and in this condition an electrostatically neutral strong magnet can be used to attract them, drag them across the surface and in some cases repel them.*

In the laboratory, bees can sense not only the compass direction but also the intensity and the gradient of this magnetic field (SCHMITT et al. 1993). It was found in a 1982 publication (KUTERBACH et al. 1982) already that the magnetite found in bees is the source of this sensitivity to magnetic fields, and this theory was recently checked and finally confirmed (HSU et al. 2007). We also found ferrite particles together with pollen lodged in the bristles of the body surface; these might also be responsible for the above-mentioned magnetic moment.

It has been demonstrated that the birds' magnetic compass only functions in a certain range of intensities between 43 μT and 56 μT – precisely in the range of the earth's magnetic field intensity. After a three-day adaptation period the animals could, however, also orientate themselves in fields of 16 μT and 150 μT (SCHNEIDER et al. 1992) – interpreted as an adaptation to the environment.

The platypus of Australia (Ornit-horhynchus anatinus) has the electrical receptors for detecting its prey, in its bill. The receptors can sense direct and alternating voltages in the range of 20 mV and have a connection to the Trigeminus nerve. Fish with similar receptors use the acoustical nerve for transmission of the electrical stimulus. This shows that evolution exploited the electrical and magnetic environment in different ways. The Lorenzian ampoules of fish are capable of distinguishing between stimuli of magnetical or electrical origin (BROWN et al. 1978). It has not been established whether the receptors of platypus also have this capability. This question is of interest because ducks also have bill receptors. Although these are specialised to react to mechanical stimuli, they are so sensitive that the mechanical Coulomb forces accompanying electrical fields might well be detectable as well.

When magnetic fields penetrate an organism, two fundamentally different aspects must be clarified:

1. *Is the organism merely subjected to a large increase in energy - or*
2. *does the organism gain information?*

In various insect species we are aware of a time function based on magnetic field variations. In particular, the feeding habit of termites is correlated with the 27-day solar cycle (BECKER, 1973), and there is also an increased building activity for a few days around new and full moon in laboratory experiments – as it is with bees. It is also known that termites show directional behaviour under the influence of extremely low field strengths (BECKER 1976, 1979). Time triggers via similar channels sensing sun and moon appears a reasonable assumption.

The changes to the circadian activity rhythm of the house sparrow (Passer domesticus) can be correlated with cyclical changes of the earth's magnetic field. The sparrow reacts down to 200 nT in laboratory experiments.

Without doubt, light is the dominant timing mechanism of life. But also the earth's magnetic field is meanwhile recognised as a timing mechanism.

3.2 Bees and other small life forms under investigation

Insects have many aids for their navigation and orientation in space: sunlight, also polarised (WARNKE, 1975), gravity, aromatic molecules, colour as electromagnetic oscillation in a specific frequency range, variations in air pressure, occasionally also the degree of ionisation of the air (ALTMANN et al. 1971, WARNKE, 1976). Many species, however, cannot do without the magnetic field.

In this respect, bees are welcome objects for experimentation. Because different modalities of their orientation are inseparably linked to the magnetic field of the earth and to electromagnetic oscillations (LINDAUER and MARTIN 1968; HÜSING et al. 1959, SCHUA 1952, WARNKE, 1976).

In our working group, we recorded the directional behaviour of captive bees in an artificial field and during the night. A preference to assume rest positions with the body either parallel or orthogonal to the field lines was evident.

They share this alignment reaction with other insects such as various termites (BECKER, 1963), diptera (BEKKER et al. 1964) and Drosophila (WEHNER et al. 1970).
The behaviour of termites (BEKKER, 1963) was studied particularly intensively in Germany, that of the Christmas beetle (SCHNEIDER, 1961, 1963) in Switzerland and that of insects, worms, snails, snakes and other small creatures in the USA. The investigations concentrated on the influence of cosmic physical fields in which the magnetic field time and again played a pivotal role. All experiments confirmed the existing relationships. They also all showed, however, that constant laboratory conditions are impossible in practise, because cosmic influences change the magnetic component in any normal room and cage, thereby affecting the orientation behaviour of the animals.

The experiments with Christmas beetles and termites may be termed spectacular. In accordance with the above literature, Christmas beetles not only determine their rest position by magnetic and electrostatic fields, but also by interference patterns of gravitational waves of terrestrial and cosmic matter. In the final analysis, the evidence points to the influence of a physical field or radiation, varying in space and time in accordance with an unknown programme, that is registered through an unknown organ in the Christmas beetle for an unknown purpose, but the existence of which physicists doubt because it cannot be measured by any instrument. The Christmas beetle therefore becomes the instrument for measuring this unknown agent. The effect is often intimately coupled to that of the magnetic fields (SCHNEIDER, 1974). The orientation at rest is based on the Christmas beetle choosing the position of least or most symmetrical stimuli when awakening from the rigor of cold. Using interference patterns and models resonating with gravitational Earth-Sun waves, complex combinations of dynamic stimuli were constructed, to which the Christmas beetle responded by changing its position (SCHNEIDER, 1972).

Also termites (Isoptera), whose feeding activity and O_2 consumption are important indicators, react to more than just magnetic components. Their communication modes also include natural electromagnetic sferics impulse patterns, gravitational influences and electrical fields. The statistical correlation between the feeding activity of termites in the laboratory and the number of deaths in Berlin is described in detail; the consequences of this are as yet unfathomable. There is an increased frequency of human deaths on the days on which termites feed less. The authors point to the magnetic field of the earth and its variation with solar influences as the common factor linking the apparently unconnected facts. Further down, other and earlier literature is cited in which an increased incidence of human death is described during unusual variations in the magnetic field.

3.3 Birds as prototypes of magnetic field orientation

This research shows that birds' orientation by magnetic fields has been a frequently discussed topic for decades. Thanks to the thorough and meticulous work of a number of researchers (WILTSCHKO, WALCOTT, MERBEL), it is today beyond doubt that several species of birds sense the earth's magnetic field and use it to establish their position during migration. As described for insects and snails, some species of birds are also particularly sensitive to a range of magnetic field strengths corresponding exactly to the earth's magnetic field – the robin, for instance. When the field is attenuated or amplified, the birds become disoriented. Setting on a certain field range could, however, change through adaptation.

The mechanism by which birds sense magnetic fields has meanwhile been largely explained. An area with iron-containing tissue was discovered in the skull of pigeons. Strangely, only one half of the skull contains material that is permanently magnetic. But opposite to this, material was found that is only very weakly permanently magnetic. Measurements indicate magnetite inclusions - the same crystal that was found in bees, bacteria, snails, whales and humans. The magnetite-containing tissue of the pigeons is even supplied with nerve ends that can sense the orientation changes signalled by the crystals (WARNKE, 1993).

It could be demonstrated at the Zoological institute of the University of Frankfurt/Main that the top half of the pigeon's bill has three magnetite-containing bodies, with a neuron ending at each of these. They constitute a three-channel system enabling the brain to construct a spatial picture of the surrounding magnetic field the pi-

geon can use to orientate itself in flight (source: TV programme *Planet Wissen* in BR on 18.09.2007 at 16.15 on carrier pigeons. Reference by W. Sönning).

Birds also have magnetite in the edge of the bill. In addition, light and magnetic fields result in an increase of certain free radicals in the eye, the concentration of which can obviously be accurately registered by the animals (WARNKE, 1995). This relationship will be dealt with again further on.

3.4 Animals with a navigation system are extremely sensitive to electrical and magnetic fields

Birds having a navigation system are extremely sensitive to the weather. A thunderstorm changes the magnetic field, light and many other characteristics – potentially causing the orientation to collapse. Birds and other animals are particularly sensitive to a solar eclipse. They exhibit an abnormally changed behaviour: sometimes lethargic, sometimes restless. Research attributes the reactions to the suddenly occurring electromagnetic long and medium wave radiation, typical for night time, but surprising with the suddenly occurring darkness of a solar eclipse. The lack of ionisation in the ionosphere by light has the effect of many oscillating impulses propagating 100 times better on the surface of the earth.

This unexpected electromagnetic impulse effect may also, in principle, explain the early warning system animals have for earthquakes. The so-called sensitivity to weather or inclement weather, traceable to short electromagnetic impulses with a certain frequency content and rapidly decreasing amplitudes, has also been known for a long time.

These impulses originate at frontal weather systems, where colder air from sub-polar regions undercuts warm subtropical air masses. In the regions where warm or cold fronts mix, thermodynamically driven turbulent air currents with vertical and horizontal components are created. This is in essence where the abovementioned natural electro-magnetic impulse radiation of the atmosphere, also known as sferics, is created. Many life forms such as insects, frogs, birds and various mammals react to this meteorologically based impulse activity in the atmosphere. By receiving and frequency-analysing these "weather code" signals of changes in the weather or approaching thunder-storms, they can then dive for cover or fly around these thunderstorm regions (WARNKE, 2006).

Walter Sönning: "These weather signals or sferics are indicators of unstable processes in the troposphere – the weather-creating layer of the atmosphere -, since their source is in the weather centre. They originate in invisible discharges between positive and negative space charge clouds, created and maintained by different processes of ionisation such as cosmic radiation, UV radiation, natural radioactivity or the Lenard effect (= spray electrification or break-up of droplets or ice crystals with opposite charges). In terms of physics, our air could therefore also be described as a "plasma" gas. When differing space charges of possibly predetermined magnitude are electrically equalised, the ion-front of this basic plasma or gas discharge propagates at velocities of about 200 km/s along a tubular channel of about 40 cm diameter in the direction of the maximum potential difference, covering distances between 40 and 100 metres, until the electrical potentials are equalised. If the ion density in the air is sufficiently high, the following discharge impulse follows immediately. Each of these invisible and "quiet" discharges that occur at varying intensities in all weather conditions, is the source of an electromagnetic, three-dimensional impulse or space wave, a so-called EMP or primal impulse, similar in its waveform to impulses from other sources (nerves, atmospheric nuclear explosions etc.). This 3-dimensional wave propagates at the speed of light. When recorded on an oscilloscope, for instance, it vaguely resembles a sinusoidal half-wave, but has a steeper rise time and an exponential decay of the amplitude. In a Fourier analysis, it is therefore not equivalent to a sine wave of a certain frequency.

Depending on the meteorological and atmospheric electrical propagation conditions, these EMP's are dampened at a distance of 60 to 100 km from the source to lower frequency sinusoidal Fourier components with a continuous spectrum between approx. 3 kHz and 60 kHz. True to their origin in an impulse discharge, these "impulses" have waveshapes of a few oscillations with rapidly decaying amplitudes from a maximum down to zero. Particularly well-defined impulse shapes in the total collection of atmospheric impulses convey, through their resonating sinusoidal oscillations at certain frequencies and also in the subsequent impulse frequencies up to 100 Hz, the meteorological information on their origin and propagation conditions – like a kind of code. These impulses can be displayed after suitable electronic filtering and are known in the technical literature as CD sferics a.t.B. (CD = convective discharge, i.e. created in atmospheric convection or turbulence without luminosity; a.t.B. = according to BAUMER). They gained special significance, however, at the beginning of the eighties in the context of industrial four-colour copper gravure printing. In this context, their highly differentiated effectiveness in the diffusion capability of bio-chemical biological membrane systems, in dependence on characteristic weather processes, was also shown.

The signals of visible lightning, occurring over the period of the main lightning discharge comprising of virtually uninterrupted sequences of such EMP's, together showing impulse periods up to tenths of seconds with a continuous spectrum into the MHz range, are a strictly different phenomenon.

As such, however, they are suitable as a special weather or thunderstorm signal for the animal and possibly the plant world, i.e. for any organism fitted with the corresponding reception sensors.

Sferics or atmospherics of the various kinds could therefore deliver an almost complete picture of the weather of the day, including prognostic clues, for a biological strategy, considering that the sferics propagate from a weather front at the speed of light and are travelling for hundreds of kilometres, always clearly recognisable as encoded weather to those who have the reception sensors. This can be proven by the example of the reactions of the biochemical membrane system of dichromate gelatine. Also: throughout evolutionary time, both the constant impulse frequency spectrum of the CD sferics a.t.B. and the

daily excursions, constant in their climatological average, have provided a wealth of precision information on the meteorological and geophysical environment to those equipped with the receptors for the signals and the experience; which is more than today's weather services can achieve with the most modern high-tech equipment." (End of the contribution by Walter Sönning).

Animals have a typical electrical charge pattern for each weather phase. Since all movement of charge is associated with forces, animals can analyse the approaching weather via the electrical quantities, even long before the arrival of a thunderstorm.

As a function of special electrical weather events, the bodies of the animals are therefore affected through a complicated interaction of different components: charged, reverse charged, discharged, dielectrically polarised. Polarisation is by a natural electrical DC field. It can be shown that animals are slowly electrically charged in good weather, whilst approaching thunderstorms cause a rapid discharge due to a high concentration of small ions in the atmosphere and charging changes rapidly between positive and negative as the thunderstorm approaches.

Insects such as bees receive these oscillations and recognise them as storm warnings. We were able to show that bees return in great numbers when these oscillations are simulated and transmitted, using a highly amplified signal generator signal. If the amplitudes of the artificial oscillations overlap with the natural signals, however, the return rate rapidly decreases. The bees fail to find their way home.

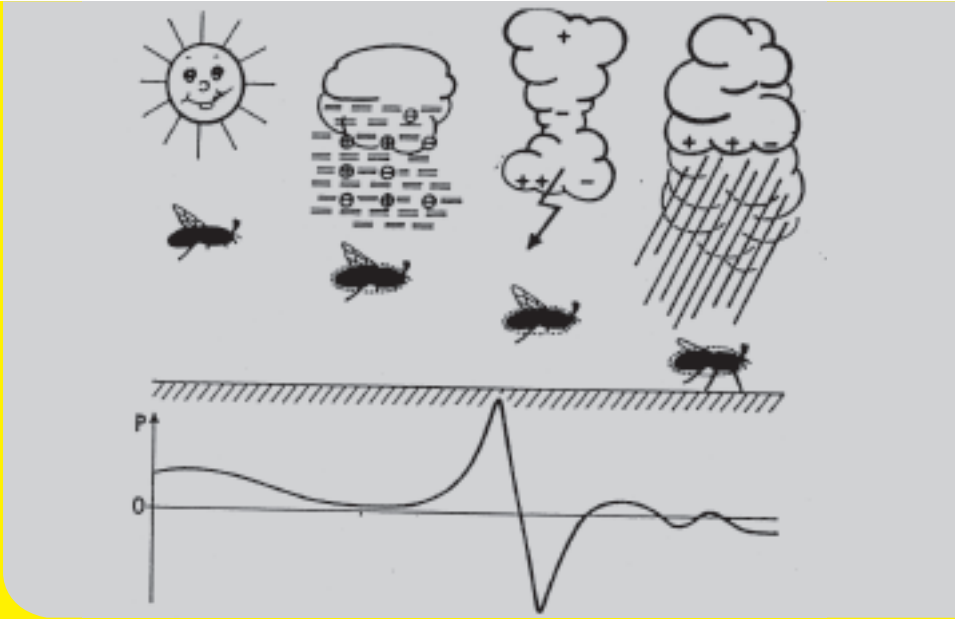

Fig. 2: Top sketch: *The electrical charging of the insects changes typically as the weather parameters change. The bottom curve shows the changes in the electrical field of a freely flying bee as a function of the weather condition.*
Warnke 1989, Copyright Ulrich Warnke

The sensitivity of the honeybee to weather is based mainly on electromagnetic information. When an approaching thunderstorm threatens the bees, flying bees return en masse when the natural 10 – 20 kHz component of the sferics activity increases within a radius of approx. 200 km (WARNKE 1973). The suction performance of the bees also correlates with the approach of the front and the associated sferics (SCHUA, 1952).

And ultimately, bees even use the receptor channel for electromagnetic waves for communication. Russian researchers found in 1975 already that bees generate electromagnetic signals with a modulation frequency between 180 and 250 Hz as they perform their communication dance. Hungry bees react to the frequencies by holding their antennae erect (ESKOV et al. 1976).

Such electromagnetic communication impulses of the antennae when touching another bee can be measured with an oscilloscope (WARNKE, 1989).

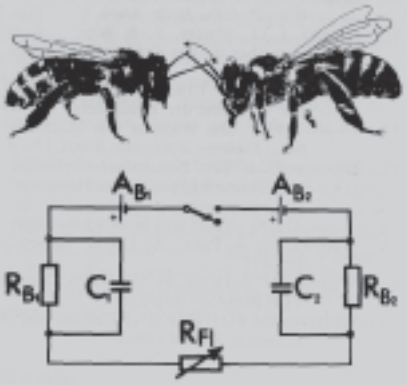

Fig. 3: *Bees communicate via electrical "switching" when their antennae touch.*
Warnke 1989, Copyright Ulrich Warnke

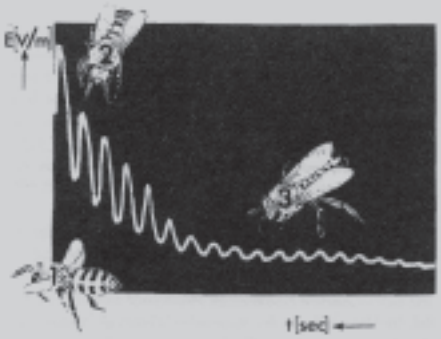

Fig. 4: *Oscillogram of the electrical field of a bee flying past (1). The field strength rises as it approaches a receiver (2) and drops again at a distance from the receiver (3).*
König, H. Unsichtbare Umwelt. Heinz Moos Publishers, Munich 1973. Copyright Ulrich Warnke

Some bird species, such as carrier pigeons, are sensitive to exactly the same electromagnetic oscillation amplitudes as the bees. Birds, particularly species of duck, also communicate by means of electrical fields (WARNKE, 1989). This interesting aspect will be dealt with in more detail below.

3.5 Humans are also sensitive to weather through electromagnetic pulses

The interest in sferics and their effect was greater in the sixties than it is today. In those days, a number of valuable overviews were compiled of their effects on the organism (REITER, 1960; ASSMANN, 1963).

Mammals and man are also influenced by sferics.
Sferics impulses change the tissue pH independent of the amplitude of the field. This is true in the minimal field strengths occurring in nature and also in the laboratory with simulated impulses and increased field strengths. Especially in the frequency band between 2 and 20 kHz, in which the energy of the atmospheric-electrical waves is at a peak, the effect is the strongest. Pain associated with amputations and with brain injury also correlates with the presence of sferics both in the laboratory and in nature (REITER, 1960). The paper by Reiter also contains notes on the triggering of bronchial asthma, heart and circulatory disorders, insomnia, headaches, glaucoma, gall and urinary convulsions, heart attacks and strokes – among other by sferics.

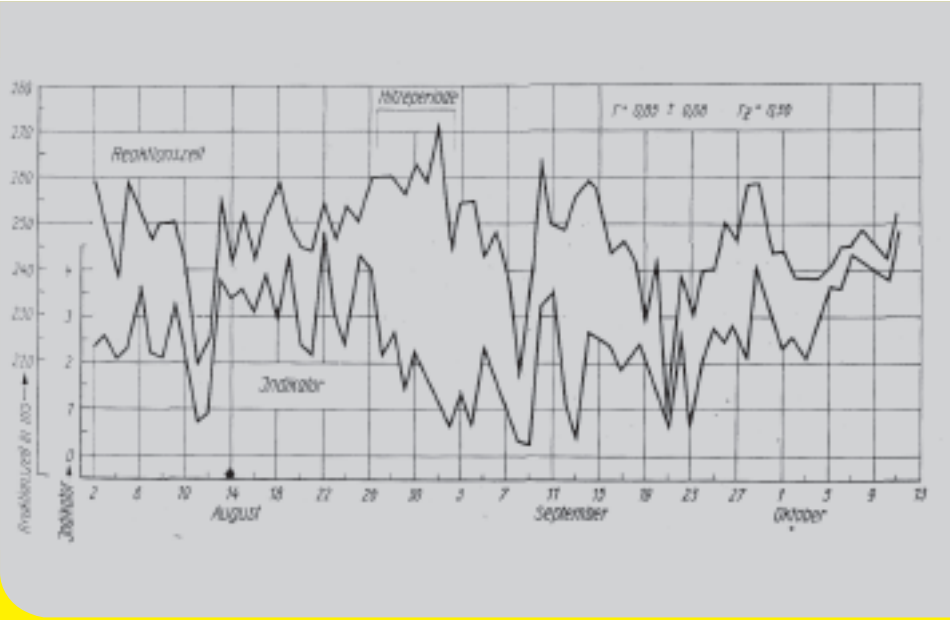

Fig. 5: *Significant linear correlation between electromagnetic very long wave activity and average reaction times of exhibition visitors.*
Reiter, R. 1960 Meteorobiologie und Elektrizität der Atmosphäre. Akademische Verlagsges. Geest & Portig, Leipzig

It has been known for a long time that certain weather conditions give rise to thromboses, heart attacks and embolisms; the correlation is statistically significant (ARNOLD, 1969; BREZOWSKY, 1965). A significant increase in platelet adhesion could be shown with certain electromagnetic oscillations such as those generated by exchange of electrical charge in the frontal regions of the atmosphere. These longwave sferics easily penetrate into buildings. The mean impulse repetition frequency is in the region of 5-15 imp/sec, i.e. in the biologically active window. Thrombocyte adhesion was measured in subjects in a controlled laboratory study using a sferics stimulator (JACOBI et al. 1975). The result was a highly significant ($p < 0.0005$) increase in adhesive property at a carrier frequency of 10 kHz and an impulse repetition frequency of 10 Hz. The thrombocyte adhesiveness was reduced at repetition frequencies of 2.5 and 20 Hz and with no electrical signals. Pharmaka (75 mg Dipyridamol plus 300 mg Acetyl salicylic acid) prevents sferics-related thrombocyte adhesiveness. Mentally unstable subjects were more affected by the change in adhesiveness than stable ones.

The daily work performance is also correlated with diurnal sferics activity (RANTSCHT-FROEMSDORF, 1962).

After further investigation by Jacobi (1977), the physiologic detector location was found to be in the head. If the head is largely screened from sferics, the thrombocyte adhesiveness disappears under otherwise equal experimental conditions – a result that is not in agreement with the effects of screening found by other researchers.

The fundamental sferics frequency is 7.5 Hz, considering the speed of propagation of the electromagnetic oscillations generated by the lightning discharge and the resonant path given by the circumference of the earth between the earth's surface and the ionosphere. The bandwidth of the fields is several kHz.

The correlation between heart attacks and weak magnetic field variations has been described in 1979 in Nature, one of the foremost scientific magazines.

This result is not an isolated case. Other experiments even found a correlation between the average number of deaths and earth's magnetic activity.

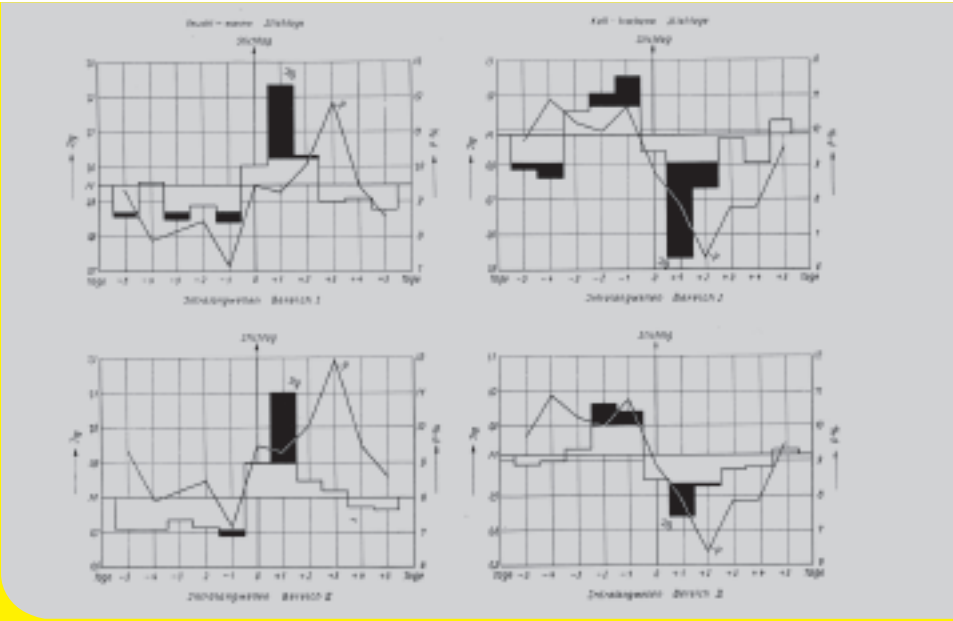

Fig. 6: *Significant synchronicity of very long waves and contracting poliomyelitis. The black bars show days of low (bars downward) or high (bars upward) sferics activity and the superimposed curves show the correlated levels of poliomyelitis contraction in the fifties.*

Reiter, R. 1960 Meteorobiologie und Elektrizität der Atmosphäre. Akademische Verlagsges. Geest & Portig, Leipzig

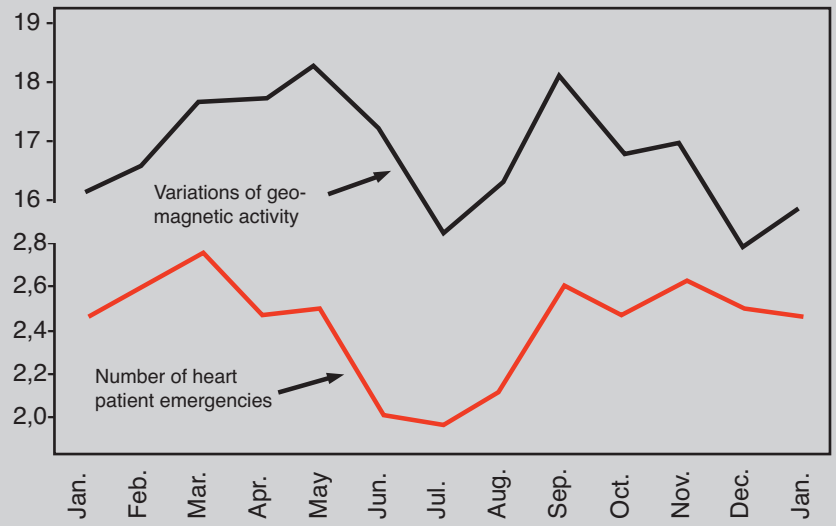

Fig. 7: *Daily emergency hospital admissions for heart attacks as monthly average (bottom curve) and geomagnetic activity (top curve)*

Malin SRC, Srivastava BJ. Correlation between heart attacks and magnetic activity. Nature 1979;277:646-648

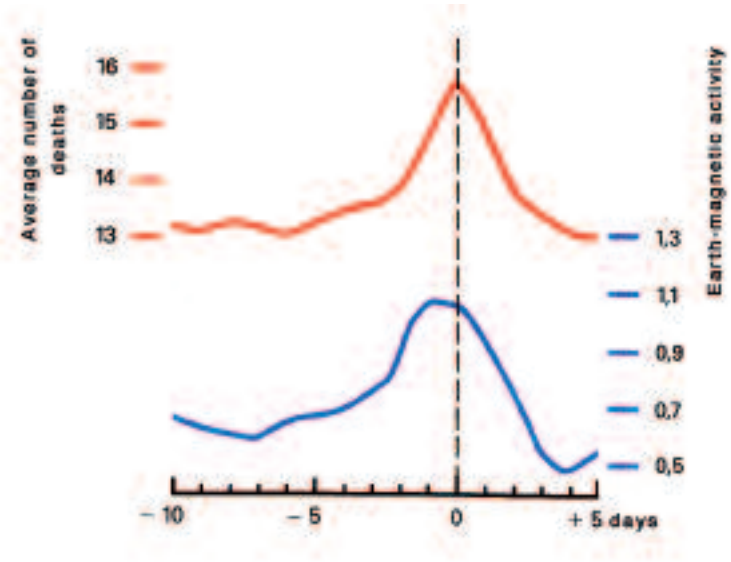

Fig. 8: *Magnetic storms (bottom) and fatalities from nervous and cardiovascular illnesses.*
Weiß 1991

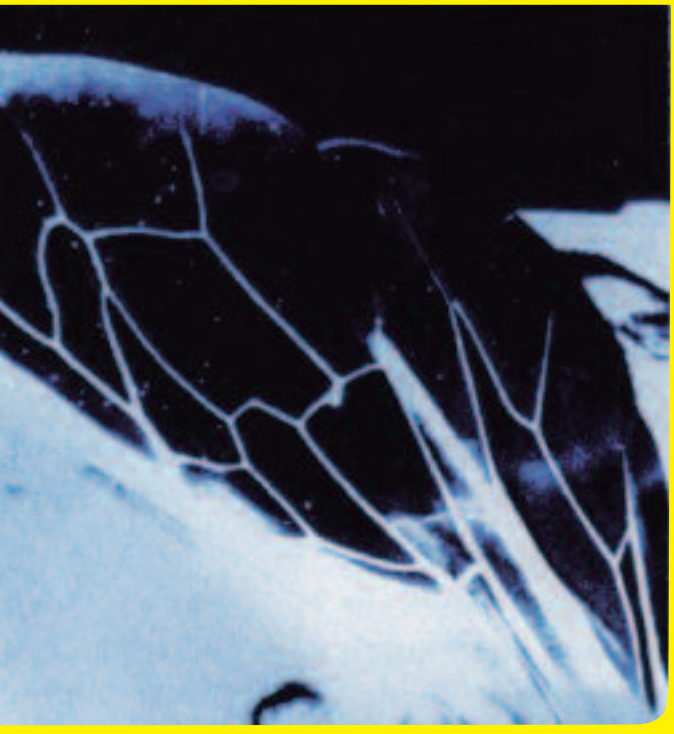

Fig. 9: *Wing of a bee under a scanning electron microscope. The electrical current pattern was recorded. All the white regions have high electron mobility, whilst the darker areas are highly electrostatically charged due to low electron mobility. Discharge is very difficult.*
Warnke 1989, Copyright Ulrich Warnke

3.6 Bees transmit electrical fields

Electrical fields with high amplitudes are always in evidence when the unipolar charge accumulations creating the fields cannot be repeatedly neutralised. Charges are easily neutralised when they are highly mobile.

All land-based insects with rigid body shells (cuticula) and also animals with scales, shields, feathers and hair have used these structures to form surfaces that have excellent electrical insulating properties. These body parts have semi-conducting properties and are piezo-electric and pyro-electric – distortion and temperature changes therefore both create electrical effects. The conductivities are therefore subject to the well-known laws of semiconductor theory: temperature changes, light effects, microwave effects, changes to atmospheric ion concentration – all these parameters change the conductivity pattern.

The areas of different conductivity can be shown in a visually impressive way – demonstrated here on a bee's wing - by using a scanning electron microscope with sample current imaging.

In terms of electrostatic charging, it is also important whether the animals are in flight or on the ground. Animals having sweat, scent and adhesion glands afford excellent galvanic contact. Animals walking on hoofs, toes or claws are largely isolated from earth, however.

There is a salient point about different insects. Flies, bees and others have a glandular adhesive pad (arolium) between two toes on their feet. This adhesive pad can be folded in or folded out when walking.

When the arolium is folded in, the animals walk on their claws, insulating them electrically from the environment allowing them to get statically highly charged up. If the arolium is folded out and touches the surface on which it is walking, however, the in-

sect is instantly discharged, assuming the electrical potential of the surface. In bees, this happens just prior to taking off from a flower, in which case certain parts of the animal are discharged or obtain a different charge or sometimes even reverse polarity. Since flowers normally are at earth potential, the "arolium switch" effectively standardises the insect's potential to zero. When the bees arrive at the hive, they carry different charges that they picked up in flight and that cannot dissipate that fast (WARNKE, 1977).

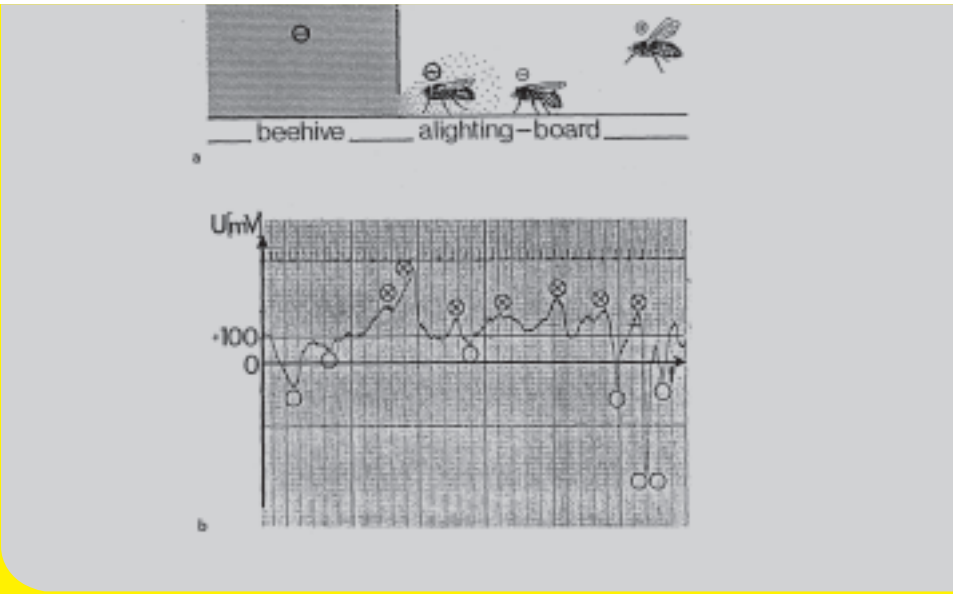

Fig. 10: *Every bee landing at the hive carries a specific charge (circle with cross) thereby changing its pattern of charge at the hive entrance, determined by the total electrical charge of the colony. Every departing bee carries with it electrical charge from the hive (circle).*
Warnke 1989, Copyright Ulrich Warnke

When two surfaces make contact on the molecular level (10 to the power of minus 10 m), positive and negative charges are separated at the point of contact through charge transfer. Many such points are activated in a short space of time by friction. Frictional electricity is one of man's oldest observations and has lent its name to the entire electrical discipline (electron: Greek for amber). It is therefore surprising that we thus far hardly spared a thought for the significance of electricity in animals.

Especially in flight, animals could become statically highly charged through friction between air molecules and body tissue – up to electrical field strengths in excess of 1 000 V/cm.

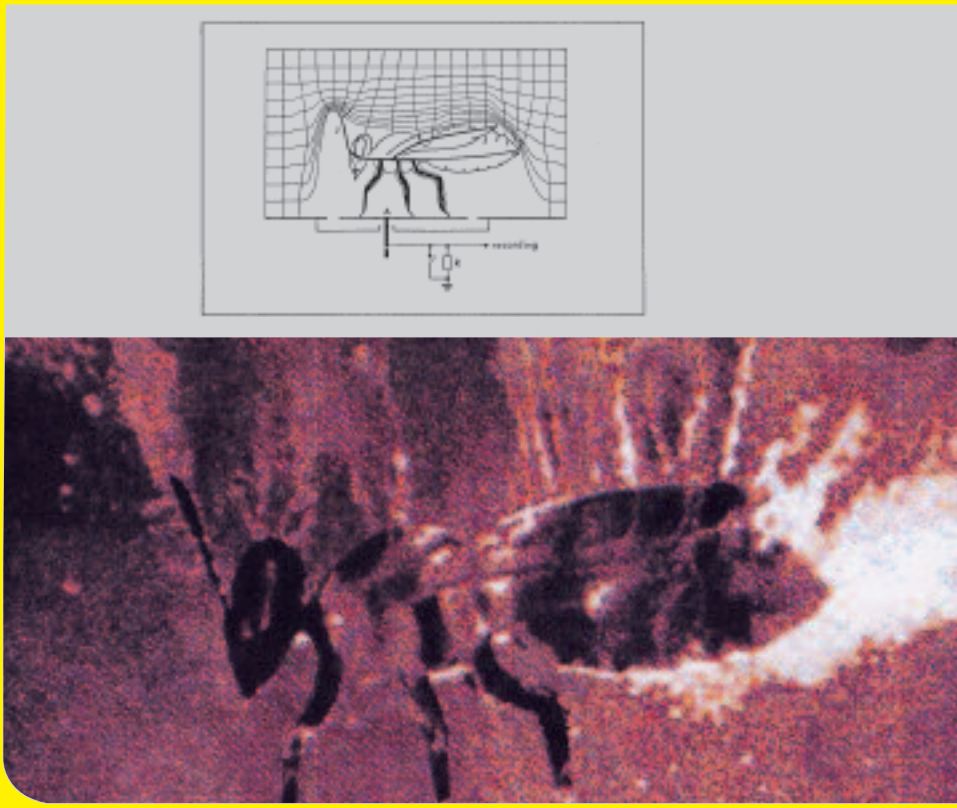

Fig. 11: *A bee in an electrical field; top: a construction, bottom: an experiment. It is shown how the field strength increases around certain surface structures.*
Warnke 1989, Copyright Ulrich Warnke

Fig. 12: *Bee in flight in an electric field. The fields around the antennae are particularly strong.*
Warnke 1986, Copyright Ulrich Warnke

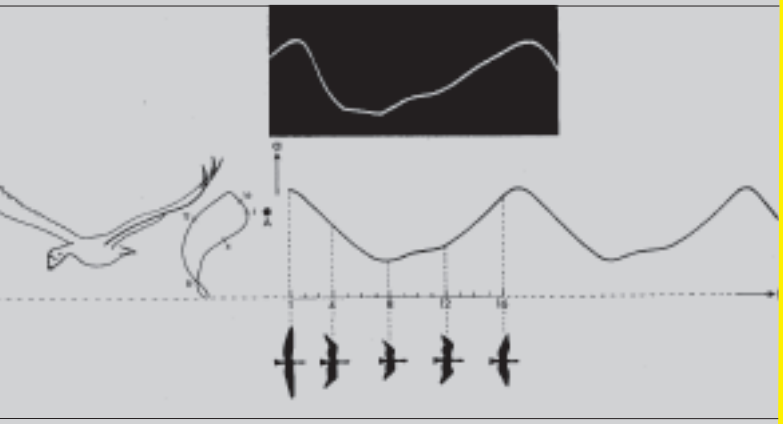

Fig. 13: *Wing movement and the electrical field – with reference to the wing – are in phase.*
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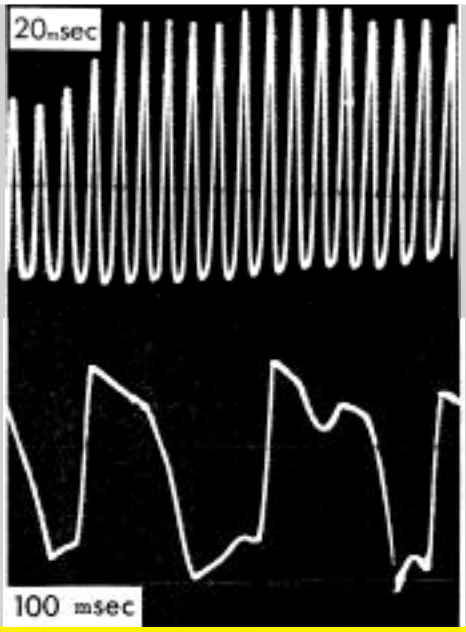

Fig. 14: *Oscillogram of the alternating electrical field around bees (top) and pigeons (bottom) in a wind tunnel.*
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To increase these field strengths, animals have various aids such as protruding spikes on insect wings, but especially the field focussing effect of insects' antennae is measurable, developing appreciable Coulomb forces.

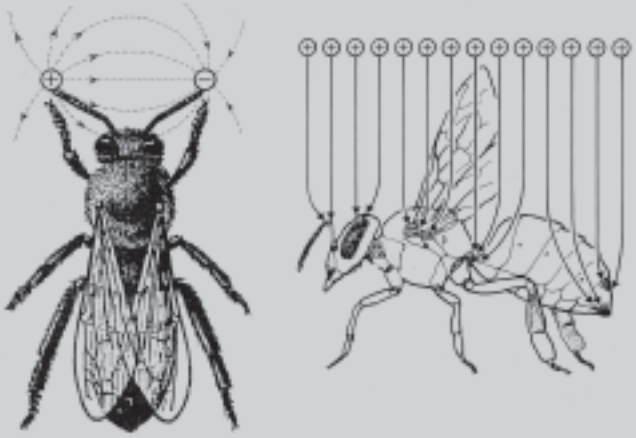

Fig. 14.1: *Representation of a measurable "dipole effect" on the antennae of the honeybee. Bees are able to change the polarity of their antennae at will (e.g. from positive to negative charge) – within a second. The dotted lines are an indication of the forces in the field.*
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3.7 Effects of technically generated fields on bees

We investigated the reaction of bees to artificially created electrical fields in the laboratory (WARNKE 1975, 1976, WARNKE et al. 1976) and found the following: 50 Hz AC fields with field strengths of 110 V/cm cause significant restlessness of the bees in their enclosure. The colony temperature increases greatly. The defence of the social territory is uncontrollably increased to the point where individuals in a colony stab one other to death. They no longer recognise one other.

After a few days in the field, the bees tear their brood from the cells; no new brood is reared. Honey and pollen are also depleted and then no longer collected. Bees that were newly established in their hives shortly before the start of the experiment always abandon the hive again and disappear when the electrical field is switched on. Bees that have lived in their hive for a long time, plug all the cracks and holes with propolis, including the entrance. This otherwise only happens in winter in a cold draught.

Since an acute lack of oxygen develops when the cracks and the entrance are plugged, the bees attempt to introduce air by intensive fanning. In this process, the wing muscles generate temperatures high enough to melt the wax. The animals attempt to fight the temperature increase by more fanning. In the end, the colony burns itself out. This implies the death of all members of the colony – which we could obviously prevent in future.

With very sensitive colonies, the reaction signal was measurable from field strengths of 1 V/cm and frequencies between 30 Hz and 40 kHz. When the field is switched on, the animals suddenly move their wings and buzz at frequencies of 100–150 Hz (WARNKE 1973, 1976, WARNKE et al. 1976).

With signals in the frequency range of 10 to 20 kHz, the aggressiveness was increased and the homing ability much reduced even though the natural meteorological and electromagnetic environment was intact in the flight space (WARNKE, 1973).

Fig. 15: *Wing section of bees enlarged with scanning electron microscope. Observe the special structures serving to focus the electrical field.*
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Scientists from the University of Koblenz-Landau conducted several experiments, looking at different aspects and questions, to measure the homing behaviour of bees (Apis mellifera carnica) as well as the development of mass and area of the combs under the influence of electromagnetic radiation (KUHN et al. 2001, 2002, STEVER et al. 2003, 2005, HARST et al. 2006).

They recorded an increase in agility, an increased swarming drive and no winter clustering when under the influence of EM radiation of cordless telephones.

In other experiments with base station fields of the DECT cordless telephones (1 880-1 900 MHz, 250 mW EIRP, 100 Hz pulsed, 50 m range, permanent exposure), the weight and area development of the colonies was slower compared to the colonies that were not exposed to a field.

The homing ability of the bees was tested from five days after the DECT telephones were introduced. There were significant differences in the return times of the colonies that were in the field and those that were not. No more than six of the bees exposed to the field ever returned – sometimes none returned. With the bees not exposed to a field, there were returning bees at any point in time of the experiment.

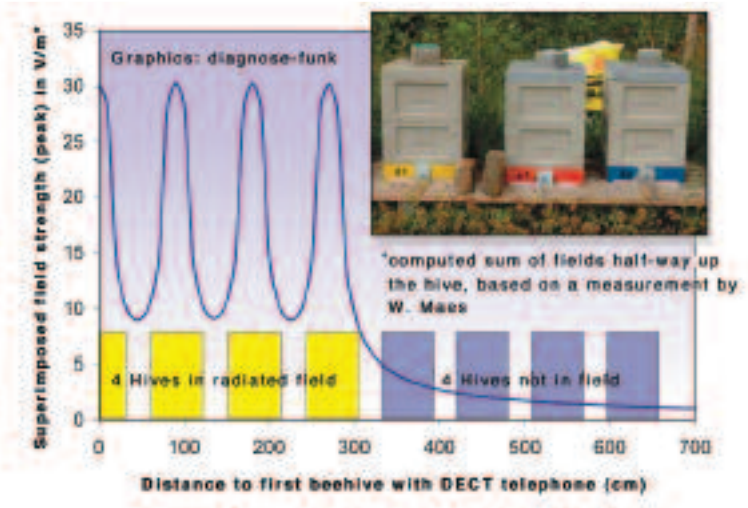

Fig. 16: *Estimated diagnosis radio field strength in the four beehives with and four without DECT telephone installations at the University Koblenz-Landau. The beehives were not electromagnetically screened, implying that the control colonies were also subjected to some field strength.*

Diagnosefunk, http://www.diagnose-funk.ch/impressum.php

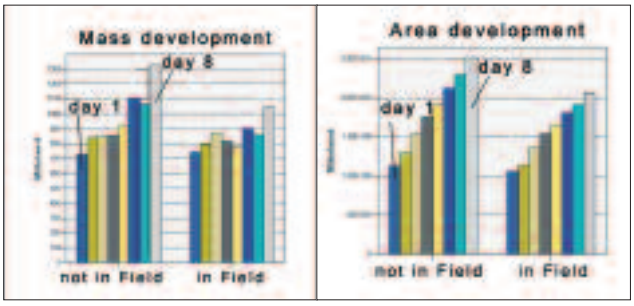

Fig. 18: *Mass and surface development of combs of bees in and outside of a field.*

Harst et al. 2006

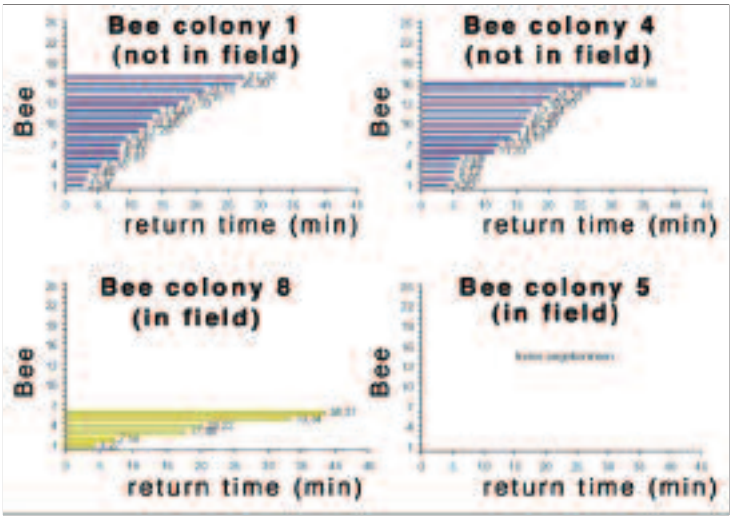

Fig. 17: *Top left and right: return times of bees not subjected to a field; bottom: return times and non-return when subjected to a field. Of the bees from hives not exposed to a field, 40% returned in total, of those subjected to a field only 7% returned.*

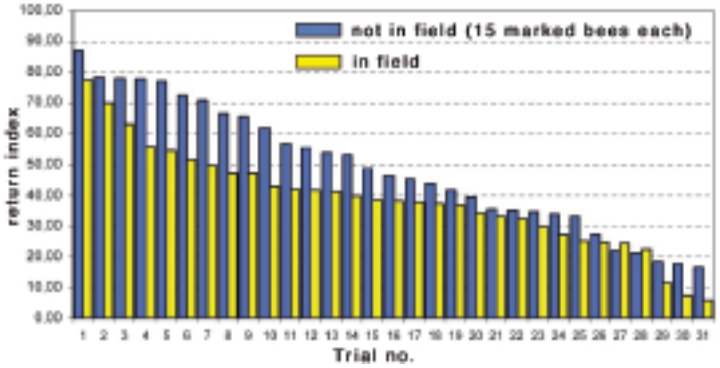

Fig. 19: *Significant difference in the homing behaviour of bees subjected to a field and others. A higher index indicates more returned bees and/or shorter return times.*

Harst et al. 2006

Two earlier NASA financed studies by one of their working groups found neither an increased fatality rate of bees in high frequency fields (2.45 GHz, CW) nor diminished orientation (WESTERDAHL et al. 1981a/b).

3.8 The highly sensitive region for interference of bees

If a new food source is discovered within 80-100 m, the bee performs a circular dance on the comb in the hive. If the food source is further away, communication is by means of a waggle dance. This waggle dance of the honeybee communicates information on the direction and distance of the new food source relative to the hive. In this dance, the returning worker bee initially traces a straight line and then dances sideways and down in a semi-circle. She then again starts along the straight and dances a semi-circle downwards again, but to the opposite side. The distance to the food source is given by the number of deflections of the abdomen on the straight (waggling). These waggles can also be measured in the form of electrical and magnetic alternating fields.

The distance to the food source is registered by reference to optical features of the landscape over which the bees are flying. The information on the direction to the food source is given by the angle between the straight line to the food source and the azimuth of the sun in each case. This angle is conveyed in the darkness of the hive via the direction of the dance with respect to the vertical (gravitational vector).

All this can be proven. The credit for discovering this evolved strategy of bee communication goes to the Austrian Karl von Frisch (FRISCH von, 1967). But we know in the meantime that the communication processes are associated with far more complicated mechanisms.

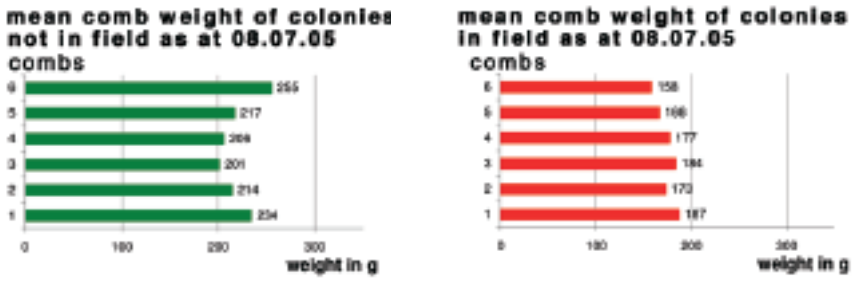

Fig. 20: *Starting with the same comb mass, the average values of the total mass of the colonies subjected to a field and those that were not, were 1326g and 1045g at the end of the test. The difference is therefore 281g (21.1%)*
Harst et al. 2006

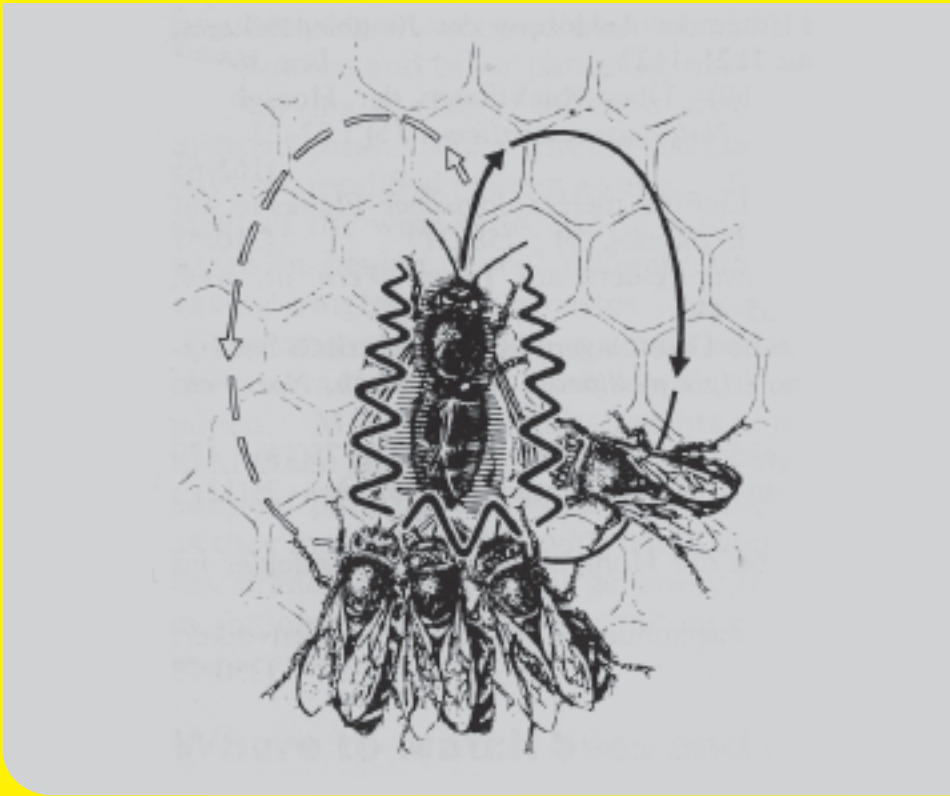

Fig. 21: The waggle dance of the bees generates electrical oscillating fields.
Warnke 1989, Copyright Ulrich Warnke

Apart from the position of the sun, the bees can also identify polarisation of the light. And in case of overcast skies, the positions of permanent landmarks are memorised (DYER, 1981).

Navigation to the food sources and back to the hive makes use of other physical quantities, however: these are exactly those quantities that have existed on the surface of the earth for millions of years –taking us back to our subject. How does the bee know the azimuth of the sun at any given moment?

She needs this information to recognise the time of day. And she needs to know about time because many flowers only open at a particular time of day and because navigation is coded via the position of the sun.

The answer to this question illustrates how finely nature has analysed the naturally occurring energies and forces, making these available to the organism. The higher the sun in the sky, the more the atmosphere heats up. The higher the atmospheric temperature, the faster the atmospheric molecules move. The faster the molecules, the more energetic the collisions between them. The larger the collision forces, the larger the air volume and the more intense the turbulences manifesting themselves also as eddies. These eddies ultimately also affect the ionosphere. The increased movement of ions in the ionosphere generates huge electrical currents. These directional electrical mass-flow currents in turn generate strong magnetic fields.

These magnetic fields reach the earth's surface and have a typical diurnal pattern – analogous to the described effect of solar radiation. They are characteristic diurnal magnetic field variations, superimposed on the largely uniform magnetic field of the earth. Exactly these variations can be measured by the bees. And they use these measurements to calculate the azimuth of the sun and the time of day.

In the experiments on navigation and orientation, this magnetic field component is recognised as a so-called "precision error" in the performance of the waggle dance. The expression "precision error" was created when a deviation of the dance direction from the principle described above was noticed, but the influence of the magnetic field was as yet unknown. Since a few decades we now know: the reason lies in the consideration of the magnetic field variation which modulates the direction angle of the waggle dance (KIRSCHVINK, 1981). The "remaining precision error" in the dance disappears if the entire magnetic field is compensated to 0-4%.

The maximum sensitivity of the bee to earth's magnetic variations is around 26 nT. It must be emphasised here already that the system is particularly sensitive in the naturally existing physical range. Significantly amplifying the magnetic field compared to the normal biological range, causes a stronger variation in direction communication. If the field is amplified to 10-times that of the earth's magnetic field, the colony swarms, away from its hive.

The question of how bees sense these magnetic field variations has been investigated in a number of studies (GOULD et al. 1978, 1980, GOULD 1986, FRIER et al. 1996, HSU et al. 1994, KALMIJN et al. 1978, KIRSCHVINK 1992, KIRSCHVINK et al. 1981, 1991, 1997, WALKER et al. 1985, 1989 a/b/c, COLLETT et al. 1994).

To summarise, it may be said that (HSU et al. 2007): The construction of combs and the homing capability of bees change if the bees are subjected to magnetic fields superimposed on the earth's magnetic field. Bees in free flight can sense extremely slight variations of the magnetic field intensity - in the range of 26 nT. They can be trained to magnetic anomalies, but only provided the changes remain stable for a longer period.

Many experiments proved that an accumulation of bio-magnetite particles (Fe_3O_4) serves as receptor of the magnetic field. These iron granules are arranged in a band in the abdomen of the bee. They have a diameter of only about 0.5 µm and are located in special cells, the trophocytes. Magnetite has the effect of amplifying the magnetic variations. If 30% of the intensity of the horizontal earth field component is modulated, the activity of the neurons in the ganglion of the abdomen changes (SCHIFF, 1991).

Apart from super-paramagnetic magnetite, FeO-OH was also found in the abdomen. Magnetic material was also shown to be present in the antennae, head and claws of stingless bees.

The iron granulates are enclosed in small vesicles, touched by a cell framework. As in higher organisms, microscopic filaments (micro-tubules) serve as the cell framework. The vesicles also contain some phosphorus and calcium together with the iron. The density of the iron granules is 1.25g/cm³, that of the Fe_3O_4 magnetite is 5.24g/cm³.

Where does the magnetic material come from? Most of the iron originates from pollen (approx. 0.16 µg/mg) (BOYAIN-GOITIA et al. 2003). If an additional magnetic field is applied to the bee, the size and shape of the biomagnetic granula changes (HSU et al. 2007). These changes are detected by the micro-tubules and micro filaments, and the trophocytes thereafter secrete more Ca^{2+}. The fat cells of the bee also show this effect, but much less so than the trophocytes. It has been known for a long time that cells secrete Ca^{2+} under the influence of a weak magnetic field; macrophages, for instance (FLIPO et al. 1998), astrocytoma cells (PESSINA et al. 2001, ALDI-NUCCI 2000) and chrome-affine cells (MORGADO-VALLE et al. 1998).

It is also known that the Ca^{2+} secretion can be triggered by many different cell changes such as changes to the structure of membranes, changes to the electrical membrane and cell surface potential and changes to the structure and distribution of protein within the membrane. The magnetic field can stimulate two mechanisms for increasing the Ca^{2+} content in the cells: firstly by opening Ca^{2+} channels and by increased flow of external molecules into the cell; secondly by an increased release of Ca^{2+} from storage inside the cell (IKEHARAA et al. 2005, PETERSEN 1996). This explains the increased accumulation of Ca^{2+} in fat cells.

The magnetite mechanism amplifies the effects tremendously (SCHIFF, 1991). The property of the granules, to expand in an external magnetic filed, turns them into magnetic field sensors (TOWNE et al. 1985). The affected micro filaments make contact with the cell membrane (HSU et al. 1993, 1994), affecting signal transfer into the cell.

If the colchicine and latrunculin B toxic substances, known to shut down the micro-tubules and micro filaments, are administered, then an additionally applied magnetic field will not increase the Ca^{2+} in the cells.

A model of the magnetic field orientation is therefore as follows: If the bee flies parallel to the magnetic field lines, the magnetic granule vesicles will expand; if she flies vertically to the field lines, the granules contract. This change of shape is sensed by the cyto-framework and communicated to the membrane.

That is where Ca^{2+} channels are correspondingly opened or closed. This signal transfer results in a

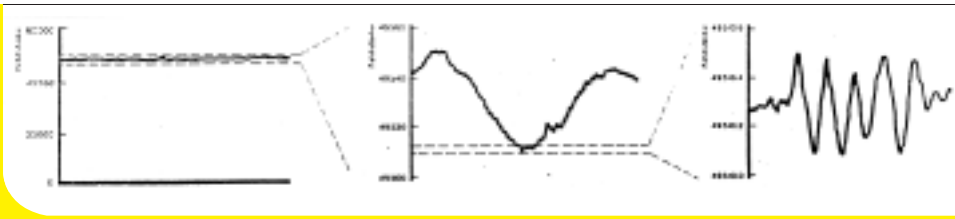

Fig. 22: *Variations in earth's magnetic field: Sensitivity of the measurements increased a 1000 times in each case. Diurnal rhythms and micro-pulsations are visible, utilised by bees and other organisms for orientation in space and time.*
Warnke 1978

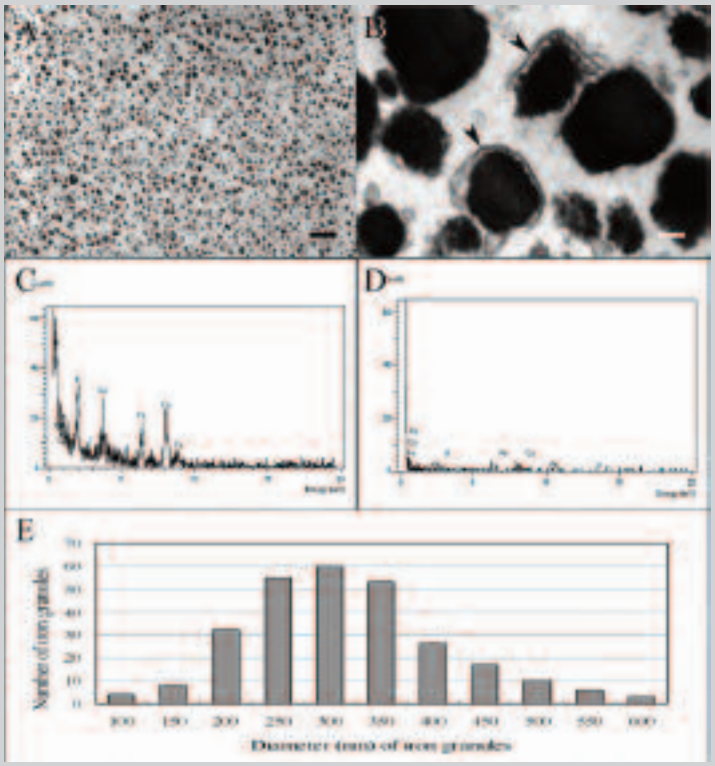

Fig. 23:
A) Iron granules in the trophocytes of the honeybee (bar: 1 µm)
B) Iron granules enclosed in lipid membranes (bar: 100 nm)
C) and D) Energy dispersing radiation analysis of the granules; they contain calcium, phosphorus and iron.
E) Histogram of the granule sizes.

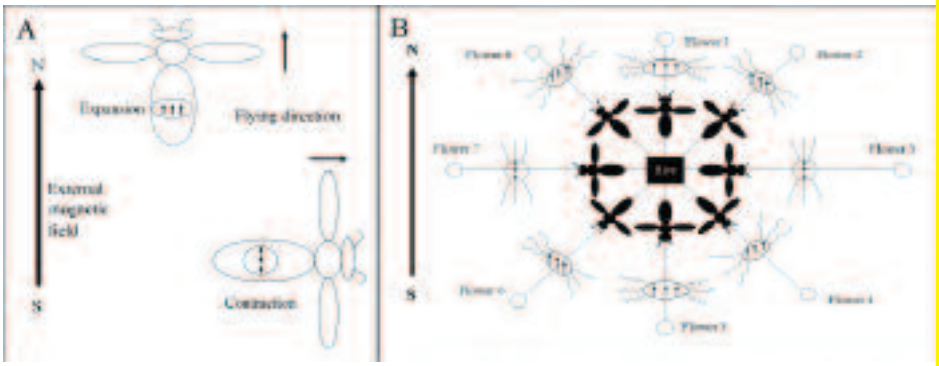

Fig. 24: Schematic of the magnetic field orientation of a bee through use of the magnetic granules.

magnetic field map for the duration of a flight, that can be used for orientation – particularly also for returning home, by reversing the time sequence of the magnetic field (RILEYet al. 2005, MENZEL et al. 2005). It is extraordinary that, in this process, variations of 26 nT can be sensed against the background of earth's 45 000 nT.

This model explains:

1. *The flight from the hive to the food source must be in a straight line. Bees navigate by means of a memory map (RILEY et al. 2005, MENZEL et al. 2005).*
2. *During the known circular orientation flights, the magnetic field is mapped over 360°. It is known that the orientation flight is indispensable for successful return to the hive (BECKER 1958, CAPALDI et al. 2000, WINSTON 1987). Nature arranged this similarly to the pigeons, who also circle several times before flying to wards their goal.*

3.9 Constant change in the magnetic environment makes learning impossible for the bees

Bees learn the patterns of the landscape they fly over and also use the magnetic field to differentiate. This is always the case when other orientation aids such as sunlight are covered by clouds. The optical patterns are therefore also associated with a magnetic coordinate (FRIER et al. 1996).

Bees may be conditioned to magnetic deviations from the normal earth magnetic field (WALKER et al. 1989a); they can also be trained to recognise small changes in the earth's magnetic field (WALKER et al. 1989b). It is a prerequisite that the change in the magnetic field remains constant over the learning period. If the field varies continuously, learning becomes impossible.

But this is exactly the situation the bees find themselves in, with wireless communication fields. The magnetic component is continuously changing – during the day and at night.

3.9.1 HAARP changes the natural diurnal variation of the magnetic fields

The information on the HAARP project is thanks to Guy Cramer (USA); it was made available to me by Joris Everaert (Belgium).

HAARP (High-frequency Active Auroral Research Project) is the abbreviation for a military project of the US Air Force and Navy. 180 towers have been erected in an uninhabited area near the city of Gakona in Alaska, together constituting an antenna complex. The frequency is around 2.5-10 MHz and the power is extremely high at 3 million Watt ("high power, high frequency phased array radio transmitter"). This is the strongest technical transmitter on earth. Its effectiveness is increased by linking the antenna array with another antenna array in Alaska, via HIPAS (High Power Auroral Stimulation). The transmitters communicate with submarines deep in the ocean and scan the horizon as a type of deep earth radar.

But the frequencies are also absorbed by the ionosphere. They heat up certain layers, creating ion turbulences by day, that are modulated onto the earth magnetic field as unnatural magnetic fields. This masks the regular effects the sun has on the ionosphere. As such, the bees lose an orientation that served them for millions of years as a reliable indicator of the time of day – encoded in the regular variations of the magnetic field changes as the sun rises and the ionosphere temperature rises.

The effects of the HAARP transmitter activity should be further investigated especially in Canada, the USA and Europe. Since the disappearance of the bees was first documented in precisely these countries, a causal relationship can no longer be excluded. The following simultaneous events tend to confirm this: In 2006, the increase of the transmitting power from 960 000 Watt to four times that power (3 600 000 Watt), was approved for the first time. Exactly in this year, reports originated in all the "scanned" transmission regions of the disrupted homing ability of bees.

Another disruptive effect may play a role. Through the irregular heating of the ionosphere, the air at great heights begins to "glow", with visible frequencies in the near infrared region (630 nm) and the associated magnetic field can be detected at the earth's surface (PEDERSEN et al. 2003, RODRIGUEZ et al. 1998).

Since the bees use not only the UV component of sunlight for orientation, but also the longer infrared wavelengths (EDRICH et al. 1979, VAN DER GLAS 1977) the new light in the sky may also be a new disrupting stimulus to them.

Fig. 25: *HAARP location and construction.*

3.10 Disrupted NO system damages learning ability, olfactory orientation and the immune system

In following, we will further detail the significance of the (NO) system and the consequences of its disruption – in other experimental animals and particularly also in humans. The salient fact is that the NO system is affected by magnetic and electromagnetic oscillations and may in the worst case become totally disrupted - finally destroying molecular functions.

As in mammals, nitric oxide (NO) normally acts as a carrier of information in insects as well. The synthesis and excretion of NO is particularly high in the insect brain. In bees, NO plays a role in the ability to smell and in learning processes (MÜLLER, 1997).

As proven in humans, if the NO system of bees is disrupted through the effect of technical magnetic fields, they lose the ability to orientate themselves by smell and the vital learning programme also becomes defunct. But since NO also materially controls the immune system, disruptions to the NO household always affect the immune defences of the organism as well.

Dennis van Engelsdorp of the American Association of Professional Apiculturists (University of Pennsylvania), in his report on the investigation into the disappearance of bees, says:

"We have never seen so many different viruses together. We also found fungi, flagellates and other micro-organisms. This multiplicity of pathogens is confusing." It is also striking that the excretion organs of the bees are affected. Dennis van Engelsdorp suspects that a weakened immune system may be behind the mysterious phenomena (VAN ENGELSDORP 2007). But he rightly asks: "Are these agents the causative stress factor or the consequences of a totally different stress?"

Diana Cox-Foster, a member of the CCD working group, says: *"It is very alarming that the deaths are associated with symptoms that have never been described before".* It appeared that the immune system of the animals had collapsed and some bees suffered from five or six infections simultaneously. But dead bees are nowhere to be found (Spiegel 12/2007).

3.11 Birds sense high frequency transmitters

Birds also sense high frequency transmitters very clearly and belong to the group of animal species that reacts very sensitively to electromagnetic fields. They absorb the impinging energy particularly intensively via the feathers of their wings (CHOU et al. 1985, VAN DAM et al. 1970, BIGU-DEL-BLANCO et al. 1975 a/b).

How sensitively and promptly they react can be demonstrated by an example. Chicks exposed to a high power microwave field flee within seconds (TANNER, 1966). Investigations have, in particular, also shown how strongly microwave radiated fields affect the behaviour within a flock (WASSERMANN et al. 1984). It has repeatedly been observed that flocks of migratory birds split up when nearing a power station, to circumvent the station as if avoiding an invisible obstacle, only to re-unite again in flight afterwards. Technical disturbances in the frequency range of natural sferics, but with higher amplitudes, cause massive loss of orientation in migrating birds. The V-formation of cranes, for instance, is disrupted as they fly over transmitter stations. This phenomenon is particularly pronounced over water surfaces parallel to the flight path, which reflect electromagnetic waves.

Researchers have for a long time been pondering on how flocks of birds and also insect swarms and schools of fish stay together. It is surprising, for instance, that large flocks of starlings in an area of an estimated 500 m^2 or more, packed with birds, can perform complex flying manoeuvres within 5 milliseconds. But how can the animals, each at a different location in the flock, receive and react to signals in a short time? Transmission by sound would require more time and visual observation of a lead animal is blocked by other animals.

A hypothesis that the flying manoeuvres were coordinated by electromagnetic signals therefore appeared reasonable. Such a signal, propagating at approximately the speed of light, could reach all individuals at the same time and independent of their position. This hypothesis appears more plausible when taking into consideration that the flying animals are highly electrostatically charged.

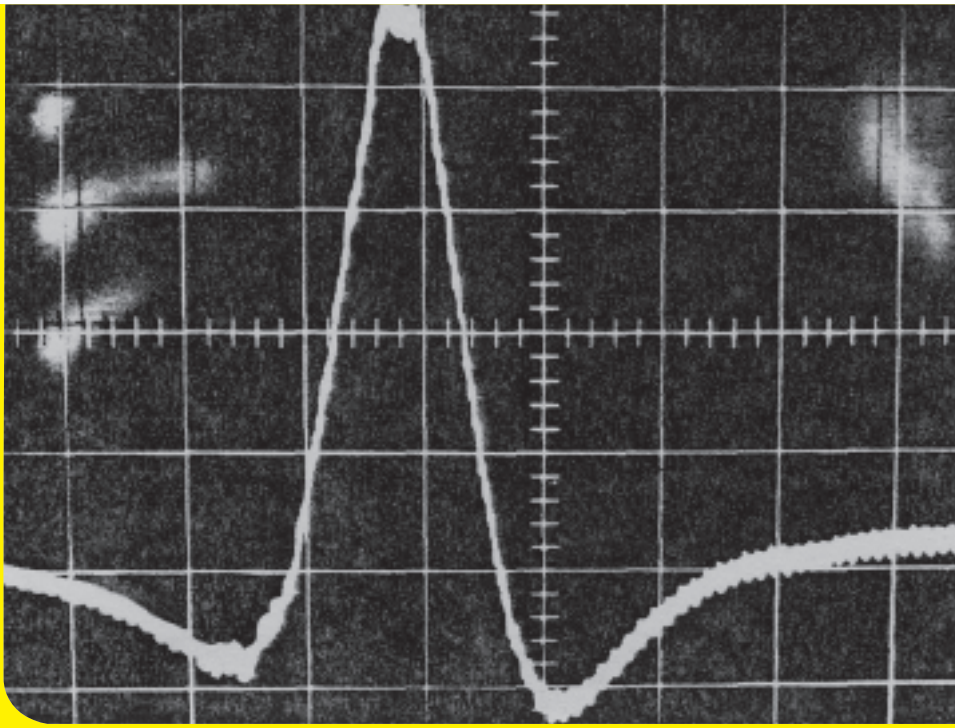

Fig. 26: *Electrical field of a passing flock of birds. The small superimposed oscillation is interpreted as interference by the beat of individual wings.*
Warnke 1989, Copyright Ulrich Warnke

We were able to record by oscilloscope that the electrical field caused by the aggregation of animals resulted in a predominantly positive overall electrostatic field. The figure also shows the very small wing beat modulation compared to the total electrical field. This modulation can be explained as a "beat" resulting from all the individual wing beats.

This beat frequency is always smaller than the wing beat frequency of an individual. The maximum beat amplitude is always much larger than the individual wing beat amplitude, however. The measured values are dependent on meteorological conditions and the geometry around the measurement.

These data allow us to conclude that flocks of small birds flying at a height of about 40 metres are electrically charged to more than 6 000 Volt. We can only speculate about the type of coded signals given for direction changing manoeuvres. It appears that each individual bird has a set beat frequency and amplitude that is corrected immediately it weakens, by changing the direction of flight.

There are presently two theories explaining the typical wedge-shaped flight formation of larger birds:

One of these assumes unhindered contact and simultaneously minimum danger of collision. The other relates aerodynamic advantage to energy economy. The first theory is based on experience with formation flying of military aircraft; the second is based mainly on calculations.

Both theories leave a couple of questions unanswered, however. How sensitive is the system to cross-winds? When a critical wind speed is exceeded – should turbulences behind the wings not distort the formation or even break up the flock? Why do the members of the flock not permanently remain in the minimum energy zone? And why is there never a formation in reverse – open to the front? Can the recognisable geometric particularities of the total formation, considering species-specific bird size and typical distances, be explained by wing-induced updrafts?

In the following, our theory of biologically sensible formations, published 25 years ago, is repeated. It describes a functional system of nature that is largely immune to meteorological interference parameters. Electrical and magnetic external fields can, however, completely destroy the formation by superposition on the biological system's own fields.

The system we are discussing allocates a position to each animal, but also considers all the flying members of the formation. It could also be identified by the analysis of formations filmed in nature. Let us inspect some facts in more detail.

Bird species flying in formation generally maintain a typical order, even in the case of only two birds flying:

The second bird flies laterally displaced behind the first. The electrical force relationships in space are in agreement with the electrical forces determined experimentally and depicted schematically in Fig 27. The highest field strengths are at the bill, the tail and the wing tips. Referring to the bird at the back, the bill-head region is charged in the alternating field of the wings of the first bird, creating an increased force field. Simultaneously, however, the wingbeat of the bird at the back induces charges in the tail region or the extremities facing backwards and resting against the body of the first bird. There is therefore a force field between these body parts as well. The respective induced charges are coupled - as shown in the model – by the electrical field. The balancing charges of opposite polarity, released from the former equilibrium, are free to move. They generate an effective new and measurable field. The bird under consideration, i.e. the second one, therefore not only received induced charges from the first bird but also indirectly - i.e. via the tail end of the first bird – originating from itself. The field strength diminishes approximately as the square of the distance from the inducing charges. The magnitude of the active forces is therefore a function of the distances. Each bird is connected to every other bird via electrical fields of a certain amplitude and direction. These fields can be calculated for each species of bird – yielding the typical formation.

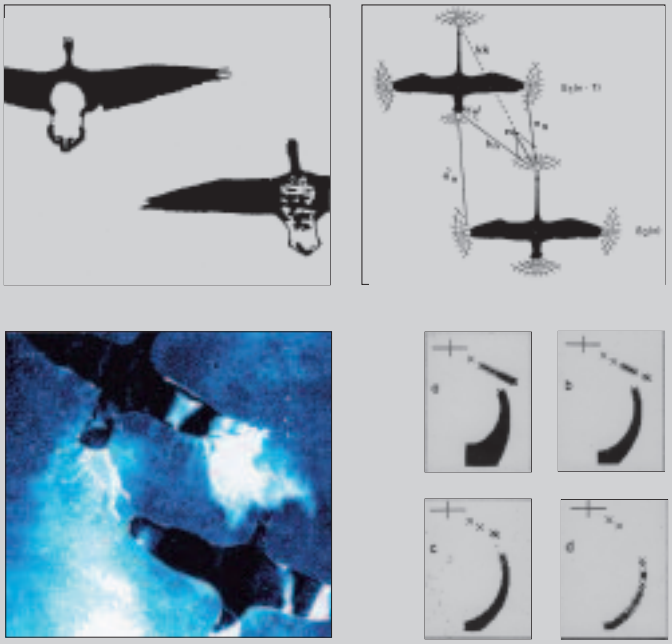

Fig. 27: *Birds use electrical fields for formation flying. Top left: Two geese in formation flight. Bottom left: Experimental model to visualise the electrical field forced between these birds. Top right: Vector diagram of the field distribution. Bottom right: Calculation of the position of the bird behind with reducing degrees of freedom a-d.*

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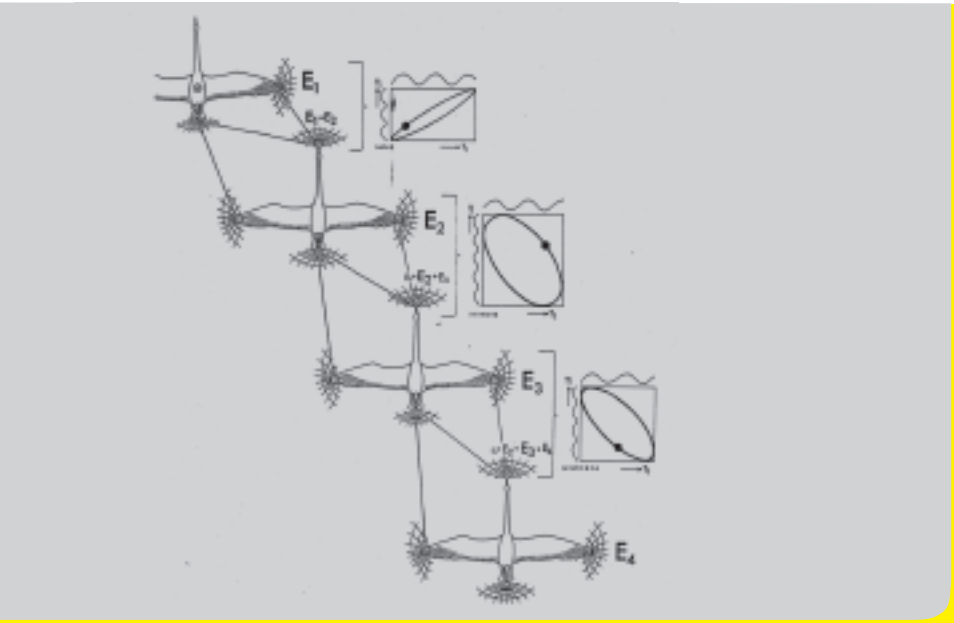

Fig. 28: *V-formations can be constructed by means of an equation that I developed on the basis of physical laws. Comparisons with photographs of natural bird formations show that the assumptions are correct: The formations are given by the Coulomb forces between birds that are electrically charged in flight.*
Warnke 1989, Copyright Ulrich Warnke

It is significant that long necked birds in particular, tend to fly in formation. Their long neck offers the advantage that the detectors in the head region – such as the highly sensitive mechanoreceptors, which also respond to the electrical field forces, can receive signals in flight largely free from the interference of their own body. Observations of their flight behaviour show that the head region compensates for all the movements of the body itself, thereby not having any own oscillations.

Electromagnetic fields therefore have a role to play in formation flying of birds as well. They serve as orientation and navigation aid and determine the position of a single animal in the flock. Depending especially on wing width, wing span and body length, our observations and calculations show that the biophysical relationships influence the species-typical V-formation flying of flocks. Computer calculations of the flight order allow us to predict natural formation flights. And photographic records, vice-versa, also agree well with computer simulations.

The observations demonstrate a unique information and orientation system of the animal kingdom. But they also explain why this is destroyed by the interference of technically generated electrical and magnetic fields.

Due to interference, it would not be possible to measure the magnetic field of the earth inside a flock of birds and its periodic variations caused by the individuals. The reason lies in the moving electrical wing charges, not only generating a weak magnetic field component (induction B approx. 0.01 pT), but also inducing voltages in neighbouring matter – like an AC generator. Only the bird flying at the tip of the formation will perceive a largely undisturbed earth magnetic field component for navigation, independent of changing superpositions - provided it is sufficiently far removed from its compatriots. The remaining animals must therefore do without own navigation mechanisms and couple themselves to the birds flying in front via an electromechanical reception channel.

The birds fly straight ahead, i.e. in the desired migration direction, if the direction of the total electrical force corresponds to the direction of the connection to the head of the bird flying in front. The connecting line between heads is visible by day and can be localised by night through calls.

The recognition of direction and magnitude of the electrical total force vector is by highly sensitive mechanoreceptors at the circumferential edge of the bill. Magnetite was also found here: Through ferromagnetic resonance, magnetite is an excellent absorber of microwaves in the 0.5-10.0 GHz band. Superimposed modulations can be transformed into acoustic vibrations via the magneto-acoustic effect (KIRSCHVINK, 1996).

Correspondence of the direction of the electrical force with the head-head line assigns to each bird a prescribed position in his flock; this position can be mathematically expressed and accurately calculated. All the results of the 22 formations investigated so far confirm the theory. It may be concluded from these data that the birds' electrical characteristics have an important biological function for transfer of information (WARNKE, 1978, 1984, 1986, 1989).

3.12 Magnetite and free radicals as a magnetic compass

Artificial oscillating magnetic fields deny migrating birds the possibility to orientate themselves. The investigation covered the effect of either an electromagnetic frequency band of 0.1 – 10 MHz, or a single frequency of 7 MHz, both superimposed vertically on earth's magnetic field. These investigations again showed that not only magnetite was required for orientation and navigation but that other mechanisms such as free radicals, played an important role as well.

Because the frequencies used in the experiments correspond to the transition energy from singlet to triplet in free radicals-pairs. The animals can obviously utilise this mechanism for orientation by targeted control (RITZ et al 2004).

The following overall picture emerges: The magnetite crystals found in the bill of the animals indicate the intensity of the magnetic field. But the animals receive complementary information on the direction of orientation via the free radical levels. Using these data, they are able to know at each stage of their flight what their instantaneous location is with reference to their biological magnetic field (WILTSCHKO et al. 2005) map.

If migrating birds are subjected to a stronger magnetic impulse, they will change their direction of flight. They can even be sent in the exact opposite direction with artificial fields superimposed on earth's magnetic field. Magnetic impulses convey information on the direction of migration; generated false impulses can also corrupt the migration direction (WILTSCHKO et al. 2006).

Summary

Bees and other insects, also birds, utilise the magnetic field of the earth and electromagnetic high frequency energy such as light. Through free radicals and simultaneously reacting magnetite conglomerates they can orientate themselves and navigate. Technically generated electromagnetic oscillations in the MHz region and low frequency magnetic impulses consistently disrupt the natural orientation and navigation mechanisms they were given through evolution.

The following can be concluded from the results of studies by other working groups and from own investigations:

1. The chitin shell of bees' and birds' feathers are semi-conducting and have piezo- and pyroelectrical properties. These body parts transform pulse-modulated high frequency into mechanical acoustic oscillation frequency. One of its important functions is the dielectric sensitivity to electromagnetic fields in the microwave region.

2. The presence of magnetite particles in the nano-range was shown in the abdomen of bees and the head region of birds. Through ferromagnetic resonance, magnetite is an excellent receiver of microwave radiated fields in the 0.5 to 10.0 GHz frequency range. In this way, pulsed microwave energy is transformed into acoustical vibrations (magneto-acoustic effect).

3. It was shown that free flying bees are capable of detecting magnetostatic fluctuations and extremely low-frequency magnetic fields with very weak inductions (from 26 nT) against the background of the 30 000 – 50 000 nT magnetic field of the earth.

4. Magnetic field impulses oriented parallel to earth's magnetic field lines, with repetition frequencies in the region of 250/sec. are responsible for clear precision errors of up to +10% in the orientation dances of bees.

5. The levels of magnetic induction in today's technically distorted environment are generally between 1 nT and 170 000 nT in the low frequency region and between some nT and a few thousand nT in the high frequency region. These values therefore generally exceed the threshold sensitivity of bees for magnetic field changes.

6. In honeybees, the NO system in the antennae has a function in the sense of smell and in learning processes. Disruptions of NO production through magnetic fields and electromagnetic oscillations have thus far been proven only in mammals. Expectations are, however, that the mechanism of disruption is the same in insects. In this case, the sense of smell and learning processes in the orientation of bees would be severely impaired.

In any event, if all the scientifically proven facts are considered, it is clear why wireless communication technologies, with their overall density of superimposed electrical, magnetic and electromagnetic fields, should disrupt the orientation and navigation of many birds

4. Humans suffer functionality disorders

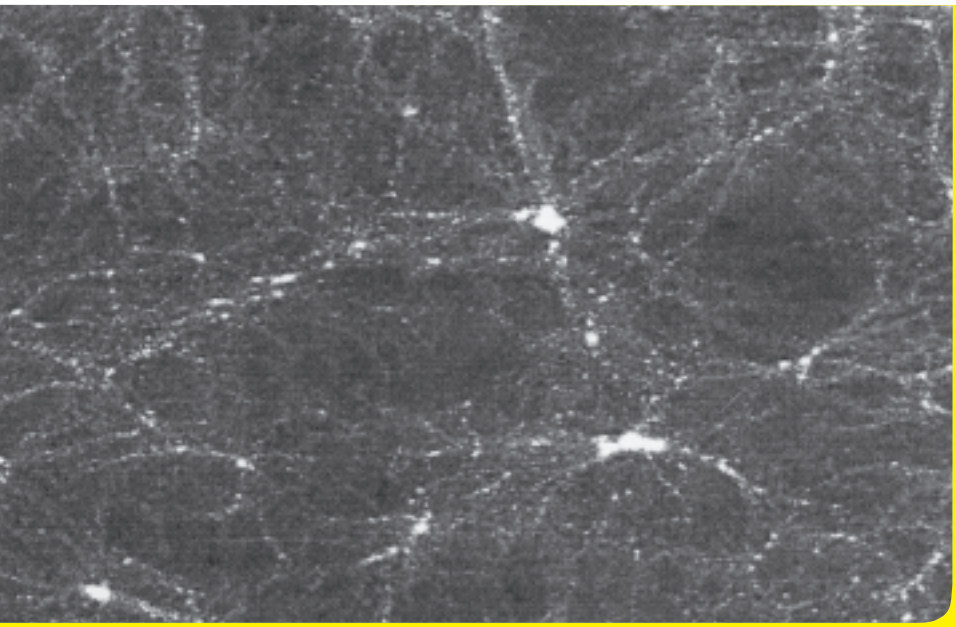

Fig. 29: *All flying organisms and also other animals, including humans, are caught up in an "impenetrable" network of electromagnetic oscillations and fields. The superpositions illustrated in this model result in points of particularly high power density or field strengths.*

Humans do not have sensory organs via which electrical and magnetic energies can be detected. But these energies nevertheless envelop humans as a tightly woven net of electromagnetic oscillations and radiating fields.

We recognised the problem in the seventies already in connection with our bee experiments and called it, in our laboratory jargon, "electrosmog". The name has established itself, also via the media.

It has in the meantime been proven that humans too can transform the specific energies and forces into information, without having a specific sensory organ to do this. But the question up to now has always been: How do they do it? And to what extent can the fields damage our health?

Let us first ask what the direct effect is on humans of the high frequency energy that is spread almost uniformly across the globe for communication purposes, and then investigate whether the subjectively frequently repeated claim that this is damaging our health can possibly be true.

This requires the following steps:

1. **Finding trends:** Do we have scientific literature causally correlating the epidemiologically recorded data on functional disorders and symptoms of disease in a human study group with the exposure to electromagnetic fields in the mobile radio and wireless communication range?

2. **Finding a causal mechanism:** Can a plausible mechanism be found that can explain functional disorders and disease systems as the result of exposure to these electromagnetic fields?

3. **Proof of health disorder and subsequent damage:** Can the function disorder as described be scientifically proven to be the result of subjectively described disease symptoms?

4. **Excluding a nocebo effect** (unfounded expectations that negatively affect health): Do we have sound scientific procedures, such as the double-blind method, showing that the symptoms of illness are not "imaginary" and are generally rapidly reversible after the physical stress fields have been "switched off"?

The answer to these four questions will determine whether subjectively described symptoms of illness can be ascribed to a collective nocebo effect or whether those responsible are required to face consequences.

4.1 On the question of finding trends

Do we have scientific literature causally correlating the epidemiologically recorded data on functional disorders and symptoms of disease of an organism with the exposure to electromagnetic fields in the mobile radio and wireless communication range?

The answer is not treated in detail here, because it has been dealt with on several occasions elsewhere (WARNKE, 2005).

To summarise, it must be noted: There is a body of differentiated scientific literature that identified a causal correlation between epidemiologically recorded data on functional disorders and symptoms of illness of the human organism, and exposure to electromagnetic

fields in the range of mobile radio and wireless communication. We therefore have an unassailable trend result.

4.2 On the effective mechanism

Can we identify a plausible effective mechanism that causally explains functional disorders and symptoms of illness as the result of exposure to electromagnetic fields?

The answer to this question does not only affect humans but analogously also birds and bees in many respects. It exposes an effective mechanism that has attracted our attention on several occasions before: The disruption of the nitrogen monoxide (NO) system. There are probably other effective mechanisms as well. But we shall only differentiate and elucidate the effective relationships of this mechanism at this point.

Nitrogen monoxide (NO) is a gas and free radical (contains unpaired electrons) that evolution has deployed as a regulator of vitality very early already – even in bacteria. This extremely important and indispensable gas is only beneficial to the organism, provided a) a certain concentration is not exceeded and b) there is no degeneration to so-called reactive nitrogens and reactive oxidative species (RNS and ROS) – i.e. no cascade-like release of newly formed free radicals and poisonous substances.

4.2.1 Disruption of the redox balance

The NO system is closely related to the so-called redox system, which is extremely important to our molecular functions. What does this mean? Every organism needs a balanced ratio of electron excess and electron deficiency. This is also called redox balance. Oxygen compounds neutralise electron charges, causing "oxidant stress". Oxidant stress is particularly intensive if free radicals and reactive oxygen species (ROS) (e.g. superoxide anion, hydrogen-peroxide) and reactive nitrosative species (RNS) (e.g. peroxinitrite) largely prevent the antioxidative processes from re-establishing an adequate electron charge.

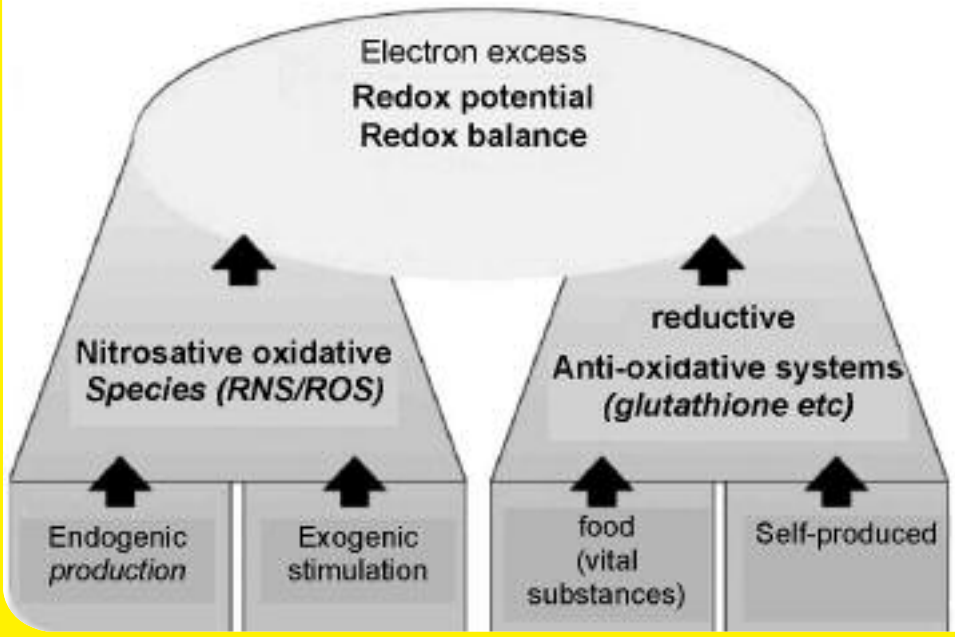

Fig. 30: *Substances with an excess of electrons are indispensible for metabolism if humans and many animals want to remain healthy. Electromagnetic oscillations destroy this electron excess and form nitrosative-oxidative species (RNS/ROS). The situation is fatal to a person if anti-oxidants are also absent in the diet.*

Shifting the redox balance towards oxidation may now result in cell damage. Oxidation may, for instance, damage unsaturated fatty acids, proteins and DNA, but particularly also the membrane – with serious consequences for heredity, energy creation and immune response.

Exposure to electrical, magnetic and electromagnetic fields disrupts the redox balance through oxidant/ nitrosative stress. This can no longer be denied in the face of many in vitro and in vivo experiments – also in humans.

Latest results on the creation of oxidant/nitrosative stress through mobile radio frequencies

Human blood cells exposed to mobile radio in standby mode show increased quantities of free radicals, resulting in lipid peroxidation (MOUSTAFA et al. 2001).

In rabbits and cells of other origin, the activity of the SOD enzyme, which neutralises free radicals, increases when exposed to mobile radio (IRMAK et al. 2002, STOPCZYK et al. 2002).

The damaging oxidative processes and NO are increased in rat brains exposed to mobile radio fields; they can be alleviated again by administering antioxidants (Ginko biloba) (ILHAN et al. 2004).

The damaging oxidative activity is increased in the skin tissue of rats exposed to mobile radio fields; this can be alleviated by administering the melatonin hormone (AYATA et al. 2004).

Acute exposure to unmodulated 930 MHz electromagnetic fields in vitro, increases the oxidant stress level in rat lymphocytes treated with iron ions (ZMYSLONY et al. 2004).

Kidney tissue of rats shows increased levels of free radicals when exposed to mobile radio fields. The damaging effects can be alleviated through various antioxidants (OZGUNER et al. 2005). The destructive effect can be neutralised by administering melatonin hormone (OKTEM et al. 2005).

Heart tissue exposed to mobile radio fields shows an increase in the activity of free radicals. This can be reduced through antioxidants (OZGUNER et al. 2005).

When exposed to mobile radio fields, eyes show an increased activity of free radicals; this can be alleviated through administering antioxidants and melatonin hormone (OZGUNER et al. 2006).

Melatonin can limit the lipid peroxidation caused by 900 MHz mobile radio fields in the hippocampus of rats, but not in the cortex (KOYLU et al. 2006).

When exposed to mobile radio fields of base stations (SAR 11.3 mW/kg), the oxidant stress level increases; the neutralising enzyme activity is simultaneously reduced (YUREKLI et al. 2006).

Compared to controls, the mobile radio signal (GSM-DTX 2W/kg) creates increased oxidative species levels in immuno-relevant human cells (LANTOW et al. 2006).

Electromagnetic high frequencies and magnetic low frequencies create stress symptoms in lymphocytes that are similar, but not identical to heat shock (BELYAEV et al. 2005).

The effect of a 890-915 MHz mobile radio field (with 217/sec. impulse rate, 2 W max. power, SAR 0.95 W/kg) was tested on guinea pigs. The setting was on 11hr 45min stand-by and 15 min talk mode. The malonaldialdehyde (MDA), Glutathion (GSH), Retinol (Vitamin A), Vitamin D3, Vitamin E und catalase enzyme activity (CAT) content in the brain tissue and in the blood was chosen as the effective indicator. The MDA level rose in the brain tissue; the GSH level and CAT activity were reduced. In the blood, the MDA levels increased, as did the Vitamin A, E and D3 levels, and the CAT activity rose. The GSH level simultaneously decreased here as well. The authors conclude from this that mobile radio produces oxidant stress in the brain tissue of test animals (MERAL et al. 2007).

These results are also confirmed for the kidney in a further study (TOHUMOGLU et al. 2007).

Stimulation of the nitrogen monoxide NO free radical by electrical, magnetic and electromagnetic fields, observed for a long time, is of importance in these effects. A chronological listing below:

Electromagnetic and magnetic radiated fields promote the production of nitrogen monoxide (NO) in organisms. A chronological literature compilation

WARNKE 1979, 1980, 1984, 1993, 1994
Weak pulsating magnetic fields create an immediate effect and stimulate NO production in humans.

MIURA et al. 1993
NO increases when a weak field of high frequency radio signals is switched on; measured directly in the brain.

LAI AND SINGH 1996
DNA destroyed through electromagnetic influence; later (2004) traced back to NO stimulation.

BAWIN et al. 1996
Magnetic fields (1 or 60 Hz, 5.6, 56, µT) had no effect when the NO synthase enzyme was pharmacologically inhibited. The effect could, on the other hand, be forced by binding NO to haemoglobin.

ADEY 1997
NO is a normal regulator of EEG rhythms and, in pathological cases, of epilepsy.

Weak magnetic fields (1 Hz, 100 µT), modulate the NO action.

KAVALIERS et al. 1998
A 60 Hz, 141 µT magnetic field affects the NO and NO synthase actions.

SEAMAN et al. 1999 and SEAMAN et al. 2002
Provided the body has sufficient supplies of nitrite, rapid increase of NO production when exposed to radio frequency pulses (SAR of 0.106 W/kg).

ENGSTRÖM et al. 2000
NO plays a role in the pathophysiology of oxidative stress, including Parkinson and Alzheimer disease through electromagnetic impulses.

YOSHIKAWA et al. 2000
A low frequency electromagnetic field increases the generation of NO.

PAREDI u.a. 2001
The production of NO also increases under exposure to the electromagnetic fields of mobile phones.

DINIZ et al. 2002
The increased proliferation of cells exposed to pulsating electromagnetic fields is caused by NO.

KIM et al. 2002
Pulsating electromagnetic fields amplify the neuronal NO synthase expression.

LAI AND SINGH 2004
Inhibitor of NO synthase (7-nitroindazol) blocks the effects of weak magnetic alternating fields (60 Hz, 10 µT).

ILHAN et al. 2004
Frequencies used by mobile radio (900 MHz) cause increased activity of NO levels, increase malondialdehyde, increase xanthin oxidase, decrease superoxide dismutase and glutathione peroxidise - thereby destroying the brain of rats. Antioxidants (Ginkgo biloba) counter this.

YARIKTAS et al. 2005
The NO level in the mucosa of the nose increases when exposed to mobile radio fields (900 MHz).

AKDAG et al. 2007
The long-term effect (2 hours per day for 10 months) of a low frequency pulsed magnetic field on rats reduces the NO production below the nominal values.

It has been known for many decades already that weak low frequency magnetic fields increase the levels of free radicals. It is therefore not necessary to quote further literature at this point.

4.2.2 Primary mechanism found: Enzymes transferring electrons are magneto-sensitive

Stimulation of free radicals – including NO – through physical fields and radiated fields is therefore scientifically and reliably proven. But viewed critically, this is no proof of damage unless the underlying primary mechanism is identified.
For this reason, we searched for a long time for a link to explain the damaging effect. And we have found it in one of the latest studies: The NADH oxidase enzyme exhibits a high – and quite reproducible – sensitivity for magnetic and electromagnetic fields of mobile phones (FRIEDMAN et al. 2007).

This sensitivity had been known for quite some time in connection with other oxidases such as cytochrome oxidase (BLANK et al. 1998, 2001 a/b). For a long time, it was believed that NADH oxidase was active only in certain cells such a phagocytes. But it was known for quite some time that it was sensitive to gravitation (NASA, 2006). In the meantime, homologues of NADH oxidase were discovered in various tissues and were collectively included in the NOX family (NOX1, N0X3, N0X4, N0X5, DUOX1 and DU0X2).

The NOX family is also responsible for a large range of pathological processes, especially neurodegeneration and heart diseases (BEDARD et al. 2007).

These oxidase enzymes are magnetically sensitive due to their capability of shepherding electrons through plasma membranes. When electrons move, an electrical current flows that in turn builds up its own magnetic field and also generates electromagnetic high frequency oscillations through acceleration and deceleration of electron movement. All these processes create sensitivity to external fields.

The electron transfer is finally responsible for the production of superoxide radicals and other reactive oxygen species (ROS). The consequences of this are far reaching in completely different areas, because radicals and ROS are very aggressive. In this way, the destruction of viruses and bacteria is promoted, the creation of proteins is forced through reinforced gene expression and finally cell proliferation is supported at the cost of cell differentiation.

Over-stimulation is a threat. It is analogous to a drug or medicine: Dosed correctly, the substance can be beneficial; but overdosing can be poisonous. This is exactly what happens with permanent exposure to magnetic and electromagnetic fields.

In detail, this process is as follows: It is a fact that the NADH oxidase enzyme also produces the superoxide anion (O_{2^-}°) free radical. Superoxide anion is damaging to the NO budget, among other. NO may be deactivated and may subsequently degrade, negatively affecting various vital parameters (WARNHOLTZ et al. 1999).

What is new is the realisation that NADH oxidase also forces the generation of NO by stimulating the eNOS enzyme (SUZUKI et al. 2006, RACASAN et al. 2005). This stimulation of eNOS then becomes a further source of increased superoxide anion radical generation (SEINOSUKE et al. 2004). This is not the end of the list in this fatal loop of overstimulation, because the NADH oxidase system also stimulates the formation of toxic hydrogen peroxide (H202), which also increases NO production by up to 100% (LI et al. 2002). These two additional NO stimulants explain the abovementioned increased NO production under the influence of magnetic fields and electromagnetic radiated fields – also through mobile radio communication.

But this is the start of a vicious circle. Because overstimulation of the eNOS enzyme, that in the final analysis is also an agent for increased NO production, also increases superoxide anion radicals on its own (SEINOSUKE et al. 2004). Nature, however, also has a cleverly devised countermeasure against excessive and dangerous NO production threatening overproduction of a radical: The more stimulated hydrogen peroxide, which also increases the NO production, is an agent for de-activating eNOS co-factors, which finally prevents the NO production by affecting the membrane receptor (JAMES et al. 2001). Such a reduction of NO has also been found before under long-term exposure to stronger magnetic fields (AKDAG et al. 2007). Even if the NO now appears to be regulated, the damaging effects of ROS remain intact.

The real pathological effects arise afterwards. We have to consider, in addition, that both the NO and ROS, which includes superoxide anion, are important modulators of the vascular tonus and are architects of the adhesive interaction of leucocytes, platelets and endothelium. The two molecules of NO and of superoxide anion, however, have opposite effects: NO is normally beneficial in a healthy life cycle; ROS, however, prepares the system for special regulation when disruptions occur.

The functions are thereby flexibly adjusted. This allocation of functions disappears, however, under the influence of an external magnetic and electromagnetic field: NO and ROS now react together. In this event, their specific effective potential is destroyed and toxic substances are created, such as peroxinitrite (0N00-) (MÜNZEL et al. 1999). This peroxinitrite in turn reacts with hydrogens, creating more hydrogen peroxide.

Because this mechanism is so important, we shall summarise it in one sentence: The serious pathological disruption is caused by exposure to magnetic and radiated fields resulting in the creation of additional reactive oxygen species (ROS) such as superoxide radicals and hydrogen peroxide, that combine with the increasingly produced NO to form extremely toxic peroxinitrite, that in turn reacts with hydrogens to form more hydrogen peroxide. The consequences of the pathological process are listed further down.

Many vital substances, required for functioning of the body, are rendered useless.

If the cascade of effects is disrupted, the normal and healthy effects of NO are restored (HORNIG et al. 2001).

The NADH oxidase is important in another sense as well. It is also found in the cell nucleus where it can – depending on the redox system – control the gene expression, but can also damage genes (MASUKA, 2006).

Let us therefore state in response to the question of a conclusive effective mechanism: The existing scientific literature abundantly documents disruptions of the redox

balance in organisms through reactive oxidative and nitrogenous species (ROS/RNS), causally connected to the exposure to electromagnetic fields of mobile radio and wireless communication.
An unambiguous effective damaging mechanism has therefore been found.

4.3 On the question of deterioration of health and damage

Can the functional disruptions thus explained be considered the scientifically proven reasons for the subjectively described symptoms of disease?

The proven effective mechanism is important also because it shows that the subjective ailments of many people are based on biological facts that can be explained. If you are aware of the cascades of effects described hereunder, you will better understand why "electrosmog" is damaging.

4.3.1 Functional disruptions and symptoms of disease

Electromagnetically induced excessive ROS/RNS stimulation may be differentiated into three effective phases that are passed through sequentially:
1. Stimulation of free radicals,
2. Stimulation of highly toxic peroxinitrite,
3. Stimulation of highly toxic peroxide radical.

The following processes are serious: Cell components are destroyed; the antioxidants absorbed with the food and the substances with excess electrons produced by the organism itself are spent; the harmful cholesterine increases. People feel tired, tense, battle various inflammations.

Pain is felt in places. More detail on the individual steps is given below.

First complex: Stimulation of free radicals such as superoxide O_2-° and NO leads to
- activation of protooncogenes
- damage to the mitochondria genome
- damage to the cell nucleus genome
- damage to the membranes
- oxidation of the polyene fatty acids of the membranes; release of cardiolipins (auto antibody formation)
- oxidation of SH groups, causing enzyme blocking
- activation of proteases (cell damage)
- activation of transcription factors.

Second complex: Stimulation of highly toxic peroxinitrite from superoxide anion O_2° together with NO (O_2° -+ NO = ONOO°)
NO has three times the affinity for superoxide O_2-° that O_2-° has for the neutralising superoxide dismutase; the peroxinitrite
- oxidises vitamin C
- oxidises uric acid
- oxidises cholesterine
- oxidises sulfhydryl groups (destroys thioles)
- oxidises polyene fatty acids of the membranes (initiates lipid peroxidation)
- causes DNA breaks
- activates kinases (phosphor lipase 2)
- activates polymerase (PAPP); this destroys NAD+, leading to a cellular energetic catastrophy.
NO and peroxinitrite react to form nitrogendioxide (NO_2); this deactivates superoxide dismutase (MnSOD), i.e. inhibiting the neutralising enzymes of the mitochondria (mt-Mn-SOD). These reactions alone result in massive metabolism disruptions already.

Third complex: Stimulation of highly toxic peroxide radical (HO_2°-) from superoxide and peroxinitrite with the involvement of hydrogen
Peroxide H00° has a redox potential of +1000 mV, making it highly oxidising.. An addition to the listing in complex 2, peroxide also oxidises:
- Polyene fatty acids
- Tocopherol (Vit E)
- Lycopene
- Co-enzyme Q 10

The functional disruptions are manifest in disease symptoms, as described in more detail below.

4.3.2 The "Acquired Energy Dyssymbiosis Syndrome" (AEDS)

The clinical picture of the "Acquired Energy Dyssymbiosis Syndrome" describes a deficiency of cell energy – with simultaneous derailment of the cell environment. This leads to "mitochondropathy": energy creation is blocked; the power generators for cell energy are transformed into copious sources of free radicals.

The changes have serious consequences:

1. Inflammation processes spread and release further substances that are harmful when overdosed (tumour necrosis factor TNFα and time and again nitrogen monoxide). We must also not forget that inflammations are on the increase in our industrial society and that arteriosclerosis and heart attacks – the primary cause of death – are ultimately caused by inflammations. This point of view has already been accepted among the scientifically active medical fraternity today.

2. Aerobic glycolysis (glycolysis despite the presence of oxygen) is activated as "emergency power generator" – which is in turn associated with:

- stimulation of proto-oncogenes (precursors to cancer genes)
- increased release of superoxide radicals
- lactate acidosis (excessive acidification)

3. The mitichondric genome finally mutates. But especially this pathological change can be hereditary via the female gender. It burdens the progeny for the generations to come.

Overview: Physiopathological consequences of nitrosative/oxidative stress

I. Disruption of mitochondrial activity
II. Disruption of sugar utilisation (pathological lactate acidosis)
III. Disruption of the neurotransmitter function
IV. Disruption of the cholesterine metabolism
V. Disruption of the steroid hormone synthesis (corticoids)
VI. Disruption of the haem system
VII. Generation of mutations, esp. the mitochondrial DNA (hereditary)
VIII. Disruption of apoptosis

Catalogue of symptoms and diseases (excerpt), derived from the known effective mechanisms of nitrosative/oxidative stress

- Sleep disorders
- High level of fatigue: no relaxation, recuperation times ineffective
- Psychosomatic performance lapses
- Major phases of restlessness and "panic disorder"
- Corpulence
- Chronic hypoglycemia
- Increased cholesterine and triglycerid values
- Lactate acidosis
- Fibromyalgy FMS (nitroso serotonin auto-antibody formation)
- Autoimmune diseases
- Arteriosclerosis
- M. Parkinson
- Chronic inflammation processes, especially in the nervous system, with multiple sclerosis and amyotropic lateral sclerosis
- Haem synthesis disruptions (porphyria)
- Lactose intolerance
- Pathological energy deficit PED (WARNKE, 1989)
- Chronic immune insufficiency (high infection susceptibility)
- Functional disruptions of the thyroid
- Myopathy
- Encephalopathy
- Polyneuropathy
- Enteropathy
- Cancer
- AIDS

To summarise, we can answer the question as to whether subjective reports of illness have an objective basis as follows: The redox balance is disturbed via the direct influence of weak magnetic and electromagnetic fields on the NADH oxidase. The result is oxidative/nitrosative stress. It leads to disruptions and prevention of vital functions. In the course of these processes, exactly those disease symptoms subjectively described by those affected and exposed to radiated fields, are in evidence.

Hereditary pathological changes passed on via the mother should, in particular, draw our attention to the effects that will only manifest themselves in generations to come.

4.4 On the exclusion of a nocebo effect.

Do we have scientifically designed methods, such as the "double blind" method, proving that the symptoms of disease cannot be attributed to fears but that they are generally reversible after "switching off" the physically stressing fields (unbeknown to the participants), after a short period of time?

All the scientific investigations that addressed this question reply to this question with "yes":

The various problems disappear if the influence of the radiation or the ROS/RNS formation is "switched off" (e.g. ABELIN 1999, ABELIN et al. 1995, HORNIG et al. 2001, PETROV1970, TNO study 2004).

Health is not, however, restored if the disruptions have already led to serious damage such as DNA destruction or tumours.

5. Summary

For many decades, research results showing that the natural electrical and magnetic fields and their variation are a vital precondition for the orientation and navigation of a whole range of animals, have been freely available.

What has also been known to science for many decades is that we as humans depend on this natural environment for many of our vital functions.

Today, however, this natural information and functional system of humans, animals and plants has been superimposed by an unprecedented dense and energetic mesh of artificial magnetic, electrical and electromagnetic fields, generated by numerous mobile radio and wireless communication technologies.

The consequences of this development have also been predicted by the critics for many decades and can now no longer be ignored. Bees and other insects disappear, birds avoid certain areas and are disoriented in other locations. Humans suffer from functional disorders and diseases. And those that are hereditary are passed on to the next generation as existing defects.

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Glossary (GL)

Information: This concept is generally understood in everyday life and has gained a position of central importance, especially in modern bio-sciences. "Informed society" demands to be in a position to inform itself about everything if possible, at any time and any place in the world. Analogously, it is of cardinal importance to a living organism of any kind, not only to be in a position to communicate with its environment via information carriers, but the control of its internal vital functions must also be assured, which is again possible only through the exchange of "information".

Electromagnetic (EM) fields of all kinds and magnitudes (including light, UV and infrared radiation, microwaves, etc.) were chosen by evolution as particularly suitable carriers of information because they are able to flood the living space of organisms spontaneously and fully, affording every individual immediate access to its information content.

This is available in the ordered structure of the EM fields themselves, described in physics as waves, which propagate at the speed of light with alternating electrical and magnetic field components. Because, in accordance with Faraday's law of induction (1831), the changes in a magnetic field induce changes in an electrical field.

The force/field lines of magnetic and electrical fields are in the form of vectors between positive and negative poles and we can therefore describe them as electrical or magnetic flux and a flux density orthogonal to a unit surface area, e.g. 1 m^2.

The actual information in an EM field resides – similar to acoustics – in the number of oscillations per second (=frequency) and also in the amplitude of the oscillations. If an EM field of higher frequency is interrupted at a certain rate (facilitated only through modern digital technology), low frequency pulsed high frequency radiation is created, whereby the cyclic rate can also be used for information purposes.

The traditional technical method of transmitting "information" is called modulation. In this way, a continuous low frequency carrier wave, subject to less interference during propagation in space, is overlaid (modulated) with the higher frequencies of music and voice, allowing the information to be transmitted over large distances.

EA few common physical units:

Ampere (A): current amplitude
Volt (V): electrical voltage
V / meter (E): electrical field strength
Watt:(W): power (=VA)
Joule (J): electrical energy (=W sec)
Tesla (T): magnetic induction (=V sec/m^2)

Number units

(k)	Kilo ...	* 1000
(M)	Mega ...	* 1000 000
(G)	Giga ...	* 1000 000 000
(T)	Tera ...	* 1000 000 000 000
(m)	Milli ...	* 0.000
(µ)	Mikro ...	* 0.000 000
(n)	Nano ...	* 0.000 000 000
(p)	Pico ...	* 0.000 000 000 000

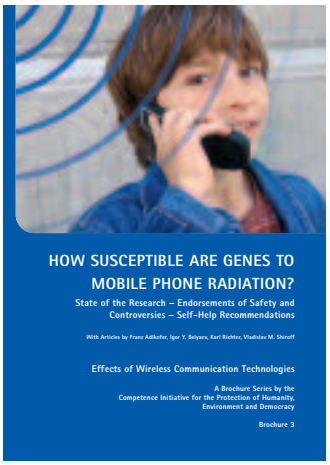
Now Brochure 3 of the Series *Effects of Wireless Communication Technologies* is also available in English:

How Susceptible Are Genes to Mobile Phone Radiation?

State of the Research – Endorsements of Safety and Controversies – Self-Help Recommendations

With Articles by Franz Adlkofer, Igor Y. Belyaev, Karl Richter, Vladislav M. Shiroff

2008



In their articles, the experts in biomedicine and biosciences Prof. Franz Adlkofer, Prof. Igor Y. Belyaev, and Vladislav M. Shiroff show the broad range of international research efforts that document DNA and chromosome damages as well as chronic diseases resulting from electromagnetic radiation exposures. This is about non-thermal effects well below current exposure limits. UMTS radiation turns out to be especially hazardous.

"The endorsement of safety by the German Mobile Telecommunication Research Programme regarding the health risks of mobile phone radiation is based rather on wishful thinking than facts," says Franz Adlkofer. Exposure limits that do not account for non-thermal effects or the exposure duration do not provide protection but are rather unsafe. In commissions and research programs, which are paid by the public for the protection of its health, those scientists set the tone whose main objective it is to issue endorsements of safety and support existing exposure limits. They pursue "witch hunts" against allegedly fraudulant laboratories. But obviously they do not realize that their denial of the international body of evidence is the most offensive of all scientific frauds possible. Since this turns the entire population into potential victims.

As long as this is supposed to be the "independent" research the public and environment is at the mercy of, we should not expect any protection or precaution from the government, reasons Prof. Karl Richter. It seems to be more imperative than ever before that independent scientists and responsible citizens—with the support of foundations and environmentally minded sponsors—take the organization of independent health protection projects into their own hands, as a program for self-help. The brochure provides recommendations to this end.

The brochure can be downloaded for free from www.broschuerenreihe.net

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About this Brochure

The bioscientist Ulrich Warnke knows the electromagnetic workings of nature better than most. In this brochure, which opens a new science series by independent scientists, medical doctors, and technicians, he shows how nature uses much wisdom and sensitivity in employing electric as well as magnetic fields in the creation of life. But, therefore, he is also in a position to convincingly criticize how foolish and irresponsible we are as we interfere with this delicate natural balance today. According to the findings of this brochure, we are currently in the process of destroying in less than a few decades what nature took to create over millions of years.
The outlook is all the more worrisome because it is not based on hypotheses and probabilities but the work of verifiable and reproducible effect mechanisms. We think that the protective provisions of the German Constitution obligate the responsible elected officials to draw the necessary conclusions. Anybody who still relies on downplaying the risk, the most convenient of all strategies used most frequently to pretend that there were no known serious risks, only signals that short-term economic interests are more important to this person than the future of the coming generations.

Ulrich Warnke summarizes the findings of his brochure as follows:
"Today, unprecedented exposure levels and intensities of magnetic, electric, and electromagnetic fields from numerous wireless technologies interfere with the natural information system and functioning of humans, animals, and plants. The consequences of this development, which have already been predicted by critics for many decades, cannot be ignored anymore. Bees and other insects vanish; birds avoid certain places and become disorientated at others. Humans suffer from functional impairments and diseases. And insofar as the latter are hereditary, they will be passed on to next generations as pre-existing defects"

Prof. Dr. K. Hecht, Dr. med. M. Kern, Prof. Dr. K. Richter, Dr. med. H.-Chr. Scheiner

About the Author
The main research areas of Dr. rer. nat. Ulrich Warnke, an internationally renowned bioscientist at Saarland University, include biomedicine, environmental medicine, and biophysics. For decades his research interest centered especially on the effects of electromagnetic fields.

The scientific jigsaw puzzle: Fitting the pieces of the low-level radiation debate

Jan Beyea

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IT IS 5 MINUTES TO MIDNIGHT

Feature

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The scientific jigsaw puzzle: Fitting the pieces of the low-level radiation debate

Jan Beyea

Abstract

Quantitative risk estimates from exposure to ionizing radiation are dominated by analysis of the one-time exposures received by the Japanese survivors at Hiroshima and Nagasaki. Three recent epidemiologic studies suggest that the risk from protracted exposure is no lower, and in fact may be higher, than from single exposures. There is near-universal acceptance that epidemiologic data demonstrates an excess risk of delayed cancer incidence above a dose of 0.1 sievert (Sv), which, for the average American, is equivalent to 40 years of unavoidable exposure from natural background radiation. Model fits, both parametric and nonparametric, to the atomic-bomb data support a linear no-threshold model, below 0.1 Sv. On the basis of biologic arguments, the scientific establishment in the United States and many other countries accepts this dose-model down to zero-dose, but there is spirited dissent. The dissent may be irrelevant for developed countries, given the increase in medical diagnostic radiation that has occurred in recent decades; a sizeable percentage of this population will receive cumulative doses from the medical profession in excess of 0.1 Sv, making talk of a threshold or other sublinear response below that dose moot for future releases from nuclear facilities or a dirty bomb. The risks from both medical diagnostic doses and nuclear accident doses can be computed using the linear dose-response model, with uncertainties assigned below 0.1 Sv in a way that captures alternative scientific hypotheses. Then, the important debate over low-level radiation exposures, namely planning for accident response and weighing benefits and risks of technologies, can proceed with less distraction. One of the biggest paradoxes in the low-level radiation debate is that an individual risk can be a minor concern, while the societal risk—the total delayed cancers in an exposed population—can be of major concern.

Keywords

atomic bomb, debate, dose, linear no threshold model, low level radiation, one time exposure, protracted exposure, radiation, risk

To those outside the scientific community, it might come as a surprise that, until 2005,[1] essentially no large-scale epidemiologic studies directly demonstrated the existence of risks related to protracted radiation exposures—the kind that would be expected from releases from nuclear reactors or dirty bombs. Historically, atomic-bomb data—which look at the one-time exposures to Hiroshima and Nagasaki survivors—have dominated

quantitative risk estimates for any type of low-level exposure to ionizing radiation, including protracted exposure. The standard approach to calculating risk estimates for long-term exposure has been to use biologic arguments—that is, concepts of cancer initiation, promotion, and repair, coupled with data from cellular experiments—to conclude that long-term exposure entails lower risk than sudden exposure, by a factor of two to ten (Healy, 1981); only in the last decade has the scientific community unofficially settled on a factor of two (Preston, 2011; UNSCEAR, 2006).

Presumably, a factor of two should have had a rather minor impact on policy, which should have meant a quick end to this portion of the story on low-dose radiation risks. No such luck. In fact, there has been, and continues to be, considerable debate among members of the scientific community, political and industry leaders, and the public around the claim that atomic-bomb data is relevant to estimating risks from *protracted* exposures. This debate has contributed to the delay in updating some US regulatory dose limits that are based on a pre-1990 understanding of radiation risks.

Three new studies could very well change the balance of the debate, as knowledge of them—one on off-site citizens and two on radiation workers—percolates into the wider discussion.

Deconstructing the debate

The debate over radiation risks has many tentacles that extend into the fields of biology, epidemiology, medicine, sociology, and political science. The biggest tentacle penetrates directly into the political sphere, wrapping itself around arguments on energy policy and the consequences of radioactive releases like those at Chernobyl and the Fukushima Daiichi Nuclear Power Station. Quantitative estimates of health risks affect public policy, although sometimes it takes many decades before scientific studies affect regulations (see Brock and Sherbini, 2012, in this issue of the *Bulletin*). Likewise, it also may take years before these studies trickle down to the public and industry stakeholders.

To some in the public, the quantitative aspects determined by experts are irrelevant; they argue that experts are not to be trusted and that the existence of *any* imposed risk of cancer is unacceptable. Others believe that evolution has provided humans with repair mechanisms that protect against natural background radiation; they reason that the radiation risk at doses close to the background is, in fact, zero. But for researchers in the field, and committees of scientists trying to reach consensus and assemble what amounts to a scientific jigsaw puzzle, reaching quantitative conclusions about risk is not so simple. Researchers cannot solely rely on gut instincts; they must analyze data, scrutinize their findings, and rigorously defend these findings.

Though the debate takes on many shapes, it always revolves around one magical number: 0.1 sievert (Sv), the dividing line between what is considered high and low exposure today. It is equivalent to about 40 cumulative years of the average unavoidable background radiation and to about 40 years of average medical diagnostic radiation in the United States (Einstein, 2009; NCRP, 2009).[2] And from this magical

number, more disputes spring, specifically on the radiation risks below 0.1 Sv, as well as the risks from protracted radiation exposures above and below this number. The debates can be brutal—so much so that, at times, they make the spats between William Jennings Bryan and Clarence Darrow look tame.

One-time exposure above the dividing line

Since the United States dropped atomic bombs over Hiroshima and Nagasaki in 1945, it has worked with Japan to produce 14 periodic joint reports, known as Life Span Studies, on the fate of more than 80,000 bomb survivors. What makes these regular reports so formative—and why analysis of the atomic-bomb data continues to dominate quantitative risk estimates today—is that the vast data set, including regular follow-ups on the study population, has produced consistent epidemiologic results, providing little room for contention on the radiation risks related to acute exposures above 0.1 Sv. Despite some limitations (see Richardson, 2012, in this issue of the *Bulletin*), analysis of the atomic-bomb dose data presents a clear picture that a linear no-threshold (LNT) model—the theory that radiation risk declines in proportion to dose, but never goes to zero— holds for a large range of survivor doses (see Figure 1).[3]

But atomic-bomb data, some argue, focus on high doses and are therefore irrelevant to the low-dose debate.[7] However, as Figure 1 shows, the data set contains a wide-range of doses—including those that are quite relevant to

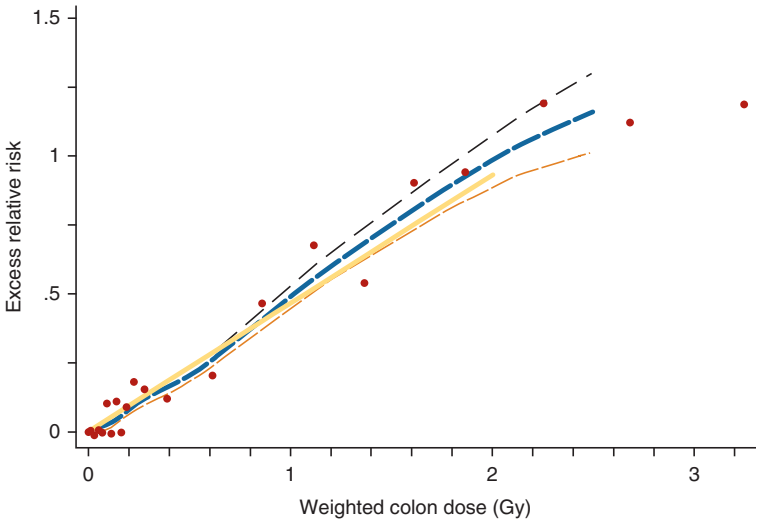

Figure 1. Solid cancer-incidence dose response for atomic-bomb survivors.
Source: Preston et al. (2007). This figure is reproduced with permission from the Radiation Research Society.
Notes: This figure shows excess relative risk versus "weighted colon dose" in units of gray (Gy)—these units are equivalent to Sv.[4] The solid line represents a smoothed version of the data that does not assume the data are linear.[5] Dashed curves represent one standard deviation. Note the tight error bands around the central curve. The horizontal access on the chart refers to colon dose, which is taken as a surrogate for the tissue dose to all organs; this may differ slightly. Each small tick mark corresponds to 0.2 Gy; half of this is what is considered to be low-dose radiation today. The vertical axis has units of excess relative risk (ERR) that have been found to fit radiation data better than absolute risk models.[6] It is important to note that this figure illustrates a dose response for an entire population.

occupational exposure limits, as well as those that match accumulated background radiation and medical-diagnostic doses, which are normally considered to be low. Bear in mind that these doses are *in addition to* the natural background radiation that the survivors had already received.

Over the decades, as new excess cancers have emerged in the atomic-bomb cohort at lower and lower doses, the number that defines "low dose" has shrunk fivefold to its current value of 0.1 Sv. At the same time, the estimated risk has risen tenfold since 1980;[8] thus, it is of little surprise why there is continuing concern about low-dose radiation. So the natural question is: When will the estimated-risk increases *stop*? Fortunately, further dramatic changes are not expected in the atomic-bomb data—certainly not for adults at doses above 0.1 Sv—because a sufficient number of excess cancers has ensured tight confidence bounds, or limits.[9]

Epidemiologic data can include many individual variations, including subgroups of people with different genetic susceptibilities (see Greenland, 2012, and Richardson, 2012, both in this issue of the *Bulletin*). These variations are too often lost in the debate over low-level radiation effects. For instance, some researchers argue that raw, dose-category data, specific to children, indicates an LNT response down to 0.01 Sv. Further evidence of a strong difference in susceptibilities among groups—such as from DNA sequence variations—may lead to calls for tighter health and industry regulations (Locke, 2009).

The LNT theory predicts that background radiation exposure and medical diagnostic exposures slightly increase a population's future cancer rates. The cancers don't appear immediately but are diagnosed five years to more than 50 years after exposure. Delayed cancers are the usual focus of the low-level radiation debate, but delayed stroke and heart disease account for "about one third as many radiation-associated excess deaths as do cancers among atomic bomb survivors" (Shimizu et al., 2010).

Protracted exposures above the dividing line

For years, nuclear power advocates have argued that the atomic-bomb cancer data were insignificant to nuclear reactor regulations and irrelevant to nuclear reactor risk assessments—not just because the atomic-bomb doses were supposedly too high, but because the bomb exposures occurred suddenly. These advocates, along with a number of researchers, argued that the body's DNA repair mechanisms assist in the recovery from slow exposures caused by routine reactor releases. Even doses from accidental releases would not be as bad as atomic-bomb doses, these advocates claimed, because radioisotopes in the body or on the ground decay with predictable half-lives, protracting the radiation dose.[10] But conventional wisdom was upset in 2005, when an international study, which focused on a large population of exposed nuclear workers, presented results that shocked the radiation protection community—and foreshadowed a sequence of research results over the following years.

15-country nuclear worker data

It all started when epidemiologist Elaine Cardis and 46 colleagues surveyed some 400,000 nuclear workers from 15 countries in North America, Europe, and Asia—workers who had experienced

chronic exposures, with doses measured on radiation badges (Cardis et al., 2005). The prediction of total excess cancers for these nuclear workers was striking: Cancer deaths in this population increased by 1 to 2 percent, making past nuclear work a rather dangerous industrial occupation relative to others. (It should be noted that Cardis's study looked at workers exposed many years ago, when efforts to reduce workers' radiation exposure were less effective than they are today.)

This study revealed a higher incidence for protracted exposure than found in the atomic-bomb data, representing a dramatic contradiction to expectations based on expert opinion. Further, this challenged the relevance of cell dose-rate experiments to human epidemiology. However, the dose response did not include as tight error lines as in the atomic-bomb data. Even though the incidence data were statistically significant, some researchers, along with industry and medical radiation advocates, quickly attacked the study.

Seizing on the data from Canada—the country with the highest excess relative risk (ERR)-per-Sv rate—the critics contended that the study was flawed; they charged that it be repudiated by the authors, which it never was. Atomic Energy of Canada Limited's industry consultants continue to focus on the Canadian segment of the data, particularly on the reliability of the dose estimates.[11] Their relentless attacks have been effective in neutralizing the study, despite the authors' defenses.[12]

UK radiation workers

A second major occupational study appeared a few years later, delivering another blow to the theory that protracted doses were not so bad. This 2009 report looked at 175,000 radiation workers in the United Kingdom, and was an update to earlier reports of the same data set. Sufficient diseases had appeared since the previous assessment, making the cancer risk statistically significant and the same as in the atomic-bomb data. Again, protracted exposures did not turn out to be less dangerous than acute exposures.

12 worker studies combined

After the UK update was published, scientists combined results from 12 post-2002 occupational studies, including the two mentioned above, concluding that protracted radiation was 20 percent more effective in increasing cancer rates than acute exposures (Jacob et al., 2009). The study's authors saw this result as a challenge to the cancer-risk values currently assumed for occupational radiation exposures. That is, they wrote that the radiation risk values used for workers should be increased over the atomic-bomb-derived values, not lowered by a factor of two or more.

If history is any guide, it is questionable that this analysis and the results of other studies will lead to actual changes in what defines worker-exposure limits. Industry pushback is very strong, as can be seen by the efforts of the California-based Electric Power Research Industry (EPRI), a nonprofit energy consortium. In 2009, the group issued a damning report that dismissed all of the new, high results in the 12 occupational studies, citing the work as either flawed or irrelevant to the exposures received by the most exposed nuclear workers (EPRI, 2009), which, EPRI says, are

around 0.02 Sv per year. Their concerns about the irrelevance of protracted studies are puzzling, because an annual exposure at 0.02 Sv over a period of 10 years would be 0.2 Sv—an accumulated exposure well above the low-dose dividing line of 0.1 Sv.

Techa River data

So what about the risks to the general population? In 2007, one study—the first of its size—looked at low-dose radiation risk in a large, chronically exposed civilian population; among the epidemiological community, this data set is known as the "Techa River cohort." From 1949 to 1956 in the Soviet Union, while the Mayak weapons complex dumped some 76 million cubic meters of radioactive waste water into the river, approximately 30,000 of the offsite population—from some 40 villages along the river—were exposed to chronic releases of radiation; residual contamination on riverbanks still produced doses for years after 1956.

Here was a study of citizens exposed to radiation much like that which would be experienced following a reactor accident. About 17,000 members of the cohort have been studied in an international effort (Krestinina et al., 2007), largely funded by the US Energy Department; and to many in the department, this study was meant to definitively prove that protracted exposures were low in risk. The results were unexpected. The slope of the LNT fit turned out to be higher than predicted by the atomic-bomb data, providing additional evidence that protracted exposure does not reduce risk.[13] Furthermore, as seen in Figure 2, the raw data showed cancer excess around 0.1 Sv of protracted exposure, before any linear fit is made. The distinction between acute and chronic exposures no longer exists in epidemiologic data. But as with the 15-country study, the Techa River study was attacked, particularly on the reliability of doses. EPRI discounted the study, claiming it contradicted other studies on low background-radiation areas in India and China. However, EPRI failed to mention in its 2009 report the limitations of such studies in high-background-radiation regions,[14] not to mention that the confidence bounds around the estimate were consistent with the risks from the atomic-bomb study (Tao et al., 2012).

Too much is at stake in terms of the cost of worker and public protection to expect the nuclear industry to be anything but skeptical of studies that undermine past practices and positions. The industry will want unequivocal evidence. Thus, the debate over protracted exposures will continue, probably even after the next US National Academy of Sciences and the Institute of Medicine's Biological Effects of Ionizing Radiations (BEIR) scientific committee issues a communal judgment five to ten years from now.[17]

Protracted exposures below the dividing line

Though they inspire and instigate forward-thinking research, the above studies do not put the debate over low-risk radiation to rest. In fact, the debate goes beyond this, to an even thornier issue: namely, the dose response *below* the divide at 0.1 Sv.[18] The debate over low doses is as intense as the debate over protracted-versus-acute exposure. Why? Because doses in this range are

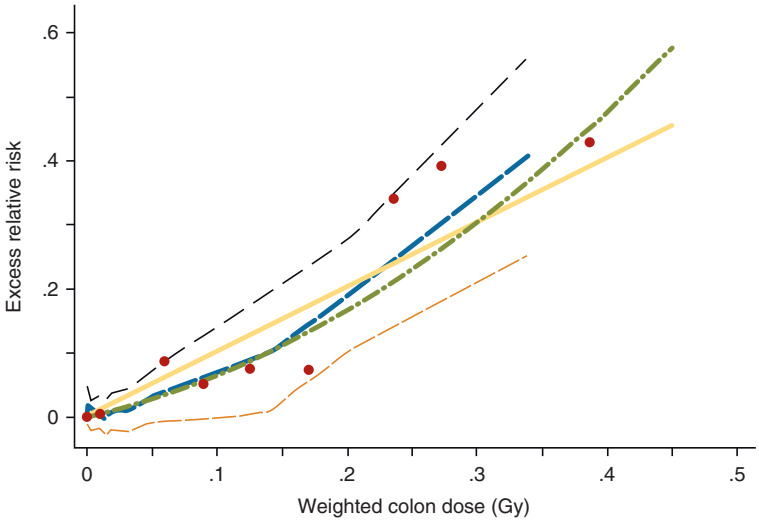

Figure 2. Solid cancer-incidence dose response for the Techa River cohort.
Source: Krestinina et al. (2007). This figure is reproduced with permission from the authors; © Oxford University Press.
Notes: This figure shows excess relative risk versus weighted dose in units of Gy (equivalent to Sv for the purposes of this article).[15] The solid line represents the linear fit. The thick dashed line represents a nonparametric fit to the data.[16] The thinner dashed curves represent one standard deviation. The scale of the dose axis is expanded compared with Figure 1, with tick marks in this graph set to intervals of 0.1 Gy. The bounds on the curves are quite wide. And the slope is higher than for the atomic-bomb survivor curve in Figure 1.

those of most concern to a public skeptical about nuclear power's side effects. Without low-dose risk estimates, it is not possible to predict the full consequences of events like Fukushima and Chernobyl; it is not possible to make estimates of the consequences of relying on nuclear power; nor is it possible to understand the consequences of relying on a high-level waste-storage site like Yucca Mountain.

Medical-diagnostic doses also often fall in this range, although the public is less concerned about them than doses from nuclear power or nuclear waste (see Slovic, 2012, in this issue of the *Bulletin*). Still, doctors, public health officials, emergency planners, and responders need to understand the risks at these doses.

Some public officials and nuclear energy supporters say doses below 0.1 Sv, particularly below 0.01 Sv, are nothing to worry about, while nuclear activists contend they are very dangerous. Personal interests can play a role in fanning the flames of the debate. In summary, there are scientific, medical, governmental, and political reasons for knowing the risks below 0.1 Sv: for example, creating an informed public, choosing energy sources, advancing scientific knowledge, facilitating an appropriate balance of risks from medical diagnostics. But there are obstacles, as well: like sabotaging lucrative business ventures and potentially amplifying risk perceptions.

Setting the record

Experts, governments, industry, and the public aren't left to their own devices to settle this debate. Due to the complex

nature of the issue—and the many opinions that it elicits—two major scientific committees oversee this matter, periodically reporting on new evidence related to quantitative risk estimates. They are the BEIR committee and the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

UNSCEAR's reports are compiled by staff and a small group of knowledgeable consultants (UNSCEAR, 2006). The BEIR reports, on the other hand, have a more elaborate procedure that has a more transparent process (National Research Council, 2006).[19] The reports' conclusions usually agree, but the UNSCEAR report, being a product of the United Nations, must be cognizant of national politics in UN countries—this means that the report never states that some risk continues down to zero dose. Such careful phrasing ensures that the LNT, and the risk numbers associated with it, can be used around the world for cost–benefit analyses and other regulatory purposes. Agencies can justify the use of the LNT solely on the basis of adopting a conservative or precautionary approach, thereby escaping strong objections from industry leaders and dissenting researchers.

In the UNSCEAR reports, for example, the dose models have risks going toward zero dose, but the authors do not write that the risks definitely reach zero—rather, they provide an obtuse explanation that "the inability to detect increases in risks at very low doses using epidemiological methods does not mean that the cancer risks are not elevated." No doubt, there is concern at the United Nations that too much talk about cancer risk at low doses will amplify risk perception (see Kasperson, 2012, in this issue of the *Bulletin*).[20]

The BEIR committee, which does not answer to any government, is more direct in its pronouncements. Based on their extensive review of the biologic evidence, including epidemiology, animal data, cellular data, and cancer theory, they conclude that the risk decreases with dose, but never goes to zero. In fact, their exact words are:

> A comprehensive review of the biology data led the committee to conclude that the risk would continue in a linear fashion at lower doses without a threshold and that the smallest dose has the potential to cause a small increase in risk to humans. (National Research Council, 2006)

Still, science is a contested territory, so scientific dissent from these reports is to be expected. For the sake of understanding how layered the arguments are, it is worth exploring these theoretical dissents.

Supralinear response

One theory that uses biologic evidence to predict a response greater than the LNT is a supralinear response. Such evidence is based on studies of cellular communication from radiation-damaged cells—chemical communication that transfers damage to an undamaged cell, multiplying the deleterious effect of the original radiation (the bystander effect).[21] Other evidence comes from studies of genomic instability, a phenomenon in which radiation damage doesn't show up until several cell generations have passed (Morgan and Sowa, 2009; see also, Hill, 2012, in this issue of the *Bulletin*).

In a 2012 study on atomic-bomb survivor mortality data (Ozasa et al., 2012), low-dose analysis revealed unexpectedly

strong evidence for the applicability of the supralinear theory. From 1950 to 2003, more than 80,000 people studied revealed high risks per unit dose in the low-dose range, from 0.01 to 0.1 Sv. The study's authors, themselves, did not go so far as to suggest a supralinear response, saying only that the results were difficult to interpret. However, advocates for supralinear response are likely to see a simple explanation, namely supralinearity. Note that such effects do not show up in studies of cancer *incidence* in the atomic-bomb studies.

Zero response

In contrast to theories of supralinear responses, some industry stakeholders argue that the response might be zero for doses up to a threshold, below 0.1 Sv. A completely zero response is unlikely, given the heterogeneity of human populations, including differing immune and repair systems among people. However, a quasi-threshold, with a dose response below 0.1 Sv, is a standard theoretical possibility and a hypothesis that some researchers strongly believe will be vindicated one day, thereby confounding the conventional view of an LNT dose response.

In 2007, the latest cancer-incidence results were released on atomic-bomb survivors from 1950 to 1998; in this update, there was a mathematical fit to a threshold at 0.04 Sv, as well as a fit to the LNT model.[22] However, these findings were not reiterated in the 2012 update on cancer mortality, which reported a response that appeared to rise above the LNT prediction at low doses.

The French National Academy and Institute of Medicine put out their own short report advocating for a quasi-threshold based largely on cellular data (Aurengo et al., 2005) and criticizing those who think otherwise. In turn, the French study has been criticized, not just on the merits, but also for lack of objectivity.[23,24] For LNT dissenters, the French Academy's study has been their counterpoint when the authority of the US BEIR report is invoked. Thus, any layperson wishing to engage in the discussion must reach a decision on which of these reports is likely to contain the most credible scientific judgments.

Hormesis theory

Demonstration of a quasi-threshold would be unlikely to assuage those who abhor radiation-producing technology on existential grounds, but it might eventually affect regulations and overall opinion. The radiation hormesis theory—that some radiation is beneficial—would provide more comfort, if it could be demonstrated. The best evidence for this concept in humans can be found in national data on home radon measurements and lung cancer rates at the county level. However, the reliance on cancer data aggregated to the county level has been roundly criticized by epidemiologists (Lubin, 2002). Results from more sophisticated epidemiologic studies of the same association do show the expected dose response when individual cancers are matched to dose (Darby et al., 2005; Krewski et al., 2006).

Though it still is a pet topic of enterprising journalists, the radiation hormesis theory is no longer of much interest to researchers. The BEIR VII report, published in 2006, discounted

the concept; the French Academy of Sciences took it more seriously, while discounting other evidence that suggests the response might be supralinear at low doses.

Given the increase in radiation from medical diagnostics and the interest in protracted exposure, the possible existence of a threshold or hormetic effect for public policy appears to be a moot issue for developed countries when it comes to future exposures. Even if the level of medical diagnostic exposures does not increase in the future, over the course of 40 years most people in developed countries will receive an average of 0.1 Sv from medical procedures, alone. With this in mind as a dose starting point for millions of people, it is fair to say that any exposure to radioactive elements from a nuclear accident or a dirty bomb would definitely contribute to their delayed cancer risk.

Adaptive response

Of more current interest than hormesis is the concept of adaptive response, where low doses of radiation can prime cells to withstand later, higher doses of radiation (see Hill, 2012, in this issue of the *Bulletin*). The idea is that very low doses, like a vaccination, teach the body how to recognize and repair or remove radiation-damaged cells. Thus, subsequent chronic doses would be less dangerous. Under some theories, this effect can lead to a sublinear response at doses below 0.1 Sv (Morgan and Sowa, 2009). In other words, the excess risk at low doses could be less than predicted by the LNT. The range of doses for which this effect might be applicable is not known; nor is it known whether it might compensate for deleterious bystander effects and genomic instability.

LNT as matter of convenience

It should be noted that all of these cellular effects—including bystander effect, genomic instability, and adaptive response, some of which are thought to have effects working in opposite directions—could already be incorporated into the linear human dose-response curve (Morgan and Sowa, 2009), making the debate much ado about nothing.

Many professional risk analysts, especially those with calm temperaments, do not fret much about the debate over dose response below 0.1 Sv. They simply handle it as a standard problem in uncertainty management, much as they handle many other parts of risk assessment calculations: They take the LNT as the midrange, add uncertainty bounds around it, and possibly use subjective-likelihood distributions to accommodate alternative scientific hypotheses. This is essentially the approach that has been followed in calculations supporting compensation of weapons-test veterans and workers in the weapons complex (Kocher et al., 2008), although the possibility of a threshold or hormesis has not been included in this work. If non-linear, dose-response models are included—for example, threshold or hormesis models—consistency would be necessary and dose terms would need to be added for medical technology and, possibly, background radiation.

Dealing with the uncertainty components from gaps in knowledge about low-level radiation effects is essential (Hoffman et al., 2011). According to these risk analysts, by quantifying uncertainty,

the most important debates over low-level radiation exposures can proceed with less distraction (e.g., planning for accident response and weighing benefits and risks of technologies). However, this approach does not satisfy critics of the LNT, because the average risks usually come quite close to the LNT predictions, even though the uncertainty bounds on the resulting predictions may include their views.

Conclusion

The public, legislators, and journalists are often at a loss to deal with the charges and counter charges that surface in the debate over low-level radiation exposures. It does not help to listen to industry leaders, nuclear activists, or individual researchers, who, one after another, propound their competing images of the underlying truth. Given the complexities, the only alternative for most people is to rely on scientific committees, like the BEIR committee and UNSCEAR, recognizing that the scientific jigsaw puzzle is incomplete. Not all pieces fit correctly, but a reasonable idea of the true situation emerges from the recognizable image visible from the pieces already assembled.

It is now reasonably clear that protracted exposure does not protect against radiation-induced cancer. Rather, it is the cumulative radiation exposure from all sources that must be examined. In developed countries, the average accumulated dose from medical procedures is now so high that a significant percentage of the population in these countries will be above 0.1 Sv. Therefore, this population will be primed for radiation-induced, delayed cancers from releases from nuclear reactors or dirty bombs, even using the hypothetical dose-response models of the LNT dissenters. There is no longer a convenient excuse to avoid using the LNT to estimate consequences from real or projected releases of radioactive materials, even when the dose of concern is below 0.1 Sv.

Particularly when it comes to cost–benefit decisions on retrofitting reactors or planning for spent-fuel pools, regulations that depend on estimates of cancer risks are using LNT slope coefficients that are decades out of date (see Brock and Sherbini, 2012, in this issue of the *Bulletin*). Thus, pressure to update regulations may build, as awareness grows of the five-to-tenfold disparity between the risk estimates per unit dose recommended by scientists today and the older values still used by regulators in cost–benefit calculations for determining allowable doses.

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Notes

1. There had been hints in some earlier, smaller, occupational studies, e.g., Wing et al. (1991).
2. When exposures are only to gamma and beta rays, they are usually measured in units of grays (Gy). But when other types of radiation are involved in a dose calculation—for example, neutrons and alpha particles—the comparable unit is either a "weighted gray" or a sievert. These latter units weigh different types of radiation by their estimated effectiveness in increasing delayed cancer rates; therefore, doses and health risks can be compared among epidemiologic studies that involve different mixtures of radiation types.

3. Some analysts add a quadratic term to account for any curvature in the dose-response curve. However, at low doses, this linear-quadratic model becomes a linear model.
4. Weighted colon dose multiplies the neutron dose component by an effectiveness factor of 10 (Chomentowski et al., 2000).
5. No model is assumed, which means the fit is nonparametric. Instead, the data are smoothed and used to define straight-line segments. The circles indicate the excess relative risk at the mean dose in each of the 22 specific dose categories.
6. An ERR of 0.1 means that the cancer rate has increased by 10 percent. To get an absolute risk, one multiplies the ERR by the baseline cancer rate.
7. Some critics also argue, incorrectly, that the atomic-bomb data have no control groups. In fact, it has the best types of control groups epidemiologic methods can offer. When a study can present excess health effects as a function of dose, it has internal controls for comparison. Subjects in each dose category serve as controls for each other, all the way down to zero dose.
8. The 1980 Biologic Effects of Ionizing Radiation (BEIR) report found that the slope of the response was 10 times lower than the value in the 2006 BEIR report; the 1995 BEIR report found it was twice as low (Marshall, 1990; National Research Council, 2006; Reissland, 1981). Interestingly, as the slope of the birth-defect response decreased considerably over time, so, too, did public interest in the matter; perhaps the direction of change in these slopes defines, in part, public concern.
9. Some caveats: First of all, unexpected results are always a possibility and could very well appear in the next study. Second, molecular analysis of future tumors may one day lead to identification of subgroups with dose-responses that are much higher than the population average. Also, new cancer cases will emerge in the future for those exposed at young ages; possibly, these rates will be dramatically different in old age than current projections expect. As a result, lifetime risks for those exposed at young ages could conceivably change significantly.
10. At the time, this theory was supported by the interpretation of experiments on cells showing that, for the same total dose, cellular damage increased the faster the dose was delivered. Consequently, there was strong support for scaling down the risks determined from the bomb data, when it came to predicting cancer from chronic, protracted exposures. These experiments did not involve human cancer, in which development is a more complex process than can be inferred from experiments on isolated cells. Furthermore, the dose response measured in these experiments was for the total cellular damage, not the damage restricted to those components that affect cancer development, which could have their own, distinct dose response.
11. Cardis's critics do not accept that the Canada results simply reflect the highest data point among a set with wide variance; they have spent extensive energy focusing on the weaknesses of only this study, while overlooking or ignoring weaknesses in other studies with lower ERR/Sv results (Ashmore et al., 2010; Boice, 2010). If Canada, the study with the highest ERR/Sv, is removed from the study, as the critics wish, the overall results will no longer be statistically significant. Blind reliance on 95 percent confidence limits is no longer the practice in epidemiology, but it remains a widespread practice among stakeholders—when they will benefit from discounting data. Studies are assessed as a group, for instance, in the context of the other studies discussed in this article.
12. The findings were not greatly influenced by data from any one country: Formal statistical tests provided no evidence for differences in risk between countries. Thus, there was no statistical basis for removing the highest data point. Analyses excluding one country at a time produced excess relative risks per Sv ranging from 0.58 (excluding Canada) to 1.25 (excluding the United Kingdom). Only by excluding Canada did the results lose statistical significance.
13. To date, none of the epidemiology studies dealing with protracted exposures have

explicitly accounted for the effect of uncertainty in dose estimation. Paying attention to uncertainty in dose estimation is perhaps most important with the Techa River data and some of the studies of background radiation discussed later in the text, because mathematical models are used in part to reconstruct individual exposures, filling in gaps in direct measurements. Accounting for measurement uncertainty strengthened the findings of an association with radiation in studies of thyroid disease following nuclear weapons tests (Lyon et al., 2006).

14. Two epidemiologic studies, one in India (Nair et al., 2009) and one in China (Tao et al., 2012), are notable because they include individualized doses, which typically would mean they rely on internal controls by dose category, like the analysis of the atomic-bomb survivors. However, the individualized dose method is weakened in these studies, because the authors mixed together distinct geographic regions, some with low doses and some with high. No separate analyses were given in the studies to account for different baseline cancer rates in each region; nor was there stratification by region. Had there been, it is likely that the confidence intervals would have increased. As it was, the confidence intervals around their slightly negative slopes were quite wide, limiting their usefulness in potentially contradicting other studies, as EPRI maintains they do. Early markers of cancer risk, namely dose-related chromosomal aberrations (China) and mitochondrial DNA mutations (India) have been found in these high-background regions, casting some doubt on the null epidemiologic findings in these studies. Both studies exclude persons under 30, the age period when radiation-induced leukemia is extremely high according to atomic-bomb results. In the Chinese mortality study the authors note the difficulty in diagnosing liver cancer mortality. When liver cancer is removed from the analysis, the ERR/Sv is positive and the upper confidence interval for the ERR/Sv is much greater than that for the other studies mentioned in this article, including the 15-country study and the Techa River cohort study. Thus, from this perspective, the study of high background radiation in China is not at all inconsistent with studies showing risks of protracted exposure greater than predicted by analysis of the atomic-bomb data. The study in India did not provide an analysis with liver cancer removed, so a comparison cannot be made. For a more positive view of these types of studies, see Boice et al. (2010). For a discussion of other studies in high-background-radiation regions, see Hendry et al. (2009).
15. The weights here correspond to different times spent near the riverbank (Standring et al., 2009).
16. To obtain this curve, no model was assumed, which means the fit is called nonparametric: Instead of fitting to a model (e.g., a linear model), a running average of the data was used to define the curve.
17. The next BEIR report is not yet in the planning.
18. Because many more cancers are expected in the atomic-bomb cohort in the next 20 years, more information can be expected to emerge on the low-dose range in the future. Given the 50 years it has taken for the atomic-bomb analyses to produce powerful results, we cannot expect Fukushima data to contribute much for a great many decades, particularly because the average dose is likely to be lower. However, the ability to perform genetic sequencing of removed tumors offers a new opportunity to expand the power of epidemiologic studies.
19. Presentations to the BEIR committee are open to the public. The biographies of the committee members appear in the report. So, too, are the names of the numerous outside reviewers listed in the final report. Both of these procedures allow outsiders to assess whether or not the committee is balanced.
20. It is perhaps out of the same concern to avoid social amplification of risk that the UNSCEAR authors have declined to use the LNT to predict the total number of excess cancers that will result over time as a result of the Chernobyl accident.

Such a number would be very small compared with the number of cancers that would have appeared without the accident. One of the biggest paradoxes in the low-level radiation debate is that an individual risk can be a minor concern, while the societal risk (total delayed cancers in an exposed population) can be of major concern.

21. Some argue that bystander effects could also be protective, signaling the body to increase repair efforts.
22. The use of a pure threshold in the fit was a mathematical convenience; a quasi-threshold would have fit just as well.
23. According to the criticism, too many members had strong prior views tied to their relationships with the French nuclear industry or their medical practice in radiation medicine. In contrast to the policy followed in preparation of the BEIR reports, no biographies of the authors were provided in the report of the French Academies, deepening suspicion that something was being hidden.
24. Furthermore, the French study did not undergo the intensive peer-review process used with the BEIR committee reports. Of course, the BEIR report process is not perfect, either, as history shows. In its 1980 report, for example, the committee muffed the slope of the LNT (Marshall, 1990). However, the BEIR committees do follow processes established by the US National Academies of Sciences and the US Institute of Medicine, which require assembling a group of scientists with a broad range of perspectives. Attempts are made to balance biased views, which are inevitable in any sizeable committee of active scientists or medical professionals.

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Author biography

Guest editor of the *Bulletin*'s special issue on low-dose radiation risks, **Jan Beyea** is a nuclear physicist, who, for 40 years, has listened to, and sometimes participated in, the debate over risks from low-level radiation exposure. He is a co-author of papers on environmental epidemiology, including a study of the Three Mile Island accident. Beyea has been a member and reviewer of numerous studies for the National Research Council, most recently serving as a committee member for the completed study *America's Energy Future*, and the ongoing study, *The Feasibility of Inertial Fusion Energy*. He currently is a member of the World Trade Center Health Registry Scientific Advisory Committee. He advises plaintiff law firms on litigation strategy in large, toxic tort cases, where he has watched some of the most prominent researchers in the world go head to head, debating the risks of low-level radiation. He is chief scientist at Consulting in the Public Interest.

Exhibit B : Comment by Drs. Lennart Hardell, Fredrik Soderqvist, PhD and Michael Carlberg, MSc.

Section 3.5.1.1 Epidemiological Studies, RF fields epidemiology, Pages 57-68

We have read the SCENIHR 2013 Preliminary opinion on Potential health effects of exposure to electromagnetic fields (EMF), especially relating to epidemiological studies on neoplastic diseases. It is concluded at page 4 in the abstract that "*Based on the most recent cohort and incidence time trend studies, it appears that the evidence for glioma became weaker while the possibility of an association with acoustic neuroma remains open*".

This statement is not based on facts but on selective inclusion of studies with omission of the most recent publications, e.g. from our research group (the Hardell group). Our studies were well known to the Expert group since Dr Kjell Hansson Mild was one of these experts and also a co-author in most of the Hardell group studies. In fact he communicated our studies to the SCENIHR expert group obviously without response. If these studies had been included it would be apparent that the final conclusions on brain tumour risk in SCENIHR are not based on scientific facts. In contrast the evidence for glioma and acoustic neuroma would become stronger if recent publications had been included.

In the Terms of Reference (page 16) it is stated that the Committee is requested e.g.:

1. To update its opinions of 2009 in the light of newly available information
2. To give particular attention to issues affected by important gaps in knowledge in the previous opinions, especially:
    - The potential adverse effects of EMF on the nervous system, including neurobehavioral disorders, and on the risk of neo-plastic diseases;

It seems as if the Committee has been anxious to include 'newly available information' at least regarding some studies, e.g. **Benson VS, Pirie K, Schüz J, Reeves GK, Beral V, Green J. Int J Epidemiol 2013, Sep 27**, see page 64, not included in reference list. On the contrary our studies were excluded. In the following a summary is given.

Background:

The carcinogenic effect of RF-EMF on humans was evaluated at a meeting during 24 – 31 May 2011 at the International Agency for Research on Cancer (IARC) at WHO in Lyon, France. The Working Group consisted of 30 scientists representing four areas: 'animal cancer studies', 'epidemiology', 'exposure' and 'mechanistic and other relevant data' (http://monographs.iarc.fr/ENG/Meetings/vol102-participants.pdf). One of us, LH, was invited as an expert in the epidemiology group. On 31 May 2011 IARC categorised RF-EMFs from mobile phones, and from other devices that emit similar non-ionising electromagnetic fields, as a Group 2B, i.e. a 'possible', human carcinogen. The decision was almost unanimous.

The IARC decision on mobile phones was based mainly on two sets of case-control human studies on brain tumour risk; our studies from Sweden (the Hardell group) and the IARC Interphone study. Both provided complementary and supportive results on positive associations between two types of brain tumours; glioma and acoustic neuroma, and exposure to RF-EMF from mobile phones. No consistent evidence was found for meningioma, a benign type of brain tumour. After the IARC meeting we have published further studies with new data, both overview of studies with meta-analysis (number 1 below) and our case-control study including brain

tumour cases diagnosed during 2007-2009 (number 2-4 below). Furthermore we applied the Hill viewpoints on the risk for brain tumours associated with use of mobile and cordless phones (number 5 below). These criteria were developed in the 1960's during the height of the tobacco and lung cancer controversy.

Recent studies from the Hardell group not included in SCENIHR 2013:

1. **Hardell L, Carlberg M, Hansson Mild K. Use of mobile phones and cordless phones is associated with increased risk for glioma and acoustic neuroma. *Pathophysiology* 2013;20:85-110. Epub 2012 Dec 21.**

Abstract
The International Agency for Research on Cancer (IARC) at WHO evaluation of the carcinogenic effect of RF-EMF on humans took place during a 24-31 May 2011 meeting at Lyon in France. The Working Group consisted of 30 scientists and categorised the radiofrequency electromagnetic fields from mobile phones, and from other devices that emit similar non-ionising electromagnetic fields (RF-EMF), as Group 2B, i.e., a 'possible', human carcinogen. The decision on mobile phones was based mainly on the Hardell group of studies from Sweden and the IARC Interphone study. We give an overview of current epidemiological evidence for an increased risk for brain tumours including a meta-analysis of the Hardell group and Interphone results for mobile phone use. Results for cordless phones are lacking in Interphone. *The meta-analysis gave for glioma in the most exposed part of the brain, the temporal lobe, odds ratio (OR)=1.71, 95% confidence interval (CI)=1.04-2.81 in the ≥10 years (>10 years in the Hardell group) latency group. Ipsilateral mobile phone use ≥1640h in total gave OR=2.29, 95% CI=1.56-3.37. The results for meningioma were OR=1.25, 95% CI=0.31-4.98 and OR=1.35, 95% CI=0.81-2.23, respectively. Regarding acoustic neuroma ipsilateral mobile phone use in the latency group ≥10 years gave OR=1.81, 95% CI=0.73-4.45. For ipsilateral cumulative use ≥1640h OR=2.55, 95% CI=1.50-4.40 was obtained.* Also use of cordless phones increased the risk for glioma and acoustic neuroma in the Hardell group studies. Survival of patients with glioma was analysed in the Hardell group studies yielding in the >10 years latency period hazard ratio (HR)=1.2, 95% CI=1.002-1.5 for use of wireless phones. This increased HR was based on results for astrocytoma WHO grade IV (glioblastoma multiforme). Decreased HR was found for low-grade astrocytoma, WHO grades I-II, which might be caused by RF-EMF exposure leading to tumour-associated symptoms and earlier detection and surgery with better prognosis. *Some studies show increasing incidence of brain tumours whereas other studies do not. It is concluded that one should be careful using incidence data to dismiss results in analytical epidemiology.* The IARC carcinogenic classification does not seem to have had any significant impact on governments' perceptions of their responsibilities to protect public health from this widespread source of radiation.

2. **Carlberg M, Söderqvist F, Hansson Mild K, Hardell L. Meningioma patients diagnosed 2007-2009 and the association with use of mobile and cordless phones, *Environ. Health* 2013;12:60, doi:10.1186/1476-069X-12-60. Epub Jul 19, 2013**

Abstract
BACKGROUND: To study the association between use of wireless phones and meningioma.
METHODS: We performed a case--control study on brain tumour cases of both genders aged 18--75 years and diagnosed during 2007--2009. One population-based control matched on gender and age was used to each case. Here we report on meningioma cases including all available controls. Exposures were assessed by a questionnaire. Unconditional logistic regression analysis was performed.
RESULTS: In total 709 meningioma cases and 1,368 control subjects answered the questionnaire. *Mobile phone use in total produced odds ratio (OR) = 1.0, 95% confidence interval (CI) = 0.7-1.4 and cordless phone use gave OR = 1.1, 95% CI = 0.8-1.5.* The risk increased statistically significant per 100 h of cumulative use and highest OR was found in the fourth quartile (>2,376 hours) of cumulative use for all studied phone types. There was no statistically significant increased risk for ipsilateral mobile or cordless phone use, for meningioma in the temporal lobe or per year of latency. Tumour volume was not related to latency or cumulative use in hours of wireless phones.
CONCLUSIONS: *No conclusive evidence of an association between use of mobile and cordless phones and meningioma was found.* An indication of increased risk was seen in the group with highest cumulative use but was not supported by statistically significant increasing risk with latency. Results for even longer latency periods of wireless phone use than in this study are desirable.

3. **Hardell L. Carlberg M, Söderqvist F, Hansson Mild K. Pooled analysis of case-control studies on acoustic neuroma diagnosed 1997-2003 and 2007-2009 and use of mobile and cordless phones. *Int J Oncol.* 2013;43:1036-1044. Epub 2013 Jul 22.**

Abstract
We previously conducted a case-control study of acoustic neuroma. Subjects of both genders aged 20-80 years, diagnosed during 1997-2003 in parts of Sweden, were included, and the results were published. We have since made a further study for the time period 2007-2009 including both men and women aged 18-75 years selected from throughout the country. These new results for acoustic neuroma have not been published to date. Similar methods were used for both study periods. In each, one population-based control, matched on gender and age (within five years), was identified from the Swedish Population Registry. Exposures were assessed by a self-administered questionnaire supplemented by a phone interview. Since the number of acoustic neuroma cases in the new study was low we now present pooled results from both study periods based on 316 participating cases and 3,530 controls. Unconditional logistic regression analysis was performed, adjusting for age, gender, year of diagnosis and socio-economic index (SEI). Use of mobile phones of the analogue type gave odds ratio (OR) = 2.9, 95% confidence interval (CI) = 2.0-4.3, increasing with >20 years latency (time since first exposure) to OR = 7.7, 95% CI = 2.8-21. Digital 2G mobile phone use gave OR = 1.5, 95% CI = 1.1-2.1, increasing with latency >15 years to an OR = 1.8, 95% CI = 0.8-4.2. The results for cordless phone use were OR = 1.5, 95% CI = 1.1-2.1, and, for latency of >20 years, OR = 6.5, 95% CI = 1.7-26. Digital type wireless phones (2G and 3G mobile phones and cordless phones) gave OR = 1.5, 95% CI = 1.1-2.0 increasing to OR = 8.1, 95% CI = 2.0-32 with latency >20 years. *For total wireless phone use, the highest risk was calculated for the longest latency time >20 years: OR = 4.4, 95% CI = 2.2-9.0.* Several of the calculations in the long latency category were based on low numbers of exposed cases. Ipsilateral use resulted in a higher risk than contralateral for both mobile and cordless phones. OR increased per 100 h cumulative use and per year of latency for mobile phones and cordless phones, though the increase was not statistically significant for cordless phones. *The percentage tumour volume increased per year of latency and per 100 h of cumulative use, statistically significant for analogue phones. This study confirmed previous results demonstrating an association between mobile and cordless phone use and acoustic neuroma.*

4. **Hardell L, Carlberg M, Söderqvist F, Hansson Mild K. Case-control study of the association between malignant brain tumors diagnosed 2007-2009 and mobile and cordless phone use.** ***Int J Oncol.*** **2013;43:1833-1845. Epub 2013 Sep 24**

Abstract
Previous studies have shown a consistent association between long-term use of mobile and cordless phones and glioma and acoustic neuroma, but not for meningioma. When used these phones emit radiofrequency electromagnetic fields (RF-EMFs) and the brain is the main target organ for the handheld phone. The International Agency for Research on Cancer (IARC) classified in May, 2011 RF-EMF as a group 2B, i.e. a 'possible' human carcinogen. The aim of this study was to further explore the relationship between especially long-term (>10 years) use of wireless phones and the development of malignant brain tumours. We conducted a new case-control study of brain tumour cases of both genders aged 18-75 years and diagnosed during 2007-2009. One population-based control matched on gender and age (within 5 years) was used to each case. Here, we report on malignant cases including all available controls. Exposures on e.g. use of mobile phones and cordless phones were assessed by a self-administered questionnaire. Unconditional logistic regression analysis was performed, adjusting for age, gender, year of diagnosis and socio-economic index using the whole control sample. Of the cases with a malignant brain tumour, 87% (n=593) participated, and 85% (n=1,368) of controls in the whole study answered the questionnaire. *The odds ratio (OR) for mobile phone use of the analogue type was 1.8, 95% confidence interval (CI)=1.04-3.3, increasing with >25 years of latency (time since first exposure) to an OR=3.3, 95% CI=1.6-6.9. Digital 2G mobile phone use rendered an OR=1.6, 95% CI=0.996-2.7, increasing with latency >15-20 years to an OR=2.1, 95% CI=1.2-3.6. The results for cordless phone use were OR=1.7, 95% CI=1.1-2.9, and, for latency of 15-20 years, the OR=2.1, 95% CI=1.2-3.8. Few participants had used a cordless phone for >20-25 years.* Digital type of wireless phones (2G and 3G mobile phones, cordless phones) gave increased risk with latency >1-5 years, then a lower risk in the following latency groups, but again increasing risk with latency >15-20 years. Ipsilateral use resulted in a higher risk than contralateral mobile and cordless phone use. Higher ORs were calculated for tumours in the temporal and overlapping lobes. Using the meningioma cases in the same study as reference entity gave somewhat higher ORs indicating that the results were unlikely to be explained by recall or observational bias. This study confirmed previous results of an association between mobile and cordless phone use and malignant brain tumours. These findings provide support for the hypothesis that RF-EMFs play a role both in the initiation and promotion stages of carcinogenesis.

5. **Hardell L, Carlberg M. Using the Hill viewpoints from 1965 for evaluating strengths of evidence of the risk for brain tumors associated with use of mobile and cordless phones.** ***Rev Environ Health*** **2013;38:97-106. doi: 10.1515/reveh-2013-0006.**

Abstract
BACKGROUND: Wireless phones, i.e., mobile phones and cordless phones, emit radiofrequency electromagnetic fields (RF-EMF) when used. An increased risk of brain tumors is a major concern. The International Agency for Research on Cancer (IARC) at the World Health Organization (WHO) evaluated the carcinogenic effect to humans

from RF-EMF in May 2011. It was concluded that RF-EMF is a group 2B, i.e., a "possible", human carcinogen. Bradford Hill gave a presidential address at the British Royal Society of Medicine in 1965 on the association or causation that provides a helpful framework for evaluation of the brain tumor risk from RF-EMF.
METHODS: All nine issues on causation according to Hill were evaluated. Regarding wireless phones, only studies with long-term use were included. In addition, laboratory studies and data on the incidence of brain tumors were considered.
RESULTS: *The criteria on strength, consistency, specificity, temporality, and biologic gradient for evidence of increased risk for glioma and acoustic neuroma were fulfilled. Additional evidence came from plausibility and analogy based on laboratory studies. Regarding coherence, several studies show increasing incidence of brain tumors, especially in the most exposed area. Support for the experiment came from antioxidants that can alleviate the generation of reactive oxygen species involved in biologic effects, although a direct mechanism for brain tumor carcinogenesis has not been shown. In addition, the finding of no increased risk for brain tumors in subjects using the mobile phone only in a car with an external antenna is supportive evidence. Hill did not consider all the needed nine viewpoints to be essential requirements.*
CONCLUSION: Based on the Hill criteria*, glioma and acoustic neuroma should be considered to be caused by RF-EMF emissions from wireless phones and regarded as carcinogenic to humans,* classifying it as group 1 according to the IARC classification. Current guidelines for exposure need to be urgently revised.

SUMMARY

During 2013 our research group has published results from further studies on brain tumour risk associated with use of mobile and/or cordless desktop phones. We published data on tumour risk for use of these devices during 20 years or more. Clearly we find again an increased risk for malignant brain tumours including the most common type glioma (‘brain cancer’). We find also increased risk of acoustic neuroma, a benign tumour of the hearing nerve (number VIII). These tumours usually lead to hearing problems (deafness), tinnitus and dizziness although rarely lethal. Still we find no clear increased risk for meningioma, even after 20 years use of the mobile phone.

Especially worrying is that we find highest risk for glioma and acoustic neuroma in subjects who started use of the wireless phone before the age of 20 years. We have also found that the prognosis of glioma (astrocytoma grade IV) is worse the longer time one has used the wireless phone. That means that long-term use shortens the survival.

Further research has thus strengthened the evidence in support of an increased risk of malignant brain tumours and acoustic neuroma associated with use of mobile phones. Based on the latest findings and using the so called Hill viewpoints from the 1960’s exposure to RF-EMF from mobile phones may now be classified as a human cancer causing agent, Group 1, according to the definitions used by IARC.

It is unfortunate that SCENIHR has disregarded these findings and instead relies heavily on the much criticised Danish cohort study on mobile phone users with poor exposure data. We have discussed the many shortcomings in that study, see **Söderqvist F, Carlberg M, Hardell L. Review of four publications on the Danish cohort study on mobile phone subscribers and risk of brain tumors. *Reviews Environmental Health*. 2012; 27: 51-58.** SCENIHR lacks reference to our publication and accordingly also critical comments on the Danish cohort study. The same lack of critical review applies to the study by Benson et al, included in SCENIHR, but without acknowledge of the limitations in that study.

The CEFALO study on brain tumour risk in children is included in SCENIHR, however without a critical review of the study. For example use of cordless phones was assessed only during the 3 first years of use, a most peculiar definition. Our review of that study is omitted from SCENIHR, see **Söderqvist F, Carlberg M, Hansson Mild K, Hardell L. Childhood brain tumour risk and its association with wireless phones: a commentary. *Environmental Health*. 2011; 10: 106.**

In addition to the Danish cohort study and the UK study by Benson et al SCENIHR relies heavily on time trend analyses. However the conclusion by IARC in the 2011 evaluation was that: "*Time-trend analyses did not show an increased rate of brain tumours after the increase in mobile phone use. However, these studies have substantial limitations because most of the analyses examined trends until the early 2000s only. Such analyses are uninformative if excess risk only manifests more than a decade after phone use begins, or if phone use only affects a small proportion of cases—eg, the most heavily exposed, or a subset of brain tumours*." See **Baan R, Grosse Y, Lauby-Secretan B, *et al*. Carcinogenicity of radiofrequency electromagnetic fields. *Lancet Oncology*. 2011; 12: 624-626.**

In our publication number 4 above, we presented restricted cubic spline plot of the relationship between latency of wireless phone use and malignant brain tumours, see figure below. The solid line indicates the OR estimate and the broken lines represent the 95% CI. Adjustment was made for age at diagnosis, gender, SEI-code and year of diagnosis. Obviously the latency is 20+ years for malignant brain tumours according to these results. Thus, it confirms the conclusion by IARC on incidence data that "*Such analyses are uninformative if excess risk only manifests more than a decade after phone use begins";* in fact it may even be two decades based on our data. Our results are also in agreement with de Vocht et al "*According to these ecological results the latency period is at least 11-12 years, but probably more than 20 years."* See **de Vocht F, Hannam K, Buchan I. Environmental risk factors for cancers of the brain and nervous system: the use of ecological data to generate hypotheses. *Occup Environ Med* 2013; 70: 349-356.**

In summary, the preliminary SCENIHR conclusion that glioma risk is weaker now is not scientifically justified. The only way that conclusion could be reached by SCENIHR is to exclude critical studies that present evidence to the contrary, i.e. studies that report the risk of glioma (and acoustic neuroma) is stronger now than in 2009. Including our studies would give different conclusions supported by critical review of the limitations in cohort studies and incidence data. The Preliminary Opinion should be sent back to the Committee for new evaluation of the scientific data, and should integrate the results of these published data.

1) Hardell L, Carlberg M, Hansson Mild K. Use of mobile phones and cordless phones is associated with increased risk for glioma and acoustic neuroma. *Pathophysiology* 2013;20:85-110. Epub 2012 Dec 21.

2. Carlberg M, Söderqvist F, Hansson Mild K, Hardell L. Meningioma patients diagnosed 2007-2009 and the association with use of mobile and cordless phones, *Environ. Health* 2013;12:60, doi:10.1186/1476-069X-12-60. Epub Jul 19, 2013

3. Hardell L. Carlberg M, Söderqvist F, Hansson Mild K. Pooled analysis of case-control studies on acoustic neuroma diagnosed 1997-2003 and 2007-2009 and use of mobile and cordless phones. *Int J Oncol.* 2013;43:1036-1044. Epub 2013 Jul 22.

4. Hardell L, Carlberg M, Söderqvist F, Hansson Mild K. Case-control study of the association between malignant brain tumors diagnosed 2007-2009 and mobile and cordless phone use. *Int J Oncol.* 2013;43:1833-1845. Epub 2013 Sep 24

5. Hardell L, Carlberg M. Using the Hill viewpoints from 1965 for evaluating strengths of evidence of the risk for brain tumors associated with use of mobile and cordless phones. *Rev Environ Health* 2013;38:97-106. doi: 10.1515/reveh-2013-0006.

Respectfully submitted

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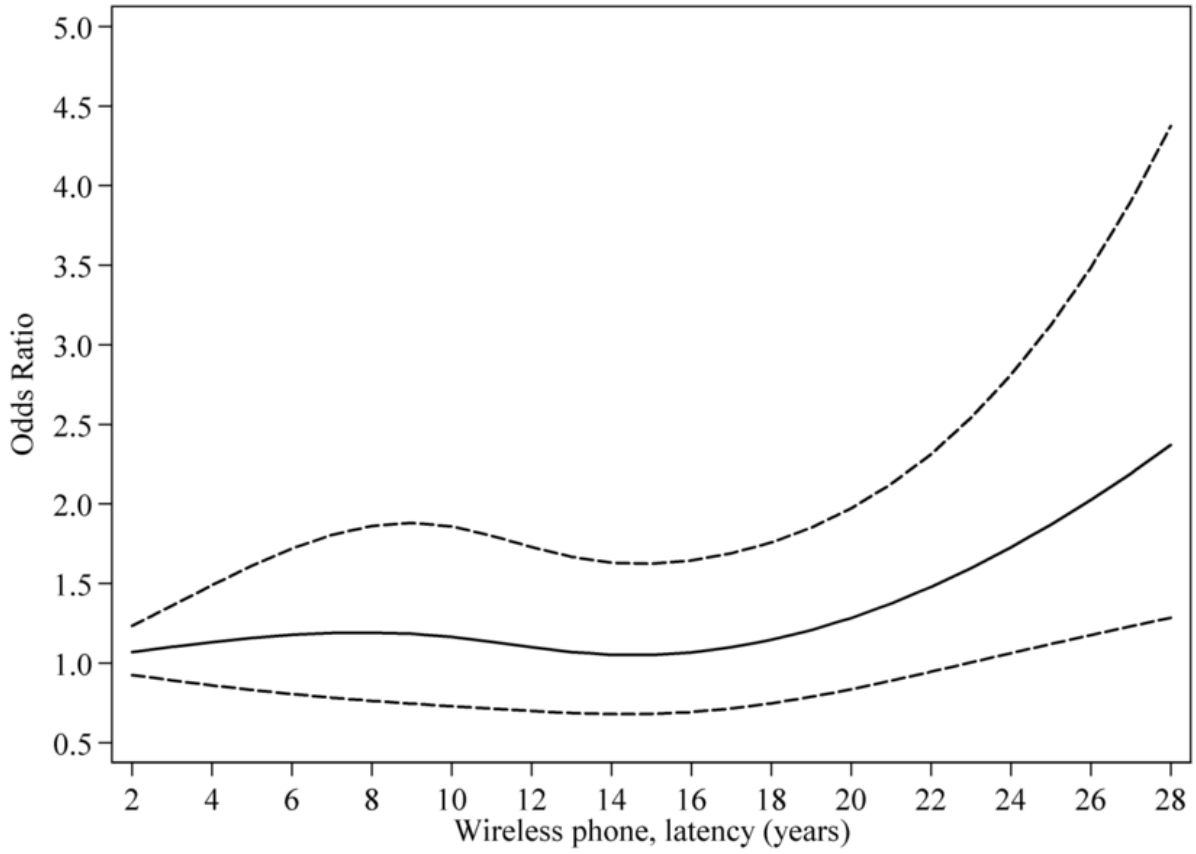
Attached Figure

In our publication **Hardell L, Carlberg M, Söderqvist F, Hansson Mild K. Case-control study of the association between malignant brain tumors diagnosed 2007-2009 and mobile and cordless phone use. Int J Oncol. 2013;43:1833-1845. Epub 2013 Sep 24,** we presented restricted cubic spline plot (see figure below) of the relationship between latency of wireless phone use and malignant brain tumours, see figure below. The solid line indicates the OR estimate and the broken lines represent the 95% CI. Adjustment was made for age at diagnosis, gender, SEI-code and year of diagnosis. Obviously the latency is 20+ years for malignant brain tumours according to these results. Thus, it confirms the conclusion by IARC on incidence data that "*Such analyses are uninformative if excess risk only manifests more than a decade after phone use begins";* in fact it may even be two decades based on our data. Our results are also in agreement with de Vocht et al "*According to these ecological results the latency period is at least 11-12 years, but probably more than 20 years."*



Restricted cubic spline plot of the relationship between latency of wireless phones and malignant brain tumours. The solid line indicates the OR estimate and the broken lines represent the 95% CI. Adjustment was made for age at diagnosis, gender, SEI-code and year of diagnosis. Population based controls were used. (Hardell et al *Int J Oncol.* 2013;43:1833-1845. Epub 2013 Sep 24)

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Electromagnetic pollution from phone masts. Effects on wildlife

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Abstract

A review on the impact of radiofrequency radiation from wireless telecommunications on wildlife is presented. Electromagnetic radiation is a form of environmental pollution which may hurt wildlife. Phone masts located in their living areas are irradiating continuously some species that could suffer long-term effects, like reduction of their natural defenses, deterioration of their health, problems in reproduction and reduction of their useful territory through habitat deterioration. Electromagnetic radiation can exert an aversive behavioral response in rats, bats and birds such as sparrows. Therefore microwave and radiofrequency pollution constitutes a potential cause for the decline of animal populations and deterioration of health of plants living near phone masts. To measure these effects urgent specific studies are necessary.

Keywords: Effects on wildlife; Effects on birds; Electromagnetic radiation; Mammals; Microwaves; Mobile telecommunications; Non-thermal effects; Phone masts; Radiofrequencies

1. Introduction

Life has evolved under the influence of two omnipresent forces: gravity and electromagnetism. It should be expected that both play important roles in the functional activities of organisms [1]. Before the 1990's radiofrequencies were mainly from a few radio and television transmitters, located in remote areas and/or very high places. Since the introduction of wireless telecommunication in the 1990's the rollout of phone networks has caused a massive increase in electromagnetic pollution in cities and the countryside [2,3].

Multiple sources of mobile communication result in chronic exposure of a significant part of the wildlife (and man) to microwaves at non-thermal levels [4]. In recent years, wildlife has been chronically exposed to microwaves and RFR (Radiofrequency radiation) signals from various sources, including GSM and UMTS/3G wireless phones and base stations, WLAN (Wireless Local Area Networks), WPAN (Wireless Personal Area Networks such as Bluetooth), and DECT (Digital Enhanced (former European) Cordless Telecommunications) that are erected indiscriminately without studies of environmental impact measuring long-term effects. These exposures are characterized by low intensities, varieties of signals, and long-term durations. The greater portion of this exposure is from mobile telecommunications (geometric mean in Vienna: 73% [5]). In Germany the GSM cellular phone tower radiation is the dominating high frequency source in residential areas [6]. Also GSM is the dominating high frequency source in the wilderness of Spain (personal observation).

Numerous experimental data have provided strong evidence of athermal microwave effects and have also indicated several regularities in these effects: dependence of frequency within specific frequency windows of "resonance-type"; dependence on modulation and polarization; dependence on intensity within specific intensity windows, including super-low power density comparable with intensities from base stations/masts [4,7–9]. Some studies have demonstrated different microwave effects depending on wavelength in the range of mm, cm or m [10,11]. Duration of exposure may be as important as power density. Biological effects resulting from electromagnetic field radiation might depend on dose, which indicates long-term accumulative effects [3,9,12]. Modulated and pulsed radiofrequencies seem to be more effective in producing effects [4,9]. Pulsed waves (in blasts), as well as certain low frequency modulations exert greater

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biological activity [11,13–15]. This observation is important because cell phone radiation is pulsed microwave radiation modulated at low frequencies [8,9].

Most of the attention on possible biological effects of electromagnetic radiation from phone masts has been focused on human health [5,16–21]. The effects of electromagnetic pollution on wildlife, have scarcely been studied [22–25].

The objective of this review is to detail advances in knowledge of radiofrequencies and microwave effects on wildlife. Future research may help provide a better understanding of electromagnetic field (EMF) effects on wildlife and plants and their conservation.

2. Effects on exposed wildlife

2.1. Effects on birds

2.1.1. Effects of phone mast microwaves on white stork

In monitoring a white stork (*Ciconia ciconia*) population in Valladolid (Spain) in vicinity of Cellular Phone Base Stations, the total productivity in nests located within 200 m of antennae, was 0.86 ± 0.16. For those located further than 300 m, the result was practically doubled, with an average of 1.6 ± 0.14. Very significant differences among total productivity were found ($U = 240$; $P = 0.001$, Mann–Whitney test). Twelve nests (40%) located within 200 m of antennae never had chicks, while only one (3.3%) located further than 300 m had no chicks. The electric field intensity was higher on nests within 200 m (2.36 ± 0.82 V/m) than nests further than 300 m (0.53 ± 0.82 V/m). In nesting sites located within 100 m of one or several cellsite antennae with the main beam of radiation impacting directly (Electric field intensity >2 V/m) many young died from unknown causes. Couples frequently fought over nest construction sticks and failed to advance the construction of the nests. Some nests were never completed and the storks remained passively in front of cellsite antennae. These results indicate the possibility that microwaves are interfering with the reproduction of white stork [23]. (Fig. 1)

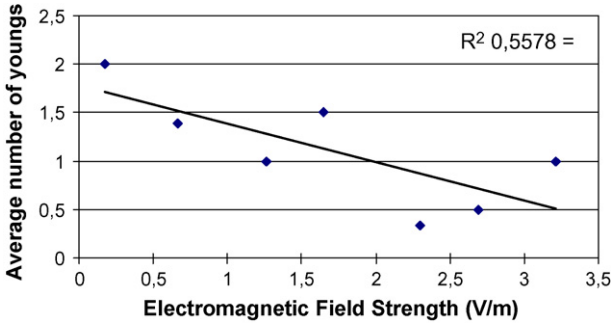

Fig. 1. Average number of youngs and electric field intensity (V/m) in 60 nests of white storks (*Ciconia ciconia*) (Hallberg, Ö with data of Balmori, 2005 [23]).

2.1.2. Effects of phone mast microwaves on house sparrows

A possible effect of long-term exposure to low-intensity electromagnetic radiation from mobile phone (GSM) base stations on the number of house sparrows during the breeding season was studied in Belgium. The study was carried out sampling 150 point locations within six areas to examine small-scale geographic variation in the number of house sparrow males and the strength of electromagnetic radiation from base stations. Spatial variation in the number of house sparrow males was negative and highly significantly related to the strength of electric fields from both the 900 and 1800 MHz downlink frequency bands and from the sum of these bands (Chi-square-tests and AIC-criteria, $P < 0.001$). This negative relationship was highly similar within each of the six study areas, despite differences among areas in both the number of birds and radiation levels. Fewer house sparrow males were seen at locations with relatively high electric field strength values of GSM base stations and therefore support the notion that long-term exposure to higher levels of radiation negatively affects the abundance or behavior of house sparrows in the wild [24].

In another study with point transect sampling performed at 30 points visited 40 times in Valladolid (Spain) between 2002 and 2006, counting the sparrows and measuring the mean electric field strength (radiofrequencies and microwaves: 1 MHz to 3 GHz range). Significant declines ($P = 0.0037$) were observed in mean bird density over time, and significantly low bird density was observed in areas with high electric field strength. The logarithmic regression of the mean bird density vs. field strength groups (considering field strength in 0.1 V/m increments) was $R = -0.87$; $P = 0.0001$ According to this calculation, no sparrows would be expected to be found in an area with field strength >4 V/m [25]. (Fig. 2)

In the United Kingdom a decline of several species of urban birds, especially sparrows, has recently happened [26]. The sparrow population in England has decreased in the last 30 years from 24 million to less than 14. The more abrupt decline, with 75% descent has taken place from 1994 to 2002. In 2002, the house sparrow was added to the Red List of U.K. endangered species [27]. This coincides with the rollout of mobile telephony and the

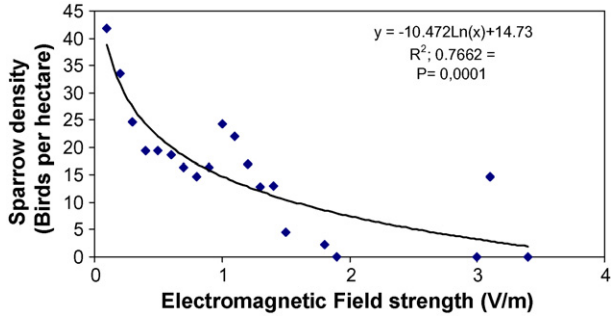

Fig. 2. Mean sparrow density as a function of electric field strength grouped in 0.1 V/m. (Balmori and Hallberg, 2007 [25]).

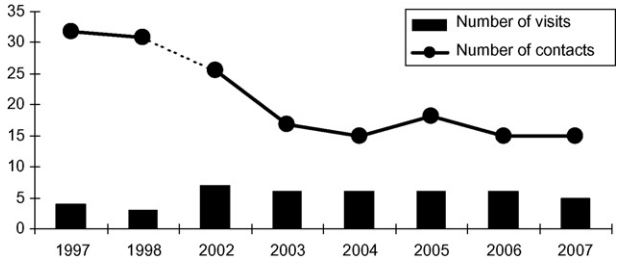

Fig. 3. Annual number of contacts (Mean) for 14 species studied in "Campo Grande" urban park (lack the information of the years 1999–2001).

possible relationship of both circumstances should be investigated.

In Brussels, many sparrows have disappeared recently [28]; similar declines have been reported in Dublin [29]. Van der Poel (cited in Ref. [27]) suggested that sparrows might be declining in Dutch urban centres also.

2.1.3. *Effects on the bird community at an urban park*

Microwaves may be affecting bird populations in places with high electromagnetic pollution. Since several antennas were installed in proximities of "Campo Grande" urban park (Valladolid, Spain) the bird population has decreased and a reduction of the species and breeding couples has occurred. Between 1997 and 2007, of 14 species, 3 species have disappeared, 4 are in decline and 7 stay stable (Balmori, unpublished data) (Fig. 3). In this time the air pollution (SO2, NO2, CO and Benzene) has diminished.

During the research some areas called "silence areas" contaminated with high microwave radiation (>2 V/m), where previously different couples usually bred and later disappeared, have been found. Several anomalies in magpies (*Pica pica*) were detected: plumage deterioration, locomotive problems (limps and deformations in the paws), partial albinism and melanism, especially in flanks [30]. Recently cities have increased cases of partial albinism and melanism in birds (*Passer domesticus*, *Turdus merula* and *P. pica*) (personal observation).

2.1.4. *Possible physiological mechanisms of the effects found in birds*

Current scientific evidence indicates that prolonged exposure to EMFs, at levels that can be encountered in the environment, may affect immune system function by affecting biological processes [3,31,32]. A stressed immune system may increase the susceptibility of a bird to infectious diseases, bacteria, viruses, and parasites [33].

The plumage of the birds exposed to microwaves looked, in general, discolorated and lack of shine. This not only occurred in ornamental birds; such as peacocks, but also in wild birds; such as, tits, great tits, house sparrows, etc (personal observation). We must mention that plumage deterioration is the first sign of weakening or illnesses in birds since damaged feathers are a sure sign of stress.

Physiological conditions during exposure minimize microwave effects. Radical scavengers/antioxidants might be involved in effects of microwaves [4].

Microwaves used in cellphones produce an athermal response in several types of neurons of the birds nervous system [34]. Several studies addressed behavior and teratology in young birds exposed to electromagnetic fields [23,25,35–37]. Most studies indicate that electromagnetic field exposure of birds generally changes, but not always consistently in effect or in direction, their behavior, reproductive success, growth and development, physiology and endocrinology, and oxidative stress [37]. These results can be explained by electromagnetic fields affecting the birds' response to the photoperiod as indicated by altered melatonin levels [38].

Prolonged mobile phone exposure may have negative effects on sperm motility characteristics and male fertility as has been demonstrated in many studies made in man and rats [39–46]. EMF and microwaves can affect reproductive success in birds [23,25,35,36,47]. EMF exposure affected reproductive success of kestrels (*Falco sparverius*), increasing fertility, egg size, embryonic development and fledging success but reducing hatching success [35,36].

The radiofrequency and microwaves from mobile telephony can cause genotoxic effects [48–55]. Increases in cytological abnormalities imply long-term detrimental effects since chromosomal damage is a mechanism relevant to causation of birth defects and cancer [55].

Long-term continuous, or daily repeated EMF exposure can induce cellular stress responses at non-thermal power levels that lead to an accumulation of DNA errors and to inhibition of cell apoptosis and cause increased permeability of blood–brain barrier due to stabilization of endothelial cell stress fibers. Repeated occurrence of these events over a long period of time (years) could become a health hazard due to a possible accumulation of brain tissue damage. These findings have important implications with regards to potential dangers from prolonged and repeated exposure to non-ionizing radiation [56,57].

Pulsed magnetic fields can have a significant influence on the development and incidence of abnormalities in chicken embryos. In five of six laboratories, exposed embryos exhibited more structural anomalies than controls. If the data from all six laboratories are pooled, the difference for the incidence of abnormalities in exposed embryos and controls is highly significant [58]. Malformations in the nervous system and heart, and delayed embryo growth are observed. The embryo is most sensitive to exposure in the first 24 h of incubation [58]. An increase in the mortality [59] and appearance of morphological abnormalities, especially of the neural tube [13,60,61] has been recorded in chicken embryos exposed to pulsed magnetic fields, with different susceptibility among individuals probably for genetic reasons. A statistically significant high mortality rate of chicken embryos subjected to radiation from a cellphone, compared to the control group exists [62,63]. In another study eggs exposed to a magnetic

field intensity of 0.07 T showed embryonic mortality during their incubation was higher. The negative effect of the magnetic field was manifested also by a lower weight of the hatched chicken [64]. Bioelectric fields have long been suspected to play a causal role in embryonic development. Alteration of the electrical field may disrupt the chemical gradient and signals received by embryo cells. It appears that in some manner, cells sense their position in an electrical field and respond appropriately. The disruption of this field alters their response. Endogenous current patterns are often correlated with specific morphogenetic events [65].

Available data suggests dependencies of genotype, gender, physiological and individual factors on athermal microwave effects [4,9]. Genomic differences can influence cellular responses to GSM Microwaves. Data analysis has highlighted a wide inter-individual variability in response, which was replicated in further experiments [4]. It is possible that each species and each individual, show different susceptibility to radiation, since vulnerability depends on genetic tendency, and physiologic and neurological state of the irradiated organism [15,35–37,61,66–68]. Different susceptibility of each species has also been proven in wild birds exposed to electromagnetic fields from high-voltage power lines [47].

2.2. Effects on mammals

2.2.1. Alarm and aversion behavior

Rats spent more time in the halves of shuttle boxes that were shielded from 1.2 GHz. Microwaves irradiation. The average power density was about 0.6 mW/cm^2. Data revealed that rats avoided the pulsed energy, but not the continuous energy, and less than 0.4 mW/cm^2 average power density was needed to produce aversion [69]. Navakatikian & Tomashevskaya [70] described a complex series of experiments in which they observed disruption of rat behavior (active avoidance) from radiofrequency radiation. Behavioral disruption was observed at a power density as low as 0.1 mW/cm^2 (0.027 W/kg). Mice in an experimental group exposed to microwave radiation expressed visible individual panic reaction, disorientation and a greater degree of anxiety. In the sham exposed group these deviations of behavior were not seen and all animals show collective defense reaction [71]. Microwave radiation at 1.5 GHz pulsing 16 ms. At 0.3 mW/cm^2 power density, in sessions of 30 min/day over one month produced anxiety and alarm in rabbits [72].

Electromagnetic radiation can exert an aversive behavioral response in bats. Bat activity is significantly reduced in habitats exposed to an electromagnetic field strength greater than 2 V/m [73]. During a study in a free-tailed bat colony (*Tadarida teniotis*) the number of bats decreased when several phone masts were placed 80 m from the colony [74].

2.2.2. Deterioration of health

Animals exposed to electromagnetic fields can suffer a deterioration of health and changes in behavior [75,76].

There was proof of frequent death in domestic animals; such as, hamsters and guinea pigs, living near mobile telecommunication base stations (personal observation).

The mice in an experimental group exposed to microwave radiation showed less weight gain compared to control, after two months. The amount of food used was similar in both groups [71]. A link between electromagnetic field exposure and higher levels of oxidative stress appears to be a major contributor to aging, neurodegenerative diseases, immune system disorders, and cancer in mammals [33].

The effects from GSM base transceiver station (BTS) frequency of 945 MHz on oxidative stress in rats were investigated. When EMF at a power density of 3.67 W/m^2, below current exposure limits, were applied, MDA (malondialdehyde) level was found to increase and GSH (reduced glutathione) concentration was found to decrease significantly ($P < 0.0001$). Additionally, there was a less significant ($P = 0.0190$) increase in SOD (superoxide dismutase) activity under EM exposure [77].

2.2.3. Problems in reproduction

In the town of Casavieja (Ávila, Spain) a telephony antenna was installed that had been in operation for about 5 years. Then some farmers began blaming the antenna for miscarriages in many pigs, 50–100 m from the antenna (on the outskirts of the town). Finally the topic became so bad that the town council decided to disassemble the antenna. It was removed in the spring 2005. From this moment onwards the problems stopped (C. Lumbreras personal communication).

A Greek study reports a progressive drop in the number of rodent births exposed to radiofrequencies. The mice exposed to 0.168 μW/cm^2 become sterile after five generations, while those exposed to 1.053 μW/cm^2 became sterile after only three generations [22].

In pregnant rats exposed to 27.12 MHz continuous waves at 100 μW/cm^2 during different periods of pregnancy, half the pregnancies miscarried before the twentieth day of gestation, compared to only a 6% miscarriage rate in unexposed controls, and 38% of the viable foetuses had incomplete cranial ossification, compared to less than 6% of the controls. Findings included a considerable increase in the percentage of total reabsorptions (post-implantation losses consequent to RF radiation exposure in the first post-implantation stage). Reduced body weight in the exposed dams reflected a negative influence on their health. It seems that the irradiation time plays an important role in inducing specific effects consequent to radiofrequency radiation exposure [78]. There was also a change in the sex ratio, with more males born to rats that had been irradiated from the time of conception [2]. Moorhouse and Macdonald [79] find a substantial decline in female Water Vole numbers in the radio-collared population, apparently resulting from a male skew in the sex ratios of offspring born to this population. Recruits to the *radio-tracked* population were skewed heavily in favour of males (43:13). This suggests that radio-collaring of females caused male-skewed sex ratios.

Mobile phone exposure may have negative effects on sperm motility characteristics and male fertility in rats [46]. Other studies find a decrease of fertility, increase of deaths after birth and dystrophic changes in their reproductive organs [11]. Intermittent exposure showed a stronger effect than continuous exposure [4]. Brief, intermittent exposure to low-frequency EM fields during the critical prenatal period for neurobehavioral sex differentiation can demasculinize male scent marking behavior and increase accessory sex organ weights in adulthood [80].

In humans, magnetic field exposures above 2.0 mG were positively associated with miscarriage risk [81]. Exposure of pregnant women to mobile phone significantly increased foetal and neonatal heart rate, and significantly decreased the cardiac output [82].

2.2.4. Nervous system

Microwaves may affect the blood brain barrier which lets toxic substances pass through from the blood to the brain [83]. Adang et al. [84] examined the effect of microwave exposure to a GSM-like frequency of 970 MHz pulsed waves on the memory in rats by means of an object recognition task. The rats that have been exposed for 2 months show normal exploratory behavior. The animals that have been exposed for 15 months show derogatory behavior. They do not make the distinction between a familiar and an unfamiliar object. In the area that received radiation directly from "Location Skrunda Radio Station" (Latvia), exposed children had less developed memory and attention, their reaction time was slower and neuromuscular apparatus endurance was decreased [85]. Exposure to cell phones prenatally and, to a lesser degree, postnatally was associated with behavioral difficulties such as emotional and hyperactivity problems around 7 years of age [86]. Electromagnetic radiation caused modification of sleep and alteration of cerebral electric response (EEG) [87–89]. Microwave radiation from phone masts may cause aggressiveness in people and animals (personal observation).

2.3. Effects on amphibians

Disappearance of amphibians and other organisms is part of the global biodiversity crisis. An associated phenomenon is the appearance of large numbers of deformed amphibians. The problem has become more prevalent, with deformity rates up to 25% in some populations, which is significantly higher than previous decades [90]. Balmori [91] proposed that electromagnetic pollution (in the microwave and radiofrequency range) is a possible cause for deformations and decline of some wild amphibian populations.

Two species of amphibians were exposed to magnetic fields at various stages of development. A brief treatment of early amphibian embryos produced several types of abnormalities [92]. Exposure to a pulsed electromagnetic field produced abnormal limb regeneration in adult Newts [93]. Frog tadpoles (*Rana temporaria*) developed under electromagnetic field (50 Hz, 260 A/m) have increased mortality. Exposed tadpoles developed more slowly and less synchronously than control tadpoles and remain at the early stages for longer. Tadpoles developed allergies and EMF caused changes in blood counts [94].

In a current study exposing eggs and tadpoles ($n = 70$) of common frog (*R. temporaria*) for two months, from the phase of eggs until an advanced phase of tadpole, to four telephone base stations located 140 m away: with GSM system 948.0–959.8 MHz; DCS system: 1830.2–1854.8; 1855.2–1879.8 MHz. and UMTS system: 1905–1910; 1950–1965; 2140–2155 MHz. (electric field intensity: 1.847–2.254 V/m). A low coordination of movements, an asynchronous growth, with big and small tadpoles, and a high mortality (90%) was observed. The control group ($n = 70$), under the same conditions but inside a Faraday cage (metallic shielding component: EMC-reinforcement fabrics 97442 Marburg Technic), the coordination of movements was normal, the development was synchronously and the mortality rate was only 4.2% [95].

2.4. Effects on insects

The microwaves may affect the insects. Insects are the basis and key species of ecosystems and they are especially sensitive to electromagnetic radiation that poses a threat to nature [96].

Carpenter and Livstone [97] irradiated pupae of Tenebrio molitor with 10 GHz microwaves at 80 mW for 20–30 min and 20 mW for 120 min obtained a rise in the proportion of insects with abnormalities or dead. In another study exposing fruit flies (*Drosophila melanogaster*) to mobile phone radiation, elevated stress protein levels (Hsp70) was obtained, which usually means that cells are exposed to adverse environmental conditions ('non-thermal shock') [98]. Panagopoulos et al. [99] exposed fruit flies (*D. melanogaster*) to radiation from a mobile phone (900 MHz) during the 2–5 first days of adulthood. The reproductive capacity of the species reduced by 50–60% in modulated radiation conditions (emission while talking on the phone) and 15–20% with radiation nomodulated (with the phone silent). The results of this study indicate that this radiation affects the gonadal development of insects in an athermal way. The authors concluded that radio frequencies, specifically GSM, are highly bioactive and provoke significant changes in physiological functions of living organisms. Panagopoulos et al. [100] compare the biological activity between the two systems GSM 900 MHz and DCS 1800 MHz in the reproductive capacity of fruit flies. Both types of radiation were found to decrease significantly and non-thermally the insect's reproductive capacity, but GSM 900 MHz seems to be even more bioactive than DCS 1800 MHz. The difference seems to be dependent mostly on field intensity and less on carrier frequency.

A study in South Africa finds a strong correlation between decrease in ant and beetle diversity with the

electromagnetic radiation exposure (D. MacFadyen, personal communication.). A decrease of insects and arachnids near base stations was detected and corroborated by engineers and antenna's maintenance staff [101]. In houses near antennas an absence of flies, even in summer, was found.

In a recent study carried out with bees in Germany, only a few bees irradiated with DECT radiation returned to the beehive and they needed more time. The honeycomb weight was lower in irradiated bees [102]. In recent years a "colony collapse disorder" is occurring that some authors relate with pesticides and with increasing electromagnetic pollution [96].

The disappearance of insects could have an influence on bird's weakening caused by a lack of food, especially at the first stages in a young bird's life.

2.5. *Effects on trees and plants*

The microwaves may affect vegetables. In the area that received radiation directly from "Location Skrunda Radio Station" (Latvia), pines (*Pinus sylvestris*) experienced a lower growth radio. This did not occur beyond the area of impact of electromagnetic waves. A statistically significant negative correlation between increase tree growth and intensity of electromagnetic field was found, and was confirmed that the beginning of this growth decline coincided in time with the start of radar emissions. Authors evaluated other possible environmental factors which might have intervened, but none had noticeable effects [103]. In another study investigating cell ultrastructure of pine needles irradiated by the same radar, there was an increase of resin production, and was interpreted as an effect of stress caused by radiation, which would explain the aging and declining growth and viability of trees subjected to pulsed microwaves. They also found a low germination of seeds of pine trees more exposed [104]. The effects of Latvian radar was also felt by aquatic plants. *Spirodela polyrrhiza* exposed to a power density between 0.1 and 1.8 $\mu W/cm^2$ had lower longevity, problems in reproduction and morphological and developmental abnormalities compared with a control group who grew up far from the radar [105].

Chlorophylls were quantitatively studied in leaves of black locust (*Robinia pseudoacacia* L.) seedlings exposed to high frequency electromagnetic fields of 400 MHz. It was revealed that the ratio of the two main types of chlorophyll was decreasing logarithmically to the increase of daily exposure time [106].

Exposed tomato plants (*Lycopersicon esculentum*) to low level (900 MHz, 5 V/m) electromagnetic fields for a short period (10 min) measured changes in abundance of three specific mRNA after exposure, strongly suggesting that they are the direct consequence of application of radio-frequency fields and their similarities to wound responses suggests that this radiation is perceived by plants as an injurious stimulus [107]. Non-thermal exposure to radiofrequency fields induced oxidative stress in duckweed (*Lemna minor*) as well as unespecific stress responses, especially of antioxidative enzymes [108].

For some years progressive deterioration of trees near phone masts have been observed in Valladolid (Spain). Trees located inside the main lobe (beam), look sad and feeble, possibly slow growth and a high susceptibility to illnesses and plagues. In places we have measured higher electric field intensity levels of radiation (>2 V/m) the trees show a more notable deterioration [109]. The tops of trees are dried up where the main beams are directed to, and they seem to be most vulnerable if they have their roots close to water. The trees don't grow above the height of the other ones and, those that stand out far above, have dried tops (Hargreaves, personal communication and personal observation). White and black poplars (*Populus sp*.) and willows (*Salix sp*.) are more sensitive. There may be a special sensitivity of this family exists or it could be due to their ecological characteristics forcing them to live near water, and thus electric conductivity. Other species as *Platanus sp*. and *Lygustrum japonicum,* are more resistant (personal observation). Schorpp [110] presents abundant pictures and explanations of what happens to irradiated trees.

3. Conclusions

This literature review shows that pulsed telephony microwave radiation can produce effects especially on nervous, cardiovascular, immune and reproductive systems [111]:

- Damage to the nervous system by altering electroencephalogram, changes in neural response or changes of the blood–brain barrier.
- Disruption of circadian rhythms (sleep–wake) by interfering with the pineal gland and hormonal imbalances.
- Changes in heart rate and blood pressure.
- Impairment of health and immunity towards pathogens, weakness, exhaustion, deterioration of plumage and growth problems.
- Problems in building the nest or impaired fertility, number of eggs, embryonic development, hatching percentage and survival of chickens.
- Genetic and developmental problems: problems of locomotion, partial albinism and melanism or promotion of tumors.

In the light of current knowledge there is enough evidence of serious effects from this technology to wildlife. For this reason precautionary measures should be developed, alongside environmental impact assessments prior to installation, and a ban on installation of phone masts in protected natural areas and in places where endangered species are present. Surveys should take place to objectively assess the severity of effects.

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Raytheon Microwave Gun Recalled Amidst Controversy **Ethical and operational cases against the pain gun**

John Hudson Jul 19, 2010

A controversial microwave weapon called the Active Denial System has been recalled from Afghanistan, according to an Air Force spokesperson. The pain gun generates a targeted burning sensation in humans using millimeter waves. The device was plagued by a series of technical and safety issues. On top of that, a number of public commentators opposed it on humanitarian grounds. There's no official explanation for the recall, but here's what critics have said about it in recent weeks:

- **What Is the Active Denial System?** Sharon Weinberger at AOL News describes it as a "controversial nonlethal weapon that uses microwave energy to create intense pain...The weapon is designed to shoot an invisible beam of energy at people, creating an intense burning sensation that forces them to flee. The Air Force has called it the 'goodbye effect.'"

- **It's Very Effective,** writes the Wall Street Journal's Nathan Hodge, who felt the effects of it firsthand: "I dutifully took my turn. Even though I was standing several hundred meters downrange, I could immediately feel the heat when the operator fired. It wasn't that bad, at first: It was a miserably cold morning, and pain ray gave a nice blast of heat, like someone had opened an oven door right in front of me. But it quickly became unbearable. Instinctively, I stepped away."

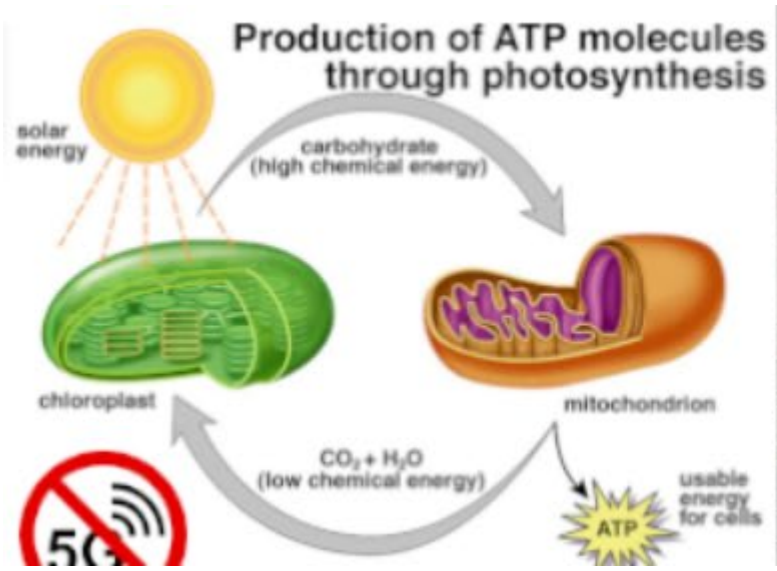
- **Will This Really Help the War Effort?** wonders Noah Shachtman at Wired: "I'm sure they're telling themselves that the generally non-lethal microwave weapon is a better, safer crowd control alternative than an M-16. But those ray-gun advocates better think long and hard about the Taliban's propaganda bonanza when news leaks of the Americans zapping Afghans until they feel roasted alive."

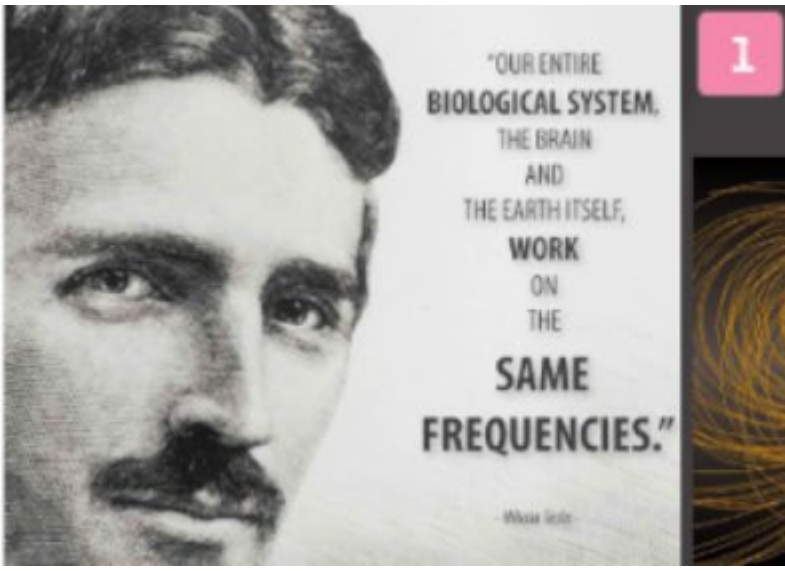
- **This Tactic Is Unconscionable,** writes Digby at Hullabaloo: "Setting aside the fact that using a 'pain ray' in general is a horrible idea, how much more horrible is it to use in a country that already sees itself invaded by men who look like robot insects and where unmanned planes kill targets from a distance? It's hard not to see that as a weapons laboratory on a people who have no means to protest."

- **A Disturbing Trend,** writes Ando Arike at Harper's: "Although 'first-generation' weapons like rubber bullets and pepper spray have gained a certain acceptance, despite their many drawbacks, exotic technologies like the Active Denial System invariably cause public alarm. Nevertheless,The trend is now away from chemical and 'kinetic' weapons that rely on physical trauma and toward post-kinetic weapons that, as researchers put it, 'induce behavioral modification' more discreetly. One indication that the public may come to accept these new weapons has been the successful introduction of the Taser—apparently, even the taboo on electroshock can be overcome given the proper political climate."

Please see effects on Heart: https://www.ncbi.nlm.nih.gov/pubmed/1006224?dopt=Abstract

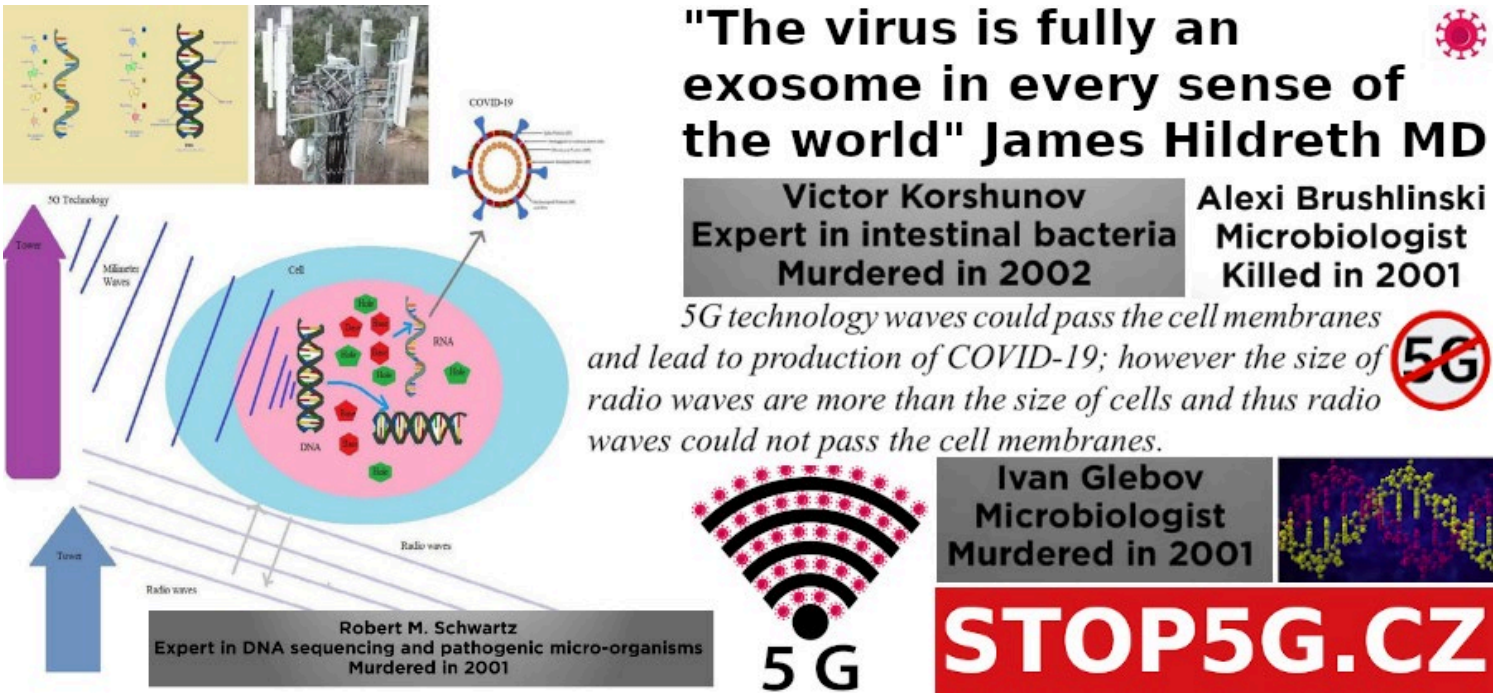
https://stop5g.cz/us/tag/weapons/





Tag: Weapons

How Everyone Will Test Positive For COVID-19 – PCR Tests – 5G Technology and induction of coronavirus in skin cells



If you want to find the secrets of the universe, think in terms of energy, frequency and vibration.

Nicola Tesla

We know that the prescribed PCR tests are not detecting Covid-19 genome. According CDC's own literature (CDC 2019 – Novel Coronavirus 2019-nCoC – Real-time RT-PCR Diagnostic Panel) **Positive results are**

indicative of active infection with 2019-nCoV but do not rule out bacterial infection or co-infection with other viruses. They are detecting all varieties of Coronavirus, including the common cold and counted it as Covid-19.

How Everyone Will Test Positive For COVID-19

A positive test result shows you may have antibodies from an infection with the virus that causes COVID-19. However, there is a chance a positive result means that you have antibodies from an infection with a virus from the same family of viruses called coronaviruses, such as one that causes the common cold.

Having antibodies to the virus that causes COVID-19 may provide protection from getting infected with the virus again.

It has been pointed out for months, that geographical location experiencing the most cases of covid also seem to have active 5g technology. 5G Launches In Wuhan Weeks Before Coronavirus Outbreak After video went viral in which David Icke suggested that 5G somehow responsible for positive cases of Covid-19 YouTube deleted and begin to deleting all videos on the subject.

5G Technology and induction of coronavirus in skin cells

– M. Fioranelli, A. Sepehri, M.G. Roccia1, M. Jafferany, O. Yu. Olisova,K.M. Lomonosov and T. Lotti1,

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This paper gives scientific explanation of relationship between 5G technology and Coronavirus.

In this research, we show that 5G millimeter waves could be absorbed by dermatologic cells acting like antennas, transferred to other cells and play the main role in producing Coronaviruses in biological cells. DNA is built from charged electrons and atoms and has an inductor-like structure. This structure could be divided into linear, toroid and round inductors. Inductors interact with external electromagnetic waves, move and produce some extra waves within the cells. The shapes of these waves are similar to shapes of hexagonal and pentagonal bases of their DNA source. These waves produce some holes in liquids within the nucleus. To fill these holes, some extra hexagonal and pentagonal bases are produced. These bases could join to each other and form virus-like structures such as Coronavirus. To produce these viruses within a cell, it is necessary that the wavelength of external waves be shorter than the size of the cell. Thus 5G millimeter waves could be good candidates for applying in constructing virus-like structures such as Coronaviruses (COVID-19) within cells.

Continue reading “How Everyone Will Test Positive For COVID-19 – PCR Tests – 5G Technology and induction of coronavirus in skin cells”
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Author stop5g.czPosted on 07/31/2020Categories Health Risks, Scientific StudiesTags Biotechnology, Bioweapons, Control Management System, Coronavirus, Covid-19, Directed-Energy-Weapons, Economic & Biological Terrorism, Mitochondria - mtDNA, Nanotechnology, Power behind 5G, Vaccine, Weapons1 Comment on How Everyone Will Test Positive For COVID-19 – PCR Tests – 5G Technology and induction of coronavirus in skin cells

[SPACEX – 5G – Earth in Microwave Oven – Satellites – Frequencies from 10.7 GHz to 86 GHz – Directed Energy Weapons – Palpitations – Abnormality of the Heartbeat]

ON MAY 26, SPACEX FILED an application with the Federal Communications Commission for 30,000 "next-generation" ("Gen2") satellites. They should orbit at between 328 km (203 miles) and 614 km (380 miles) in altitude. They should use frequencies from 10.7 GHz to 86 GHz. They should aim focused beams that can cover the Earth in a mosaic of overlapping cells, each cell being about 8 kilometers in diameter (5G Apocalypse – The Extinction Event). Wake up people!

The databases filed with the FCC by SpaceX indicate that 40,700 1-MHz channels are available to each satellite, and that a minimum of 7.8125 MHz of spectrum is needed for each user, if it's counted them correctly. Which means the Gen2 Starlink satellites could be capable of serving up to 150 million Internet users at the same time. (Project BlueBeam – Directed Energy Weapons, Holograms in the Sky, 5G Satellites, LRAD – Medusa)

This is not a good thing

Arthur Firstenberg requested to hear from people who have been having heart palpitations since April 22. With its launch of 60 more satellites on April 22, SpaceX brought the number of its "first generation" ("Gen1") satellites up to 420, which is the number it had previously announced it needed for "minor" coverage of the mid-latitudes to about 56 degrees north and south. The responses to my request have come from far and wide, and I find them extremely disturbing. Here are some of them: ***"I had a horrible bout of palpitations one evening while upstairs,"*** wrote Julie from Bulgaria. "I keep a journal and had recorded it, as I felt as though I was going to pass out or worse! The date? The 23rd of April."

"I checked my calendar back on April 22," wrote Crystal from California. "Yes indeed, I was a MESS that day with heart palpitations. I was also extremely dizzy, fatigued, confused, irritable and bloated. I was such a mess."

"Not only have I been having heart palpitations for three weeks now," wrote Elena from France on May 20, "I am having breathing difficulties. I am only 33 and in perfect health otherwise, doing a lot of sport and eating well. There have been a couple of nights when I thought I would have a heart attack, I was suffocating, could not breathe and my heart was beating so hard and fast, you could hear it from another room."

"In April about the 22nd I awakened with double vision," wrote John from Alabama. "I went to the ER and a CT scan was done and I was referred to a neurologist. He said that I had a stroke."

"I love earthing – just walking barefoot on the earth," wrote Suzy from England. "I have noticed these last days that when I put my feet on the earth I feel like there is a jagged vibration instead of the peace that I usually experience."

"For the last month or so I have been getting the most heavy and intense heart palpitations I have ever experienced," wrote Ivan from British Columbia, Canada on May 20. "Also in this last month my ability to get a good night's sleep has deteriorated significantly for no apparent reason."

"I have been having heart palpitations," wrote Rebecca from the state of Washington on May 21, "and my nine-year-old daughter has been complaining of feeling heartbeat in her head and even her legs. This began a few weeks ago."

Continue reading "SPACEX – 5G – Earth in Microwave Oven – Satellites – Frequencies from 10.7 GHz to 86 GHz – Directed Energy Weapons – Palpitations – Abnormality of the Heartbeat"
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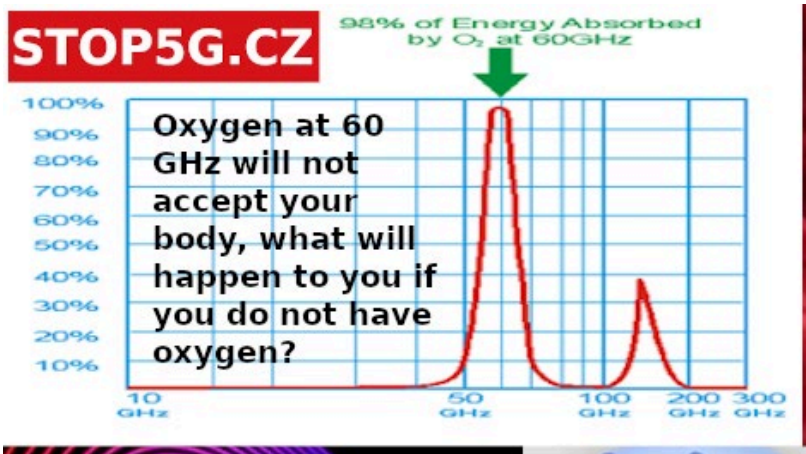
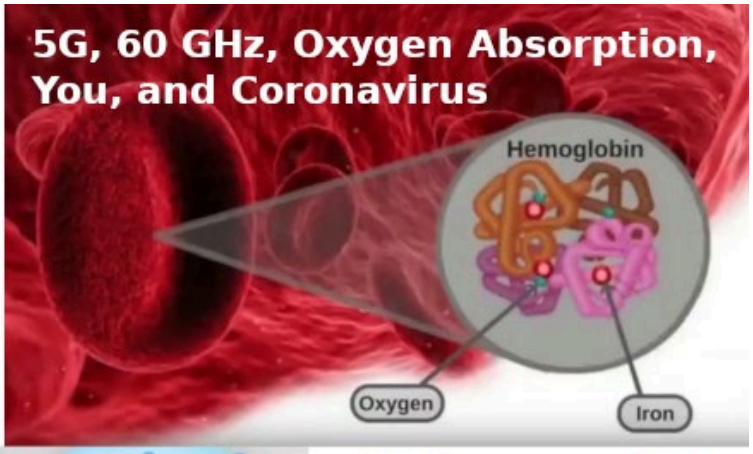
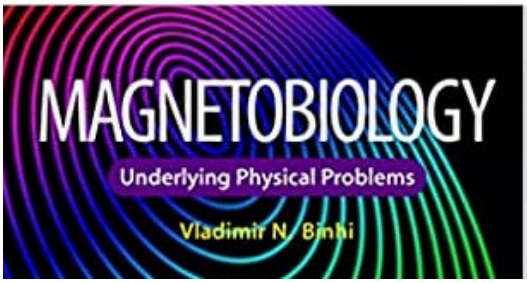
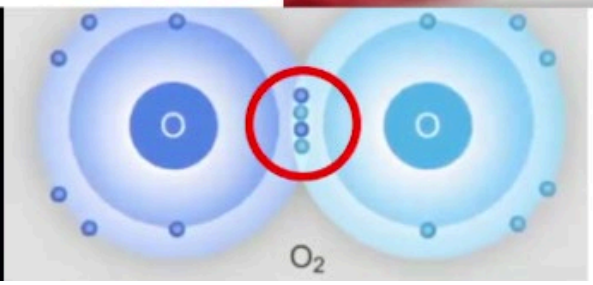
Author stop5g.czPosted on 06/04/2020Categories Cancer, Health Risks, Killing The NatureTags Bioweapons, Control Management System, Directed-Energy-Weapons, Economic & Biological Terrorism, Health Effects, Health Hazard, HIgh-Powered-Laser, Holograms in the Sky, Power behind 5G, Secret Militarized Armaments in Residential Technology, Secret-Space-Program, Weapons

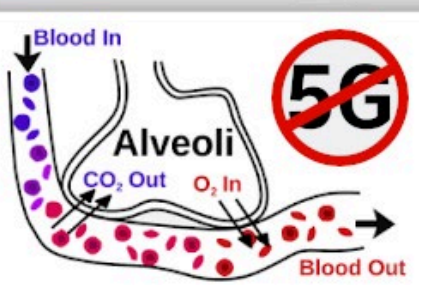
5G – 60GHz Wireless Network – Oxygen Absorption – Unable to Breath











Oxygen the atom is O. Oxygen the molecule is 0^2. Two atoms together. These two atoms form the oxygen molecule and share some electrons. 60 GHz causes electrons surrounding oxygen molecules to spin, akin to how high-powered microwaves running on 2.4 impact molecules in food such as water. They're heating, in part, by

impacting those molecules to rotate or oscillate with each wave. The movement energy from the rotation of these super tiny water molecules helps heat the rest of the food.

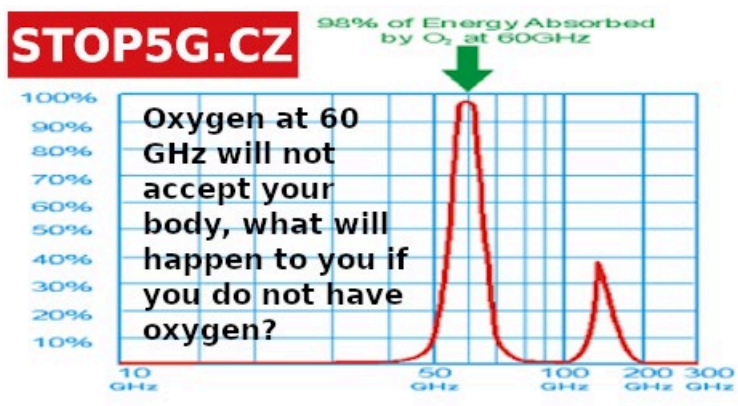
In a similar way that 2.4 causes H^20 to oscillate, 5G/60 GHz even at low power causes electrons on oxygen molecules to spin; changes to the spin frequencies on oxygen electrons impact human biology.

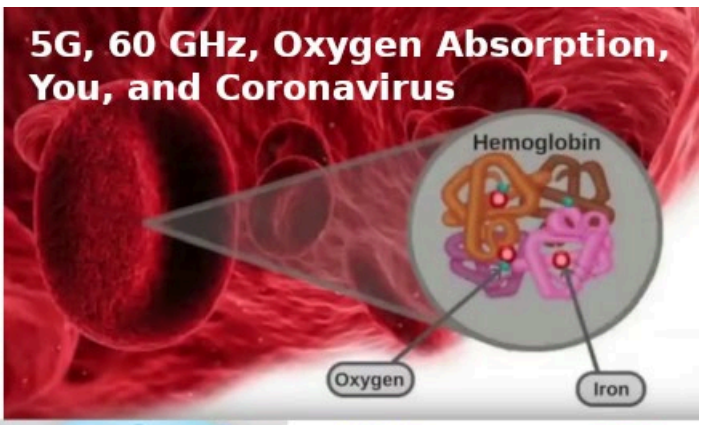
The *impact of oxygen molecules spinning the electrons is that it makes the hemoglobin unable to uptake the oxygen and get it to the rest of your body.*

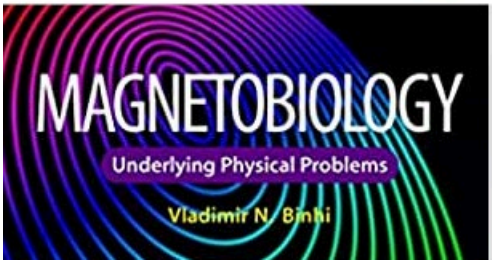
60GHz Wireless Network

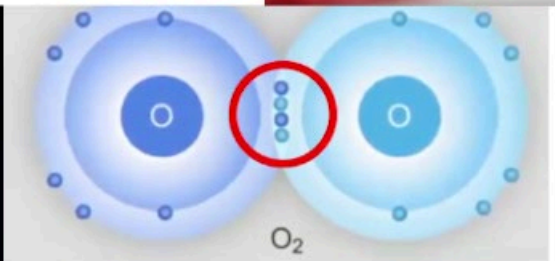
60GHz V-band wireless has many technical advantages as High speed links or lack of interference. The 57-64 GHz band is located in the millimeter-wave portion of the electromagnetic spectrum, where the wavelength varies from ten millimeters (30 GHz) down to one millimeter (300 GHz).

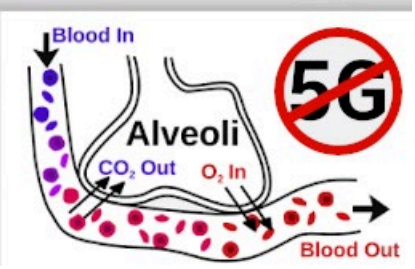
[Continue reading "5G – 60GHz Wireless Network – Oxygen Absorption – Unable to Breath"]

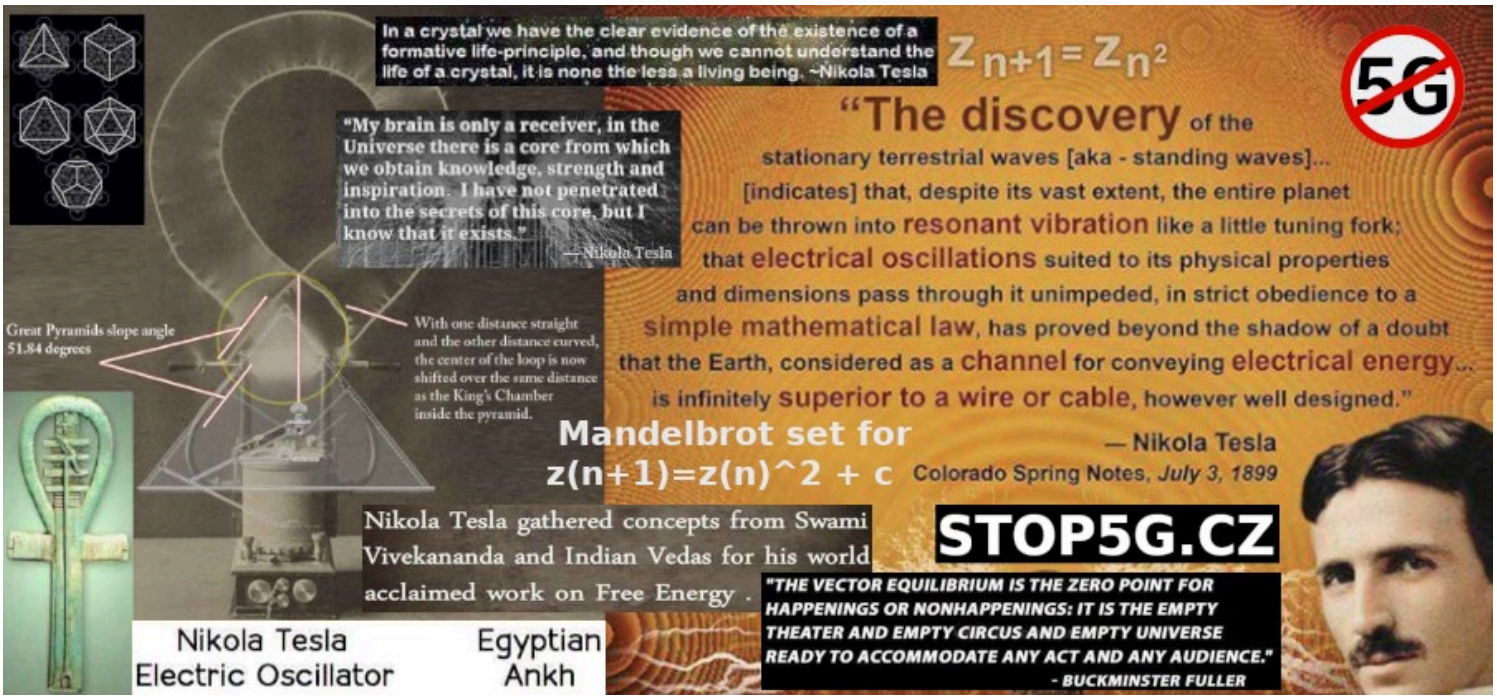


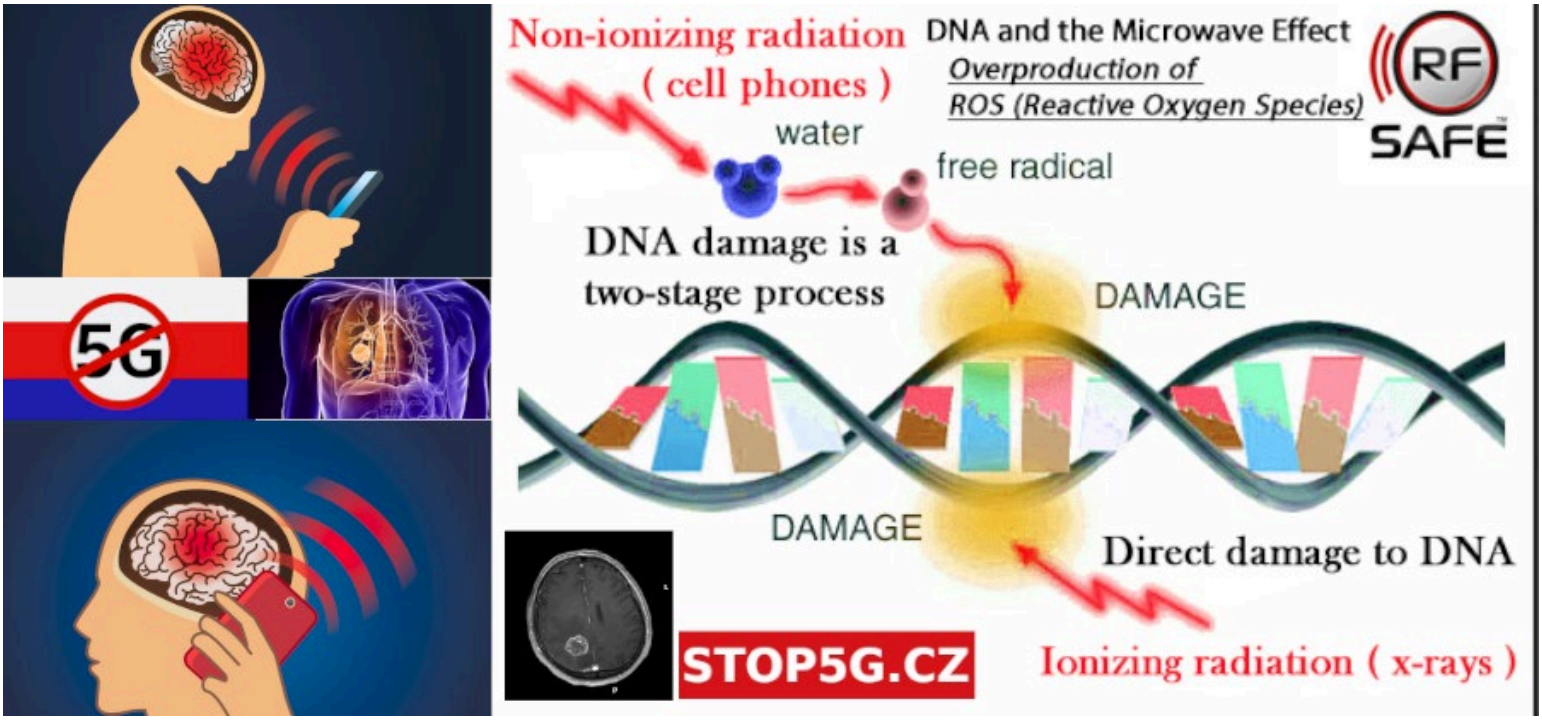


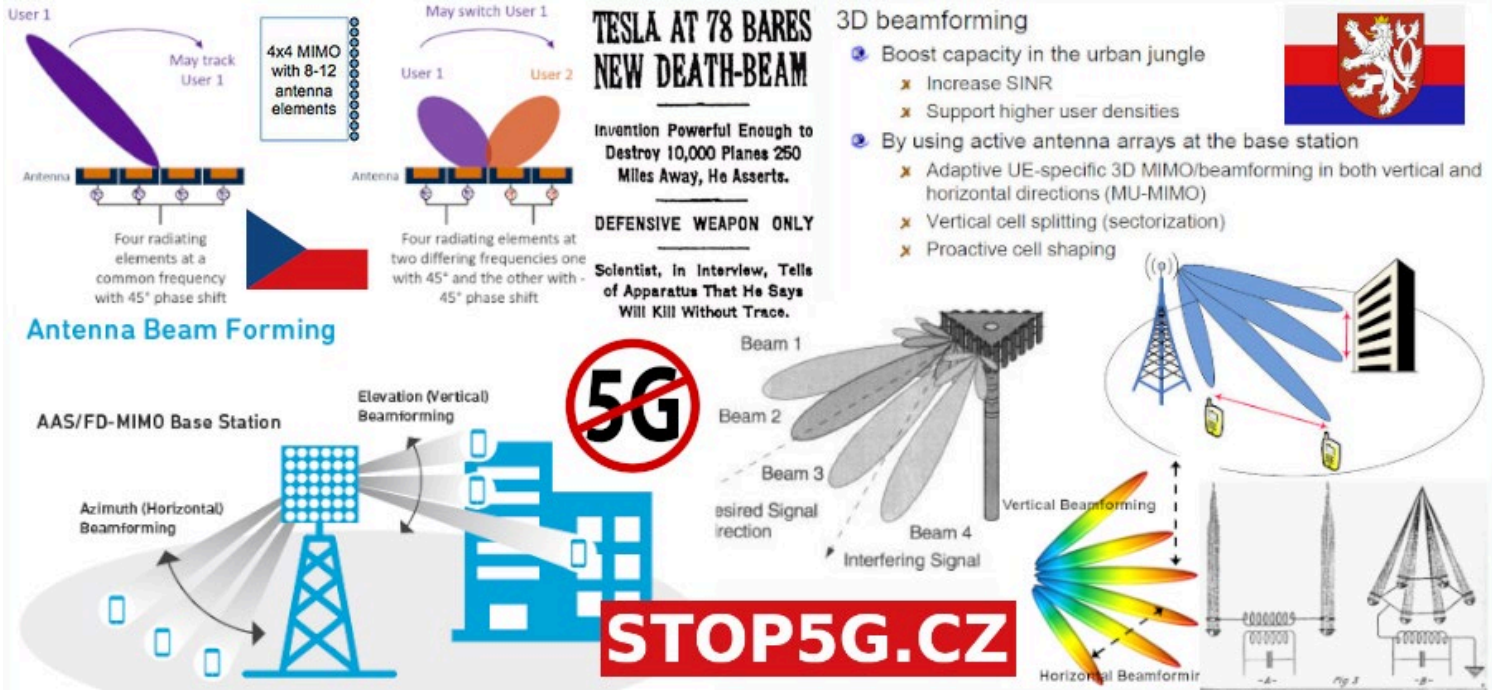







In a crystal we have the clear evidence of the existence of a formative life-principle, and though we cannot understand the life of a crystal, it is none the less a living being. ~Nikola Tesla
$z_{n+1} = z_n^2$
5G
"My brain is only a receiver, in the Universe there is a core from which we obtain knowledge, strength and inspiration. I have not penetrated into the secrets of this core, but I know that it exists."
—Nikola Tesla
"The discovery of the stationary terrestrial waves [aka - standing waves]... [indicates] that, despite its vast extent, the entire planet can be thrown into resonant vibration like a little tuning fork; that electrical oscillations suited to its physical properties and dimensions pass through it unimpeded, in strict obedience to a simple mathematical law, has proved beyond the shadow of a doubt that the Earth, considered as a channel for conveying electrical energy... is infinitely superior to a wire or cable, however well designed."
— Nikola Tesla
Colorado Spring Notes, July 3, 1899
Great Pyramids slope angle 51.84 degrees
With one distance straight and the other distance curved, the center of the loop is now shifted over the same distance as the King's Chamber inside the pyramid.
Mandelbrot set for z(n+1)=z(n)^2 + c
Nikola Tesla gathered concepts from Swami Vivekananda and Indian Vedas for his world acclaimed work on Free Energy .
STOP5G.CZ
"THE VECTOR EQUILIBRIUM IS THE ZERO POINT FOR HAPPENINGS OR NONHAPPENINGS: IT IS THE EMPTY THEATER AND EMPTY CIRCUS AND EMPTY UNIVERSE READY TO ACCOMMODATE ANY ACT AND ANY AUDIENCE."
- BUCKMINSTER FULLER
Nikola Tesla Electric Oscillator
Egyptian Ankh


5G
Non-ionizing radiation (cell phones)
DNA and the Microwave Effect
Overproduction of ROS (Reactive Oxygen Species)
RF SAFE
water
free radical
DNA damage is a two-stage process
DAMAGE
DAMAGE
Direct damage to DNA
STOP5G.CZ
Ionizing radiation (x-rays)


User 1
May track User 1
4x4 MIMO with 8-12 antenna elements
Antenna
Four radiating elements at a common frequency with 45° phase shift
May switch User 1
User 1
User 2
Antenna
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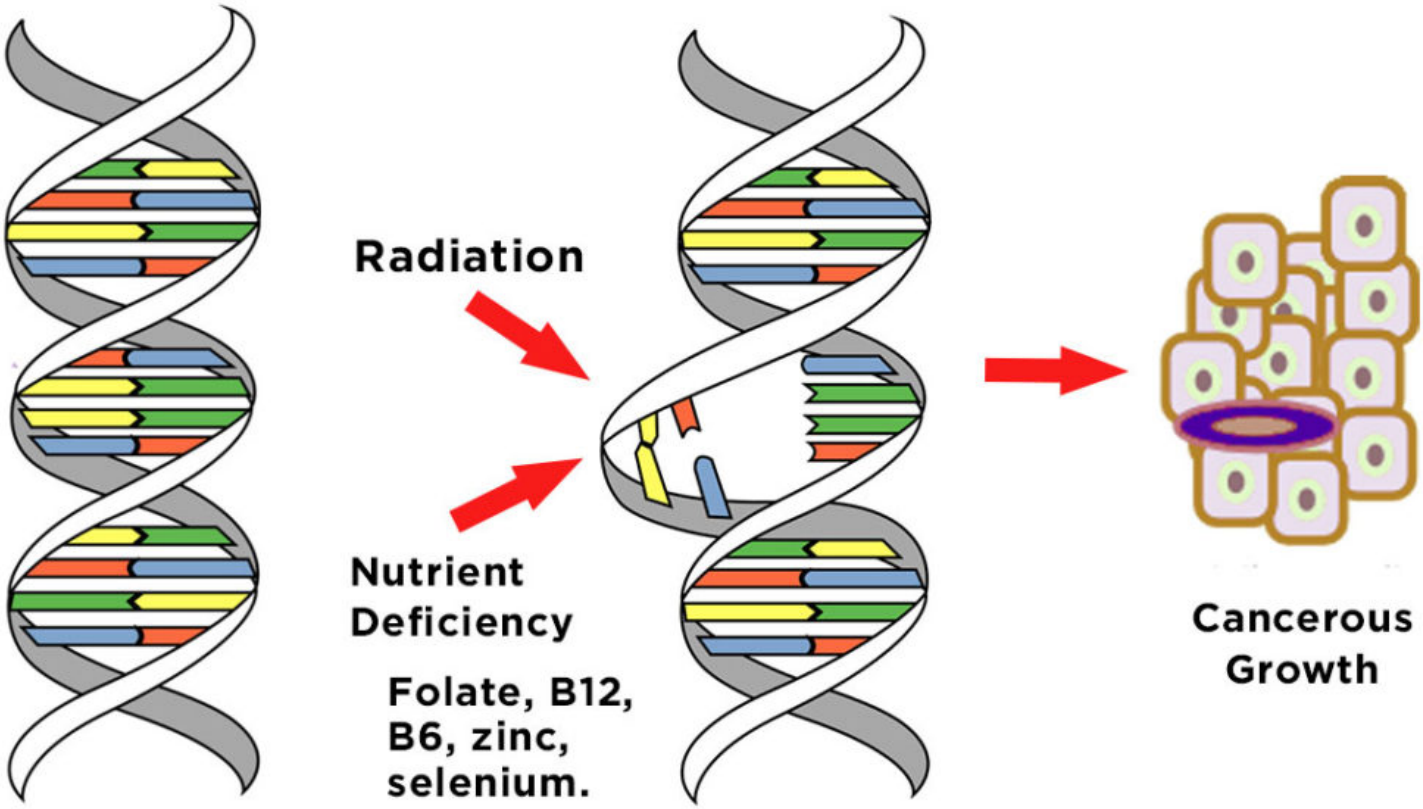

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Exposure to Extremely Low-Frequency Electromagnetic Fields Modulates Na^+ Currents in Rat Cerebellar Granule Cells through Increase of AA/PGE_2 and EP Receptor-Mediated cAMP/PKA Pathway

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Abstract

Although the modulation of Ca^{2+} channel activity by extremely low-frequency electromagnetic fields (ELF-EMF) has been studied previously, few reports have addressed the effects of such fields on the activity of voltage-activated Na^+ channels (Na_v). Here, we investigated the effects of ELF-EMF on Na_v activity in rat cerebellar granule cells (GCs). Our results reveal that exposing cerebellar GCs to ELF-EMF for 10–60 min significantly increased Na_v currents (I_{Na}) by 30–125% in a time- and intensity-dependent manner. The Na_v channel steady-state activation curve, but not the steady-state inactivation curve, was significantly shifted (by 5.2 mV) towards hyperpolarization by ELF-EMF stimulation. This phenomenon is similar to the effect of intracellular application of arachidonic acid (AA) and prostaglandin E_2 (PGE_2) on I_{Na} in cerebellar GCs. Increases in intracellular AA, PGE_2 and phosphorylated PKA levels in cerebellar GCs were observed following ELF-EMF exposure. Western blottings indicated that the Na_V 1.2 protein on the cerebellar GCs membrane was increased, the total expression levels of Na_V 1.2 protein were not affected after exposure to ELF-EMF. Cyclooxygenase inhibitors and PGE_2 receptor (EP) antagonists were able to eliminate this ELF-EMF-induced increase in phosphorylated PKA and I_{Na}. In addition, ELF-EMF exposure significantly enhanced the activity of PLA_2 in cerebellar GCs but did not affect COX-1 or COX-2 activity. Together, these data demonstrate for the first time that neuronal I_{Na} is significantly increased by ELF-EMF exposure *via* a cPLA2 AA PGE_2 EP receptors PKA signaling pathway.

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Introduction

A number of studies have noted that exposure to extremely low-frequency electromagnetic fields (ELF-EMF) alter animal behaviors and modulate biological effects, including changes in gene expression, regulation of cell survival and promotion of cell differentiation [1–3]. In addition, exposure to ELF-EMF induces changes in cerebral blood flow in old Alzheimer's mice. Enzyme activity in the cytosol or at the membrane and subsequent alternations in intracellular signaling are found in lymphoma B cells and Chinese hamster lung (CHL) cells upon exposure to ELF-EMF [4–6]. ELF-EMF can also modify the biophysical properties of cell membranes, such as changes in the membrane permeability of carbonic anhydrase [7], stimulation of the activity of Ca^{2+}-activated potassium channels via increases in Ca^{2+} concentration [3,8] and increased the expression level of Ca^{2+} channel protein [9]. However, very few studies have investigated the effects of EMF on sodium channels, in particular, the voltage-gated sodium (Na_v) channels which are highly expressed in neurons.

Voltage-gated sodium channels (Na_V) are one of the primary classes of ion channels responsible for driving neuronal excitability in both the central and peripheral nervous system. Na_V are clinically important because they play an important role in the generation of neuronal activity and alterations in Na_V are key factors in a number of pathologies [10]. Recent studies have revealed that Na_V channels participate in the rising phase of the neuronal action potential and contribute to many cellular functions including apoptosis, motility and secretory membrane activity [11–13]. Moreover, the EMF exposure was recently reported to modulate neuronal excitation and neurogenesis, which may be related to Na_V channel activity [8,14,15]. Thus, a thorough investigation of the influence of ELF-EMF on Na_V channels and the corresponding mechanism of action could help to uncover the effects of ELF-EMF-induced biological effects on brain physiology, pathogenesis and neural development.

Cerebellar granule cells (GCs) occupy a key position in the cerebellar–cortical circuitry by forming the input layer of the major cerebellar afferent system. Cerebellar GCs grown in primary culture express tetrodotoxin (TTX)-sensitive Na_V channels which are responsible for action potentials (APs) and for the code relay in the cerebellar circuitry [16,17]. Cerebellar GCs are widely used as a model for neuronal cell development and apoptosis [18–20]. We have previously shown that the I_{Na} densities of cerebellar GCs are modulated by the lipid products ceramide and arachidonic acid (AA). Ceramide reduces the I_{Na} of

cerebellar GCs by increasing calcium release through the ryanodine-sensitive Ca^{2+} receptor [21] while elevation in intracellular AA levels increases the I_{Na} of cerebellar GCs through the PGE_2-mediated activation of the cAMP/PKA pathway [22]. The present study was conducted to determine whether exposure to ELF-EMF influences the Na^+ channels of cerebellar GCs and, if so, whether this effect is mediated by changes in ceramide and/or arachidonic acid. The data presented in this report demonstrate that the activity of neuronal Na^+ channels is significantly increased by ELF-EMF stimulation. Notably, the effect of ELF-EMF is mediated by an increase in $cPLA_2$ activity and subsequent changes in intracellular concentration of arachidonic acid (AA) and EP receptor-mediated activation of the cAMP/PKA signaling pathway are involved.

Results

First, we investigated the actions of extremely low frequency electromagnetic fields (ELF-EMF) on the I_{Na} of cerebellar GCs. An I_{Na} was elicited by a depolarization step to −20 mV from the holding potential of −100 mV. When cerebellar GCs were exposed to ELF-EMF (1 mT) for 10 min, the amplitude of the I_{Na} was increased by approximately 51.8% ±3.8% ($n = 12$, $P<0.05$) compared to cells that were not exposed to ELF-EMF ($n = 8$, Fig. 1A). However, the mean capacitance of recorded cells for the control group (13.05±0.40 pF, $n = 7$) and for the ELF-EMF treatment group (12.45±0.77pF, $n = 6$) showed no significant difference ($P = 0.48$). The similar in capacitance indicated that the increased current density upon ELF-EMF exposure was not due to different in abnormal cell morphology. In addition, the increase in I_{Na} density induced by ELF-EMF exposure was time dependent. When cerebellar GCs were exposed to ELF-EMF for 30 min, 60 min or 90 min, the density of the I_{Na} increased by 67.1% ±4.38% ($n = 8$, $P<0.05$), 125.6% ±8.26% ($n = 16$, $P<0.05$), 102.4% ±4.1% ($n = 9$, $P<0.05$), respectively, compared to controls (Fig. 1B). We also tested the effects of low-density ELF-EMF (0.4 mT) on I_{Na}. The results shown in Fig. 1C indicated that, when cerebellar GCs were exposed to 0.4 mT ELF-EMF, a longer exposure time was needed to induce an increase in I_{Na} density. The density of I_{Na} was only increased by 3.62% ±2.38% ($n = 6$) when cerebellar GCs were exposed to ELF-EMF (0.4 mT) for 6 h. Upon an increase in the length of cell exposure to ELF-EMF (0.4 mT) to 12 h, the I_{Na} density increased by 31.6% ±3.38% ($n = 8$, $P<0.05$, Fig. 1D). Because a previous study indicated that when cells are exposed to ELF-EMF over a long term, their levels of protein expression may be affected [5], which will be difficult to further identify the primary factor involved in the ELF-EMF-induced I_{Na} increase. Thus, we chose to focus on the mechanism by which a relatively short-term exposure to a 1 mT ELF-EMF induces an I_{Na} increase.

Next, we investigated the effects of ELF-EMF on the voltage-gating properties of I_{Na} channels. The activation properties of I_{Na} in cerebellar GCs following exposure to ELF-EMF were studied using the appropriate voltage protocols. I_{Na} were evoked by a 20 ms depolarizing pulse from a holding potential of −100 mV to potentials between −70 and 20 mV, with 5 mV steps 5 s intervals (Fig. 2A). Fig. 2B illustrated a voltage-current curve in which the maximum activation potential was changed from −27.3±0.9 mV to −32.5±2.5 mV when cerebellar GCs were exposed to ELF-EMF for 60 min ($n = 13$ for control and $n = 12$ for ELF-EMF exposure, $P<0.05$). A value for steady-state activation of I_{Na} was then obtained by normalizing the conductance as a function of the command potential; conductance was calculated as $G_{Na} = I_{Na}/(Vm1/2–Vrev)$. The data points were fitted to the Boltzmann function $G_{Na}/G_{Na}\text{-max} = 1/\{1+\exp[(Vm1/2–Vm)/k]\}$. As shown in Fig. 2C, after cerebellar GCs were exposed to ELF-EMF for 60 min, the half-activation potentials changed from −40.93±0.67 mV to −46.87±1.3 5 mV ($n = 10$, $P<0.05$), with slope factors of 3.7±0.1 mV and 4.6±1.0 mV ($n = 10$). These data indicate that ELF-EMF exposure significantly shifts the voltage dependence of the steady-state activation of I_{Na} of cerebellar GCs.

Next, we studied the effects of ELF-EMF exposure on the voltage dependence of the steady-state inactivation of I_{Na} channels. I_{Na} were elicited using 1-s conditioning pre-pulses ranging from −100 to −40 mV in steps of 5 mV prior to a −10 mV test pulse (Fig. 2D). The steady-state inactivation curve was then fitted using the Boltzmann equation $I_{Na}/I_{Namax} = 1/\{1+\exp[(V_m–V_{m1/2})/k]\} + A$. In the 11 cells studied, the $V_{m\ 1/2}$ values were −72.7±0.74 mV ($n = 6$) and −68.2±0.75 mV ($n = 5$) for cells with or without ELF-EMF exposure, respectively (Fig. 2E). These data indicate that the steady-state inactivation curve of I_{Na} in cerebellar GCs did not significantly shift upon exposure to ELF-EMF.

Our previous study showed that elevation in arachidonic acid (AA) concentration increased I_{Na} through prostaglandin E_2 (PGE_2)-mediated activation of the cAMP/PKA pathway [22]. In the present study, the effect of ELF-EMF exposure on I_{Na} and the I_{Na} steady-state activation curve was similar to the effect of AA on I_{Na}. We therefore tested whether cAMP/PKA activation was involved in the increase in I_{Na} in cerebellar GCs subjected to ELF-EMF exposure. The results in Fig. 3A showed that H-89, a selective PKA antagonist, significantly attenuated the increase in I_{Na} elicited by ELF-EMF exposure. Incubating cerebellar GCs with 10 μM H-89 for 60 minutes decreased the evoked I_{Na} by 42.7% ±4.0% ($n = 9$, $P<0.05$). There was, however, only 12.4% ±6.4% (n = 14) in I_{Na} after exposure to ELF-EMF in the presence of H89. Hence, H89 suppressed the induction of the I_{Na} activity after ELF-EMF exposure. Similarly, administration of 10 μM dibutyryl cAMP (db-cAMP, a embrane-permeable cAMP analog) produced a significant increase of I_{Na} by 47.2±6.6% ($n = 7$, $P<0.05$). Notably, exposure to ELF-EMF did not further potentiate the effect of db-cAMP on I_{Na} (54.8±8.9%, $n = 20$). Hence, these data support our conclusion that cAMP/PKA pathway is involved in the effect of ELF-EMFs on I_{Na}.

In addition, we determined the intracellular levels of phosphorylated PKA (pPKA) by immunoblot assays and found significant increase in phospho-PKA after ELF-EMF exposure. These data indicate that when the cells were exposed to ELF-EMF, the intracellular levels of pPKA were increased by 38.6% ±3.76% ($n = 4$, $P<0.05$), 42.4% ±4.32% ($n = 4$, $P<0.05$),30.4% ±1.5% ($n = 4$, $P<0.05$) and 17.8±2.14% ($n = 4$, $P<0.05$), respectively (Fig. 3C). These data suggest that PKA activation is associated with the ELF-EMF-induced increase in I_{Na} in cerebellar GCs.

Previous study indicated that Na_V activities can be modulated by the cAMP/PKA pathways upon phosphorylation of the α-subunits of Na_V channels [23]. Besides increases in the modification of steady-state activation propriety, exposure to ELF-EMF might also elicit insertion of additional Na_V channels into the membrane, which might then further account for the ELF-EMF-induced up-regulation of I_{Na}. To investigate whether ELF-EMF induced insertion of new Nav channels on the membrane, we first ascertained that Na_V 1.2 α-subunits plays a significant role in Na_V channel of cerebellar GCs as reported previously [17]. As shown in Fig. 4A, the expression of Na_V 1.2 was significantly reduced by siRNA. Similarly, the current amplitude of I_{Na} was also significantly reduced. The current amplitude of I_{Na} recorded from

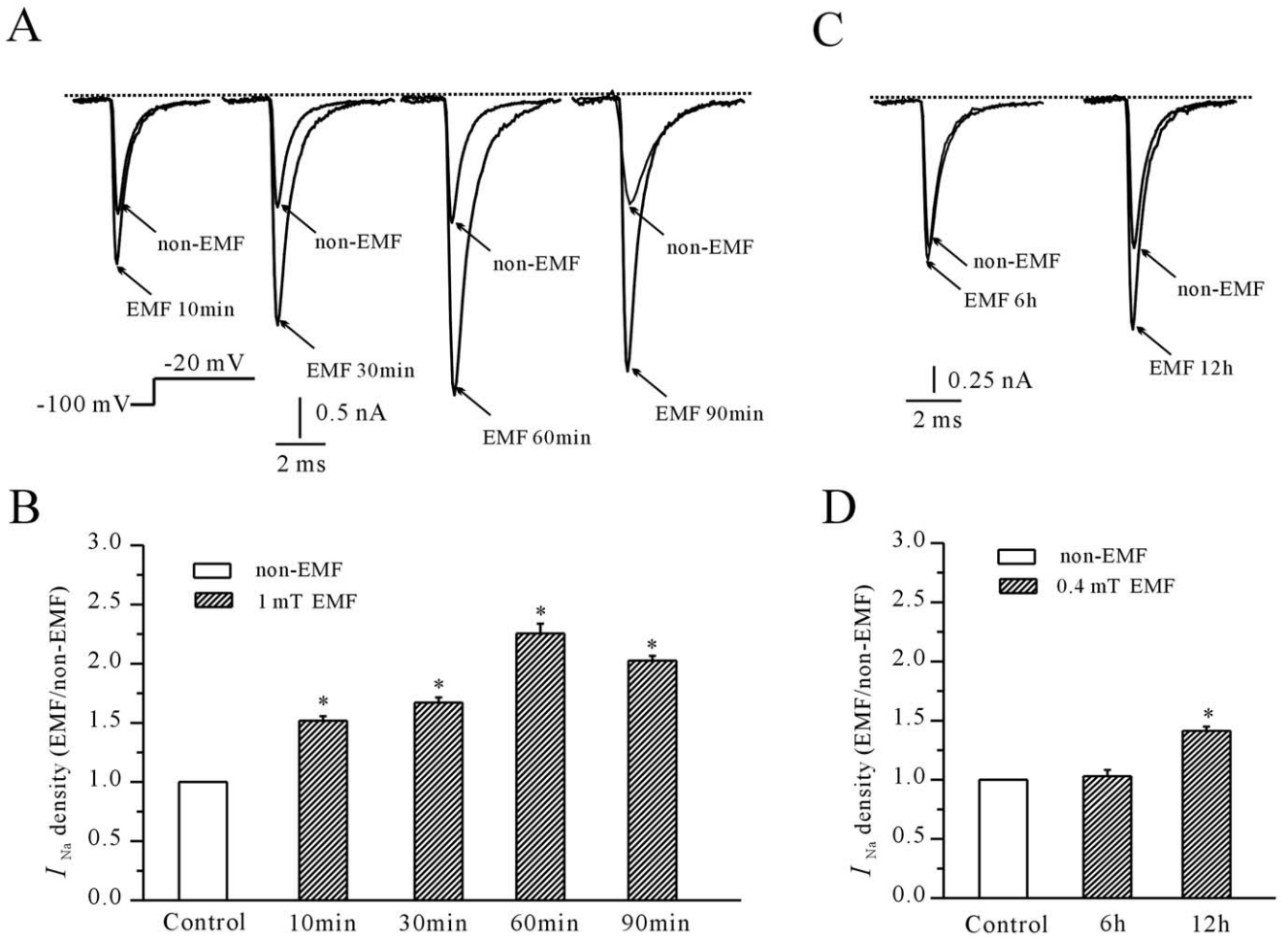

Figure 1. Time-dependent increase in I_{Na} in cerebellar GCs following exposure to ELF-EMF (1 mT or 0.4 mT). Superimposed I_{Na} evoked by a 20 ms depolarizing pulse from a holding potential from −100 to −20 mV. Current traces were obtained from cerebellar GCs exposed to ELF-EMF (1 mT) for lengths of time ranging from 10 min to 90 min. (B) Statistical analysis of the activating effects of ELF-EMF (1 mT) exposure at various times on the density of I_{Na}. The data are reported as the mean ± S.E.M. from 8–16 cells. *, $P<0.05$ compared to control using a one-way ANOVA test. (C) I_{Na} traces obtained from cerebellar cells exposed to ELF-EMF (0.4 mT) for 6 h and 12 h. (D) Statistical analysis of the activating effects of ELF-EMF (0.4 mT) exposure for 6 h and 12 h on the density of I_{Na}. The data are reported as the mean ± S.E.M. from 8–10 cells. *, $P<0.05$ compared to control using Student's *t*-test.
doi:10.1371/journal.pone.0054376.g001

the control group was −1400.32±162.15 pA ($n=7$), and it was reduced to −207.89±95.55 pA ($n=5$, $P<0.05$) after knocking down the Na_V 1.2 gene (Fig. 4B).

Next, we determined the levels of Na_V 1.2 protein on membrane surface using biotinylation assay. The data obtained from four independent experiments showed that the Na_V 1.2 protein on the cerebellar GCs membrane (Na_V 1.2 M) was increased by 21.8% ±3.3% after exposed to ELF-EMF for 60 min (Fig. 4C). The total expression levels of Na_V 1.2 protein (Na_V 1.2 T), however, was not affected after exposure to ELF-EMF (Fig. 4D). These data indicate that exposure to ELF-EMF activates PKA, which then modulates I_{Na}, in part, by insertion of new Na_V channels into the membrane.

It is well known that the cellular effects of PGE_2 are mediated through a family of G-protein-coupled receptors designated EP1, EP2, EP3 and EP4 [24,25]. Of these, EP2 and EP4 are involved in activation of the cAMP/PKA pathway [26]. Our previous study demonstrated that all four types of EP receptors mRNA are found in cerebellar GCs [22]. Because EP2 and EP4 can activate the PKA pathway, we used EP2 and EP4 receptor antagonists (AH6809 and AH23848, respectively) to investigate whether EP receptors played a role in the activation of PKA after exposure to ELF-EMF. As shown in Fig. 5A and 5B, in the presence of 20 μM AH6809 or 20 μM AH23848, 60 minutes of ELF-EMF exposure only increased I_{Na} by 9.54% ±4.7% ($n=6$) and 5.52±4.71% ($n=5$), respectively. In the absence of the EP receptor antagonists, exposure to ELF-EMF increased I_{Na} to 125.6% ±8.26% ($n=16$, $P<0.05$). Similarly, blocking EP2 and EP4 receptors using AH6809 or AH23848 significantly reduced the ELF-EMF exposure-induced increase in pPKA levels. The results in Fig. 5C showed that in the presence of 20 μM AH6809 or 20 μM AH23848, 60 min of ELF-EMF exposure only increased intracellular levels of pPKA by 7.25% ±1.67% or 6.5% ±2.8% ($n=4$), respectively.

Because EP receptors, which stimulate the cAMP/PKA signaling pathway, are activated by PGE_2, we next studied the release of PGE_2 from cerebellar GCs following exposure to ELF-EMF using a direct rat PGE_2 ELISA kit. As shown in Fig. 6A, the amount of PGE_2 released from control cerebellar GCs was 64.36±1.88 pmol. Following exposure to ELF-EMF

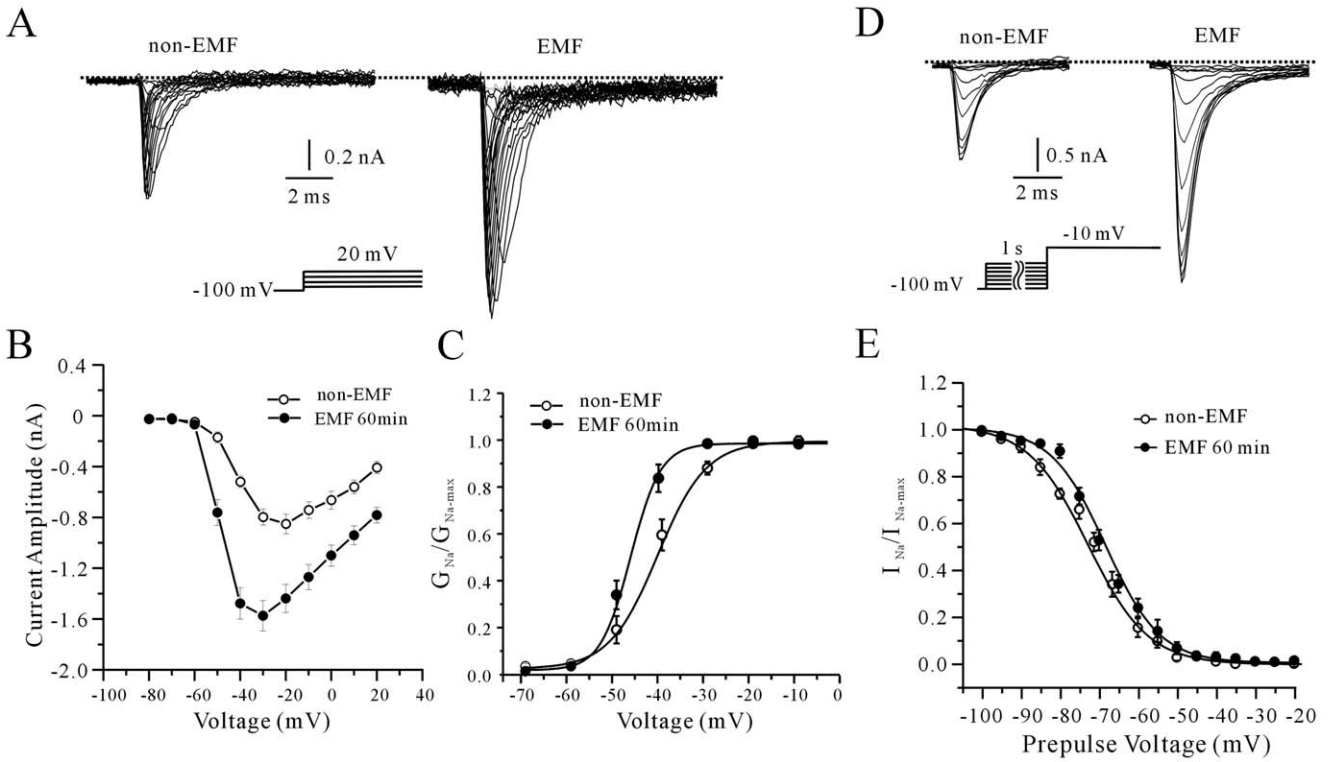

Figure 2. The effects of 1 mT ELF-EMF exposure on the steady-state activation and inactivation of I_{Na}. (A) The effects of 60 minutes of ELF-EMF exposure on the steady-state activation of I_{Na}. The cells were held at −100 mV and depolarized in 5 mV steps from −70 to 20 mV with intervals of 5 s. (B) The voltage-dependent activation curve of I_{Na} in control cells and cells exposed to ELF-EMF. The data are from 13 (control) or 12 (ELF-EMF-exposed) cells and are expressed as means ± SEM. (C) Comparison of the plot of the normalized conductance of I_{Na} as a function of the command potential in control and ELF-EMF-exposed cells. (D) The effects of 60 minutes of ELF-EMF exposure on the steady-state inactivation of I_{Na}. The voltage protocol is shown below the current record. (E) Steady-state inactivation curves of I_{Na} for control and ELF-EMF-exposed cells. The data are from 6 (control) and 5 cells (ELF-EMF-exposed) and are expressed as means ± S.E.M.
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for 10 min, 30 min, 60 min or 90 min, the PGE_2 content obtained from three independent experiments was significantly increased by 9.6% ±5.3%, 23.9% ±4.8%, 20.9% ±6.2% and 19.2% ±5.9%, respectively ($n=3$, $P<0.05$). We also assessed the levels of intracellular AA, which can be metabolically converted to PGE_2, using a direct rat AA ELISA kit to address whether the increase in PGE_2 after ELF-EMF exposure was the result of an increase in intracellular AA. The results in Fig. 6B showed that the intracellular AA levels were significantly increased following exposure to ELF-EMF. When cerebellar GCs were exposed to ELF-EMF for 10 min, 30 min, 60 min or 90 min, the intracellular AA levels measured in three independent experiments were significantly increased by 9.25±5.45%, 25.21±1.26%, 43.8±1.23% and 17.64±7.4%, respectively ($n=4$, $P<0.05$).

AA is converted to prostaglandins by either the cyclooxygenase, the lipoxygenase or the monooxygenase pathways [27]. In particular, cyclooxygenase-2 (COX-2) is reported to play a key role in the release of PGE_2 [28]. To test that the increase in I_{Na} after ELF-EMF exposure was due to an increase in intracellular AA, we investigated the effect of the selective COX-2 inhibitors flufenamaic acid (FA) and niflumic acid (NA). Administration of 10 μM FA or 20 μM NA alone reduced the I_{Na} amplitude of cerebellar GCs by 23.6% ±1.2% ($n=4$) and 14.7% ±2.3% ($n=8$), respectively. In the presence of 10 μM FA or 20 μM NA, the increase in I_{Na} induced by ELF-EMF exposure was abolished (Fig. 6C and 6D). The I_{Na} density in cerebellar GCs exposed to ELF-EMF for 60 min was increased by only 14.3±3.4% ($n=8$) or 6.3±2.7% ($n=10$), respectively, which were significantly different from those derived from cerebellar GCs exposed to ELF-EMF alone (125.6% ±8.26%, $n=16$). Similarly, FA or NA treatment abolished the increase in PGE_2 release induced by ELF-EMF exposure (Fig. 6E). Data obtained from three independent experiments showed that the release of PGE_2 from cerebellar GCs exposed to ELF-EMF for 60 min was only increased by 3.3% ±3.0% and 2.6±1.5% in the presence of FA or NA, respectively.

To ascertain the role of COX in mediating the effects of ELF-EMF on cerebellar GCs, we determined the activities of both COX-1 and COX-2 using selective COX-1 and COX-2 ELISA kits. When cerebellar GCs were exposed to ELF-EMF for lengths of time ranging from 10 min to 90 min, the intracellular activity of COX-1 was increased from 5.0±1.2% to 6.3±2.2% (Fig. 7A) while the activity of COX-2 was increased from 6.1±2.6% to 9.7±3.9% (Fig. 7B). Hence, neither COX-1 nor COX-2 activity was significantly different than non-ELF-EMF-exposed cells. These data suggest that the increase in PGE_2 release after exposure to ELF-EMF was due to an increase in intracellular AA rather than in COX enzyme activity.

Given that cytosolic phospholipase A_2 ($cPLA_2$) also plays an important role in producing intracellular AA [29], we measured the activity of intracellular $cPLA_2$ in cerebellar GCs before and after ELF-EMF exposure using an ELISA kit and immunocytochemistry. As shown in Fig. 7C, ELF-EMF exposure significantly

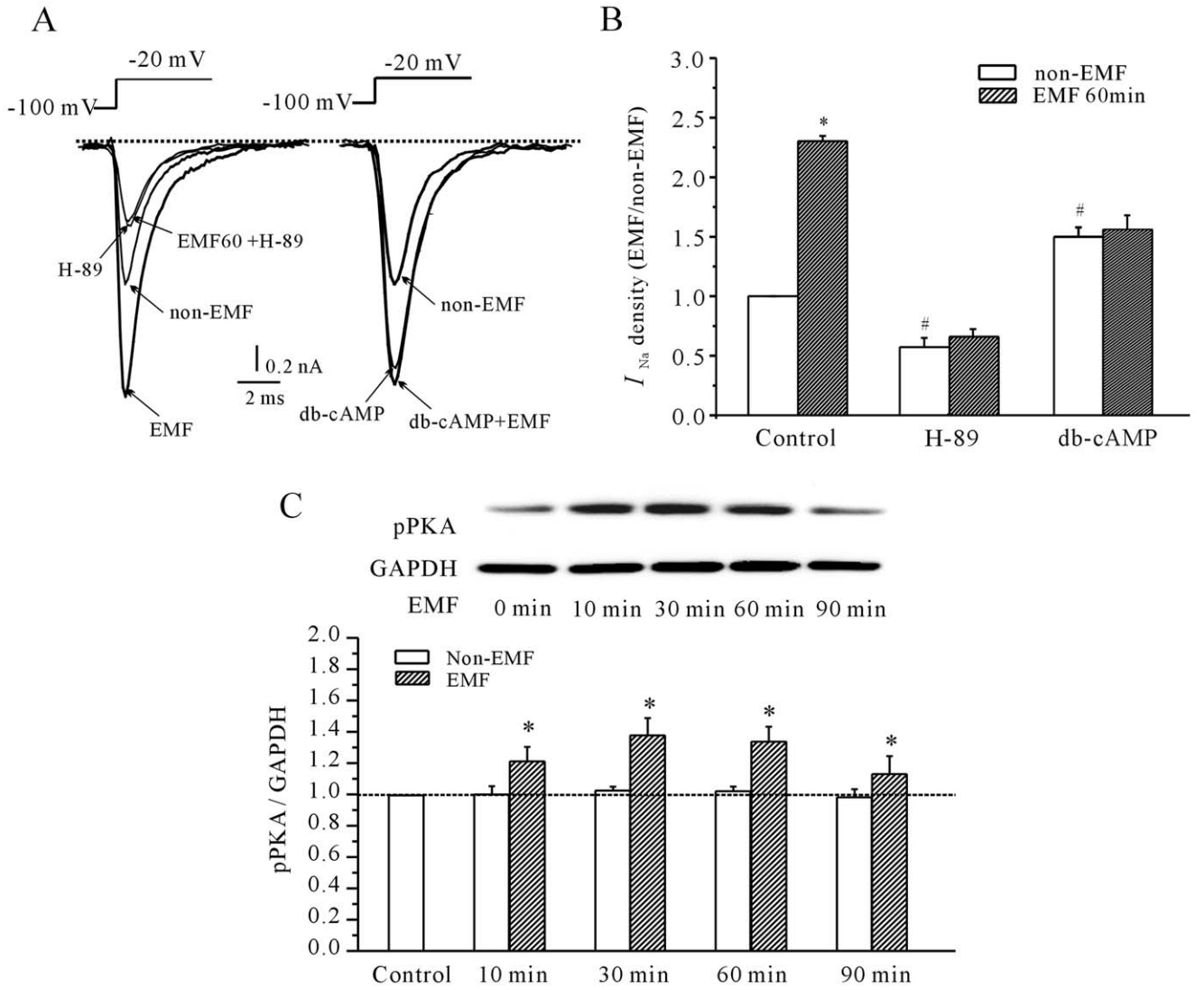
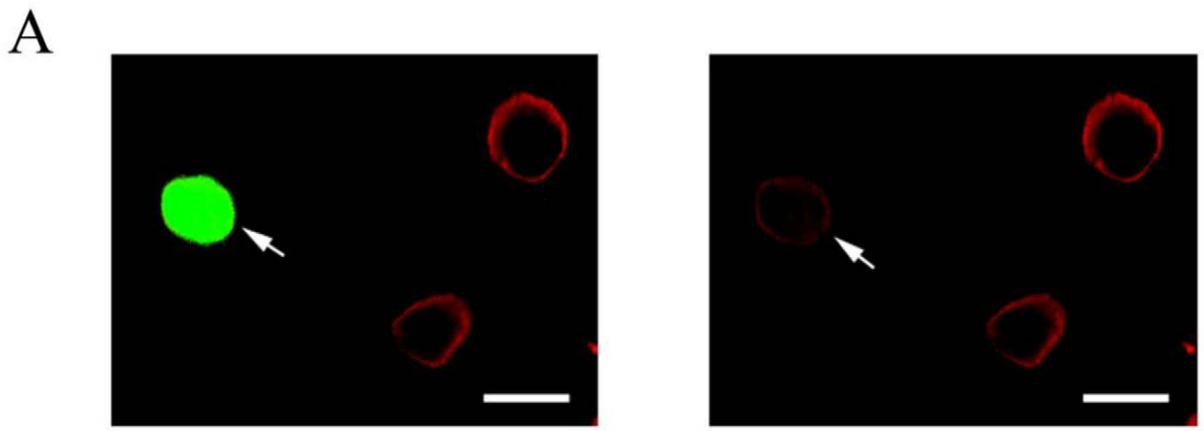


Figure 3. Involvement of the PKA pathway in the increase in I_{Na} induced by ELF-EMF exposure. (A) Current traces show the inhibitory effects of the selective PKA antagonist H-89 and db-cAMP on the increase in I_{Na} induced by a 60-minute exposure to a 1 mT ELF-EMF. (B) Statistical analysis of the inhibitory effects of H-89 and db-cAMP on the increase in I_{Na} density induced by a 60-minute exposure to a 1 mT ELF-EMF. The data are reported as the mean ± S.E.M. from 10–12 cells. *, $P<0.05$ compared to control (non-ELF-EMF group) using a Student's *t*-test. #, $P<0.05$ compared to the corresponding control (without H-89 and db-cAMP) non-ELF-EMF group using a Student's *t*-test. (C) Western blot analysis of the effects of ELF-EMF exposure on cellular pPKA levels. Upper panels show representative samples; the statistical analysis is shown in the lower panels; *, $P < 0.05$ compared to the corresponding control using Student's *t*-test.
doi:10.1371/journal.pone.0054376.g003

enhanced cPLA$_2$ activity, especially in the first 10 min to 30 min after exposure. Data obtained from four independent experiments indicated that exposing cerebellar GCs to ELF-EMF for 10 min, 30 min, 60 min or 90 min significantly increased cPLA$_2$ activity by 19.78±6.93%, 15.25±2.7%, 5.92±1.61% and 1.76±2.0%, respectively ($n=4$, $P<0.05$). The effects of ELF-EMF exposure on intracellular cPLA$_2$ levels in cerebellar GCs were confirmed by immunostaining. As shown in Fig. 7D, a low level of cPLA$_2$ labeling was detected in cerebellar GCs without exposure to ELF-EMF (Fig. 7D, left). After exposure to ELF-EMF, cerebellar GCs showed a significant increase in staining for cPLA2 (Fig. 7D, right), indicating that ELF-EMF exposure significantly increased intracellular cPLA$_2$ levels. A model depicting the possible mechanisms involved in the modulation of I_{Na} by ELF-EMF exposure in cerebellar GCs is shown in Fig. 8.

Discussion

Although ELF-EMF exposure has been previously reported to modulate the activity of ion channels, few studies to date have measured the effects of EMF exposure on neuronal I_{Na}. Here, we report for the first time that ELF-EMF exposure enhances I_{Na} in cerebellar GCs. In particular, exposure of cerebellar GCs to ELF-EMF influences the activity of PLA$_2$, thus stimulating the production of intracellular AA, which is then converted to PGE$_2$. PGE$_2$ then enters the extracellular space and binds to EP receptors, activating the cAMP/PKA pathway and accounts for the induction of I_{Na}.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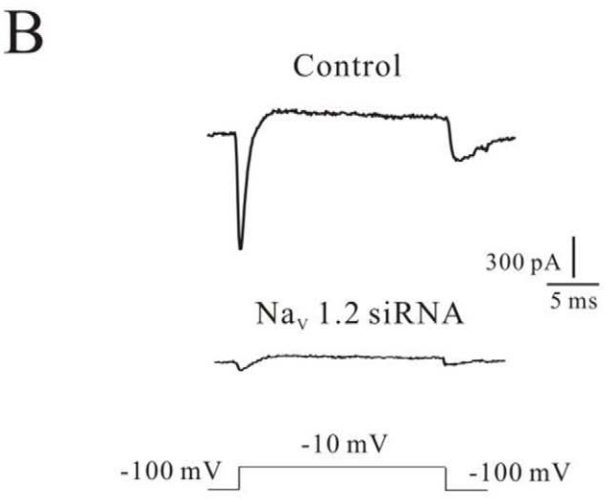
B
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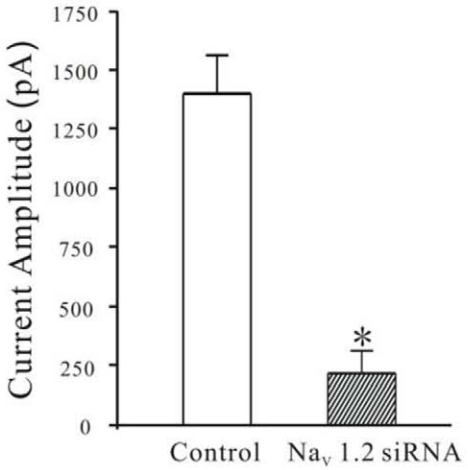
Current Amplitude (pA)
1750
1500
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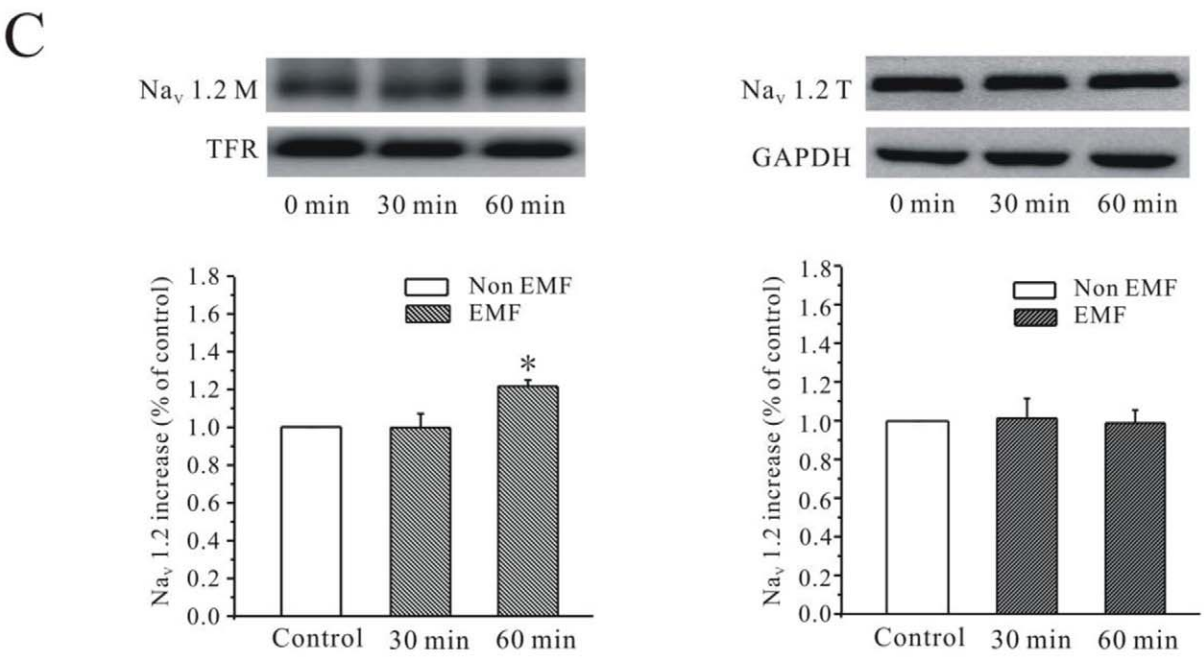
Control
Na$_V$ 1.2 siRNA


C
Na$_V$ 1.2 M
TFR
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Na$_V$ 1.2 increase (% of control)
Non EMF
EMF
*
Control
30 min
60 min
Na$_V$ 1.2 increase (% of control)
Non EMF
EMF
Control
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Figure 4. ELF-EMF exposure increased the $Na_V1.2$ α-subunit on the membrane in cerebellar GCs. (A) Cells expressing Na_V 1.2 were labeled with $Na_V1.2$ specific antibody (red one) and transfected GC cells showing strong eGFP expression (left, see arrowhead). Cells transfected with siRNA vectors (same cell in the right, see arrowhead) showed dramatic reduction in Na_V 1.2 expression. Scale bar was 10 μM. (B) The current recordings in a control cell and a post-transfected cell of Na_V 1.2 siRNA plus eGFP. Current evoked by a 20 ms depolarizing pulse from a holding potential of −100 to −20 mV. (C) Na_V 1.2 protein on membrane surface (Na_V 1.2 M) was detected with the biotinylation assay after 30 or 60-minute exposure to a 1 mT ELF-EMF. Upper panels show representative samples, TFR (transferrin) was used as the loading control; the statistical analysis is shown in the lower panels. *, $P< 0.05$ compared to the corresponding control using Student's *t*-test. (D) Western blot analysis of the total level of Na_V 1.2 expression (Na_V 1.2 T) after 30 or 60-minute exposure to a 1 mT ELF-EMF.
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ELF-EMF Increases I_{Na} in Rat Cerebellar GCs and Alters Na_V Channel Kinetics

Although several ion channels, such as Ca^{2+} and Ca^{2+}-activated K^+ channels [8,9], are known to be modulated by EMF, the effects of EMF on Na_V channels are poorly understood. Arthur D. Rosen's studies in GH3 cells indicated that there was a slight shift in the current-voltage relationship and a less than 5% reduction in peak current during 125 mT static magnetic field exposure [30].The authors speculated that a physical deformation in the liquid crystal membrane may be associated with these changes [30]. However, the changes observed in the steady-state activation characteristics of Na_V channel kinetics during exposure to ELF-EMF in our study are due to an AA metabolite-induced increase in I_{Na}, a result that is similar to those obtained previously [22]. Interestingly, the effects of ELF-EMF on carbonic anhydrase entrapped in liposomes seem to exclude the role of protein molecules but in favor of a direct action on charged lipids of the membrane [7]. Moreover, in experiments using Ca^{2+}-activated K^+ channels in dorsal root ganglion-isolated neurons, Marchionni et al. did not observe modifications in single-channel behavior that suggested a direct action of EMF on membrane proteins [8], consistent with the hypothesis that ELF-EMF-stimulated enhancement of I_{Na} in rat cerebellar GCs is not related directly to physical changes within the membrane and that an AA metabolism-related pathway might be involved. The discrepancy of these two reports may be due to the use of different cell type and different form of EMF source.

The time course for the effects of ELF-EMF on the activity of Na_V in this study is noteworthy. In previous studies, the effects of exposure to EMF differed significantly based on whether the exposure occurred for minutes, hours or days. Here, we demonstrate that exposure to ELF-EMF induced similar effects on I_{Na} in rat cerebellar GCs regardless the condition is 1 mT stimulation for a short time or 0.4 mT stimulation for a longer time. Notably, it is generally believed that short-term changes induced by EMF are mediated by modifications in enzyme activity in the cytosol or the membrane [4,31,32] while the long-term exposure to EMF may induce changes in nuclear functions such as gene transcription and cell cycle regulation [33,34]. Moreover, a

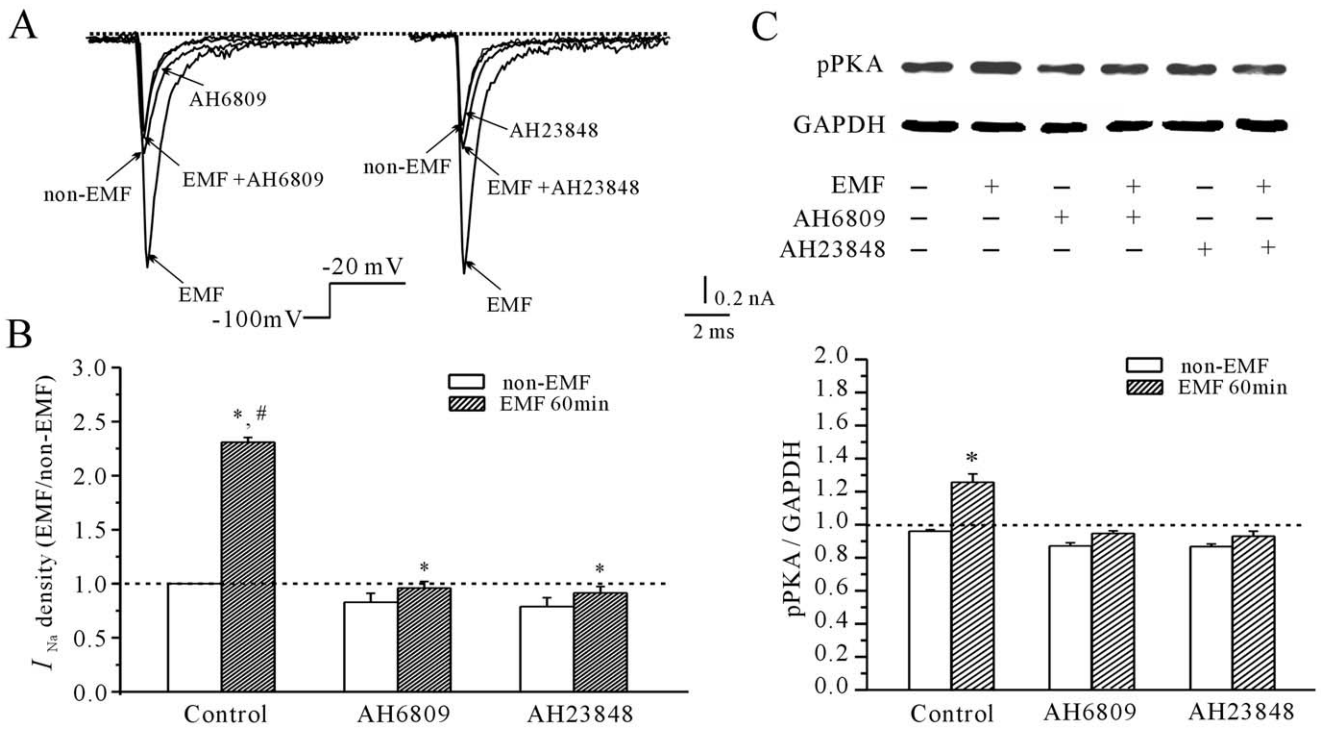

Figure 5. Effects of EP receptor antagonists on the increase in I_{Na} density induced by ELF-EMF exposure. (A) Current traces show the blocking effect of the EP2 and EP4 receptor antagonists AH6809 and AH23848 on the increase in I_{Na} induced by a 60-minute exposure to a 1 mT ELF-EMF. (B) Statistical analysis of the inhibitory effect of AH6809 and AH23848 on the I_{Na} density increase induced by a 60-minute exposure to a 1 mT ELF-EMF. #, $P<0.05$ compared to the corresponding control (non-ELF-EMF) using Student's *t*-test. *, $P<0.05$ compared to ELF-EMF exposure alone using a Student's *t*-test. (C) Western blot analysis of the inhibitory effect of AH6809 and AH23848 on intracellular PKA phosphorylation induced by a 60-minute exposure to a 1 mT ELF-EMF. Upper panels show representative samples; the statistical analysis is shown in the lower panels; *, $P< 0.05$ compared to the corresponding control using Student's *t*-test.
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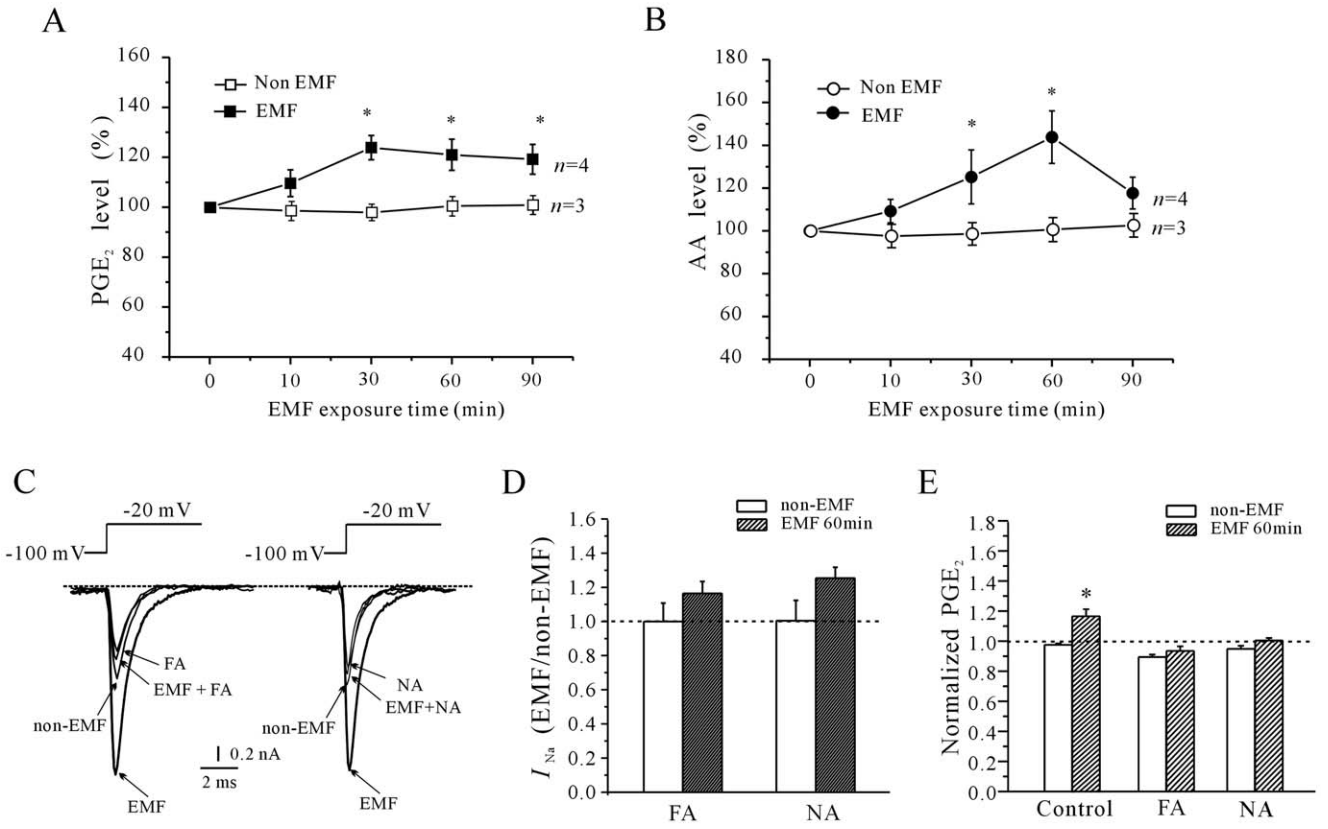

Figure 6. Effects of the AA/PGE$_2$ pathway on the ELF-EMF exposure-induced increase in I_{Na} in cerebellar GCs. (A) PGE$_2$ release from cerebellar GCs exposed to 1 mT ELF-EMF for various lengths of time. The data are from three and four independent experiments, respectively. *, $P<$ 0.05 compared to the corresponding control using Student's *t*-test. (B) Intracellular AA levels in cerebellar GCs exposed to 1 mT ELF-EMF for various lengths of time. The data are from three and four independent experiments, respectively. *, $P<$ 0.05 compared to the corresponding control using Student's *t*-test. (C) Current traces show the inhibitory effects of the COX-2 inhibitors flufenamaic acid (FA) and niflumic acid (NA) on the increase in I_{Na} induced by 60 minutes of exposure to a 1 mT ELF-EMF. (D) Statistical analysis of the effects of FA and NA on the increase in I_{Na} induced by a 60-minute exposure to a 1 mT ELF-EMF. (E) Statistical analysis of the effects of FA and NA on PGE$_2$ release induced by a 60-minute exposure to a 1 mT ELF-EMF.

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previous study in cerebellar GCs indicated that a five-day EMF exposure contributes to premature expression of GluRs, and leads to more rapid cellular maturation [35]. To avoid the influence of multiple factors due to long-term EMF exposure, we performed all our experiments at 1 mT EMF exposure for a short time, which we believe it is well-suited to access the effect of ELF-EMF on intracellular signaling pathways.

ELF-EMF Exposure Enhances I_{Na} via PGE$_2$-mediated Activation of the cAMP/PKA Pathway

It has been reported that the cAMP/PKA pathway can modulate Na_V activity. In particular, the α-subunits of Na_V channels are preferred substrates for phosphorylation by cAMP/PKA [36]. Either activation or inhibition of Na_V channels has been reported, which is probably due to the difference in cell model used [37,38]. Our previous study demonstrated that intracellular application of AA increases the activity of Na_V via the activation of the cAMP/PKA pathway in cerebellar GCs [22]. Consistent with the previous findings, we observed that the PKA signaling plays an important role in the increase in I_{Na} after exposure to ELF-EMF. In light of our findings that ELF-EMF activates PKA signaling (Fig. 3), modifies steady state properties of the Na_V (Fig. 2) and increases insertion of Na_V into the membrane (Fig. 4), we speculate that the effect of ELF-EMFs on I_{Na} is likely exerted at multiple levels. In addition to the changes in voltage-gating property and insertion of additional Na_V channels into the membrane, exposure to ELF-EMFs may also modulate the single channel properties by phosphorylation of channel protein. Recording of single-channel activity, however, is of technically challenging and requires specialized set up for such precise measurement. Nonetheless, the possible regulation of Na_V channels upon PKA phosphorylation warrants future investigations.

Previous studies by Sibylle Thumm et al. reported that ELF-EMF (20 Hz, 7–8 mT) exposure for 60 min resulted in an increase in PKA activity in human skin fibroblasts and rat embryonic osteoblasts [39]. The underlying mechanism by which PKA was activated by ELF-EMF exposure, however, was not known. In synovial fibroblasts of an osteoarthritis patient, ELF-EMF exposure-induced changes in cAMP levels were associated with a selective increase in adenosine receptor expression [33]. Similarly, our results indicate that exposure to ELF-EMF induces an increase in PKA activity and that treatment with EP2 and EP4 antagonists abolished this effect. Moreover, we observed that, along with EP receptor activation, PGE$_2$ levels were also increased following ELF-EMF exposure. Our data indicate that the effects of ELF-EMF exposure on PKA activity might not reflect a direct effect on this enzyme. Rather, PKA activation is mediated by elevations of

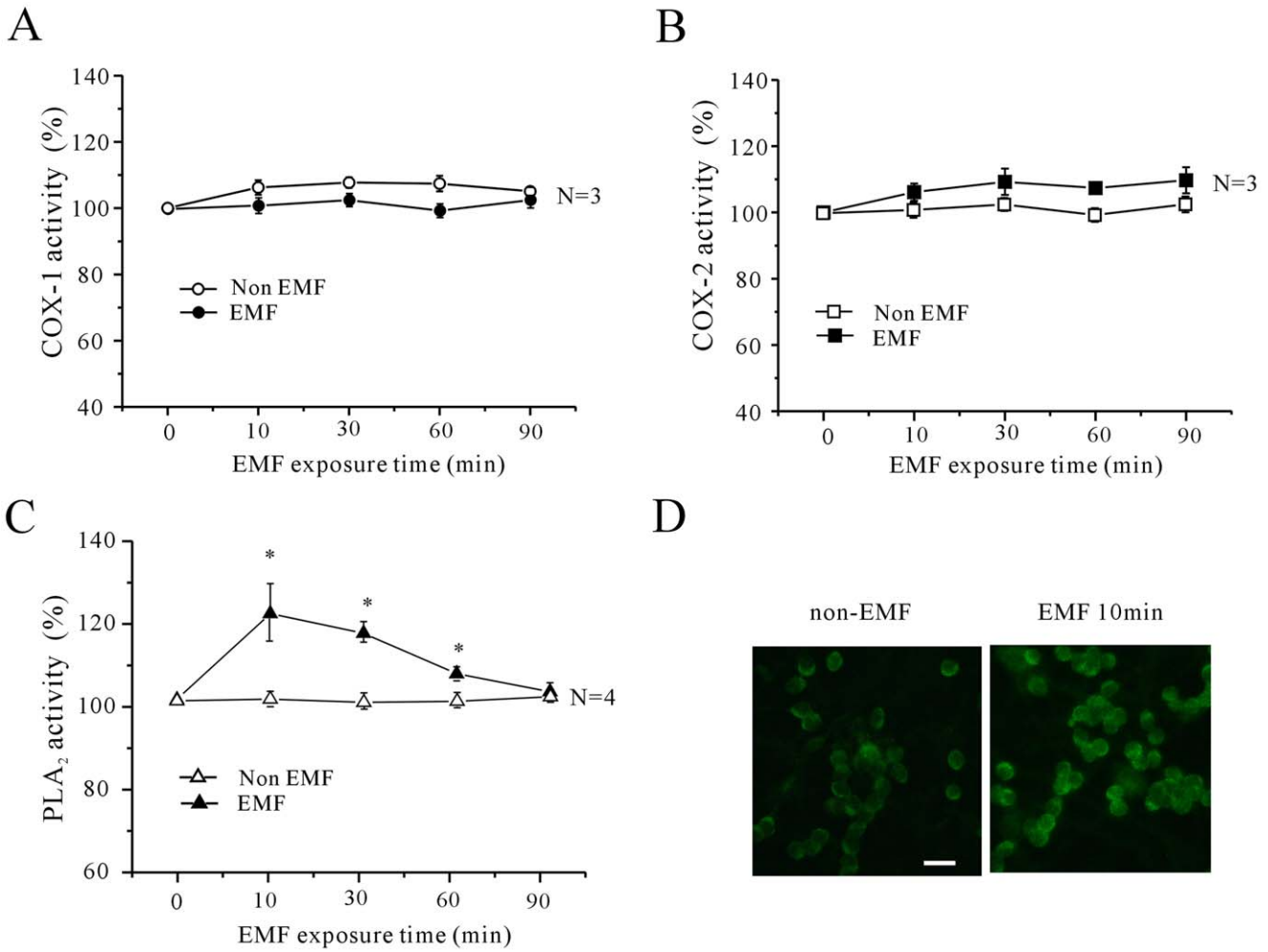

Figure 7. Effects of exposure to a 1 mT ELF-EMF on intracellular COX-1, COX-2 and cPLA$_2$ activities in cerebellar GCs. (A and B) COX-1 and COX-2 activity were measured in cerebellar GCs exposed to a 1 mT ELF-EMF for various lengths of time. The data are from three and four independent experiments, respectively. (C) cPLA$_2$ activity was measured in cerebellar GCs exposed to a 1 mT ELF-EMF for various lengths of time. *, $P<0.05$ compared to the corresponding control using a Student's *t*-test. (D) Immunostaining showing the effects of ELF-EMF exposure on intracellular cPLA$_2$ levels. The scale bar represents 20 μm.
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PGE$_2$, which then binds to the EP receptors to modulate PKA activity.

Increases in Intracellular PLA$_2$ Activity and AA Levels are Critical Steps in the ELF-EMF-mediated Enhancement of I_{Na}

It is well known that intracellular PGE$_2$ is derived from AA via the cyclooxygenase (COX) pathway, which includes COX-1 and COX-2 [28], and COX-2 has been reported to be the most abundant COX isozyme in neurons [40]. In our study, intracellular PGE$_2$ and AA levels were increased in cerebellar GCs following ELF-EMF exposure. Neither COX-1 nor COX-2 activity was significantly enhanced by ELF-EMF exposure. Inhibiting COX activity with specific inhibitors, however, eliminated the ELF-EMF exposure-induced increase in I_{Na}. Hence, an alternative pathway is likely involved for the increase in intracellular PGE$_2$ levels after ELF-EMF exposure.

In brain tissue, AA is mainly released downstream of cPLA$_2$. In this study, our results showed that intracellular AA levels in cerebellar GCs were significantly increased after EMF exposure. cPLA$_2$ activity, which is important for rapid AA release in neurons, was also significantly enhanced by exposure to ELF-EMF, suggesting that the increases in cPLA2 activity and AA levels are critical steps in the ELF-EMF-induced enhancement of I_{Na}. Using a cell-free PLA$_2$ assay, Song et al. failed to observe changes in PLA$_2$, including cPLA$_2$ and sPLA$_2$, following exposure to ELF-EMF (60 Hz, 0.1 or 1 mT) for 4 or 6 h [41]. The difference in these findings compared to our results in cerebellar GCs could be due to the use of a cell-free PLA$_2$ assay as cell membranes play an important role in mediating the effects of EMF on enzymatic activity [31]. Despite there is evidence for the involvement of cPLA2 activity in the responses to a wide variety of stimuli such as oxidative stress and inflammatory factors [42,43], the relevant mechanism of ELF-EMF exposure-induced cPLA$_2$ activation remains unclear.

Physiological Implications

The effects of ELF-EMF on nerve cells have been extensively studied in various organisms [8,35]. Although the reported results are variable or contradictory due to differences in the experimental conditions and in the density and/or duration of EMF

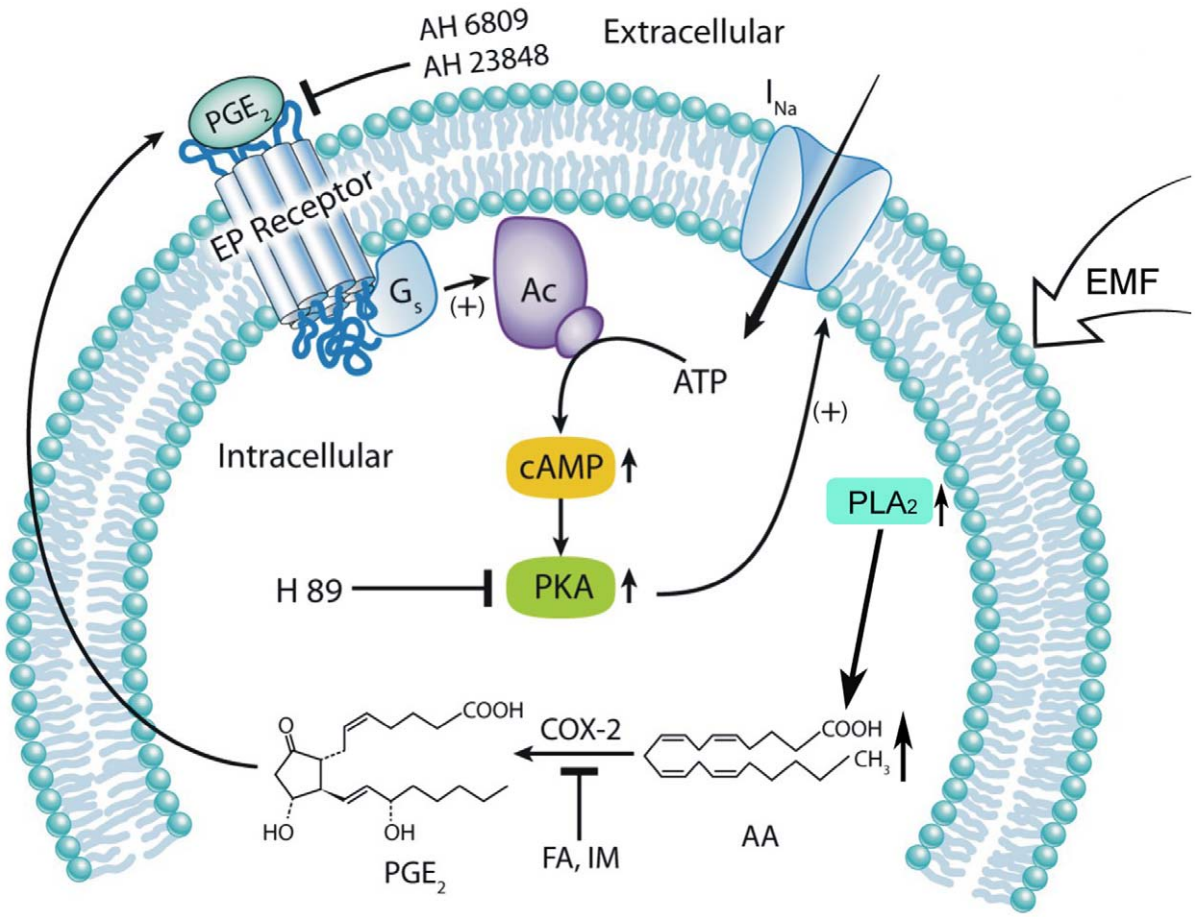

Figure 8. A proposed model depicting the mechanisms that are likely to be involved in the modulation of I_{Na} by ELF-EMF exposure in cerebellar GCs. ELF-EMF active cPLA$_2$ and up-regulated AA and PGE2, which can act in an autocrine or paracrine manner to activate EP receptors. Ligand binding of EP2/4 is associated with PKA activation and consequently modulates I_{Na}. (+), activation; (−), inhibition.
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exposure, EMF has recently been reported to modulate of neuronal excitatory functions and neurogenesis [8,14,15]. In addition, recent studies have revealed an important role for cPLA2 in the modulation of neuronal excitatory functions [29]. The findings from our molecular-level analysis of the macroscopic effects on I_{Na} produced by exposure to ELF-EMF provide evidence for an important effect of EMF on neuronal excitation in the CNS. We also observed that the effects of ELF-EMF exposure on cerebellar GCs peaked and then declined with extended exposure time. Notably, this phenomenon was observed for I_{Na} and also for enzyme activities. The observed effects is likely due to the cells reach equilibrium through self-regulation after the initial ELF-EMF exposure and its effect on cPLA$_2$ and I_{Na}. Nonetheless, the modulatory effects on neuronal excitatory caused by exposure to ELF-EMF are complicated and varied. Therefore, further exploration is required to comprehensively analyze the physiological and/or pathological effects of ELF-EMF exposure on I_{Na}, along with the resulting neuronal consequences.

Materials and Methods

Ethics Statement

This study was carried out in strict accordance with the recommendations in the Guide for the Care and Use of Laboratory Animals of the National Institutes of Health. The protocol was approved by the Committee on the Ethics of Animal Experiments of the Fudan University (Permit Number: 20090614-001). All surgery was performed under sodium pentobarbital anesthesia, and all efforts were made to minimize suffering.

Primary Cell Culture

Cells were derived from cerebellum of 7-day-old Sprague–Dawley rat pups as described previously [44]. Isolated cells were then plated onto 35-mm-diameter Petri dishes coated with poly-L-lysine (1 μg/ml) at a density of $2.5\times10^5/cm^2$. Cultured cells were incubated at 37°C with 5% CO_2 in Dulbecco's Modified Eagle's Medium (DMEM) supplemented with 10% fetal calf serum, glutamine (5 mM), insulin (5 μg/ml), KCl (25 mM), and 1% antibiotic–antimycotic solution. All experiments were carried out with cerebellar GCs during 6–8 days in culture (DIC).

Electromagnetic Field Production

The system used to expose cerebellar GCs cells to electromagnetic fields was the same used in previous studies, with some revisions (I-ONE, Shanghai, China) [33,45,46]. Briefly, a 50 Hz magnetic field was generated by a pair of Helmholtz coils placed in opposition to each other. The coils were powered by a generator system that produced the input voltage of the pulse, and the magnetic flux densities could be regulated within the range of 0 to 1.0 mT. The device was powered by an AC power generator, and

the EMF frequency and density were monitored by an EMF sensor that was connected to a digital multimeter. The geometry of the system assured a uniform field for the exposed cultured cells. The surfaces of the culture plates were parallel to the force lines of the alternating magnetic field in the solenoid. Air and culture medium temperatures were continuously monitored for the duration of experiments. The maximum temperature increase recorded in the cultures that were exposed to ELF-EMF (compared to non-exposed cultures) was $0.4\pm0.1^{\circ}C$. To identify any possible influence of this increase on our results, we compared data obtained from cerebellar GCs cultured in two different CO_2 incubators at temperature settings of 37.0 and $37.4^{\circ}C$, and the results is consistent. The incubator was keep closed all throughout the EMF or non-EMF experiments to make sure that the conditions stable. Non-EMF groups were incubated in the same incubator in which the conditions were the same as for the exposed groups but without EMF.

Patch-clamp Recordings

Whole-cell currents of granule neurons were recorded using a conventional patch-clamp technique. In 6–8 DIC cerebellar granule cells, transient I_{Na} are largely unclamped because of an event generated at a site electrotonically distant from the soma and prone to escape from clamp control, presumably the axon [47]. Therefore, we choose those cells that relatively isolated and only record currents without unclamped spike. Prior to current recordings, the culture medium was replaced with a bath solution containing (in mM): NaCl 145, KCl 2.5, HEPES 10, $MgCl_2$ 1 and glucose 10 (pH adjusted to 7.4 using NaOH). Soft glass recording pipettes were filled with an internal solution containing (in mM): CsCl 145, HEPES 10, $MgCl_2$ 2, and EGTA 5 (pH adjusted to 7.3 using CsOH). The pipette resistance was 5–6 MΩ after filling with the internal solution. Whole cell series resistances of 6–8 MΩ were routinely compensated by more than 70%. All recordings were performed at room temperature (23–25C°).

Intracellular AA Assay

Intracellular AA levels in cerebellar GCs were measured as previously described [48], with minor modifications. Briefly, 1×10^5 cells were plated in 35-mm dishes and grown to confluence. The cells were washed with 1 mL of bath solution and cerebellar GCs were exposed to 1 mT ELF-EMF for 10 min, 30 min, 60 min or 90 min. The media was then removed, and 0.3 mL of 0.45% NP40 (Sigma, St. Louis, MO, USA) was added to the plates. After a 5-minute incubation on ice, the lysate was removed from the plates and centrifuged for 5 minutes at $4^{\circ}C$. The supernatant was collected and assayed for AA levels using a direct rat AA ELISA kit (R&B, Yueyan Bio-Tech, Shanghai, China) according to the manufacturer's instructions. The data represent the means of several experiments, as indicated in the figure legends.

PGE_2 Release Assay

PGE_2 levels in the culture media were measured using highly sensitive enzyme-linked immunosorbent assay kits (R&B, Yueyan Bio-Tech, Shanghai, China) according to the manufacturer's instructions. Briefly, 1×10^5 cells were plated in 35-mm dishes and grown to confluence. The cells were washed with 1 mL of bath solution and were exposed to a 50 Hz, 1 mT EMF for 10 min, 30 min, 60 min or 90 min. The media were then collected and centrifuged for 5 minutes at $4^{\circ}C$. The supernatant was collected and assayed for levels of PGE_2. The data represent the means of several experiments, as indicated in the figure legends.

COX-1, COX-2 and PLA_2 Enzyme Activity Assays

COX-1, COX-2 and PLA_2 activities in cerebellar GCs were measured using highly sensitive, enzyme-linked immunosorbent assay kits (R&B, Yueyan Bio-Tech, Shanghai, China) according to the manufacturer's instructions. Briefly, 1×10^5 cells were plated in 35-mm dishes and grown to confluence. The cells were washed with 1 mL of bath solution and were exposed to 1 mT ELF-EMF for 10 min, 30 min, 60 min or 90 min. The media was then removed, and the cells were diluted with PBS (pH 7.2–7.4) until the cell concentration reached 1 million cells/ml. Following repeated freeze-thaw cycles, which result in cell damage and the release of intracellular components, the supernatant was collected by centrifugation for 20 min at 2000–3000 rpm and assayed for COX-1, COX-2 and PLA_2 activities. The data represent the means of several experiments, as indicated in the figure legends.

Phosphorylated Protein Kinase A Assay

The cells were lysed in HEPES-NP40 lysis buffer (20 mM HEPES, 150 mM NaCl, 0.5% NP-40, 10% glycerol, 2 mM EDTA, 100 μM Na_3VO_4, 50 mM NaF, pH 7.5, and 1% proteinase inhibitor cocktail) on ice for 30 min. After centrifugation, the supernatant was mixed with 2× sodium dodecyl sulfate loading buffer and boiled for 5 min. The proteins were separated on a 10% polyacrylamide gel, transferred to polyvinylidene difluoride membranes (Millipore, MA, USA), blocked with 10% nonfat milk and incubated at $4^{\circ}C$ overnight with a rabbit polyclonal antibody against the phosphorylated form of the PKA catalytic subunits (1:1000; Santa Cruz Biotechnology Inc., CA, USA) or a rabbit monoclonal antibody against GAPDH (1:1000; Sigma). After extensive washing with TBST, the membrane was incubated with horseradish peroxidase-conjugated anti-mouse or anti-rabbit IgG (1:10,000) (KangChen Bio-Tech, China) for 2 h at room temperature. Chemiluminescent signals were generated using a SuperSignal West Pico trial kit (Pierce, USA) and detected using a ChemiDoc XRS System (Bio-Rad Laboratories, Inc., CA, USA). The protein measurements were normalized to GAPDH and control/GAPDH as 1.0.

Biotinylation Assay

Cell surface proteins were biotinylated according to the product instruction and previously described [49]. Briefly, the neurons were incubated with 0.25 mg/mL of Sulfo-NHS-SS-biotin (Thermo scientific, Rockford, USA) for 45 min at $4^{\circ}C$, and then the reaction is blocked with 50 mM Tris (pH 8.0) for 20 min at $4^{\circ}C$. Cells were lysed in HEPES-NP40 lysis buffer. Biotinylated proteins were pulled down with Streptavidin Agrose Beads (Thermo scientific, Rockford, USA) overnight at $4^{\circ}C$ and washed for 4 times with lysis buffer. The bound proteins were eluted by the sample buffer and analyzed by western blotting.

Immunocytochemistry

To detect changes in $cPLA_2$ in cerebellar GCs following exposure to ELF-EMF, an immunocytochemical assay was performed using the following procedure. Isolated cortical neurons plated on coverslips were washed three times with 0.01 M PBS and then fixed with 4% PFA for 30 minutes, rinsed three times with PBS and pre-incubated for 1 hour in 6% normal donkey serum (v/v) in PBS plus 0.1% Triton X-100 at room temperature. The cells were then incubated with a rabbit anti-$cPLA_2$ antibody (1:100 dilution, Santa Cruz Biotechnology Inc., CA, USA) for 2 hours in a humidified air chamber. After incubation, the cells were rinsed three times with PBS and then further incubated with a secondary donkey anti-rabbit IgG tagged with FITC (1:100

dilution, Jackson ImmunoResearch Laboratories, West Grove, PA) for 30 minutes at room temperature. The coverslips were then rinsed twice in PBS and mounted onto glass slides. For labeling of the Na_v 1.2 subunit, specific mouse monoclonal antibodies (from UC Davis/NINDS/NIMH NeuroMab Facility) were used as the primary antibody (at a working dilution of 1: 200). TRITC conjugated goat anti-mouse immunoglobulin G (1: 200 dilution, from Jackson Immunoresearch Laboratories, West Grove, PA) was used as the secondary antibody.

siRNA design

Gene specific siRNA duplexes were designed to be homologous to $Na_{V1.2}$ mRNA consensus sequence (GenBank accession number X03639). Primers for loop and 3′P-dT extensions contained 19-nt siRNA were commercially obtained (Invitrogen). The sense strand of the siRNA (5′-GGATATTGGTTCCGAAAAT-3′), homologous to nt 1965–1983 of the Na_V mRNA sequence, was chosen according to the recommendations by others (http://www.dharmacon.com/DesignCenter/DesignCenterPage.aspx). Restriction site Sac I was added to the 3′ tail of resulting molecule to facilitate ligating to LentiLox 3.7.

Data Acquisition and Analysis

All currents were recorded using an Axopatch 200 B amplifier (Axon Instruments, Foster City, CA, USA) that was operated in voltage-clamp mode. A Pentium computer was connected to the recording equipment with a Digidata 1300 analog-to-digital (A/D) interface. The current was digitally sampled at 100 μs (10 kHz), and the current signals were filtered using a 5-kHz, five-pole Bessel filter. The currents were corrected online for leak and residual capacitance transients using a P/4 protocol. Data acquisition and analysis were performed using pClamp 8.01 software (Axon Instruments, Foster City, CA, USA) and/or Origin6.1 (MicroCal, Northampton, MA, USA). Statistical analysis was performed using Student's *t*-test with non-paired or paired comparisons as relevant. The values are given as the means ± S.E.M., with *n* representing the number of cells tested. A value of $P<0.05$ was considered a significant statistical difference between groups. When multiple comparisons were made, the data were analyzed by a one-way ANOVA.

Chemicals

All drugs used were purchased from Sigma-Aldrich (St. Louis, MO, USA) except for the fetal calf serum. The DMEM culture medium and antibiotic–antimycotic solution were obtained from Gibco Life Technologies (Grand Island, NY, USA). The arachidonic acid, 5,8,11,14-eicosatetraynoic acid, flufenamic acid, phorbol-12-myristate-13-acetate, AH6809 and AH23848 were first dissolved in DMSO and then diluted in extracellular solution to a final DMSO concentration of <0.2%, which by itself, did not affect I_{Na}.

Author Contributions

Conceived and designed the experiments: YAM YLH. Performed the experiments: YLH DDL YJF XQZ. Analyzed the data: YLH DDL JJY. Contributed reagents/materials/analysis tools: YJF XQZ JJY. Wrote the paper: YAM YLH.

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http://eyewiki.aao.org/Radiation_Retinopathy

Radiation Retinopathy

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Radiation retinopathy is a predictable and often radiation dose-dependent complication following exposure to any type of radiation. The diagnosis is made when there is a history of radiation exposure and a physical exam revealing the characteristic funduscopic features. The diagnosis can be further supported with fluorescien angiography or optical coherence tomography. Treatment options are limited but the mainstays include laser treatment (panretinal photocoaguation and/or focal macular laser) and injections of anti-VEGF medications or triamcinolone.

Contents

Disease Entity

Disease

Radiation retinopathy is a predictable complication following exposure to any source of radiation. It was first described in 1933 by Stallard and appears clinically as microaneurysms, telangiectases, neovascularization, vitreous hemorrhage, hard exudates, cotton wool spots and macular edema.

Etiology

Exposure to any radiation source including external beam and plaque brachytherapy. Specifically, external beam radiation as treatment for nasopharyngeal, paranasal sinus or orbital tumors, where there is limited protection for the eye, often can lead to clinically significant radiation retinopathy.[1] Plaque brachytherapy in the treatment of intraocular tumors can also cause severe damage to the immediate retina and choroid.

Risk Factors

Higher total radiation dose has been shown to increase the risk of radiation retinopathy. The fractionation, field design, type and rate of administration of radiation should also be accounted for. While there are no definite thresholds, estimates for external beam radiation range from 15 to 60 Gy, with the incidence of retinopathy increasing steadily at doses greater than 45 Gy.[2] Hyperfractionation has been associated with a decreased incidence of radiation retinopathy.[3] Patients who receive less than 25 Gy in fractions of 2 Gy or less are unlikely to develop significant retinopathy.

With plaque brachytherapy, the risk of radiation retinopathy is related to total radiation dose. In the treatment of uveal melanoma, therapeutic apical doses range from 80 to100 Gy. Factors that affect total radiation dose such as tumor height and location also increase the risk of retinopathy. Tumor thickness greater than 4 mm has been associated with a greater risk for radiation maculopathy.[4] A decreased distance to the fovea has also been associated with decreased time to maculopathy.[5]

Comorbidities such as diabetes, hypertension, simultaneous chemotherapy and pregnancy are associated with an increased risk of radiation retinopathy.[6] Risk factors for developing proliferative radiation retinopathy include younger age, pre-existing diabetes mellitus and shorter tumor distance to the optic disc.[7]

General Pathology

See below

Pathophysiology

Exposure of radiation is thought to cause preferential loss of vascular endothelial cells with relative sparing of the pericytes.[8] It is hypothesized that differential sensitivity between endothelial cells and pericytes is the result of direct exposure of the endothelial cells to high ambient oxygen and iron found in the blood which generates free radicals and leads to cell membrane damage.[9] This damage leads to occlusion of capillary beds and microaneurysm formation. The retinal ischemia from areas of retinal non-perfusion ultimately leads to macular edema, neovascularization, vitreous hemorrhage and tractional retinal detachment. In one report, the mean time to development of proliferative radiation retinopathy following plaque brachytherapy was 32 months and using Kaplan-Meier analysis, was found to develop in 7% of patients at 10 and 15 years post-plaque.[7]

Primary prevention

Appropriate shielding of the ocular structures during external beam radiation can minimize radiation exposure. As previously mentioned, hyperfractionation of external beam radiation has been associated with a decreased incidence of radiation retinopathy.

With respect to plaque brachytherapy, various strategies to decrease the radiation dose to the macula have been attempted. These include the use of collimating plaques as well as eccentric positioning of the plaques.[10],[11] A study with vitreous substitutes including silicone oil, heavy oil and perfluorocarbon demonstrated attenuation of the radiation dose from iodine-125 plaque radiation in cadaveric eyes.[12] It remains to be seen if any of these strategies ultimately reduce the incidence of retinopathy.

A randomized controlled trial assessed the efficacy of periocular triamcinolone (40 mg) given at the time of plaque application in preventing radiation maculopathy.[13] At 18-month follow-up, eyes treated with periocular triamcinolone demonstrated less macular edema on optical coherence tomography and had less moderate and severe vision loss compared to the control group. The study reported similar rates of elevated intraocular pressure and cataract progression between the two groups.

Another study examined the use of laser photocoagulation in the prevention of radiation retinopathy and maculopathy.[14] With plaque brachytherapy, a predictable area of ischemia develops in and immediately surrounding the location of the plaque. Prophylatically treating this area with scatter laser photocoagulation may theoretically prevent retinopathy. Of 16 patients who were treated prohylactically with scatter laser photocoagulation, none lost more than 3 lines of vision at final follow-up.[14]

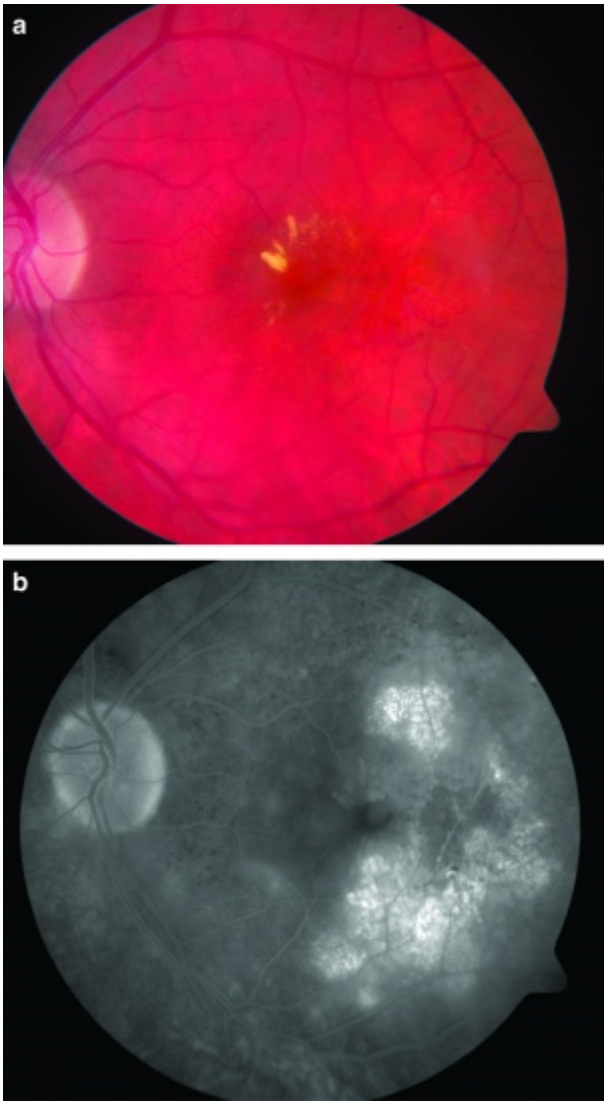
Diagnosis

History

Patients will have a history of radiation exposure. Radiation retinopathy has been reported to develop any where from 1 month[15] to 15 years[16] but most commonly occurs between 6 months and 3 years.[6]

Physical examination

Evaluation for radiation retinopathy includes a complete ophthalmologic exam, including a dilated funduscopic exam to look for pathologic features described below.



Signs [1]

Dilated funduscopic exam reveals the following features:
Retinal microaneurysms
Retinal hemorrhages
Retinal telangiectatic vessels
Retinal hard exudates
Macular edema
Cotton-wool spots
Retinal neovascularization
Vitreous hemorrhage
Tractional retinal detachment

Other associated features may include:

Optic disc edema
Neovascularization of the iris
Neovascularization of the angle or neovascular glaucoma
Cataract

The figure to the right demonstrates macular edema, exudates, microaneurysms, and vessel telangiectasias (figure a) and capillary non-perfusion and cystoid macular edema on fluorescein angiography (figure b).[17]

Symptoms

Patients with early or mild retinopathy may be asymptomatic. Other patients with more advanced disease can present with decreased vision or floaters.

Clinical diagnosis

Clinical diagnosis is based on the history and physical.

Diagnostic procedures

A fluorescein angiogram can be helpful in highlighting the microvascular features of radiation retinopathy. Indocyanine green angiography can reveal precapillary arteriolar occlusion and areas of choroidal hypoperfusion.[1] Optical coherence tomography (OCT) can be helpful in evaluating macular edema. A study by Horgan et al. found that OCT was able to detect evidence of macular edema approximately 5 months earlier than clinically detectable radiation maculopathy.[18]

Laboratory test

Not applicable

Differential diagnosis [1]

Diabetic retinopathy
Branch retinal vein occlusion
Central retinal vein occlusion
Hypertensive retinopathy
Coats' disease
Perifoveal telangiectasia

Management

Medical therapy

Vascular endothelial growth factor (VEGF) is a secreted protein that promotes vascular leakage and angiogenesis.[19] Bevacizumab is a humanized monoclonal antibody to VEGF and intravitreal bevacizumab is currently used to treat numerous ophthalmologic disorders including diabetic retinopathy, retinal vein occlusion and macular degeneration. Several studies have examined the use of intravitreal bevacizumab in the treatment of radiation retinopathy and maculopathy.[20][21][22][23] Many of the studies demonstrated an improvement in macular edema following intravitreal bevacizumab though a sustained decrease often required multiple injections. However, visual acuity was not found to improve significantly in most of the studies.

Triamcinolone acetonide is thought to downregulate various cytokines and regulate capillary permeability. It is used to treat macular edema secondary to various retinal pathologies and has similarly been used to treat radiation maculopathy. While the data is limited, some studies suggest that intravitreal triamcinolone acetonide (4 mg/0.1 ml) does transiently reduce macular edema and improve visual acuity.[24][25] Further studies are needed to determine whether these results are sustainable and whether the benefit of frequent injections outweigh the known risks of glaucoma, cataract and endophthalmitis.

Grid macular laser photocoagulation has been used to treat radiation maculopathy with variable success. Studies by Kinyoun et al. and Hykin et al. demonstrated a benefit in visual acuity following treatment. [26][27] However, the effect was not sustained with longer follow-up in the study by Hykin et al.

Sector scatter and pan-retinal laser photocoagulation has also been used to treat non-proliferative and proliferative radiation retinopathy. In a study by Finger et al., patients received sector scatter laser photocoagulation at the first sign of retinopathy, proliferative or non-proliferative.[14] Retinopathy regressed in 64% of their treated patients. Similarly, in a study by Bianciotto et al., pan-retinal photocoagulation was found to cause regression of neovascularization in 66% of eyes with proliferative radiation retinopathy.[7]

There are also case reports of successful treatment of radiation retinopathy using photodynamic therapy, hyperbaric oxygen and oral pentoxifylline.[28][29][30]

Surgery

Advanced proliferative radiation retinopathy complicated by vitreous hemorrhage and/or tractional retinal detachment may require pars plana vitrectomy.

Complications

As previously mentioned, advanced radiation retinopathy can be complicated by neovascularization, vitreous hemorrhage and/or tractional retinal detachment. Proliferative radiation retinopathy has been reported to develop in 3 to 25% of eyes treated with plaque brachytherapy.[7],[31] Neovascular glaucoma can also develop and remains a difficult and devastating complication that can lead to enucleation. In patients who received I-125 plaque brachytherapy, enucleation secondary to neovascular glaucoma are reported to occur in 1-12% of treated eyes.[32]

Prognosis

Mild non-proliferative radiation retinopathy, characterized by subtle capillary dropout and occasional microaneurysms may not significantly affect vision and may be stable for years. However, many studies report a significant decline in visual function following plaque brachytherapy. In the Collaborative Ocular Melanoma Study (COMS), patients were followed for 3 years after receiving plaque brachytherapy and life table estimates predicted that 43% of patients would have a visual acuity of 20/200 or less.[33] In patients with large tumors (defined as tumor height >7.5 mm), the percentage of patients retaining a visual acuity of 20/200 or better has been reported to be as low as 5.5%.[34]

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http://emfsafetynetwork.org/family-with-young-children-forced-to-live-in-the-cold-and-without-power-for-refusing-a-ladwp-smart-meter/

Family with young children forced to live in the cold and without power for refusing a LADWP Smart Meter.

(See Video above for how sick this meter made the family after installed.)

LOS ANGELES- Los Angeles Department of Water and Power (LADWP) has terminated electricity to the family of a middle school teacher, her husband, and their six children for refusing to have a smart meter on their home, which they say caused their family serious health problems.

In July 2012, LADWP installed a Smart Meter on Derek and Anura Lawson's home without notice or consent. Their house was part of a smart meter pilot program. Other houses in the neighborhood still have their analog meters.

That same month their four youngest children started to have serious health problems. The mother, Anura Lawson writes they had fevers "out of nowhere", "as high as 105", and they "began to have problems controlling their bodily fluids, our five year old began peeing and pooping herself, our four year began to display the same problems…" The mother also struggled with migraines, insomnia, concentration problems and other health symptoms.

The family requested LADWP restore the analog meter. LADWP then gave them what they said was an analog meter, but the health symptoms persisted. The family objected. According to Anura, LADWP ridiculed them. She says, "When I called customer service, "Jennifer" laughed at me, telling me they would not remove the meter."

When an agent of LADWP met with the family he said, "This isn't one of those 'SmartMeters' that have been making all those people sick. These are RF meters. Totally different." He talked about how safe radio was and that it had been used for years. Meanwhile the children's health problems persisted.

Clearly something had to be done.

In January 2013, after repeated, unfulfilled requests to LADWP for help, the family restored a true analog meter obtained from Jerry Day. The mother wrote that after the analog meter was restored the children's symptoms "diminished greatly, they no longer get high fevers, or suffer from loss of their bodily function."

Two weeks later, LADWP disconnected their electricity. Anura saw the workers scale a neighbor's wall, climb the power pole in their backyard and literally cut the wire to their home. Since February 11th the Lawsons have been living without electricity, without heat, without use of their appliances and without lights.

Joshua Hart, director of Stop Smart Meters! says, *"Pilot programs are supposed to be a test to see how a new system operates. When problems crop up, you don't punish customers for reporting them- you fix the problem."*

The family has been using candles and battery powered lanterns to see at night. They are cooking on a camping stove outdoors, and keeping their food cold in ice chests. The family says the incident has been extremely stressful.

This incident echoes other bullying incidents around the country, where people have been cut off after having had their smart meters removed due to health issues.

Sandi Maurer, director of the EMF Safety Network states, *"Federal law states customers should be offered smart meters, not be forced to have them on their homes. LADWP is exceeding its authority by mandating these devices."*

Jerry Day, a video producer on the forefront of empowering customers to stand up for their constitutional rights states, *"This is inexcusable. This is not responsible power company management. This is senseless abuse of utility customers."*

We agree. The Lawsons need their power switched on and an analog utility meter restored on their home. NOW.

IMPORTANT FOLLOW UP! Anura Lawson took this issue to the Los Angeles City Council meeting and their power was restored that same day.

https://www.fcc.gov/general/fcc-health-it-actions-and-activities-timeline

FCC Health IT Actions and Activities Timeline

Connect2HealthFCC

Over the years, the FCC has been active in implementing Congressional mandates, collaborating with other federal agencies (e.g., the FDA), and developing rules and policies that support adoption of broadband-enabled health care solutions and the development and availability of health-related technologies for all Americans. In addition, the Commission has a long history of addressing spectrum needs for the development of medical devices, and in facilitating innovation and entrepreneurship.

Below is a list of significant FCC actions and activities concerning efforts to foster the development of healthcare technology and to improve the quality of health care for all Americans:

2014

Efforts to Further Streamline Equipment Authorization Program: FCC issues Report and Order to amend its radiofrequency (RF) equipment certification rules to further streamline the process for bringing products to the market, including medical devices. Previously, the FCC empowered Telecommunications Certification Bodies (TCBs) in the United States and other parts of the world to certify most radio products, while certain devices could only be certified by the FCC. Under the new rules, TCBs will process all applications for certification.

Medical Body Area Network: FCC issues Order on Reconsideration and Second Report and Order in an effort to take further action to foster the development and deployment of new and innovative Medical Body Area Network (MBAN) devices. MBAN users also afforded additional flexibility to enable the implementation of technical standards for devices.

FCC-FDA-ONC Collaboration - FDASIA Health IT Report: Proposed strategy and recommendations on appropriate, risk-based regulatory framework pertaining to health information technology, including mobile medical applications, that promotes innovation, protects patient safety, and avoids regulatory duplication.

Connect2HealthFCC Task Force Formed: Formation of Connect2Health FCC Task Force announced. Task Force to focus on the critical intersection of broadband, advanced technology, and health with the primary goal of ensuring that advanced health care solutions are readily accessible to all Americans.

2013

mHealth Innovation Expo: Event showcases mobile health products, solutions, and resources for mobile health pioneers and entrepreneurs.

Experimental Licenses: Commission streamlines its rules to modernize the Experimental Radio Service (ERS) by establishing a more flexible framework to keep pace with the speed of modern technological changes while continuing to provide an environment where creativity can thrive. Commission creates three new types of ERS licenses, including one for medical testing.

2012

Healthcare Connect Fund: FCC establishes Healthcare Connect Fund (HCF) to expand health care provider access to broadband, especially in rural areas, and encourages the creation of state and regional broadband health care networks.

Summit on mHealth: Announces FCC plans to act on recommendations from mHealth Task Force report; discusses promise of mobile devices to improve health care and lower costs, including suggestions to foster innovation.

mHealth Task Force: mHealth Task Force findings and recommendations issued.

Medical Body Area Networks: FCC releases Order to allocate spectrum for Medical Body Area Networks (MBANs), making the U.S. the first country in the world to make spectrum available for this specific usage. MBANs are networks of wireless sensors, often no bigger than a Band-Aid, which can transmit data on a patient's vital health indicators to their doctor or hospital.

2011

Implantable Medical Devices: FCC adopts rules to enable a new generation of wireless medical devices (i.e., Medical Micropower Networks (MMNs)) that can used to restore functions to paralyzed limbs. MMNs are ultra-low power wideband networks consisting of transmitters implanted in the body that takes the place of damaged nerves, restoring sensation and mobility.

Actions Taken to Increase Broadband Access for All Americans: FCC announces various actions take to increase access to broadband and telecommunications services for all Americans, including an NPRM that will help promote persons' with disabilities access to advanced communications services, as well as various actions to improve communications services for Native Nations.

2010

FCC-FDA Memorandum of Understanding: FCC and FDA work together to ensure that communications-related medical innovations can swiftly and safely be brought to market.

National Broadband Plan: FCC releases National Broadband Plan, which includes a chapter on broadband-enabled health IT solutions.

2005-2009

New Rules Adopted for Advanced Medical Technologies: Commission issues Report and Order, allocating spectrum for the Medical Device Radiocommunications Service (MedRadio) and adopts technical rules for innovative new body-worn and implanted medical radio devices that can provide a variety of diagnostic and therapeutic functions from diabetes and heart monitors to pacemakers and defibrillators.

Rural Health Care Pilot Program: FCC establishes Rural Health Care Pilot Program to support state and regional broadband networks designed to bring the benefits of telemedicine and telehealth services to areas of the country where they are most needed.

2000-2004

Internet Access Program: FCC adds Rural Health Care Internet Access Program to provide a 25 percent discount off the cost of monthly Internet access.

Wireless Medical Telemetry (Remote Monitoring): FCC establishes Wireless Medical Telemetry Service (WMTS) by allocating 14 MHz of spectrum for wireless medical telemetry. WMTS spectrum is used for remote monitoring of a patient's health. WMTS systems include devices to measure patients' vital signs and other important health parameters (e.g., pulse and respiration rates) and devices that transport the data via a radio link to a remote location, such as a nurses' station, equipped with a specialized radio receiver. For example, wireless cardiac monitors are often used to monitor patients following surgery.

1995-2000

Medical Implant Communications Service: FCC responds to advances in medical implant technology by establishing the Medical Implant Communication Service (MICS) within Part 95 of its Rules. FCC sets aside three megahertz of spectrum, at 402-405 MHz, on a licensed-by-rule basis expressly for allowing physicians to establish high-speed, easy-to-use, short-range wireless links between ultra-low power medical implant transmitters and their associated programmer/control equipment. Examples of such implant devices include cardiac pacemakers and defibrillators that also monitor and report heart conditions.

Rural Health Care Telecommunications Program Established (zip file): FCC issues Universal Service Order, which includes the establishment of the Telecommunications Program, ensuring that eligible rural health care providers (HCPs) pay no more than their urban counterparts for telecommunications services. Through this program, eligible rural HCPs can obtain rates for supported services that are no higher than the highest tariffed or publicly available commercial rate for a similar service in the closest city in the state with a population of 50,000 or more people, taking distance charges into account.

Telecommunications Act of 1996: Congress directs FCC "to encourage the deployment on a reasonable and timely basis of advanced telecommunications capability for all Americans; also, to provide rural HCPs with "an affordable rate for the services necessary for the provision of telemedicine and instruction relating to such services."

Tags:
Connect2HealthFCC Task Force - Health & Medical

https://www.fda.gov/MedicalDevices/DigitalHealth/WirelessMedicalDevices/default.htm#2

Wireless Medical Devices

Description

Radio frequency (RF) wireless medical devices perform at least one function that utilizes wireless RF communication to support health care delivery. Examples of functions that can utilize wireless include transferring patient data from the device to another source, device control and programming, and monitoring patients remotely. As this technology continues to evolve, it is increasingly incorporated in the design of medical devices.

Examples of the technologies that utilize RF wireless technology include:

- Radio frequency Identification (RFID)
- Wireless Medical Telemetry

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Coordination with Federal Communications Commission (FCC)

The Federal Communications Commission (FCC) oversees the use of the public radio (RF) spectrum within which RF wireless technologies operate. The FDA coordinates our policies on wireless medical device with the FCC to improve government efficiency in the oversight of broadband and wireless enabled medical devices. Our continued work with the FCC will provide medical devices manufacturers with more predictability and a better understanding of regulatory requirements for medical devices that utilize this technology.

- Margaret A. Hamburg, M.D., Commissioner of Food and Drugs - Remarks at the FDA/FCC Public Workshop: Enabling the Convergence of Communications and Medical Systems (2010)
- Joint Statement on Wireless Medical Devices - U.S. Food and Drug Administration, Federal Communications Commission

For information on applicable FCC requirements for wireless medical devices, please refer to the following links:

- FCC: Rules and regulations for Title 47 (Telecommunications)
- FCC: Accessing Spectrum

A good summary of the specifications, output power, frequency bands, and international use of several applicable RF wireless technologies can be found in the ISO technical report TR 21730, Health Informatics – Use of mobile wireless communications and computing technology in healthcare facilities – Recommendations for the management of unintentional electromagnetic interference with medical devices (ISO/TR 21730: 2007(E)).

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Benefits and Risks

Incorporation of wireless technology in medical devices can have many benefits including increasing patient mobility by eliminating wires that tether a patient to a medical bed, providing health care professionals the ability to remotely program devices, and providing the ability of physicians to remotely access and monitor patient data regardless of the location of the patient or physician (hospital, home, office, etc…). These benefits can greatly impact patient outcomes by allowing physicians access to real-time data on patients without the physician physically being in the hospital and allowing real-time adjustment of patient treatment. Remote monitoring can also help special populations such as our seniors, through home monitoring of chronic diseases so that changes can be detect earlier before more serious consequences occur.

As wireless developers and device manufacturers increasingly utilize RF wireless technology, they should consider the following:

- Selection of wireless technology
- Quality of service
- Coexistence
- Security
- Electromagnetic Compatibility (EMC)

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Information for Patients

The use of RF wireless technology can translate to advances in health care, but patients should be informed about the safe and effective use of these devices in the course of daily life.
If you are sent home with a RF wireless medical device, talk with your physician or health care provider about any restrictions when it comes to the use of personal computers, cellular phones, or any other personal electronic devices that are commonly used in home environments, as they can interfere with signals coming from medical devices that also use wireless technology. In addition, the home electronic devices can add additional burdens on available wireless capabilities (e.g., bandwidth).

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Information for Health Care Facilities: Risk Management

Most well-designed and maintained RF wireless medical devices perform adequately. But, an increasingly crowded RF environment could impact the performance of RF wireless medical devices, which makes risk management an important part of integrating RF wireless technology into medical systems.

For additional information, please review FDA's Recommendations for EMC/EMI in Healthcare Facilities.

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Information for Industry: RF Wireless Developers and Manufacturers

Medical devices that incorporate wireless technology introduce some unique risks that should be addressed. The Radio Frequency Wireless Technology in Medical Devices focuses on considerations that should be taken into account to support safe and effective wireless medical devices. Medical device manufacturers are encouraged to read this document to help in the development, testing, regulatory submission and use of wirelessly enabled medical devices.

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RF Wireless Coexistence Challenges

All types of wireless technology face challenges coexisting in the same space. For example, devices operating under FCC Part 15 rules must accept any interference from primary users of the frequency band. (Note: FCC Part 15 is applicable to certain types of low-power, non-licensed radio transmitters and certain types of electronic equipment that emit RF energy unintentionally.)

The FDA recommends that you periodically consult the FCC website for new specifications and updated information. Mobile wireless equipment can also transmit on an unlicensed basis in frequency bands such as the Industrial, Scientific, Medical (ISM) bands. ISM bands include 900 MHz, 2.4 GHz, 5.2 GHz, and 5.8 GHz and are commonly used for cordless phones and wireless data network equipment.

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Regulations

The FDA regulates manufacturers of any electronic product through theElectronic Product Radiation Control (EPRC) and medical device provisions of federal law.

Through federal law, the FDA has formally recognized several standards related to RF wireless medical devices. When manufacturers submit pre-market notification to the FDA for device clearance or approval, declarations of conformity to these standards may eliminate the need for certain safety and effectiveness data. For more information see:

- FDA: Standards (Medical Devices)
- FDA: Recognized Consensus Standards database

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FDA Recognized Standards

- ISO 14117 (2012): Active implantable medical devices— Electromagnetic compatibility—EMC test protocols for implantable cardiac pacemakers, implantable cardioverter defibrillators and cardiac resynchronization devices
- AAMI TIR18: Association for the Advancement of Medical Instrumentation – Guidance on electromagnetic compatibility of medical devices in healthcare facilities (2010)
- ANSI/RESNA WC-2: American National Standards Institute/Rehabilitation Engineering and Assistive Technology Society of North America - Requirements and test methods for electromagnetic compatibility of electrically powered wheelchairs (2008)
- IEC 60601-1-2: International Electrotechnical Commission – Medical Electrical Equipment - Part 1-2: General Requirements for Safety - Collateral standard: Electromagnetic Compatibility - Requirements and Tests (2007)
- ANSI C63.18: American National Standards Institute - Recommended practice for an on-site, ad hoc test method for estimating radiated electromagnetic immunity of medical devices to specific radio frequency transmitters (1997)

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Other Relevant Standards for Wireless Medical Devices

The IEEE 802.11 family of standards refers to RF, over-the-air interface between a wireless client (such as a medical device) and a base station (or access point) or between two wireless clients. There are several specifications in the 802.11 family, including:

- IEEE 802.11: IEEE Standard for Information technology--Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications. This standard applies to wireless LANs and provides 1 or 2 million bits per second (Mbps) transmission in the 2.4 GHz band using either frequency-hopping spread spectrum (FHSS) or direct sequence spread spectrum (DSSS).
- IEEE 802.11a: IEEE Standard for Telecommunications and Information Exchange Between Systems - LAN/MAN Specific Requirements - Part 11: Wireless Medium Access Control (MAC) and physical layer (PHY) specifications: High Speed Physical Layer in the 5 GHz band. This standard is an extension of 802.11 that applies to wireless LANs and provides up to 54 Mbps in the 5 GHz band. The 802.11a standard specifies an orthogonal frequency division multiplexing encoding scheme rather than FHSS or DSSS.
- IEEE 802.11b: IEEE Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher Speed Physical Layer (PHY) Extension in the 2.4 GHz band. This standard is an extension to 802.11 that applies to wireless LANS and provides 11 Mbps transmission (with a fallback to 5.5, 2 and 1 Mbps) in the 2.4 GHz band. The 802.11b standard specifies only DSSS and allows wireless functionality comparable to Ethernet.
- IEEE 802.11g: IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Further Higher Data Rate Extension in the 2.4 GHz Band. This standard applies to wireless LANs and provides 20+ Mbps in the 2.4 GHz band.
- IEEE 802.11n: IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 11: Wireless LAN Medium Access Control (MAC)and Physical Layer (PHY) Specifications Amendment 5: Enhancements for Higher Throughput. This standard is an amendment to WLAN MAC and PHY specifications, intended to serve as an upgrade to all existing IEEE WLANs. An actual data transfer rate of 100 Mb/s is planned, with compatibility for devices conforming to IEEE 802.11a/b/g.

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Industry Guidance and Guides

- Radio Frequency Wireless Technology in Medical Devices – Guidance for Industry and Food and Drug Administration Staff (2013)
- Content of Premarket Submissions for Management of Cybersecurity in Medical Devices - Guidance for Industry and Food and Drug Administration Staff (2014)
- Wireless Medical Telemetry Risks and Recommendations (2000)
- Deciding When To Submit A 510(k) For A Change To An Existing Wireless Telemetry Medical Device: Final Guidance for FDA Reviewers and Industry (2000)
- Electromagnetic Compatibility Aspects of Medical Device Quality Systems

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Reporting Problems to FDA

Prompt reporting of adverse events can help the FDA identify and better understand the risks associated with RF wireless medical devices. We encourage health care providers and patients who suspect a problem or hazardous event to file a voluntary report through MedWatch: The FDA Safety Information and Adverse Event Reporting Program.

Health care personnel employed by facilities that are subject to Reporting Adverse Events (Medical Devices) requirements should follow the reporting procedures established by their facilities.

Manufacturers, distributors, importers, and device user facilities (which include many health care facilities) must notify the FDA immediately upon discovery of any accidental radiation occurrence or radiation safety defect by Reporting Adverse Events (Medical Devices).

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Additional Information

- FDA Safety Communication: Cybersecurity for Medical Devices and Hospitals Networks
- FDA: Electromagnetic Compatibility (EMC)
- Association for the Advancement of Medical Instrumentation: Healthcare Technology in a Wireless World
- Association for the Advancement of Medical Instrumentation: Wireless Technology

Wireless Medical Devices

Wireless Medical Telemetry Systems

Page Last Updated: 04/07/2016

http://www.computerworld.com/article/2512134/healthcare-it/fda-eyes-regulation-of-wireless-networks-at-clinics--hospitals.html

FDA eyes regulation of wireless networks at clinics, hospitals

Networks could become 'regulated medical devices' because of data they carry

As more hospitals and clinics plug patient monitoring equipment and other devices into traditional data networks, the closer the U.S. Food and Drug Administration (FDA) comes to regulating the networks as medical devices.

Currently, most hospitals and clinics manage medical devices on discrete networks to better ensure the safety and security of those systems. But there is a trend toward consolidation, particularly onto wireless networks, for easier management.

"We're trying to get away from separate networks and put those medical devices on the IT backbone; the problem is that backbone has never been tested to support these medical systems," said Rick Hampton, wireless communications manager for Partners HealthCare System in Boston.

In 2008, the FDA released its Medical Device Data System (MDDS) proposal, which is aimed at reclassifying health IT. The proposed regulation would define medical devices as anything that provides electronic transfer, exchange, storage, retrieval, display or conversion of medical device data without altering the function or parameters of any connected device.

"If you take a thing and connect that thing to a medical device as defined by the FDA, and that thing extracts medical data as defined by the FDA ... and it takes that data and transports, displays, stores or manipulates that data, then that thing is a medical device," Hampton said.

Partners Healthcare, which includes Massachusetts General Hospital, Brigham and Women's Hospital, and Dana-Farber/Partners CancerCare, is for now keeping its medical devices on stand-alone wireless networks, according to Hampton. But that's frustrating for IT administrators who would rather manage all of their wireless networks as a single system for convenience. At the same time, "most IT departments look at being regulated with quite a bit of disdain. Being a regulated medical device, you can't make changes to those networks willy-nilly," Hampton said.

The FDA encouraged the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) to form a joint working group to draft a standard that addresses management risks associated with medical IT networks. After years of work, the IEC 80001-1 Risk Management Standard was finalized in November by both the IEC and the Association for the Advancement of Medical Instrumentation.

The standard is aimed at protecting patient safety, patient data security, and effectiveness of care, said Karen Delvecchio, the lead systems designer at GE Healthcare. "Those three things all have some risk associated with

them in medical IT networks, and in fact they need to be balanced. Often we do things to increase effectiveness that brings safety risks. Or we may increase security to the degradation to safety risks or effectiveness."

IEC's 80001 standard defines three key areas of risk management, according Delvecchio. The first addresses risk levels to patient health. The second is effectiveness, or the ability of a healthcare organization to perform its duties. The third is data and systems security, which addresses a network's ability to protect sensitive patient information.

"A lot of people have actually been looking forward to [80001] because it organizes how to address risk management. It organizes the roles and responsibilities," Delvecchio said.

The standard, for instance, deals with such issues as electromagnetic compatibility between electronic devices and defines the requirements for risk management of IT networks that incorporate medical devices. However, the standard does not specify acceptable risk levels, and adherence isn't mandatory, at least not officially. The FDA typically takes a carrot-and-stick approach to pushing standards compliance.

"You can follow joint working groups' standards or not. If you follow them, then you get to collect money from Medicare and Medicaid. If you don't comply, then you have two choices. You can have the federal government come in and inspect your hospital, or you can decide not to accept money from Medicare or Medicaid," Hampton said. "Voluntary sometimes isn't exactly voluntary."

Last year, Jeffrey Shuren, director of the FDA's Center for Devices and Radiological Health, informally spoke before the policy committee (download PDF) of the U.S. Office of the National Coordinator for Health Information Technology. During that meeting, he discussed the possibility of regulatory oversight for health IT software.

According to Shuren, the FDA last year received reports that six patients died and 44 people were injured as a result of health IT-related malfunctions. The FDA also received 260 reports of malfunctions that had the potential to harm patients.

"Because these reports are purely voluntary, they may represent only the tip of the iceberg in terms of the problems that exist," Shuren said.

Todd Cooper, a member of the ISO and IEC joint working group, said the group is currently working on three follow-up documents to the new standard. Those documents, due out later this year, will focus on wireless networks, step-by-step risk management for healthcare organizations, and issues involving the communication of security risks and requirements.

Cooper, who established a healthcare IT consultancy called 80001 Experts LLC, described the wireless network convergence in the industry as "a complete mess.

"In fact, some people have said wireless is one of the technologies that forced the hand of 80001-1," he said. "With wired networks, you can always lay new cable because you can guarantee better system effectiveness. With wireless, you can't do that. You only have so much spectrum."

The cost of adhering to the standard could be significant. For example, hospitals will have to designate a risk management facilitator to develop processes and procedures and analyze what has or has not already been done. "The purpose of that is to expose what hidden risk has not been thought of yet," Delvecchio said.

Hampton recognizes that, before they can converge medical device and data networks, hospitals need a list of the requirements a network must meet in order for medical devices to work safely and effectively. And staff need to be trained to maintain those networks.

"Now we have to know as much about our IT network as we do about our medical device network," he said. "I'm here to tell you there's a huge gap in information that I can get from the IT world. Most IT vendors I've talked with, their notion is that 80001 doesn't affect them because they're not a medical device manufacturer. But it's not what you think you are, it's what the FDA thinks you are.

"Some hospitals have either not gone forward with the wireless network convergence or greatly constrained what they would have done. Others have gone ahead with integrating medical device alarms on their wireless devices and perhaps even turned the alarms off at the bedside, which is a no-no from a regulatory standpoint," Hampton said.

In 2002, for example, CareGroup Healthcare System in Boston lost its entire data network for four days due to physical, unmanaged changes. But its medical devices continue to work because they used a separate and discrete network.

"Had they had a truly converged network, their medical devices wouldn't have worked either," Hampton said.

Delvecchio said the medical community is keenly aware of the problems and dangers associated with converged networks -- including the unanticipated consequences when medical or communication devices are added. For example, an operating system upgrade or a security patch can cause a clinical application to go down.

"I've been to meetings of biomedical engineers. If you ask them if there are any cases where IT has disrupted patient care, all their hands go up," she said. "Sometimes it happens during the network design phase. Or it could be patient monitors, or some kind of alarming system, and when you fire it up, something else breaks."

Lucas Mearian *covers storage, disaster recovery and business continuity, financial services infrastructure and health care IT for* Computerworld*. Follow Lucas on Twitter at @lucasmearian or subscribe to Lucas's RSS feed . His e-mail address is lmearian@computerworld.com.*

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Wireless Medical Technologies: Navigating Government Regulation in The New Medical Age

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Content

Wireless Medical Technologies:

Navigating Government Regulation in the New Medical Age

I. Introduction to Wireless Medical Devices

The digital age is changing the nature of health care delivery. While politicians are debating health care reform and how to handle rising costs, the health care industry is capitalizing on new medical technologies that will both dramatically improve care and lower cost.

We are witnessing an explosive growth in medical devices that use wireless technologies, some implanted and some worn on the body, to control bodily functions and to measure an array of physiological parameters. Implanted devices can control heart rhythms, monitor hypertension, provide functional electrical stimulation of nerves, operate as glaucoma sensors, and monitor bladder and cranial pressure. External devices monitor vital signs, assist the movement of artificial limbs, and function as miniature "base stations" for the collection and transmission of various physiological parameters. Soon, miniature transponders embedded in pills will enable doctors to track and monitor drug use.[1] As microprocessors become smaller and more powerful, it is safe to predict that someday wireless technologies will be able to monitor or control nearly every bodily function and movement.

Many wireless medical devices communicate with nearby receivers that are connected to landline networks, cellular systems or broadband facilities that access the Internet. Patients no longer need to be tethered to one spot by a tangle of cables, creating a safer workplace for medical professionals and a more comfortable environment for the patient, with a reduced risk of infection. Wireless monitoring permits patients to thrive outside medical environments, reducing health care costs and enabling physicians to obtain vital information on a real-time basis without the need for office visits or hospital admissions. For aging populations, wireless medical devices offer an important solution for preventative and managed care.

II. A Multi-Agency Regulatory Environment

Wireless medical devices pose three challenging questions for regulatory authorities: (1) are they compatible with other uses of the spectrum; (2) are they safe and effective for the patient; and (3) who should bear their ultimate cost? In the U.S., three federal agencies, the Federal Communications Commission ("FCC"), the Food and Drug Administration ("FDA") and the Centers for Medicare and Medicaid Services ("CMS") are charged with answering those questions and play a crucial role in regulating the market for medical devices.

Today, almost every wireless medical device requires both FCC certification and FDA authorization before it can be marketed in the U.S. For reimbursement purposes, which are often necessary for the commercial success of a medical device, CMS must determine that the device provides "reasonable and

[1] Don Clark, "Take Two Digital Pills and Call Me in the Morning," *Wall Street Journal*, August 4, 2009.

necessary" care.

This tri-partite federal regulatory structure means that manufacturers and vendors are required to navigate myriad technical rules and policies enforced by agencies with different, and sometimes divergent, objectives. Unless these regulatory issues are taken into account at the earliest stages of the research and development process, device manufacturers could find themselves investing significant time and resources in products for which they cannot obtain government approval. Or they may find that the government will not pay for the device, curtailing or eliminating entirely the opportunity to commercialize their technology. Failure to comply with applicable regulations can bring government investigations, fines, forfeitures and other punishments, which in turn can lead to civil litigation and shareholder lawsuits. Intentional noncompliance can even result in criminal charges against corporate officers.

Currently, the FCC is in the process of allocating new spectrum and developing technical standards for several types of implants and body-worn devices. The FCC's goal is to create new opportunities for manufacturers to integrate radio technologies into medical products to improve the treatment of patients and delivery of health care. These efforts are underway as the FDA develops new guidelines for wireless medical technologies, and indeed the two agencies are at least attempting to put together a framework for sharing information.[2] Together, these efforts portend major regulatory changes as the health care industry prepares for the advent of many new wireless applications.

III. FCC Oversight

Every medical device, whether implanted or worn on the body, that uses radio technology falls within the FCC's authority to manage the electromagnetic spectrum. Under FCC rules, wireless devices must be tested for conformance to various technical standards and authorized before they may be imported, marketed or operated in the U.S.

The FCC's main goal is to ensure that wireless medical devices, like all other radio frequency devices, operate compatibly with other spectrum users. At the same time, the FCC is responding to increasing demands of health care professionals for spectrum access where they can operate wireless devices without interference. In 2009, the FCC completed one rulemaking and initiated two new ones to allocate more spectrum for medical device applications.

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[2] In July 2010, the FCC and FDA released a joint Memorandum of Understanding in which both agencies agreed to work together to promote initiatives related to the review and use of FDA-regulated medical devices that utilize radiofrequency emissions. The MOU is intended to promote collaboration and ultimately improve the efficiency of the regulatory processes for such devices. The goals of the MOU are to explore ways to: (1) enhance information sharing to ensure the safety and efficacy of medical devices; (2) improve the efficiency of both agencies' regulatory schemes; (3) promote efficient utilization of "tools" and expertise for product analysis, validation and risk identification; and (4) build "infrastructure and processes" that meet the agencies' common needs.

A. Categories of Wireless Medical Device Technologies

Generally, wireless medical devices fall into one of two informal FCC categories: short range or long range. Short range technologies transmit data from the patient to a local receiver/monitor. The local receiver may stand alone or connect to a central monitoring station. Long range technologies generally transmit patient data directly to a remote monitoring location. As new communication techniques are developed for medical applications, the FCC often must adjust its rules to accommodate these advancements.

B. Short Range Devices for Patient Monitoring, Control and Diagnostics

Available technologies and the FCC services for short range patient monitoring include:

- Inductive Implants: Historically, inductive implantable medical devices have been used to control or monitor cardio activity. Most devices operate in the bands below 200 kHz and communicate at distances of less than one foot from the patient's body.
- Medical Device Radiocommunication Service (formerly "MICS"): Allocated in 1999 for licensed communication between body implants and a nearby controller, the FCC added more frequencies to this service in 2009 for use by body-worn monitoring devices. These devices operate in the 401-406 MHz band at distances up to about 10 feet.
- Wi-Fi, Bluetooth and Zigbee: These unlicensed technologies are commonly used with cell phones, handheld devices and personal computers, but can also be used for implanted or body-worn medical devices. These devices operate in the 902-928, 2400-2483.5 and 5725-5850 MHz bands at distances up to a few hundred feet.
- Ultra-Wideband: New uses of unlicensed ultra-wideband technologies are starting to emerge for medical telemetry and imaging applications. These devices operate at very low power in almost any region of the spectrum at distances up to a few feet.
- Medical Micropower Networks: In November 2011 the FCC allocated new spectrum to accommodate the operation of implanted microstimulator devices that might lead to the creation of an artificial nervous system that could restore mobility to paralyzed limbs. These devices operate in the 413-457 MHz band at distances up to a few feet.
- Medical Body Area Networks: In May 2012 the FCC allocated new spectrum to allow a wireless personal area network ("PAN") of multiple body sensors to monitor or control patient functions. These devices operate in the 2360-2400 MHz band at distances up to a few feet.

C. Long Range Medical Telemetry

Available technologies and the FCC services for long range medical telemetry include:

- Wireless Medical Telemetry (WMTS): WMTS uses unlicensed spectrum to communicate data from body

sensors to remote monitoring locations. These devices operate in various bands between 600 and 1432 MHz band at distances up to several hundred feet.

- Worldwide Interoperability for Internet Access (WiMAX): Often referred to as a "last mile" broadband access technology, WiMAX provides wireless transmission using a variety of transmission modes, from point-to-multipoint links to portable and fully mobile Internet access. The technology provides up to 70 Mbps broadband at distances over several kilometers. The technology is based on the IEEE 802.16 standard (also called Broadband Wireless Access) and uses frequencies around 2.5 GHz in the U.S.

D. FCC Regulation of Wireless Devices

The FCC's detailed device authorization process is described in **Appendix A**. The FCC standards specify permissible frequencies, power levels, duty cycle, band sharing and frequency stability requirements, along with detailed test procedures for measuring these parameters. When advances in medical treatment are combined with radio technologies, the FCC's rules will often lag behind these developments. In such cases, rule waivers or petitions for new rules are filed with the FCC by medical manufacturers or health care organizations.

IV. FDA Oversight

The FDA regulates the marketing of all medical devices sold or imported in the U.S. Unlike the FCC, which focuses on the interference potential of radio frequency devices, the FDA's role is to ensure that such devices are safe and effective for patient use. The range of products that are classified and regulated as "medical devices" is quite broad and can include such products as medical information networks, cell phones programmed to remind users to take pills and conventional devices fitted with radio communication features.

A. Device Classification Scheme

Medical devices are placed into one of three classifications, based on risk. The lowest-risk devices are in Class 1, and most can be marketed without prior FDA permission; however, these Class 1 devices are still subject to other FDA regulations, such as labeling, listing and quality control requirements. Most wireless medical devices fall under Class 2 and may be marketed only after the FDA determines they are "substantially equivalent" to another device that is lawfully on the market. Class 3 devices are novel, generally high-risk devices for which the FDA requires proof of safety and effectiveness based on clinical trials.

Navigating the FDA process, which sometimes includes significant disagreements over the proper classification of the device, can be expensive and time-consuming. Because the FCC and the FDA have different objectives, the approval of one agency provides no guarantee that the device will clear the other.

B. FDA Guidance on Wireless Medical Devices

The FDA recognizes the increasing use of wireless medical devices and on August 13, 2013, issued a final guidance intended to help manufacturers navigate the approval process. The guidance covers the following

areas:

- Selection and performance of wireless technology
- Wireless quality of service
- Wireless coexistence
- Security of wireless signals and data
- EMC of the wireless technology
- Information for proper setup and operation
- Considerations for maintenance

C. FDA Regulation of Mobile Medical Apps

On September 25, 2013, FDA issued its long-awaited final guidance on mobile medical applications. As expected, FDA announced it will apply enforcement discretion and regulate only those mobile medical applications that are "medical devices" and whose functionality could pose a risk to patient safety if they do not function as intended. The guidance covers three categories of mobile medical apps:

- Mobile apps that connect to another device for purposes of **controlling** or **displaying, storing, analyzing or transmitting patient-specific medical device data.**
- Mobile apps that **transform the mobile platform** into a regulated medical device by using attachments, display screens, or sensors or by including functionalities similar to those of currently regulated medical devices.
- Mobile apps that **perform patient-specific analysis and provide patient-specific diagnosis or treatment recommendations.**

The FDA approval process, as well as the final guidance documents, is discussed in detail in **Appendix B**.

V. CMS Oversight

Even if a device clears both the FCC and the FDA approval processes, questions as to who will pay for it and whether the device will be marketable may remain. Medicare provides coverage for medical devices and services for more than 43 million beneficiaries. Often, for a device to be commercially viable, the manufacturer must obtain a determination that the device will be covered by Medicare.

For a medical device to be eligible for Medicare reimbursement, CMS or one of its contractors must find that the device provides "reasonable and necessary" care. Coverage determinations can be made at the national or local level. A manufacturer should consider during the initial design stages how to best position its device to receive a positive coverage determination. More details regarding CMS's procedures and coverage determinations are discussed in **Appendix C**.

APPENDIX A

Overview of FCC Regulation of Wireless Medical Devices

I. Short Range Devices for Patient Monitoring, Control and Diagnostics

(1) Inductive Implants

Historically, implantable devices used inductive coupling to communicate information between patients and doctors at frequencies below 200 kHz. Inductive devices meeting the requirements of Section 15.209 of the FCC's rules allow for the use of small antennas and generally require very little energy. Typically, information from the implanted device is accessed by means of a wand-like device placed on or close to a patient to establish the inductive communication link. Data from the implant can then be read and the implant can be programmed based on patient need.

The principal problem with implants that communicate by inductive link is that data rates are slow. As a result, the wand "reader" has to maintain contact with the patient for long periods of time, and in a therapeutic setting lengthy data transmissions can compromise patient care. Also, any movement by the patient or the reader can interrupt the session, requiring the session to be repeated. Multiple sessions with multiple implant patients can overburden a hospital's medical staff. Another problem is that there is no international harmonization of frequencies for inductive devices. This is of particular importance for patients who travel, where monitoring equipment that activates an implant in the U.S. might not be available outside the U.S. and vice versa.

Inductive implants are also used where transmission of large amounts of data is not required and continuous feedback or feedback at regular intervals is unnecessary. In addition to monitoring and controlling heart function, other common uses include monitoring of intraocular pressure, bladder pressure or cranial pressure

(2) Medical Device Radiocommunication Service (formerly the Medical Implant Communication Service)

In 1999, the FCC allocated spectrum in the 402-405 MHz band for radio communication between implanted devices and a controller either worn on the body or positioned close by. MICS is regulated under Section 95.1201 of the FCC's rules on a "licensed by rule" basis, meaning that no individual application need be filed. The 402-405 MHz band is particularly well suited for tissue penetration at relatively low power which helps extend battery life. The external controller has to be equipped with a "Listen-Before-Talk" ("LBT") frequency selection system in order to minimize interference to other licensed users in the band and to assure uninterrupted transmissions on an unoccupied channel.

MICS technology offers advantages over inductive implants. Readings may be taken from body-worn or table-top transceivers without maintaining reader contact with the patient. Further, the higher frequencies enable transmissions at high data rates.

However, for years, the MICS band languished with few users taking advantage of the new spectrum opportunity. One reason was the lack of a harmonized international standard. In 2004, the European Telecommunications Standards Institute ("ETSI") resolved this issue by publishing an EU harmonized standard for medical implant devices in the MICS band, consistent with the FCC's rules. Another factor in the delay of the MICS roll-out was that the LBT technology was expensive and time-consuming to perfect. There was also some concern that LBT might prevent the immediacy of communications that could be required between an implanted device and its controller.

Over time, any disinclination to use LBT appears to have been overcome since the technology has become much less expensive and simpler to install. Another reason, argued by some, is that the FCC's LBT frequency scanning sensitivity levels are too low to detect many ambient signals so that, in practice, LBT-equipped devices can operate with little fear of not being able to gain immediate access to a channel. Finally, it may be that the original concerns of the National Telecommunications and Information Administration ("NTIA") that incumbent spectrum users, namely radiosondes (balloon-borne instruments that measure and transmit information on atmospheric conditions), would interfere with MICS were overstated as the radiosondes have caused no difficulty to MICS users. Nevertheless, ten years after spectrum was allocated for MICS, the FCC had authorized fewer than two dozen MICS devices.

In 2009, the FCC amended its MICS rules by adding two "wing bands" at 401-402 MHz and 405-406 MHz for use by body-worn monitoring devices that do not communicate with implants. The entire service from 401-406 MHz was re-named the Medical Device Radiocommunication Service ("MDRS"). Operation in the new wing bands is permitted without the LBT requirement at very low signal levels – 250 nanowatts maximum effective isotropic radiated power ("EIRP") as opposed to LBT-enabled 402-405 MHz implants which may operate at 30dB higher power. One small portion of the lower wing band, 401.85-402 MHz, is also permitted this higher power without the LBT requirement. Bandwidth limits in the wing bands are 100 kHz instead of the 300 kHz permitted for the LBT-enabled 402-405 MHz band. Because of the very low power limits, it was anticipated that body-worn devices in the wing bands would be used for non-critical applications such as monitoring of temperature, pulse rate and other vital signs that do not require continuous monitoring to sustain life.

(3) Wi-Fi, Bluetooth and Zigbee

In 1997, just before the FCC began its efforts to establish the WMTS, the IEEE adopted the first version of the 802.11 wireless LAN standards for systems operating in the Industrial Scientific and Medical ("ISM") band at 2.4 GHz. Initially used for short range application such as transmitting signals from a transceiver to a central nurse's station (or some other point in a hospital), subsequent versions of the 802.11 standard were later approved, offering greater ranges and different data rates (*see* Appendix A-1). The equipment associated with wireless LAN has become inexpensive and reliable, and the once-feared interference from other unlicensed Part

15 devices has not materialized. Further, Wi-Fi systems are considerably less expensive than WMTS systems and, because of worldwide standardization, easier to upgrade with various vendors' devices. There is ongoing debate as to whether devices using WMTS or 802.11-based devices will ultimately be the most successful for long range medical telemetry.

These technologies are used for products regulated under Section 15.247 of the FCC's rules which governs frequency hopping and digital modulation technologies (also known as spread spectrum) that operate in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands. Bluetooth and Zigbee in particular are designed for low-power, short-range transmissions. Bluetooth was designed specifically as a replacement for cables between computers and peripheral devices, but it can also be used to monitor implanted or body-worn devices. Zigbee-enabled devices were designed to control and automate a network of devices and are capable of monitoring groups of implanted devices. Each technology has variable power levels and data rates. One significant difference is cost – Zigbee modules are approximately one-third the cost of Bluetooth modules and are designed to use considerably less battery power.[3]

(4) Ultra-wideband ("UWB") Application

UWB medical imaging devices, operating under Section 15.513 of the FCC's rules, are just beginning to emerge. UWB devices can be used for very high data rate communications (>1 Gbps), which makes the technology potentially useful for medical applications that involve large file or database transfers. In addition, UWB devices are able to detect motion, and therefore can be used to measure heart rate, respiration, and patient body movement over a very short range (less than 1m). Because they can transmit large amounts of data, UWB imaging devices can be used to create extremely sharp images of bones and internal organs. However, because the FCC's UWB power limits are very conservative, UWB-based medical monitoring devices will continue to be limited to very short-range applications and to date the FCC has authorized only a few UWB medical imaging-monitoring devices.

(5) <u>Medical Micropower Networks ("MMNs")</u>

In November, 2011, in response to a petition from the Alfred Mann Foundation, the FCC designated 24 MHz of spectrum in the 413-457 MHz range for a "medical micropower network" to accommodate operation

[3] Battery life remains a significant issue with wireless implants. Batteries last only a few years and must be replaced, which means the expense and risk of another surgical procedure, no matter how minor. There are, of course, incremental increases in battery life all the time, but more dramatic advances are also occurring. European countries are developing a rechargeable battery for FES (functional electrical stimulation) implants and testing implants containing a fuel cell that can be powered by the body's own glucose. Experimentation is also being conducted with magnetic resonators to transfer power across a distance sufficient to recharge an implant's battery. It seems likely that, at some point, battery life will exceed the useful life of an implant. Until then, however, there is a premium on implant technologies that transmit over short distances and use the least power possible.

of implanted microstimulator devices using FES techniques.[4] These devices can be "injected" into the body to form a network that would be coordinated by a portable, external master control unit. This network could serve as an artificial nervous system to restore sensation, mobility and other functions to paralyzed limbs or malfunctioning organs. The FCC requested comment on the suitability of four portions of the 413-457 MHz band for MMNs: 413-419 MHz, 426-432 MHz, 438-444 MHz and 451-457 MHz. The 410-450 MHz band is allocated primarily to the federal government, so use of the bands would require coordination with the NTIA[5].

(6) Medical Body Area Networks ("MBANs")

On May 24, 2012 the FCC adopted rules based on a proposal by General Electric Health Care ("GEHC") to allocate spectrum in the 2360-2400 MHz band for another wireless telemetry network of multiple body sensors used to monitor a patient's health.[6] This system would not involve implanted devices. As described by GEHC, such a network could be created through attachment to the patient of multiple, inexpensive, wireless sensors or network nodes at different locations on or around a patient's body to take readings such as temperature, pulse, blood glucose levels, blood pressure, respiratory function and other physiological metrics. This information would be transmitted to a hub that is either worn by the patient or located nearby. The hub could be equipped to initially process the information and then transmit the data to a central location. Essentially, the MBAN system is a way to collect data from multiple sensors, process the data and then send it through a WMTS system or by wire to a monitoring station. By creating the network, information that might otherwise be transmitted on separate, possibly conflicting, frequencies can be "bundled" and transmitted on a single frequency.[7]

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[4] *In the Matter of Amendment of Parts 2 and 95 of the Commission's Rules to Provide Additional Spectrum for the Medical Device Radiocommunications Service in the 413-457 MHz Band*, Report & Order, ET Docket No. 09-36, released November 30, 2011.

[5] Of particular concern is spectrum in the 420-450 MHz bands used on a primary basis for federal radiolocation, including ground-based, airborne and shipborne radar systems for long-range surveillance that is operated with very high power over wide bandwidths. The radar receivers are very sensitive in order to detect weak returns. Non-federal uses of the bands include land mobile base and mobile stations, and broadcasting remote pickup services. The most significant concern came from NTIA which argued that the federal government's defense-related, high-power radar systems may cause interference to MMN systems. Moreover, NTIA suggested that hundreds of MMN transmitters might cause aggregate interference to the federal systems.

[6] *In the matter of Amendment of the Commission's Rules to Provide Spectrum for the Operation of Medical Body Area Networks*, First Report and Order (Order) and Further Notice of Proposed Rulemaking, ET Docket No. 08-59, released May 24, 2012.

[7] The 2360-2400 MHz band is a particularly crowded area of the spectrum. It is allocated for sensitive federal and non-federal aeronautical telemetry for flight testing of aircraft and missiles, the radiolocation service and the Amateur Radio Service.

(7) Emerging Standards

A new wireless medical standard, IEEE 802.15.6, was recently developed for a personal area or body area network to be operated at low frequencies over very short range, with long battery life and high data rates. Proponents anticipate that the technology will be used for a very small unobtrusive body-worn device for the exchange of medical information between an implant and a wristwatch receiver.

II. Long Range Devices for Patient Monitoring and Telemetry

(1) Wireless Medical Telemetry Services (WMTS)

Before the 1990s, remote medical telemetry devices were limited to basic heart monitoring and operated under a Business Radio Service license on 18 frequencies in the 450470 MHz band and on an unlicensed basis in the TV bands at 174-216 MHz and 470-668 MHz.[8] Sensors were placed on the patient's chest to pick up electrical signals from the heart. These sensors were connected to a transceiver by short cables and the transceiver relayed the signals to a central nursing station, often through repeaters installed in the ceiling. The system worked reasonably well until 1998, when the first digital television trials took place in Dallas, Texas. DTV transmissions from TV channel 7 (174-180 MHz) that had not previously been used in the area for analog broadcasts began to interfere with the monitoring equipment at Baylor University Hospital.

Fearing that interference to heart monitors might become a national medical problem, the FCC immediately started a proceeding to allocate dedicated spectrum for wireless medical telemetry. Two years later, the FCC adopted rules under Section 95.1101 for WMTS. In the process, the FCC notified manufacturers that in two years it would stop accepting equipment authorization applications for wireless medical devices in the bands subject to interference from the high-power land mobile and television broadcast stations, and labored to convince hospitals using the band for wireless telemetry to move their activities to the WMTS spectrum. Some hospitals did not move, however, and still operate the "legacy" systems[9]. Like MICS, WMTS is licensed by rule.

The FCC provided the WMTS a total of 15 MHz of spectrum in three bands, 608-614 MHz, 1395-1400 MHz, and 1427-1429.5 MHz, for the purpose of "the measurement and recording of physiological parameters and other patient-related information via radiated bi-or unidirectional electromagnetic signals."[10] WMTS systems usually function by direct attachment to body sensors or through connection by wire to a short range system such as MICS. WMTS devices only need to be certified under Part 15 of the FCC's rules. This means

[8] Unlicensed operation for biomedical telemetry devices were authorized under Section 15.242 of the FCC's rules.

[9] The last FCC equipment authorization for a wireless telemetry device in the 174-216 and 470-668 MHz bands was granted in 2001. Section 15.242 remains in order to provide regulations for legacy equipment.

[10] The FCC is deciding now whether to permit WMTS to operate on a secondary basis between 1429.5 and 1432 MHz.

that eligible licensees (essentially medical professionals) may use WMTS devices without the formality of a license application. Depending on its location, a WMTS system typically has a useful range of 30-60m.

The use of WMTS has become widespread, but it has several disadvantages. The lower band, 608-614 MHz, is subject to interference from adjacent TV channels 36 and 38. Over the years, hospitals have been forced to install special antennas and amplifiers and experiment with filtering in order to avoid the interference. Although WMTS has 15 MHz of bandwidth, the spectrum is not contiguous, which limits its flexibility and adds to the complexity and cost of developing products by requiring the filtering of some frequencies. The total spectrum is insufficient for more than a few hundred monitors per hospital and thus cannot support transmissions from an increasing number of monitoring devices. There are no uniform standards for interoperability between manufacturers, which means that once a hospital has chosen a system from one vendor it is effectively locked into using that vendor for the life of the system (which could be 10 years or longer). A lack of uniform standards also means that it is difficult for groups of hospitals to share equipment or interconnect.

(2) WiMAX

WiMAX ("World Interoperability for Microwave Access") is generally operated at 2.5 GHz, although there are no internationally harmonized frequencies. WiMAX can transmit over considerable distances, with both fixed and mobile operations, and can theoretically transmit at data rates up to 70 Mbps (for mobile operations, 40 Mbps is a more reasonable expectation). On a small scale, WiMAX can be a direct competitor to the Wi-Fi LANS that are prevalent in most hospitals. With its large bandwidth and speed, WiMAX can transmit monitoring and diagnostic data from multiple patients without the delays inherent in low bandwidth transmissions. Only a few small WiMAX base stations are needed to cover an entire building. In larger applications, WiMAX is capable of area-wide service, connecting hospitals in a region and enabling the sharing of patient information. In its mobile form, WiMAX can be used to transmit patient data between an ambulance and a hospital.

To date, WiMAX has not proven as prevalent as its developers envisioned. On a large scale, WiMAX's network architecture requires access points and encounters the same zoning difficulties that can inhibit coverage for cellular and PCS technology. On a small scale it must compete with the entrenched Wi-Fi systems. Further clouding WiMAX's future is the advent of 4G technology which also promises bandwidth, speed and ubiquity and relies on an existing infrastructure.

A table of characteristics for the current medical telemetry bands is available in **Appendix A-1**.

III. Other Wireless Medical Technologies

Wireless medical devices operate not only pursuant to the FCC rules designed specifically for medical

use, but also operate in licensed and unlicensed spectrum not limited for medical purposes. For instance, the well-known "panic button" for the elderly is designed to comply with the rules intended for unlicensed control signals under Section 15.231 of the rules, the same rule that governs the operation of garage door openers or home security systems. When such a device is activated in an alarm situation it may operate continuously, a provision ideal for panic buttons.

The FCC has also set aside licensed "public safety" frequencies under the Part 90 rules which may be used for medical telemetry. These frequencies may be used by medical personnel, hospitals and ambulance services for the transmission of medical information generally. A system operating under these rules generally consists of both fixed and mobile stations, such as for the transmissions between ambulances and hospitals.

IV. FCC Regulation of Wireless Devices

(1) Equipment Marketing and Authorization

Almost every type of wireless transmitter must be certified for compliance with the FCC's rules before it can be imported or marketed in the U.S. It is not unusual, however, that during the development of a device a manufacturer desires to show or demonstrate it to the public, prior to certification. Over the years, the FCC has adopted exceptions to the certification rule and identified circumstances where some forms of marketing are permitted.[11] For instance, the general marketing prohibition does not apply to marketing to retailers or wholesalers (but not end users) based on sales contracts which are contingent upon eventual compliance with the applicable equipment authorization rules. Also, a device in the pre-production or design stage may be offered for sale to business, commercial, industrial, scientific, or medical users (but not users in residential environments), provided that the prospective buyer is advised in writing at the time of the offer for sale that the equipment is subject to the FCC's rules and will comply with the appropriate rules before delivery. In addition, the FCC allows equipment to be advertised or displayed (but not sold) at trade shows or exhibitions prior to receiving equipment authorization, provided the display is accompanied by a conspicuous notice explaining that the device has not been authorized by the FCC and may not be marketed until FCC authorization is obtained.

In addition, the FCC staff has made its own informal interpretations of the marketing rules and the circumstances under which a device may be legally marketed. Some of these interpretations can be found in the Office of Engineering and Technology's "Knowledge Database." Other interpretations are passed down by oral tradition, or found in copies of letters that, for one reason or other, are no longer readily available in the FCC's files.

[11] The term "marketing" is defined as the selling, leasing, offering for sale or lease, advertising for sale or lease, importation, shipment, or distribution for the purpose of selling or leasing or offering for sale or lease

There is also a general rule prohibiting operation of a device before it is authorized, but as with the marketing rules, there are exceptions. Pre-compliant operation is permitted in the following instances:

- Compliance testing
- Demonstrations at trade shows (with an accompanying notice that the device may not be marketed until authorized by the FCC)
- Demonstrations at exhibitions conducted at business, commercial, industrial, scientific, or medical locations with the accompanying notice (see above)
- Operation at the manufacturer's facilities to evaluate product performance and customer acceptability during the developmental, design or pre-production stage
- Operation at a business, commercial, industrial, scientific, or medical location to evaluate performance and customer acceptability where acceptability cannot be determined at the manufacturer's facilities because of the size or unique capability of the device, again only during the developmental, design or pre-production stage.

For devices that are "licensed by rule" (such as WMTS and MDRS), a manufacturer can operate the device during a demonstration only under the authority of an FCC licensee (*e.g.,* a hospital).

(2) Importation

Even after a device has been authorized by the FCC, it may not be brought into the U.S. without documentation describing the device and providing its date of certification or, if the device is not required to be certified, a statement that the device complies with all relevant technical standards. Devices that have not been authorized may be imported in limited quantities for the purpose of testing or for the exclusive use of the federal government.

(3) Enforcement

The FCC takes its equipment authorization rules very seriously. Through its Enforcement Bureau, the FCC has an active program of imposing penalties on companies who have either failed to obtain an authorization before importing or marketing a device, misled the FCC in the process of obtaining an authorization or marketed equipment not compliant with the technical standard test data reported to the FCC in the certification process. Forfeitures of tens of thousands of dollars for even minor violations are common.[12] The enforcement process is often an adjunct to policy. The FCC has been known to impose very large forfeitures for rule violations that are not particularly significant, but frustrate some over-arching

[12] Often, negotiations with the Enforcement Bureau lead to a consent decree – an agreement by which the FCC ends an investigation in return for a manufacturer or vendor agreeing to adopt a compliance program and the submission of a "voluntary contribution" to the U.S. Treasury.

regulatory objective.

(4) Equipment Authorization Process

As noted, all transmitters used for telemetry or patient monitoring must be FCC-certified prior to marketing.[13] The certification process involves:

- Testing: The device must be tested to show compliance with relevant FCC technical standards by an FCC-listed laboratory, and the test report together with an application form, photographs and other information must be sent to the FCC Laboratory for approval. Alternatively, a manufacturer may choose to have its application and test report approved by a Telecommunications Certification Body ("TCB"), a private entity authorized by the FCC to grant certification applications.
- Radiation Exposure: A wireless medical device, either body-worn or implanted, must be tested for compliance with the non-ionizing radiation exposure limits of Section 2.2093(d) of the FCC's rules. The limits are based on criteria published by the American National Standards Institute for localized specific absorption rates (SAR) in tissue. Compliance can be shown by computational modeling or laboratory measurement techniques. The measurement techniques require specialized equipment and expertise. At present, TCBs are excluded from evaluating SAR testing.
- Device labeling: If the device is an unlicensed device under the Part 15 rules (*e.g.,* Bluetooth, Zigbee wireless LANS) it must be labeled using language prescribed by the FCC in order to inform the user that it is an unlicensed device that is not protected from interference.

The technical standards are either spelled out in the FCC's rules themselves or in procedures adopted by standards organizations and incorporated in the FCC's rules by reference. Nevertheless, compliance with the FCC's technical standards is not the cut-and-dried matter one might suppose. There are often disputes between manufacturers, independent test laboratories and the FCC's own laboratory as to whether a given standard is applicable or the appropriate measurement procedures for determining compliance with a standard. Often there are disagreements between the FCC and the NTIA on proper measurement techniques. As an added complication, products incorporating different RF devices must be tested to meet the standards for both.

(5) Waivers

A wireless transmitter that complies with the FCC's technical standards can generally obtain a certification within several months if the application is submitted to the FCC, and within several weeks if the

[13] There are separate FCC regulations for devices containing digital circuitry. The device must also be tested to show compliance with the digital device standards but the manufacturer does not have to submit the test results to the FCC, but only verify (self-certify) that the device complies. Virtually every device that must be tested for certification must also be tested to verify compliance with the digital device standards.

application is submitted to a TCB. However, when a device does not comply with the rules, it may be possible to obtain a waiver, a lengthy process that can often take two years or more. A manufacturer seeking a waiver has to show that the device poses no greater threat of interference, or operates at a location where the possibility of interference is minimized, or perhaps should be measured using a technique better suited to reflecting compliance with the FCC's standards. Whatever the arguments made in support, a waiver petition must go on notice for public comment and then withstand a new round of comments should the FCC actually propose to grant a waiver. Usually, it can be expected that incumbent spectrum users or competitors will file an objection to a waiver petition. If the waiver requires the use of spectrum shared between government and non-government users (and most often this is the case), it is possible that the NTIA will not agree to a waiver or agree only if conditions are imposed on the petitioner. NTIA coordination alone can take months.

(6) Rulemaking

The FCC's rules are often based on snapshots of technology at a moment in time. As new technologies are developed, the FCC's rules are sometimes inadequate to accommodate them. Under these circumstances, a waiver is not a proper course of action because it would not be applicable generally. A rulemaking proceeding, on the other hand, can be used to adopt rules of generally applicability–for instance, a new spectrum allocation or formation of a new radio service. A rulemaking proceeding is governed by the Administrative Procedure Act, which requires the FCC to publish a notice of a proposed action. The public (including industry and standards groups) then has an opportunity to comment on the proposal and to file reply comments. The FCC then adopts or chooses not to adopt new regulations. As in the waiver process, it is often necessary for the FCC and the proponents of the proposed rule to negotiate with the NTIA. Coordination can be contentious and the resulting regulations are often the product of compromise. While the rulemaking process has been used to develop new technologies (*e.g.,* MICS and WMTS), it is time-consuming and mostly benefits those companies who have engaged in long term planning and can accommodate their product schedule to the FCC process. This is particularly the case for medical devices whose introduction may not only have to await adoption of a favorable rule and then FCC certification, but also FDA authorization.

(7) International Regulations

A device intended for sale internationally must also conform to the technical standards of other countries. The European countries, for instance, are in the process of internally harmonizing what had in some cases been disparate technical standards and Europe has developed its own unique approach to equipment authorization. Manufacturers wishing to sell their products abroad must navigate these regulations as well.

APPENDIX A-1 Current Medical Telemetry Bands

Standard	Frequency	Data Rate	Range
Inductive Coupling Devices	< 1 MHz	1-30 kbps	<1m
Wireless Medical Telemetry System	608-614 MHz 1395-1400 MHz 1427-1429.5 MHz	>250 kbps	30-60m
Medical Device Radiocommunication Service	401-406 MHz	250 kbps	2-10m
802.11a Wi-Fi	5 GHz	54 Mbps	120m
802.11b Wi-Fi	2.4 GHz	11 Mbps	140m
802.11g Wi-Fi	2.4GHz	54Mbps	140m
802.11n Wi-Fi	2.4/5GHz	248 Mbps	250m
802.15.1 Bluetooth Class I	2.4 GHz	3 Mbps	100m
802.15.1 Bluetooth Class II	2.4 GHz	3 Mbps	10m
802.15.4 (Zigbee)	868, 915 MHz, 2.4 GHz	40 kbps 250 kbps	75m
World Interoperability for Microwave Access (WiMAX)	2.5 GHz	70 Mbps (fixed) 40 Mbps (mobile)	Several km

APPENDIX B

Overview of FDA Regulation of Wireless Medical Devices

I. FDA Marketing Authorization Process

Medical devices that use wireless technology must also comply with the regulations of the U.S. Food and Drug Administration. A "medical device" is defined as an instrument, apparatus, implement, machine, contrivance, implant, in vitro reagent, or other similar or related article, including a component part, or accessory that is: (a) intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease, in man or other animals; or (b) intended to affect the structure or any function of the body of man or other animals. To distinguish medical devices from drugs, a device must not achieve any of its primary intended purposes through chemical action within or on the body of man or other animals and not be dependent on being metabolized for the achievement of any of its primary intended purposes.

(1) Device Classification

Devices are classified into one of three classes, based on risk. Class 1 devices are the lowest risk, and the vast majority may be marketed without prior FDA authorization. Examples include tongue depressors, canes, and scalpel blades.

Class 2 devices are medium risk, and the vast majority may be marketed only after receiving FDA authorization via the filing of a "510(k)" premarket notification. In a 510(k) application, the submitter must show its device is "substantially equivalent" in terms of safety and effectiveness to a "predicate device" that is lawfully on the U.S. market. A device is "substantially equivalent" to a predicate device if it has the same intended use and either (1) the same technological characteristics or (2) different technological characteristics and the information submitted to the FDA does not raise new questions of safety and effectiveness and demonstrates that the device is at least as safe and effective as the legally marketed device. By statute, the FDA has 90 days to act on a 510(k) submission, though the agency often requests "additional information" that will extend the total review time beyond 90 days.

Demonstrating "substantial equivalence" can be tricky business. There is no "application form" to fill out. For most types of devices, there is not even a blueprint to follow and manufacturers must do their best to determine the information that will be required by the FDA. In some cases, the FDA has published guidance documents that provide recommendations for the information to be submitted to the agency. In other cases, the FDA has formally recognized certain international consensus standards as providing information relevant to the "substantial equivalence" analysis. In any event, use of experienced counsel to prepare a 510(k) to demonstrate "substantial equivalence" and to deal with any issues raised by the FDA can help to avoid needless expenditure generating information the FDA does not need, thereby expediting FDA authorization.

Class 3 devices are high risk devices, or are devices found not substantially equivalent to a Class 1 and 2

predicate device through the 510(k) process. These devices must be "approved" by the FDA via a pre-market approval application. The PMA process is much more involved than a 510(k) and typically includes the submission of data from experimental use of the device on humans to support claims made for the device. By statute, the FDA has 180 days to act on a PMA submission, though in practice the review is usually significantly longer. As new medical devices are developed using wireless technology, manufacturers may find themselves unexpectedly in Class 3, though there is a process by which manufacturers may seek to have their devices reclassified to Class 1 or Class 2 after a 510(k) application is refused.

A PMA filing is a very serious – and expensive – undertaking. The FDA filing fee alone is over $200,000, compared to just a few thousand dollars for a 510(k) filing. Because a PMA typically requires the submission of human clinical trial data, it is advisable to meet with the FDA staff and come to an understanding as to the scope of the clinical data to be gathered and the protocols used. Several different types of meetings with the FDA are available, including informal advisory meetings and more formal meetings during which agreement may be reached as to the information to be submitted in the PMA. Prior to conducting a clinical trial, the manufacturer must also obtain an "investigational device exemption" from the FDA to permit use of the device on humans for testing purposes.

Determining how the FDA will regulate a device, and particularly a somewhat novel device, is often complex in itself. Research regarding existing devices and informal contacts with the FDA staff may be useful. If needed, a "513(g)" application may be filed requesting a formal opinion on how the device will be regulated.

(2) <u>Wireless Devices Regulation</u>

Medical devices incorporating wireless technology may be exempt from the 510(k) program, require 510(k) authorization, or require more stringent PMA approval, depending on the nature of the device. For example, "panic buttons" that are worn on the body and allow a person to place a telephone call remotely to an emergency response center are regulated by the FDA as "powered communication systems," but as of 1998 are exempt from the 510(k) program. An "ingestible telemetric gastrointestinal capsule imaging system" used to detect abnormalities of the small bowel consisting of an ingestible capsule containing a light source, camera, transmitter, and battery also requires 510(k) authorization. An implantable pacemaker that utilizes telemetry for the relay of information and instructions is an example of a Class 3 device that requires a PMA.

Regardless of the regulatory path to obtaining marketing authorization, all medical devices must be "listed" with the FDA, and all establishments that engage in FDA-regulated activity must "register" with the FDA. Once registered, such establishments are subject to inspection for compliance with the FDA's Quality System Regulation.

Finally, for devices incorporating software, as often occurs with devices utilizing wireless technology, the FDA requires that the software be separately validated. The documentation required will vary depending upon the risk posed by the automated operation. The FDA has a guidance document that explains the type of

documentation that may be required.[14]

II. FDA Recommendations for Devices Incorporating Wireless Technology

Having a product certified by the FCC is not sufficient to guarantee it will be authorized for marketing by the FDA as a medical device. Unlike the FCC, the FDA does not have specific technical requirements for wireless medical devices, but rather the device must either be found "substantially equivalent" under the 510(k) program or safe and effective under the PMA program (assuming it is not a Class 1 device exempt from the FDA marketing authorization requirements).

To assist manufacturers through the FDA authorization process, on August 13, 2013, the FDA released a detailed guidance on "Radio-Frequency Wireless Technology in Medical Devices."[15] Standards referenced in the FDA's document are listed in **Appendix B-1**. The FDA's guidance document discusses seven considerations for medical devices that incorporate RF technologies:

A. Selection and performance of wireless technology

A medical device's wireless technology and capabilities should be appropriately matched to the device's functions and intended uses. In addition, issues relating to the integrity of data transmitted wirelessly (including latency and throughput, detection, correction, and corruption control and/or prevention) and safety-related requirements of the device should be considered. Potential risks that can affect consistent and timely wireless medical device functions include data corruption and loss and interference from simultaneous transmitters in a given location. Parameters such as bit error rate, packet loss, and signal-to-noise ratio are useful in assessing and assuring data integrity and timeliness of data transmission.

Many medical devices are authorized to operate as unlicensed devices under Part 15 of the FCC rules in the industrial, scientific, and medical (ISM) frequency bands (e.g., 2400-2493.5 MHz) and are therefore not entitled to interference protection. In many cases, RF wireless medical devices and transmission streams can incorporate technology (e.g., frequency hopping protocols, correction protocols) to minimize effects of interference that may lead to data errors or corruption. Also, to help protect against EMI to other medical devices in the vicinity, FDA recommends that wireless medical device manufacturers limit the RF output of their devices to the lowest power necessary to reliably accomplish the intended functions.

[14] Available at http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/ucm085281.htm

[15] Available at http://www.fda.gov/medicaldevices/deviceregulationandguidance/guidancedocuments/ucm077210.htm

When choosing a wireless frequency band or a commercial wireless radio component, the FDA recommends that manufacturers consider:

- International availability and band allocation (e.g., applicable International Telecommunication Union Radiocommunication Sector recommendations) for medical devices because medical devices serve patients located in multiple geographic locations and patients may change their geographic locations;
- Whether the device needs to have primary or secondary radio service classification;
- How incumbent users of the selected and adjacent bands can impact a medical device's operation;
- Interference mitigation techniques for shared RF wireless frequency bands; and
- For implantable and body-worn medical devices, tissue propagation characteristics and specific absorption rates.

Under the FDA's Quality System Regulation, procedures and controls must be established for wireless medical devices and their components to ensure that the device and its components conform to specified design requirements related to the RF wireless considerations.

B. Wireless Quality of Service

Wireless Quality of Service (QoS) refers to the level of service and performance needed for the wireless functions of the medical device. Connections lost without warning, failure to establish connections, or degradation of service can have serious consequences for medical devices, compromising the transmission of high-priority alarms, time-sensitive data, and real-time control of devices. When evaluating the necessary QoS, manufacturers should consider acceptable latency, acceptable level of probability for loss of information within the network, accessibility, and signal priorities of the network.

C. Wireless coexistence

The selection of frequency and modulation should take into account other RF wireless technologies and users that might be expected to be in the vicinity of the wireless medical device system. These other wireless systems can pose risks that could result in medical device signal loss or delay that should be considered in the risk management process. The FDA recommends that manufacturers address a device's environmental specifications and needs, including:

- Associated sources of EMD expected in specific known use environments; and
- Co-channel and adjacent channel interference from medical devices and other users of the RF band.

If a wireless medical device is expected to be used in proximity to other users of the same frequency, the FDA recommends addressing the risk of interference through testing for coexistence of the device's wireless system

in the presence of the number and type of in-band sources expected to be in proximity to the device, even including situations such as when patients are sitting adjacent to one another in a waiting room.

D. Security of wireless signals and data

The FDA recommends that wireless medical devices utilize wireless protection (e.g., wireless encryption, data access controls, secrecy of the "keys" used to secure messages) at a level appropriate for the risks presented by the medical device, its environment of use, the type and probability of the risks to which it is exposed, and the probable risks to patients from a security breach. The FDA recommends that the following factors be considered during device design and development:

- Protection against unauthorized wireless access to device data and control, including use of protocols that maintain the security of the communications while avoiding known shortcomings of existing older protocols; and
- Software protections for control of the wireless data transmission and protection against unauthorized access.

Security management should also consider that certain wireless technologies attempt to make automatic connections to quickly assemble and use a network (e.g., a discovery mode such as that available in Bluetooth communications). For certain types of wireless medical devices, this kind of discovery mode could pose safety and effectiveness concerns, for example, where automatic connections might allow unintended remote control of the medical device.

For more information on this topic, see the FDA's June, 2013 draft guidance "Content of Premarket Submissions for Management of Cybersecurity in Medical Devices."[16]

E. EMC of the wireless technology

FDA recommends that EMC be an integral part of the development, design, testing, and performance for RF wireless medical devices, including consideration of applicable telecommunications standards and regulations and the potential for device RF emissions that might cause EMI with other equipment. Risk management activities should include using risk analysis to identify any potential issues associated with EMC and determining risk acceptability criteria based on information about the device and its intended use, including foreseeable misuse, sources of environmental EMD (e.g., radio transmitters, computer RF wireless equipment), and the potential for RF emissions to affect other devices.

EMC testing should include tests focused on the medical device wireless functions and technology. Some voluntary consensus standards such as the FDA-recognized consensus standard IEC 60601-1-2 "Medical Electrical Equipment – Part 1-2: General requirements for safety and essential performance – Collateral

[16] Available at http://www.fda.gov/medicaldevices/deviceregulationandguidance/guidancedocuments/ucm356186.htm.

standard: Electromagnetic compatibility – Requirements and tests" contain an exemption from the electromagnetic immunity provisions in the "exclusion band" (passband) where the medical device's RF wireless receiver or transmitter operates. According to the FDA, such standards do not adequately address whether the wireless communications will operate properly in the presence of in-band EMD (e.g., other RF emissions overlapping the frequency band utilized by the medical device wireless signals). Therefore, the medical device's wireless communication(s) should be actively transmitting while testing for susceptibility during all EMC immunity testing.

F. Information for proper set-up and operation

Proper user instructions are critical to help assure proper set-up, configuration, and performance of the wireless medical device. The FDA suggests considering the following:

- The specific RF wireless technology type (e.g., IEEE 802.11b), characteristics of the modulation, and effective radiated RF power;
- Specification of each RF frequency or frequency band of transmission and the preferred frequency or frequency band (if applicable), and specification of the bandwidth of the receiving section of the equipment or system in those bands;
- A warning that other equipment could interfere with the medical device or device system, even if the other equipment complies with CISPR emission requirements;
- Information about the needed quality of service and security for the wireless technology;
- Functions and performance of the wireless data transmissions including data throughput, latency, and data integrity;
- Information about any limitations on the number, output power, or proximity of other in-band transmitters used in the vicinity that might adversely impact a device's system operation;
- Information for the user to understand the RF wireless technology's capabilities and be able to recognize and address issues that might arise. For devices with intended use locations that are in complex RF wireless environments and consist of multiple wireless products, this should include assessment and management of the RF wireless transmitters and their use in the vicinity including transmitters both inside and outside the facility;
- Information for the user to understand the implications and limitations of using RF wireless technology outside the United States, where allocations and technical parameters may be different, possibly affecting the functioning of the device.

G. Considerations for maintenance

The FDA recommends that manufacturers continue to manage the risks associated with the use of wireless technology for the entire life cycle of the device. The procedures for implementing corrective and preventive action must include, among other things, analyses for possible trends in nonconformance information and complaints, such as reports of failures, which could include erratic or unexpected behavior of the medical device.

Because electromagnetic emissions and exposure can vary significantly with various structures, materials, and RF wireless emitter sources in the vicinity, FDA recommends that in analyzing failure trends manufacturers consider factors such as location, user application, and repeat component failures. Potential problems include:

- Additional events that may have contributed to the EMI or disruption of wireless technology resulting in inappropriate or unnecessary diagnostic procedures or interventions;
- Additional equipment used in conjunction with the device;
- Environmental conditions that might have contributed to the event; and
- Repeated device failures at the same facility or in other geographic areas.

When servicing electrically powered medical devices, care should be taken to ensure EMI protection is maintained and in good condition. Such EMI protection can include components that may be removed during service such as shields, metal covers, ferrite beads, bonds, screws, ground wires and straps. In addition, metal surfaces that are intentionally left bare for RF shielding continuity should not be painted. To reduce EMI susceptibility as electronic equipment ages, connector contacts that might have oxidized should be cleaned because oxidized contacts can act as semiconductors.

III. FDA Mobile Medical Applications Guidance

FDA identified three categories of mobile medical apps as the focus of its oversight:

- Mobile apps that connect to another device for purposes of controlling or displaying, storing, analyzing, or transmitting patient-specific medical device data. Examples include remote display of data from bedside monitors, display of previously stored EEG waveforms, or apps that provide the ability to control inflation and deflation of a blood pressure cuff through a mobile platform.
- Mobile apps that transform the mobile platform into a regulated medical device by using attachments, display screens, or sensors or by including functionalities similar to those of currently regulated medical devices. Such mobile apps are regulated just like the transformed platform. Examples include mobile apps that allow use of the attachment of electrocardiograph (ECG) electrodes to a mobile platform to

measure, store, and display ECG signals.

- Mobile apps that perform patient-specific analysis and provide patient-specific diagnosis or treatment recommendations. Examples include apps that use patient-specific parameters to calculate dosage or create a dosage plan for radiation therapy or image processing software.

Mobile apps for which FDA intends to use "enforcement discretion" and not regulate include apps that:

- Help users self-manage their diseases or conditions without providing specific treatment or treatment suggestions;
- Provide users with simple tools to organize and track their health information;
- Provide easy access to information related to users' health conditions or treatments;
- Help users document, show, or communicate potential medical conditions to health care providers;
- Automate simple tasks for health care providers; or
- Enable users or providers to interact with Personal Health Record (PHR) or Electronic Health Record (EHR) systems.

FDA also clarified that the following persons would not be regulated as medical device manufacturers:

- Manufacturers or distributors of mobile platforms such as smartphones or tablets who do not specifically intend or market their products for medical device functions.
- Distributors of apps who are engaged only in providing an online market place where mobile medical apps may be available, such as online marketplaces like "Google Play" and the "iTunes Store."
- Licensed practitioners, including physicians, dentists, and optometrists, who manufacture a mobile medical app or alter a mobile medical app solely for use in their own professional practice

APPENDIX B-1

Standards Applicable to Wireless Medical Devices

Association for the Advancement of Medical Instrumentation (AAMI)

AAMI TIR No. 18-2010, Guidance on electromagnetic compatibility of medical devices in healthcare facilities

ANSI/AAMI PC69:2007, Active implantable medical devices—Electromagnetic compatibility—EMC test protocols for implantable cardiac pacemakers and implantable cardioverter defibrillators

ANSI/AAMI/IEC 60601-1-2:2007/ (R) 2012, Medical Electrical Equipment—Part 1–2: General requirements for basic safety and essential performance – Collateral standard: Electromagnetic compatibility – Requirements and tests. This is the U.S. version of the IEC 60601-1-2 standard (see IEC below)

American National Standards Institute (ANSI) Accredited Standards Committee C63 (ASC C63)

ANSI C63.4:2009, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

ANSI C63.10:2009, American National Standard for Methods for Testing Unlicensed Wireless Devices

ANSI C63.18:1997, American National Standard Recommended Practice for an On-Site, Ad Hoc Test Method for Estimating Radiated Electromagnetic Immunity of Medical Devices to Specific Radio-Frequency Transmitters

ANSI C63.19:2007, American National Standard Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids

Electrostatic Discharge Association (ESD Association)

ANSI/ESD S20.20-2007, ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

Federal Communications Commission

Code of Federal Regulations, Title 47 – Telecommunications, Chapter I - Federal Communications Commission, Subchapter A – General

- Part 2 – Frequency Allocations and Radio Treaty Matters; General Rules and Regulations
- Part 15 – Radiofrequency Devices
- Part 18 – Industrial, Scientific, and Medical Equipment

Subchapter D - Safety and Special Radio Services

- Part 95 – Personal Radio Services

International Electrotechnical Commission (IEC)

The IEC 60601 family specifies safety standards for medical electrical equipment. EMC is addressed in IEC 60601-1-2, and IEC 60601-2-X provides standards for particular types of medical electrical equipment.

IEC 60601-1-2:2007, Medical Electrical Equipment – Part 1-2: General requirements for basic safety and essential performance– Collateral standard: Electromagnetic compatibility – Requirements and tests. This is a collateral standard to the third edition of IEC 60601-1. The third edition of IEC 60601-1-2 was published in 2007 and contains essentially the same information that was in the second edition IEC 60601-1-2:2001 and Amendment 1:2004, reformatted according to the third edition of the IEC 60601-1 standard. Emissions and immunity requirements in the third edition IEC 60601-1 are specified under Clause 17.

IEC 60601-2-X standards are for particular types of medical electrical equipment. Requirements of IEC 60601-2-X standards supersede those of IEC 60601-1 and IEC 60601-1-2. Some IEC 60601-2-X standards specify higher immunity test levels or special test setups for EMC. Some might not have been amended yet to reference the third (2007) edition of IEC 60601-1-2 and might still reference an earlier edition. Modifications to IEC 60601-1 for EMC are specified in Clause 17 in the IEC 60601-1-2:2007 edition and Clause 36 in earlier editions. (NOTE: Subclause numbers for similar provisions in IEC 60601-1-2:2007 are different from those in earlier editions.)

IEC 61326-1:2005, Electrical equipment for measurement, control and laboratory use – EMC requirements - Part 1: General requirements. Edition 2.0 was published in 2012.

IEC 61326-2-1:2005, Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-1: Particular requirements - Test configurations, operational conditions and performance criteria for sensitive test and measurement equipment for EMC unprotected applications. Edition 2.0 was published in 2012.

IEC 61326-2-6:2005, Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-6: Particular requirements - In vitro diagnostic (IVD) medical equipment. Edition 2.0 was published in 2012.

IEC 60050-161:1990, International Electrotechnical Vocabulary – Chapter 161: Electromagnetic compatibility. Amendment 2 was published in 1998. IEV online: http://www.electropedia.org/

IEC TR 80001-2-3: 2012, Application of Risk Management for IT-Networks Incorporating Medical Devices – Part 2-3: Guidance for wireless networks

Institute of Electrical and Electronic Engineers (IEEE)

P11073-00101-2008 - Guide for Health Informatics–Point-of-Care Medical Device Communication–Guidelines for the Use of RF Wireless Technology. There are several standards under the IEEE 11073 family that address health informatics point-of-care medical device communications and provide useful information.
IEEE Std 802.15.2-2003 IEEE Recommended Practice for Information Technology— Telecommunications and Information Exchange between Systems— Local and Metropolitan Area Networks— Specific Requirements Part 15.2: Coexistence of Wireless Personal Area Networks with Other Wireless Devices Operating in Unlicensed Frequency Bands.

International Organization for Standardization (ISO)

Most ISO standards for medical electrical equipment reference clauses in IEC 60601-1, including Clause 17 (previously Clause 36) and IEC 60601-1-2.

ISO/TR 16056-1, Health informatics – Interoperability of telehealth systems and networks — Part 1: Introduction and definitions

ISO/TR 16056-2, Health informatics – Interoperability of telehealth systems and networks — Part 2: Real-time systems

ISO/TR 18307, Health informatics – Interoperability and compatibility in messaging and communication standards – Key characteristics

ISO 14708-1, Implants for surgery – Active implantable medical devices – Part 1: General requirements for safety, marking, and for information to be provided by the manufacturer

ISO 14708-2, Implants for surgery — Active implantable medical devices — Part 2: Cardiac pacemakers

ISO 14708-3, Implants for surgery - Active implantable medical devices - Part 3: Implantable neurostimulators.

ISO 14708-4, Implants for surgery — Active implantable medical devices — Part 4: Implantable infusion pumps

ISO 14971 Second edition 2007-03-01 Medical devices — Application of risk management to medical devices

ISO 14117, Active implantable medical devices – Electromagnetic compatibility – EMC test protocols for implantable cardiac pacemakers, implantable cardioverter defibrillators, and cardiac resynchronization devices.

ISO technical report TR 21730, Health Informatics – Use of mobile wireless communications and computing technology in healthcare facilities – Recommendations for the management of unintentional electromagnetic interference with medical devices (ISO/TR 21730: 2007(E)).

RTCA, Inc.

RTCA/DO-160G, Environmental Conditions and Test Procedures for Airborne Equipment

APPENDIX C

Overview of CMS Regulation of Wireless Medical Devices

Most CMS coverage determinations are made on a local or regional level by clinicians at the contractors that pay Medicare claims, such as BlueCross BlueShield. Manufacturers seeking a "local coverage determination" must work with a local contractor to determine the information that will be required in a request for a determination.

In certain cases, CMS may deem it appropriate to develop a national coverage determination ("NCD") for an item or service to be applied on a national basis for all Medicare beneficiaries meeting the criteria for coverage. CMS initiates an NCD process by "opening" the NCD via a posting on the CMS coverage website. Development of a complete, formal request for an NCD can be initiated either by an outside party or internally by CMS staff. Outside parties are encouraged by CMS to engage in preliminary discussions with the agency regarding issues that may affect review of their requests. A requestor may be a Medicare beneficiary, manufacturer, provider, supplier, medical professional association, health plan, or any other party.

CMS itself may initiate an NCD in the following circumstances:[17]

- Providers, patients, or other members of the public have raised significant questions, that are supported by CMS's initial review of available data, about the health benefits of currently covered items or services, specifically regarding the Medicare population interpretation of new evidence or re-interpretation of previously available evidence indicates that changes may be warranted in current policies
- Local coverage policies are inconsistent or conflict with each other to the detriment of Medicare beneficiaries. For instance, the noted variation is not related to local differences in the capabilities of health care providers to use the technology effectively which can be resolved over time, but rather is causing significant disparities in the care available to Medicare beneficiaries that are unlikely to be addressed effectively through provider training and education or through the local coverage process
- Program integrity concerns have arisen under existing local or national policies and there is significant evidence of wide variation in billing practices not related to variation in clinical need, or of potential for fraud under existing policies
- The health technology represents a substantial clinical advance and is likely to result in a significant health benefit if it diffuses more rapidly to all patients for whom it is indicated

[17] Even Congress may seek to legislate certain coverage. *See*, e.g., S. 631 of the 110th Congress, a bill to amend Title XVIII of the Social Security Act to provide for coverage of remote patient management services for chronic health care conditions under the Medicare Program.

- More rapid diffusion of the technology is likely to have a significant programmatic impact on Medicare and on other Medicare-related public policies (e.g., reduction in health inequalities)
- Significant uncertainty exists concerning the health benefits, patient selection, or appropriate facility and staffing requirements for the new technology. The presence of significant uncertainty about benefits and risks is of particular concern when rapid diffusion of the item or service is likely when:
    - Use of the new item or service likely conflicts with existing NCDs
    - Available evidence suggests that local variation is not warranted

As part of the NCD process, CMS may request an external "technology assessment," the primary purpose of which is to evaluate the clinical and scientific evidence pertaining to the clinical benefits and risks of the technology. Certain issues may also be referred to the Medicare Evidence Development and Coverage Advisory Commission ("MEDCAC"). As of early 2010, cost effectiveness is not a factor CMS considers in making NCDs, though economic considerations may be discussed as part of the technology assessment. Considering the "comparative effectiveness" of different treatments is a hot-button topic in the health care reform debate and could possibly benefit wireless devices that can be shown to reduce hospital stays and doctor visits.

If neither a technology assessment nor referral to the MEDCAC is necessary, CMS has six months to render a proposed decision on a request for coverage. If a technology assessment or referral to the MEDCAC is made (and no clinical trial is requested), CMS has nine months to issue a proposed decision. The proposed decision is posted on the CMS website (or made public by other "appropriate" means) for a 30 day public comment period. A final decision will be issued not later than 60 days after the conclusion of the comment period.

Manufacturers who intend for the U.S. government to pay for their devices via the Medicare program should take certain issues into account beginning with the device design. For example, a manufacturer may wish for its device to be deemed "substantially equivalent" under the FDA's 510(k) program, yet be novel enough to warrant being treated as a new device by Medicare entitled to a higher payment. Device design should therefore take into account the kind of information that payers may be looking for to justify a higher payment.

If a new Current Procedural Terminology ("CPT") code is needed to identify new physician activity, significant work is required to have a new code issued by the American Medical Association. It may also be necessary to obtain a new Health Care Financing Administration Common Procedure Coding System Code ("HCPCS Code") from CMS.

Smart Meters

Smart meters are digital meters that measure a customer's electricity consumption and transmit data wirelessly to the utility. Florida investor-owned electric utilities (IOUs) have deployed two primary types of smart meters: advanced metering infrastructure (AMI) and automated meter reading (AMR). Advanced metering infrastructure meters provide two-way communications to and from a customer's meter. Automated meter reading meters are capable of transmitting a customer's usage data from the meter, but are not capable of two-way communication.

JURISDICTION

- The Florida Public Service Commission (FPSC) requires utilities to use accurate, commercially available metering devices to measure customer energy consumption.
- The FPSC cannot mandate the metering technology deployed by IOUs.
- The FPSC enforces the safety standards found in the National Electrical Safety Code for all electric utilities, which does not address radio frequency (RF) emissions.
- RF emission standards are established by the Federal Communications Commission (FCC).

HEALTH

- The FPSC's authority does not extend to health issues related to meters.
- Smart meters periodically transmit a low power signal.
- RF emissions from smart meters are well below the FCC standard.
- Smart meter transmitters are certified for compliance with RF emission standards by the FCC.
- The FCC deems that meters in compliance with these emission standards do not have adverse health impacts.

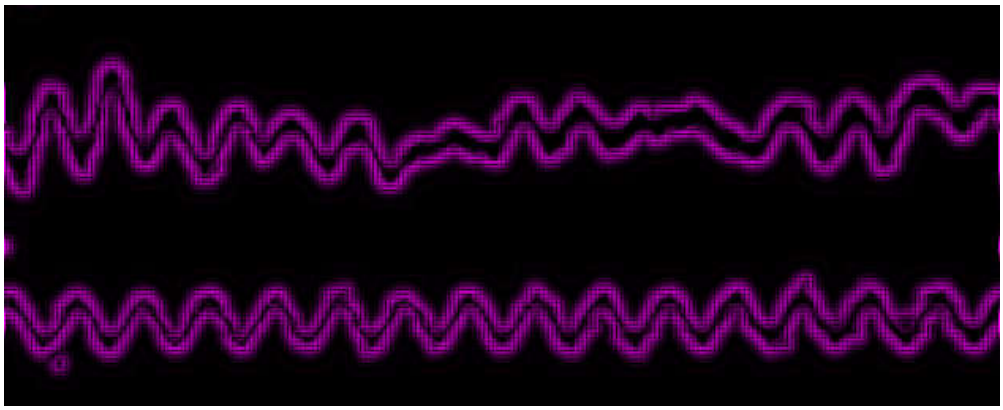
DATA SECURITY/PRIVACY

- Smart meters transmit customer energy consumption data and do not transmit customer identification information.
- The data transmitted by the smart meter is encrypted to ensure only the utility can decipher the signal.
- Florida's IOUs treat individual customer data as confidential, except for release for regulated business purposes and to comply with court orders.

FLORIDA PUBLIC SERVICE COMMISSION
2540 Shumard Oak Boulevard, Tallahassee, Florida 32399-0850
1-800-342-3552 ● www.FloridaPSC.com

http://journal.borderlands.com/1999/effects-of-6-10-hz-elf-on-brain-waves/

Effects of 6-10 Hz ELF on Brain Waves



Posted in: ELF & Wave Research, Featured Articles**Tags:** Behavior Modification, Brain Waves, David S. Walonick, ELF, Extremely Low Frequency, Thought Control

Article by **David S. Walonick**, originally printed in Borderlands (Vol. XLVI, Nos. 3&4, May – August 1990)

There is evidence that ELF magnetic waves can affect brain waves. This set of experiments was designed to study the effects of ELF rotating magnetic fields on the brain.

The specific ELF frequencies I was interested in studying are 6-10 Hertz. These frequencies are the same as those produced by the human brain in the theta and alpha states. Generally, specific brain wave frequency ranges can be associated with mood or thought patterns. Frequencies below 8 Hertz are considered theta waves. While these seem to be some of the least understood frequencies, they also seem to be associated with creative, insightful thought. When an artist or scientist has the "aha" experience, there's a good chance he or she is in theta. Alpha frequencies are from 8 to 12 Hertz and are commonly associated with relaxed, meditative states. Most people are in an alpha state during the short time immediately before they fall asleep. Alpha waves are strongest during that twilight state when we're half asleep and half awake. Beta frequencies (above 12 Hertz) coincide with our most "awake" analytical thinking. If you are solving a math problem, you're brain is working at beta frequencies. Most of our waking hours as adults are spent in the beta state.

A question of importance is: "If we can electronically shift the brain wave frequencies to alpha or theta, will a person's moods or thought patterns change to those commonly associated with those frequencies?". In other words, if we can electronically move a person's brain waves to the alpha frequencies, will they become more relaxed? Will their state of consciousness change to coincide with their brain waves, even if those brain waves were electronically induced? These are important questions with far reaching

implications.
When I began these experiments, I was well aware of the possible ethical implications involved in ELF research. For example, if I were carrying an ELF transmitter operating at alpha frequencies, would the people around me be affected as well? Would they unconsciously gravitate toward me because they'd become more relaxed as they moved closer to me? Would they like me more because they felt "good" when they were around me? What if a salesman were carrying an ELF transmitter? Would people be influenced to buy something because they were more relaxed around the salesman? Could entire populations be influenced to be comfortable with ideas they would normally reject? These, and many others, are serious ethical considerations involved with ELF research. They cannot be taken lightly.
I decided to undertake this research with full knowledge of the ethical implications. While there is the potential for misuse, a desire for knowledge and understanding are part of being human, and the potential benefits to humanity are great. What if we could treat depression, insomnia, anxiety, stress and tension with ELF magnetic fields? What if we could increase intelligence or improve learning? As in any scientific endeavor, there are both positive and negative potential uses for any discovery. One only need look at the development of atomic energy to understand the benefits/misuse dichotomy. It is my personal belief that the potential benefits to humanity justify the research.
I began by collecting all the available research on ELF fields. Lana Harris, a secondary research specialist, did an excellent job in acquiring virtually all the available research in this area. In addition to a multitude of published journal articles, several military and NASA research reports were ordered. A review of the research showed that most studies had been performed to determine the effects of 50-60 Hertz high voltage power-line fields. Since these are the frequencies of most of the world's electrical power distribution systems, the importance of understanding the effects on plant and animal life are evident. To a much lesser degree, a few researchers had concentrated on lower power and lower frequencies (the focus of this study).

Equipment

The equipment required for this research was easily attainable, with the notable exception of a stable frequency counter with .01 Hertz resolution. Accurate frequency measurements were essential for this research, so I designed and built a digital frequency counter capable of measuring frequency to the hundredth of a Hertz (plus or minus .005 Hertz). A 100 KHz crystal Colpitt's oscillator (calibrated with WWV) was used as a time base and divided by ten to the seventh power to attain the desired resolution.
Other equipment used is: a Biosone II Brainwave Monitor and Myosone 404 EMG Monitor (Bio-Logic Devices, Inc., 81 Plymouth Rd., Plainview, NY 11803); a Model 3011 Digital Display Function Generator (BK Precision Dynascan Corp., 6460 West Cortland St., Chicago, IL 60635); and IBM PC compatible computer with a clock speed of 7.16 MHz (the faster the clock speed the better); a SAC-12 A to D signal acquisition board (Qua Tech, Inc., 478 E. Exchange St., Akron, OH 44308); a Codas II video board and software release 3 (Dataq Instruments, Inc., 825 Sweitzer Ave., Akron OH 44311); a Fluke 77 digital multimeter (John Fluke Mfg. Co., Inc., PO Box C9090, Everett, WA 98260); and StatPac Gold statistical analysis software (Walonick Associates, Inc., 6500 Nicollet Ave. S., Minneapolis, MN 55423).
The transducer was a 24″ diameter hand-wound coil, consisting of 1000' of #25 magnetic

wire. The coil had a DC resistance of 32.4 ohms. It was mounted on a 26″ square piece of bakalite board for stability. Two dowels were mounted with plastic ties onto the board so they extended 24″ from opposite sides of the board and the entire apparatus was secured by two microphone stands.

Experimental Design

All twenty-two subjects were friends or acquaintances of the author. There was no remuneration to participants. The excitement or novelty of participating in a brain wave research experiment seemed to provide sufficient reward in and of itself.

Subjects were sent a pre-experiment letter briefly describing the intent of the experiment and what they could expect. They were asked not to use any drugs or alcohol for 24 hours before their appointment, and not to wear any metal jewelry. (It was thought that metal jewelry might distort the magnetic field, thus creating uncontrolled inconsistencies between subjects.)

Upon arrival at the laboratory, participants were given a short orientation to the procedure and any questions they had were answered. They were hooked up to the EEG monitor (frontal to occipital, midline) and then allowed to listen to a relaxation tape for five minutes. The purpose of the relaxation tape was to establish a "relaxation level" baseline and to relieve some of the anxiety associated with the experiment. At the end of five minutes, the headphones were removed and the subject was told they were at a relaxation level of 5 on a scale from zero to ten (0 being very tense and 10 being very relaxed). This was the baseline they were to use for reporting their relaxation level following each ELF exposure. Subjects were told that they could choose to stop the experiment at any time.

Each ELF exposure consisted of a ten second, sine-wave transmission separated from one another by 45 – 60 seconds of no exposure. The voltage fed to the coil was 3.1 VAC (RMS). The coil was positioned 18″ in front of the subjects head. The outputs from the ELF transmitter (function generator) and the brain wave monitor were fed directly into the computer A to D board, allowing both to be displayed on the computer monitor (and recorded on disk) simultaneously. The sampling rate of the A to D converter was set at 2000 samples per second for the entire experiment. This was sufficient to visually detect differences of .1 Hertz between the ELF and brain wave frequencies. Subjects were not told when a transmission was beginning. However, at the end of each transmission, they were asked to "report". This was their current relaxation level based on the zero to ten scale. They also reported any feelings they had experienced and these were recorded verbatim. Twenty-one frequencies were presented to each subject (from 6 to 10 Hertz in increments of .2 Hertz. For half the subjects, these frequencies were randomly selected. For the other subjects, they began at 10 Hertz and were decreased by .2 Hertz with each transmission. Subjects were not told the order of frequencies that would be presented to them.

Post acquisition software was used to visually examine the coherence (frequencies) and synchronously (phase relationship) between the transmitted ELF and prominent brain waves.

Results

Examination of the computer data revealed substantial differences between subjects. Some subjects showed lock-on (entrainment) over a wide frequency range, while other subjects showed no lock-on whatsoever. In general, lock-on occurred most frequently from 8.6 to 10 Hertz and less frequently below 8.6 Hertz.

One subject displayed lock-on for all frequencies from 7.4 to 10 Hertz. Two subjects displayed no lock-on over the entire frequency range. While I did not test a sufficient number of subjects to be statistically significant, I suspect that susceptibility to ELF entrainment follows the normal (bell-shaped) curve. At this time, I do not have any hypothesis that would allow us to predict who is susceptible and who is not.

Several interesting observations were readily apparent. Lock-on generally occurred very rapidly… within a quarter of a second in most cases. If lock-on did not occur at a specific frequency in the first second, it didn't at all. When the brain did lock on, the amplitude of the brain waves increased to nearly double their normal size. This is typical for naturally (non-ELF) produced alpha patterns. The brain locked on to higher frequencies (9-10 Hertz) more readily, and maintained the lock-on for the entire duration of the transmission. As the frequency was lowered (below 8.6 Hertz), lock-on for most subjects occurred in bursts, rather than being continuous. For example, there might be immediate lock-on for two seconds; then the brain would "fight" the ELF frequency for a quarter of a second, and then lock-on again for another few seconds, etc.. I use the word "fight" because it looked like the brain was fighting the ELF to maintain its own frequency. The "fight" was characterized by low amplitude beta frequencies in the 15-20 Hertz range. These may, of course, have simply been analytical type thoughts, but they were not observed when the frequency was in the 9-10 Hertz range. This "fight" became more frequent as the frequency was lowered, until no lock-on was observed at all.

None of the subjects were able to consciously detect the presence of the ELF field. One female subject was able to detect whenever the field started or ended, but could not accurately say when if it was on or off at any given time. In other words, she was able to detect the change in the magnetic field, but not the presence or absence of the magnetic field itself. She thought she felt it because it aggravated her sinuses. When lock-on occurred, the brain waves lagged behind the transmitted ELF. This appeared to have been the "reaction time" of the brain to the ELF waves (approximately 60-80 milliseconds). More accurate experimentation is needed to explore this relationship.

Subjects verbatim reports were quite revealing. (Keep in mind that none of the subjects actually said they felt the ELFs.) The most common verbatim reports occurred between 8.6 and 9.6 Hertz. Common statements were subtle "tingling" sensations in the fingers, arms, legs, teeth, and roof of the mouth. Two subjects reported a "metallic" feeling in their mouth. One subject reported a "tightness" in the chest and another subject reported a "tightness" in the stomach. Several subjects also reported sensations when the ELF frequency was between 6 and 7 Hertz. The verbatim responses in this range were "ringing" in the ears, "flushed" face, "fatigued", "tightening" in the chest and "increasing" pulse.

Lock-on occurred at lower frequencies more often when the transmitted frequencies were progressively lowered, rather than randomly presented. It would seem that the brain prefers a gradual lowering of frequency rather than a sudden or abrupt change in frequency. This may have been due to the extremely short duration of each transmission (10 seconds). It may be that this effect would disappear if longer transmission times were used.

There was no significant correlation between subjects reported level of relaxation and the ELF frequency or the occurrence of lock-on. Again, this may have been due to the extremely short duration of each transmission.

Summary

It is clear from these experiments that brain waves do in fact lock on to artificially produced ELFs in the 6 – 10 Hertz range. It is equally clear that the 10 second transmission was not sufficient to alter subjects moods to any consistent degree.

Additional Observations

Since my original experiment, I have continued to study the interaction of ELF's and brain waves. These mini-experiments were conducted more informally than my original experiment and the observations are based on only one or two subjects. They should be considered only observations until confirmed by additional study.

- A sine wave produces lock-on more readily than a square wave or a triangle wave. A sine wave output produces a rotating magnetic field where there is a gradual build up, collapse and reversal of the field intensity. A square wave output produces a pulsed alternating magnetic field where the build-up, collapse and reversal of the magnetic field is more abrupt.
- The brain is sensitive to a wide range of intensities. I have observed lock-on with power settings down to one half of a milliwatt.
- Psychics and "sensitives" are neither more or less prone to lock-on than anyone else. I have tested two well-known psychics and a Kahuna from Hawaii. While all three subjects produced more alpha that usual, it was not related to the ELF generator and they did not show unusual lock-on. It is interesting to note, that the woman who could "feel" when the field switched off and on (in my first experiment) was one of these psychics.
- Extended exposure to ELF's does alter moods, but the effect is subtle. I was not able to duplicate the "dramatic psychoactive" effect that Robert Beck has reported. Low frequencies (below 8 Hz) seem to produce a general agitation or uneasiness, while higher frequencies (8.6-10 Hz) produce a general feeling of relaxation. These are not profound effects like drug induced mood changes. The subject is not aware of any change in his consciousness or mood. From his perspective, nothing has changed. However, an outside observer can detect subtle changes (e.g. body movement). I have confirmed this by monitoring muscle activity with an EMG monitor.
- I have exposed myself to ELFs for one and two hour durations and have found that the frequencies from 8.6 to 9.8 Hertz to be sleep inducing; however, it is impossible to eliminate the placebo effect from experiments I performed on myself.
- I built and distributed several portable ELF generators for testing. I have received many reports that indicate that falling asleep with the ELF generator operating is probably not a good idea. People don't feel rested when they sleep with the ELF generator on. My personal experience supports this. ELF's may inhibit dreaming which is necessary for normal brain functioning.
- I have found three definite beneficial uses for the ELF generator: a) for relaxation, b) to eliminate jet lag, and c) the elimination of seizures in a dog.

The Story of Maynooth

Shortly after completing my first experiments, my neighbor's dog began to have seizures. Maynooth was a one year old, 190 pound Irish Wolfhound. His seizures were occurring four to five times a week. A seizure by a 190 pound dog is not a small affair. He would

trash around wildly with no awareness of his surroundings. The seizures would last 10-30 minutes. My neighbors took Maynooth to the vet, who prescribed phenobarbital to control the seizures. The drug was not effective and Maynooth continued to have regular seizures.

After discussing Maynooth's condition with my neighbor, we decided to try a portable ELF generator that Maynooth could wear to control his seizures. Seizures are accompanied by wild fluctuations in brain wave activity. We hypothesized that a portable ELF generator could control the seizures by stabilizing Maynooth's brain waves. If we could get Maynooth's brain to lock-on to an ELF frequency, we could in effect, eliminate the seizures.

I constructed a portable ELF generator about the size of a pack of cigarettes. The ELF generator was powered by a nine volt battery and had two frequencies, selectable by a toggle switch (10.0 Hz and 7.83 Hz). The 10 Hz frequency was chosen because previous experiments had shown that lock-on was more likely to occur at higher frequencies (i.e., closer to the prominent frequency of the brain). The 7.83 Hz frequency was chosen because it is the resonant frequency of the Earth and naturally occurring low intensity magnetic radiation can be detected at this frequency (Schumann, 1952).

The schematic for the portable ELF generator is illustrated. It is a twin-T oscillator followed by a high power 386 amplifier. The twin-T was chosen because of its high stability and low distortion sign wave. Construction is straight forward and the placement of parts is not critical. All parts are readily available. The two 10K frequency adjustment pots should be 10-20 turn trim pots to allow precise frequency adjustment. The 10K output level adjustment pot should be set so that the output feeding the coil is less that 100 milliwatts to comply with FCC regulations (I set Maynooth's to 10 milliwatts). The coil itself is not critical and can be wound on any iron core. Use only an alkaline or nickel-cadmium battery.

Maynooth began wearing the generator in the spring of 1988. We tried the 10 Hz frequency first. The results of the experiment were astounding to say the least. Maynooth's seizures stopped immediately when he began wearing the generator. Furthermore, Maynooth was able to completely stop taking the phenobarbital and the seizures have remained in remission. For the first three months, Maynooth wore the generator all the time in a cloth pouch from his collar. After that, the generator was only used at night and simply placed near his sleeping area.

Maynooth has had a total of three seizures following his first use of the generator. Two of these could be traced to malfunctions with the generator. The first was a broken wire from the battery connector and the second was a dead battery. The third seizure could not be explained by a hardware malfunction, although Maynooth was only using the generator during the night and the seizure occurred during the day. It should be noted, however, that this seizure was mild in comparison to his prior episodes.

Maynooth's owners were so convinced of the efficacy of the ELF generator, that they asked me to make a spare generator in case the one they had broke. Maynooth's vet (at the University of Minnesota) showed curiosity in the generator, but not enough to explore it further. They preferred to remain with a drug treatment, even though it had proven to be ineffective. Fortunately, Maynooth's owners had more sense.

Maynooth still uses the ELF generator in his sleeping area at night. The rechargeable battery is charged during the day so it is fresh each night. (The battery lasts about 6-8

hours at a 10 milliwatt power setting).

Andrija Puharich's Watch

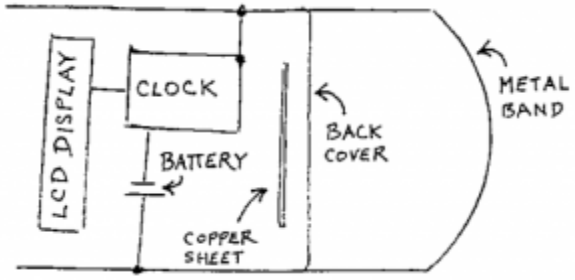
Dr. Andrija Puharich sells a watch that he claims will work a shield for ambient high frequency ELF's (40-100 Hz). An important feature of this watch would include shielding from 60 Hz power lines. I had the opportunity to try one of his watches for a few days. The owner was quite reluctant to part with it so I had to run all tests over just one weekend.

It is quite easy to monitor ambient 60 Hz radiation being absorbed by your body. Simply touch the probe of any oscilloscope and you can watch the 60 Hz wave. Your body is acting as an antenna and the amplitude on the oscilloscope is an indication of the amount of radiation you're absorbing. I found no difference in the amplitude when I was wearing the watch or when it was removed by a distance of four miles.

I attempted to determine if there was any measurable magnetic output from the watch. I used a large roll of magnetic wire as a pickup coil and connected it to the input of an EEG monitor with five microvolt sensitivity. The EEG voltage was fed directly to the A to D board of the computer. The equipment was tested for proper functioning by bringing a magnet in proximity to the pickup coil. A weak magnet moving within six inches of the pickup coil would drive the EEG monitor into saturation. The watch was placed against the coil but I could not pick up any magnetic fields from the watch. This surprised me because I was using very sensitive equipment and the watch had to be producing a magnetic field because it was using a battery. Anytime there is a current flowing (even the small current required to power a watch), there is always a magnetic field created. Either the watch was cancelling it's own magnetic field or my equipment was not sensitive enough to measure it. (It turned out to be the latter).

The final test was to hook myself up to the EEG monitor while I was wearing the watch. The output was fed into the computer so that I could do posthoc analysis. I wore the watch for 15 minutes and recorded my brain waves. The incidence of beta and alpha frequencies was not different from my "usual" brain waves. I could not substantiate Puharich's claim that the watch would act as a filter with a center frequency of 10 Hz. This particular finding may not be accurate because my excitement with the experiment may have inhibited the alpha centering that Puharich refers to.

Since I had told the person I borrowed it from that I'd take good care of the watch, that precluded the idea of disassembling it. I carried the watch with me in my backpack that weekend. As luck would have it, the back cover of the watch fell off and I got to examine the inside.

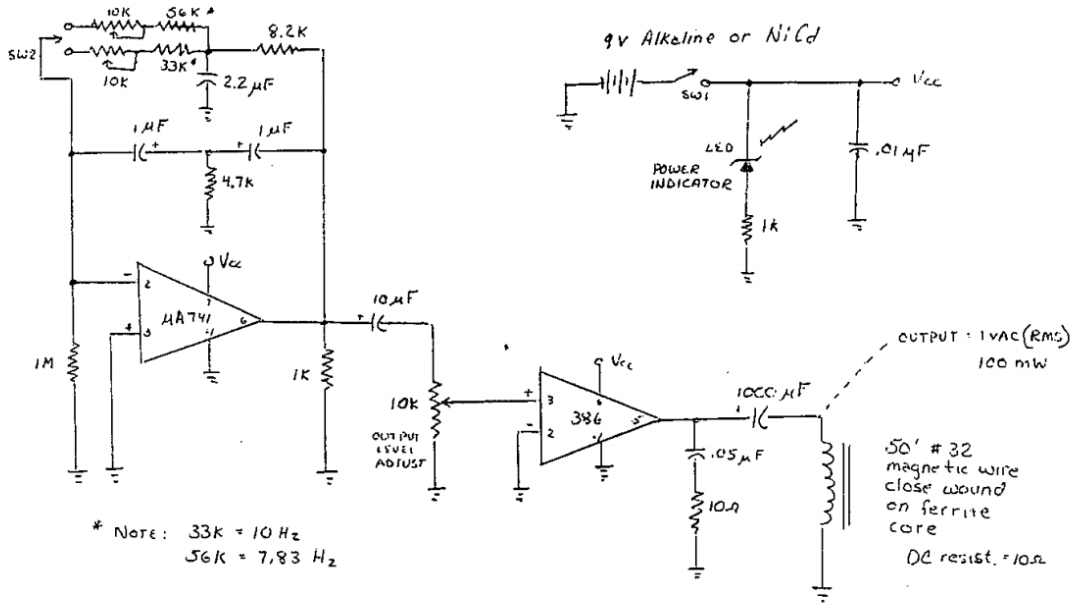


It is a digital "over-the-counter" type watch. As far as I could tell, the watch was normal in every way except that there was a square sheet of copper (about 1 cm square), wrapped in plastic packing tape inside the back cover. The tape was obviously used to insulate the

copper from the electronics of the watch and the back cover.
With the copper removed, my equipment could still not detect the magnetic fluctuations produced by the watch. If the copper sheet does do anything, my equipment was not sensitive enough to measure it. This indicates that the amplitude of the magnetic field produced by the watch was very low, probably around the amplitude of the naturally occurring magnetic fluctuations of the earth.
I do not know whether Puharich's watch works. It did not reduce the electromagnetic radiation that my body was absorbing, nor did it alter my brain wave pattern in any way I could detect. My current understanding of ELF's, electronics and magnetics does not provide a theoretical foundation for the efficacy of the watch.

Electromagnetic Pollution

When I began my research, I was only interested in the effects of ELF's on brain waves. I have since come to believe that ELF's are only the tip of the iceberg. Electromagnetic radiation may be the most harmful pollutant in our society. There is mounting statistical evidence that cancer and other diseases can be triggered by electromagnetic waves.
ELF pulse-modulated radio waves work at the cellular level. Cancer and birth defects have been increasing in this country since about 1950 (as television became popular). The average resonant frequency of the body is around 82 MHz. It is no coincidence that this is near the middle of the VHF TV band.
Even low intensity 60 Hz fields are capable of causing DNA damage and weakening the immune system. Cancer cells exposed to 60 Hz electromagnetic fields for 24 hours show a sixfold increase in their growth rate.
The evidence is becoming overwhelming that cellular functions can be switched on and off through frequency specific electromagnetic radiation that induces nuclear magnetic resonance in the cell. We may find that many diseases can be caused or cured by frequency specific radiation that is ELF pulse modulated.
In our technological society, there are few places to go where you will not be exposed to electromagnetic radiation. Television, radio and microwave radiation are abundant in all metropolitan areas. High voltage 60 Hz power lines crisscross the country. Microwaves (one of the most dangerous) are becoming increasingly common. The FCC has started to grant licences to use microwaves for cellular phones.
The powers that control the energy and communications industries will stop at no end to prevent the public from learning the truth. Their financial health depends on it. Since the military is one of the largest producers of high power electromagnetic radiation, it is not likely that we can count on government intervention.
We have probably reached a point where the only solution is in the form of a portable shield device. ELF generators may be one possible solution. My current research is in this area.



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Effect of electromagnetic field exposure on the reproductive system

Myung Chan Gye and Chan Jin Park

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Abstract

The safety of human exposure to an ever-increasing number and diversity of electromagnetic field (EMF) sources both at work and at home has become a public health issue. To date, many *in vivo* and *in vitro* studies have revealed that EMF exposure can alter cellular homeostasis, endocrine function, reproductive function, and fetal development in animal systems. Reproductive parameters reported to be altered by EMF exposure include male germ cell death, the estrous cycle, reproductive endocrine hormones, reproductive organ weights, sperm motility, early embryonic development, and pregnancy success. At the cellular level, an increase in free radicals and $[Ca^{2+}]i$ may mediate the effect of EMFs and lead to cell growth inhibition, protein misfolding, and DNA breaks. The effect of EMF exposure on reproductive function differs according to frequency and wave, strength (energy), and duration of exposure. In the present review, the effects of EMFs on reproductive function are summarized according to the types of EMF, wave type, strength, and duration of exposure at cellular and organism levels.

Keywords: Electromagnetic field, Reproduction

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Introduction

Humans in modern society are exposed to an ever-increasing number of electromagnetic fields (EMFs) generated from the production and supply of electricity, television (TV) sets, personal computer (PC), radio communication, and mobile communication. Since the 1960s, when the biological hazard of EMF exposure was studied in the Soviet Union, the safety of humans exposed to EMFs both at home and during occupational activities has become an important issue in public health. The biological effect of EMFs is currently under debate and still a controversial issue. In the present review, the effects of EMFs on reproductive function are summarized according to the types of EMFs and duration of exposure at the cellular and organism levels.

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Types of EMF and frequency of exposure

Humans in modern society are exposed to various kinds of EMFs. Extremely low frequency (ELF)-EMFs have 3 to 30 Hz frequencies and are generated from military communication. The EMFs to which humans are most frequently exposed are the 50 to 60 Hz super low frequency (SLF) EMFs generated from power cables for industrial and household electrical supplies and electronic goods. Very low frequency (VLF) EMFs with 3 to 30 kHz frequency are generated from PC monitors or TV sets. EMFs from TVs or PCs have a 6.25 μT intensity with a 20 kHz frequency [1]. The radio frequency (RF) EMFs generated from mobile phones, cordless phones, and broadcasting towers have

frequencies of hundreds of MHz. All these EMFs are non-ionizing radiation, which do not have energy to release electrons from orbit. EMFs have a wave character in short frequency and act as a magnetic field in long frequency. The strength of the electric field and magnetic field is measured in units of kV/m and μT, respectively. Household electronic goods can produce a 4 μT EMF and EMF ranges from 0.01 to 1 μT inside and outside of house [2]. The strength of SLF-EMFs is dependent on the electrical current and distance from the conductor. Therefore, SLF-EMFs are the highest near the power cable and decrease rapidly by distance.

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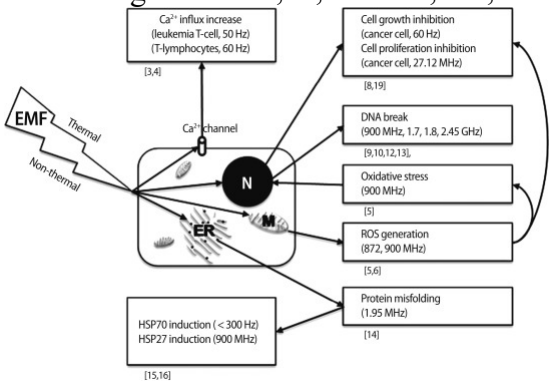
Cellular mechanism for EMF induced toxicity

At the cellular level, an increase in free radicals and $[Ca^{2+}]i$ may mediate the effect of EMFs and lead to cell growth inhibition, protein misfolding, and DNA breaks. EMFs can disrupt Ca^{2+}-dependent cell signaling. How does EL-EMF exposure affect signal transduction in cells? In human leukemia T-cell line Jurkat cells, a 50 Hz, 0.5 mT EMF was found to increase Ca^{2+} levels, blocking the effect of cholera toxin and the protein tyrosine kinase inhibitor genistein [3]. In thymic lymphocytes, Ca^{2+} influx increased during mitogen-activated signal transduction when exposed to a 60 Hz, 22 mT EMF [4], suggesting the modulating role of EMF on regulation of Ca^{2+} channels. RF EMFs of 900 and 872 MHz may enhance chemically induced reactive oxygen species (ROS) production, resulting in secondary DNA damage in human SH-SY5Y neuroblastoma cells [5,6]. Also *in vivo* experiments revealed the increased oxidative stress caused by a 900 MHz EMF, leading to endometrial histopathologic impairment in rats [7]. In prostate cancer cells, ROS induced by a 60 Hz sinusoidal EMF inhibited cell growth by apoptosis and arrested the cell cycle [8]. An RF EMF of 2,450 MHz exposure caused rearrangement of DNA segments and breakage of DNA in testes [9]. In another report, 1,800 MHz of EMF induced DNA breaks in human fibroblasts and rat granulosa cells in comet assay [10]. Similarly, an RF-EMF of 1,800 MHz induced DNA damage in Chinese hamster lung cells [11]. In addition, an RF EMF of 900 MHz and 1.7 GHz induced DNA breakage in cauda epididymal spermatozoa and embryonic stem cells in mice [12,13]. Some investigators have reported changes in protein folding by EMF. Changes in the structural fluctuation of tuna myoglobin protein was induced by EMF at the mobile phone frequency of 1.95 MHz, indicating RF EMFs as a potential risk for protein misfolding [14]. Heat-shock proteins (HSPs) were also increased by EMF exposure. In human endothelial cell line EA.hy926, HSP27 was activated by 900 MHz GSM non-thermal exposure [15]. HSP70 is induced by exposure to SLF (<300 Hz) EMFs [16]. Interestingly, HSP70 has non-thermal (EMF domain) and thermal (temperature domain) stress response promoter binding sites [17,18], suggesting that HSP70 is highly sensitive for EMF. In hepatocellular carcinoma, cell proliferation was inhibited with mitotic spindle disruption by a 27.12 MHz of RF EMF [19]. EMFs have been suggested as a cancer treatment tool with gamma irradiation. When a human breast cancer xenograft was treated with EMF and gamma irradiation at the same time, inhibitory effects on growth, angiogenesis, and metastasis were higher than in xenografts treated with gamma irradiation alone [20] (Figure 1).

Figure 1

Summary of the effects of electromagnetic fields at the cellular level. EMF, electromagnetic field; N, nucleus; ER, endoplasmic reticulum; M, mitochondria.



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Human diseases related to EMF exposure

Alterations in biomarkers following EMF exposure have been reported through *in vitro* and *in vivo* experiments using animal cells and animals, respectively. Most of what is known on the correlation between human health and EMF exposure has been drawn from epidemiological studies. The results on the hazards of EMF exposure are contradictory, leaving the conclusion unclear to date [21-23]. Currently, the biological hazard of EMF exposure is understood to be different according to frequency, type of wave, and strength (energy) of the EMF. Importantly, some people are very sensitive to certain types of EMFs. The effect of EMF exposure could be different at various toxicological endpoint levels according to the route and duration of EMF exposure and target human subjects. Therefore, the possible body or cellular functions susceptible for EMF exposure should be suggested according to the type of frequency, wave, and strength of EMF, and the safety guidelines for EMF exposure should be made according to this criteria.

Possible human diseases related with EMF exposure obtained from epidemiological studies include the life threatening diseases such as leukemia in children and adults [24,25], brain cancer in adults [26], Lou Gehrig's disease [27], depression [28], suicide [29], and Alzheimer's' disease [30]. Recently, EMFs were reported to cause DNA damage and neurological diseases at much lower levels than those proscribed by international safety guidelines. Most recently, the Bioinitiative Report (http://www.bioinitiative.org/) has noted that the current safety guidelines for EMF exposure are not sufficient and should be revised based on data from various toxicological tests [31].

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Changes in the reproductive endocrine system by EMF exposure

There are many studies on the casual relationship between SLF-EMF exposure and pineal gland function [32]. Although still under debate, EMF exposure can affect the secreting

activity of the pineal gland in several animal species as does the light. Indeed, static exposure to SLF-EMFs can affect cyclic secretions of melatonin in several species [33]. In Long-Evans rats exposed to a circularly polarized 50 Hz EMF for 6 weeks, the pineal and circulating melatonin levels decreased [34]. In cows, a 60 Hz EMF exposure for 4 weeks (16 hours per day) altered circulating melatonin and prolactin levels and the estrous cycle [35,36]. In an adult Djungarian hamster, a 60 Hz EMF exposure acutely affected the pineal and circulating melatonin levels [37]. SLF-EMF exposure directly affects the pineal gland, deteriorating the biological effect of melatonin [38]. Melatonin regulates the pulse of LHRH in the hypothalamus, influencing gonadotropin FSH and LH. Eventually, this can alter the production of gonadal sex steroids, resulting in changes in the reproductive cycle [39,40]. In cows, exposure to 60 Hz SLF-EMF at 30 μT for 24-27 days did not alter the progesterone levels but shortened the estrous stage [41]. RF-EMF exposure can affect ACTH, GH, TSH, FSH, and LH in the pituitary [42]. Most EMF-induced hormonal changes are mediated by the thermal effect of EMFs. In contrast, long-term exposure to RF-EMFs did not have a cumulative effect on the endocrine, serological, or immunological parameters [43].

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Reproductive toxicity of EMF in females

Reproductive toxicity of EMF exposure has been studied in both sexes at various endpoints [44]. Undoubtedly, reproduction is under control of the nervous system and endocrine system. In female mice, neuroendocrinological alteration was believed to be a prime cause of loss of fertility with aging [45,46]. In female mice exposed to a 20 kHz saw tooth EMF generated from a TV set or PC for 6 weeks after weaning, the estrous cycle was extended [47]. In cows, similarly, a 60 Hz, 30 μT EMF 16 hours per day extended the estrous cycle [35]. Because extension of the estrous cycle can decrease total ovulation opportunities in females during their fertile period of life, decrease in fecundity can be expected. In mouse follicle cultures, exposure to a 33 Hz SLF-EMF at 5-day intervals resulted in defects in follicle growth. In contrast, the follicles exposed to a 50 Hz EMF continued growth. 33 Hz or 50 Hz SLF-EMF exposure for 3 days inhibited the antrum formation of follicles cultured *in vitro* [48]. Together, the estrous cycle regulated by ovarian steroids might be much more sensitive to EMF exposure than the fetal development and feto-maternal interaction. In contrast, in female rats a 10 kHz, 0.2 mT sine wave EMF does not affect the estrous cycle [1], suggesting that the effect of EMFs on the estrous cycle differs according to the frequency, energy, and animal species. In adult Wistar female rats exposed continuously to a 50 Hz SLF-EMF for 3 months, the weights of the uterus and ovaries, progesterone levels, and estrogen levels in relation to the varying periods of the estrous cycle were not significantly altered [49].

When ovariectomized female Sprague-Dawley rats were exposed to a 1,439 MHz time division multiple access (TDMA) EMF for 4 hours per day for 3 days, there were no differences in uterine wet mass or serum estradiol level, suggesting no estrogenic activity related to high frequency EMFs used in cellular phones [50]. When female rats were exposed to a 900 MHz EMF for 30 min/day for 30 days, endometrial apoptosis and oxidative stress were increased [51]. Also, as an *in vivo* experiment, increased oxidative stress by a 900 MHz EMF led to the endometrial histopathologic impairment in rats [7].

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Reproductive toxicity of EMFs in males

A code division multiple access (CDMA) EMF of 848.5 MHz has no significant effect on the body, testicular, or epididymal weights, or the sperm count or apoptosis of germ cells in adult Sprague-Dawley rats [52]. Similarly, in adult male Sprague-Dawley rats exposed 30 minutes per day, 5 days a week for 4 weeks to a 900 MHz EMF, the testes weight, the testicular biopsy score count, and the percentage of interstitial tissue out of the entire testicular tissue were not significantly changed. However, the diameter of the seminiferous tubules, the mean height of the germinal epithelium, and serum total testosterone levels were significantly decreased in the EMF group. Plasma LH and FSH levels had not significantly changed following EMF exposure [53]. In prepubertal male rats (age of 5 weeks) exposed to a 1.95-GHz wide-band CDMA signal for 5 hours per day, 7 days a week for 5 weeks, neither the body weight gain or weights of the testis, epididymis, seminal vesicles and prostate, nor the number of sperm in the testis and epididymis had changed. Of note, the testicular sperm count was significantly increased without abnormalities of sperm motility or morphology, suggesting a positive effect of W-CDMA on spermatogenesis [54]. However, at a higher frequency, specifically 2.45 GHz, an EMF induced a decrease in the Leydig cell number and increase of apoptosis-positive cells in the seminiferous tubules of Wistar rats [55]. Exposure to an RF EMF of 2,450 MHz resulted in rearrangement of DNA segments and breakage of DNA in the testis [9]. An RF EMF of 900 MHz and 1.7 GHz induced DNA breakage in mouse cauda epididymal spermatozoa and embryonic stem cells [12,13]. Taken together, the RF-EMF generated by a mobile phone might be harmful to male reproductive function.

In male mice, a 60 Hz EMF did not decrease the body or testes weights but significantly increased germ cell death and abnormality in the seminiferous tubules. A 60 Hz EMF at 0.5 mT increased the TUNEL-positive spermatogonia, indicating the potentiation of DNA fragmentation, but in flow cytometry, the cell survival was not significantly altered [56]. Similarly, 60 Hz EMFs of 14 and 200 μT also induced the apoptosis of spermatogenic cells in mice [57]. In human sperm, the acrosome reaction was not altered by a 900 MHz RF-EMF from mobile phone at 2.0 W/kg strength for 1 hour though the sperm morphology was changed together with a decrease in sperm-hemizona binding, indicating that the RF-EMF exposure can decrease sperm fertility [58]. In contrast, acute exposure to a sinusoidal SLF-EMF (50 Hz, 1 mT) did not affect boar sperm viability and morphology during the first hour of incubation. SLF-EMF treated spermatozoa showed resting intracellular Ca^{2+} levels significantly lower than those recorded for controls. As a consequence, MF-SLF exposed sperm displayed a reduced motility, a modest reactivity when co-incubated with solubilized zonae pellucidae, and a reduction in oocyte penetrating ability. After 2 or 4 hours of incubation, signs of morphological damage appeared on the plasma membrane and at the acrosome, and decreased the fertilization rate. A 1 mT EMF decreased sperm function *in vivo* [59,60]. In rabbits, a 50 Hz SLF-EMF was found to be able to alter sperm motility and decrease their viability [61]. Together, SLF-EMFs negatively influence spermatozoa first by impairing cell Ca^{2+} homeostasis then by affecting sperm morphology and function. In contrast, the positive effect of SLF-EMFs on sperm was also reported. In human sperm, a 50 Hz, 5 mT square wave SLF-EMF increased sperm motility within 3 hours, and this effect was sustained for 21 hours. In contrast, a 50 Hz, 5 mT sine wave EMF and 50 Hz, 2.5 mT square wave SLF-EMF did not affect sperm motility. Therefore, the positive effect of a SLF-EMF on

sperm motility was dependent on the type and strength of the EMF [62].
The toxicity of EMF exposure to the next generation has also been reported. Male rat offspring exposed to 60 Hz, 1 mT SLF-EMF from gestation day 13 through postnatal day 21 showed a decrease in the number, diameter, area, and volume of seminiferous tubules, the height of seminiferous epithelium, and the number of Leydig cells, but connective tissues, vasculature, plasma testosterone levels, Sertoli cells, the length of seminiferous tubules, and gonadosomatic index remained unchanged. This suggests that gestational and lactational exposure to SLF-EMFs has adverse effects on the testis development [63]. In contrast, when pregnant rats were exposed to a 60 Hz, 500 μT SLF-EMF for 21 hours per day from gestation day 6 to postnatal day 21, spermatogenesis and the fertility of male offspring were not significantly different from the control [64].
Go to:

Developmental toxicity of EMFs

The developmental toxicity of EMF exposure has been studied at various endpoints [44]. The effect of EMF exposure on implantation and fetal development was reported. When female mice were superovulated and mated following exposure to a 50-Hz EMF at 0.5 mT 4 hours per day, 6 days a week for 2 weeks, the number of blastocysts was significantly decreased together with an increase in DNA fragmentation. This suggests that EMF exposure in the preimplantation stage could have detrimental effects on embryo development [65]. In swine, cleavage of fertilized eggs in the oviduct was delayed under 50 Hz, 0.75 mT EMF exposure 4 hours before ovulation, suggesting that SLF-EMFs negatively affect early embryo development [60]. When pregnant mice were exposed to a 50 Hz, 20 mT sine wave EMF during gestation day 0 to 17, embryonic survival, sex ratio, and embryonic malformation were not significantly changed, but the height and body weight of offspring were significantly increased [66]. When males and females were exposed to a 50 Hz, sine wave EMF at 5.0 mT for 9 weeks and 2 weeks before copulation, respectively, the fertility of both gametes and fetal development were not affected [67]. In mice, when the dams were exposed to a 20 kHz saw tooth EMF at 6.5 μT for 8 hours per day during pregnancy, fetal abnormality was not increased [68]. The potential hazard of EMF exposure to the dam and fetus was reviewed in [1]. There was a positive relationship between occupational monitor labor during pregnancy and the natural abortion rate [69-71]. Epidemiological studies on birth defects and abortions in pregnant women working in offices revealed that the EMF generated from a computer monitor can negatively affect human reproduction [69,72]. However, none of these kinds of reports have been verified by experiments [73]. Importantly, the reproductive hazard of EMF exposure in non-pregnant young women has not been studied well. Together, the effect of SLF-EMF exposure on embryonic development is still controversial, but some negative effects of EMFs have been reported in some animal models. Thus, it would be better to avoid or minimize casual exposure to EMFs during pregnancy.
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Conclusions and perspectives

Through *in vitro* and *in vivo* studies, EMF exposure was found to alter the reproductive endocrine hormones, gonadal function, embryonic development, pregnancy, and fetal development (Table 1, Figure 2). These effects were different according to the frequency, duration of exposure, and strength of EMFs. Humans in modern society cannot avoid

various kinds of EMFs during household and occupational activities, but should be aware of the biological hazard of EMFs. The effort to avoid EMF exposure and techniques to protect or relieve EMF radiation are required to preserve our reproductive potential.

Figure 2

Summary of the effects of electromagnetic fields (EMFs) on reproduction. , increase; , decrease or inhibition.

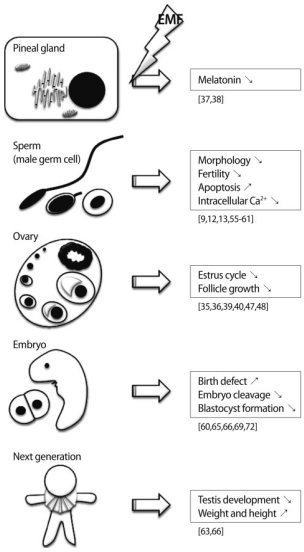

Table 1

Effects of EMF on mammalian endocrine system and reproduction

Table 1

Effects of EMF on mammalian endocrine system and reproduction

Type of EMF[b]		Frequency ranges	Usages or sources	Effect on reproduction				
				Endocrine				
				Pineal gland	Pituitary	Female	Male	Embryos
RF	SHF	3 GHz-30 GHz	Wireless internet					
	UHF	300 MHz-3 GHz	Cell phones		(N) ACTH (N) TSH (N) FSH (N) LH	(+) Endometrial apoptosis (+) Endometrial histopathologic impairment	(N) Acrosome reaction (-) Sperm morphology (-) Sperm-hemizona binding (-) Seminiferous tubule (-) Serum testosterone (N) Reproductive organ weight, prepubertal (N) Epididymal sperm count, prepubertal (+) Testicular sperm count, prepubertal (+) Apoptosis-positive cells in seminiferous tubules (+) DNA rearrangement and break in testis (+) DNA breakage in cauda epididymal spermatozoa (-) Leydig cell number	(+) DNA breakage in mouse embryonic stem cell
	VHF	30 MHz-300 MHz	FM, amateur, AM radio					
	HF	3 MHz-30 MHz						
	MF	300 kHz-3 MHz						
	LF	30 kHz-300 kHz						

Go to:

Footnotes

No potential conflict of interest relevant to this article was reported.

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March, 2014

Exhibit E: An Update on the Genetic Effects of Nonionizing Electromagnetic Fields by Prof. Henry Lai, PhD, University of Washington, Emeritus

Introduction:

The following is an update of information and abstracts on research papers published since 2006/2007 on the genetic effects of nonionizing electromagnetic fields (EMF) in the radiofrequency (RF) and extremely-low frequency (ELF) ranges. Two static magnetic field papers (Jouni et al. 2012; Wang et al., 2009) are also included. Where additional information is relevant, some earlier papers, or papers not specifically related to genetic effects, are also included with citations contained within the discussion below. A list of abstracts, with summary sentences underlined for reader convenience, can be found at the end of this paper.

Analysis of these recent publications shows that there are more papers reporting effects than no effect. With E representing a biological effect, and NE representing no biological effects, the recent literature finds RFR-genetic effects at: E=74 publications (65%); NE=40 publications (35%); and ELF-genetic effects at: E=49 (83%); NE=10 (17%).

Discussion:

1. The effects of both RF and ELF fields are very similar. This is surprising because the energies carried by these EMFs are billions of folds different. An explanation for similar genetic effects has been provided by a recent paper by Blank and Goodman (Blank M, Goodman R. DNA is a fractal antenna in electromagnetic fields. Int. J. Radiat. Biol. 87(4):409-415, 2011) in which they stated that '…the wide frequency range of interaction with EMF is the functional characteristic of a fractal antenna, and DNA appears to possess the two structural characteristics of fractal antennas, electronic conduction and self symmetry.' However, similarities in effects between ELF and RF fields have also been reported in studies of other physiological processes, e.g., neurochemical and behavioral effects (Cf. Lai, H., Carino, M.A., Horita, A. and Guy, A.W. Opioid receptor subtypes that mediate a microwave-induced decrease in central cholinergic activity in the rat. Bioelectromagnetics 13:237-246, 1992; Lai, H. and Carino, M.A. Intracerebroventricular injections of mu and delta-opiate receptor antagonists block 60-Hz magnetic field-induced decreases in cholinergic activity in the frontal cortex and hippocampus of the rat. Bioelectromagnetics 19:433-437, 1998; Lai, H., Carino, M.A. and Ushijima, I. Acute exposure to a 60 Hz magnetic field affects rats' performance in the water maze. Bioelectromagnetics 19:117-122, 1998; Wang, B.M. and Lai, H. Acute exposure to pulsed 2450-MHz microwaves affects water maze learning in the rat. Bioelectromagnetics 21:52-56, 2000.) Thus, there is a basic interaction mechanism of biological tissues with electromagnetic fields that is independent of frequency.

Many studies have implicated the involvement of free radical processes in the genetic effects of EMF: ELF-EMF (Butdak et al., 2012; Jouni et al., 2012; Luukkonen et al., 2014; Tiwari et al.,2014); RFR (Agarwal et al., 2009; Atasoy et al., 2012; Burlaka et al., 2013; Campisi et al., 2010; De Iuliis et al., 2009; Esmekaya et al., 2011; Ferreira et al., 2006; Gajski and Garaj-Vrhovac, 2009; Garaj-Vrhovac et al., 2011; Guler et al., 2010, 2012; Kesari and Behari, 2009; Kesari et al., 2010; Khalil et al., 2012; Kumar et al., 2010; Liu et al., 2013a,b; Luukkonan et al., 2009; Tomruk et al., 2010; Tkalec et al., 2013; Wu et al., 2008; Xu et al., 2010; Yao et al., 2003). Increase in free radical activity and changes in enzymes involved in cellular oxidative processes are the most consistent effects observed in cells and animals after EMF exposure. However, they are reports indicating that EMF could induce genetic effects without the involvement of free radicals (ELF-Alcaraz et al., 2013; RFR- Ferreira et al., 2006; Furtado-Filho et al., 2013) and increase in free radical after EMF exposure did not lead to genetic effects (Frahm et al., 2006). There are at least a couple of hundred published papers on the effects of EMF exposure on cellular oxidative processes. Many biological effects of EMF can be explained by intracellular changes in oxidative status, including the genetic effects reported in this review.

2. An important observation of the studies is that EMF can interact with other entities and synergistically cause genetic effects. These entities include: ELF-EMF- cisplastin (Buldak et al., 2012; El-Bialy et al., 2013), bleomycin (Cho et al., 2007), gadolinium (Cho et al., 2014); hydrogen peroxide and methyl methane sulfonate (Koyama et al., 2008), menadione (Luukkonan et al., 2011, 2014; Markkanen et al., 2008), ionizing radiation (Mairs et al., 2007; Journi et al., 2012 Yoon et al., 2014); RFR- chemical mutagens (Baohong et al., 2005), clastogens (Kim et al., 2008), x-rays (Manti et al., 2008), ultraviolet ray (Baohong et al., 2007), aphidicolin (Tiwari et al., 2008), picrotoxin (López-Martín et al., 2009), doxorubicin (Zhijian et al., 2010), and incoherent electromagnetic noise (Wu et al., 2008; Yao et al., 2008). Most of the compounds that interact with EMF are mutagens. This is important because in real life situations, a person is usually exposed to many different environmental factors simultaneously. Synergism of these factors with EMF should be considered more seriously.

3. Several long term/repeated exposure papers are included in this update: ELF-EMF (Borhani et al., 2011; Cuccurazzu et al., 2010; Erdal et al., 2007; Fedrowitz and Loscher, 2012; Mariucci et al., 2010; Panagopoulous et al., 2013; Udroiu et al., 2006), and RFR (Asasoy et al., 2012; Atli Serkeroglu et al., 2013; Burlaka et al., 2013; Chavdoula et al., 2010; Deshmukh et al., 2013; Ferreira et al., 2006; Garaj-Vrhovac et al., 2011; Guler et al., 2010, 2012; Kesari and Behari, 2009; Kesari et al., 2010; Lakshmi et al., 2010; Paulraj and Behari, 2006; Tomruk et al., 2010; Yan et al., 2008). These data are important in the understanding of the biological effects of EMF exposure in real life situation, since human environmental EMF exposure is both chronic and intermittent. Within these long-term exposure studies, there are several that investigated the effect of EMF exposure on developing animals (ELF-EMF: Borhani et al., 2011; Cuccurazzu et al., 2010;

Panagopoulous et al., 2013; Udroiu et al., 2006, RFR: Burlaka et al., 2013; Ferreira et al., 2006; Guler et al., 2010, 2012; Serkeroglu et al., 2013; Tomruk et al., 2010; Zalata et al., In press). Data of effects of EMF exposure on growth and development of young animals are urgently needed. There are several studies indicating that RFR may affect reproduction, particularly with effects on sperm physiology and DNA (Agarwal et al., 2009; Atasoy et al., 2012; Avendano et al., 2012; Chavdoula et al., 2010; de Iuliis et al., 2009; Liu et al., 2013b; Panagopoulous et al., 2007). Similar effects of ELF-EMF on sperm have also been reported, e.g., Hong R, Zhang Y, Liu Y, Weng EQ. Effects of extremely low frequency electromagnetic fields on DNA of testicular cells and sperm chromatin structure in mice. Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 23(6):414-417, 2005; Iorio R, Scrimaglio R, Rantucci E, Delle Monache S, Di Gaetano A, Finetti N, Francavilla F, Santucci R, Tettamanti E, Colonna R. A preliminary study of oscillating electromagnetic field effects on human spermatozoon motility. Bioelectromagnetics. 28(1):72-75, 2007; Iorio R, Delle Monache S, Bennato F, Di Bartolomeo C, Scrimaglio R, Cinque B, Colonna RC. Involvement of mitochondrial activity in mediating ELF-EMF stimulatory effect on human sperm motility. Bioelectromagnetics. 32(1):15-27, 2011.

4. Another area that needs more research is the biological effects of low-intensity exposure. This is particularly true for ELF-EMF, since intensities of ELF-EMF in the environment are in microtesla (μT) levels. There are many studies on biological effects of low-intensity RFR (see Table 1 in Levitt, B.B. and Lai, H. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. Environ. Rev. 18:369-395, 2010.) However, most cell and animal studies in ELF-EMF used fields in the millitesla (mT) level. Exceptions are the study of Sarimov et al. (2011) listed below in the reference section and the study of de Bruyn and de Jager (2010) (de Bruyn L and de Jager L. Effect of long-term exposure to a randomly varied 50 Hz power frequency magnetic field on the fertility of the mouse. Electromag. Biol. Med. 29(1-2):52-61, 2010).

5. Two other important findings of these recent studies are that the effects of EMF are shown to be waveform specific and cell-type specific. Regarding waveform specificity, Campisi et al. (2010) reported increases in free radical activity and DNA fragmentation in brain cells after acute exposure to a 50-Hz amplitude-modulated 900-MHz RFR, whereas a continuous-wave 9000-MHz field produced no effect. Franzellitti et al. (2010) showed increased DNA strand breaks in trophoblasts after exposure to a 217-Hz modulated 1.8 GHz-RFR, but a continuous-wave field of the same carrier frequency was without effect. Tkalec et al (2013) reported that AM-modulated (1 KHz sinusoidal) 900-MHz RFR is more potent than non-modulated field in causing DNA damage in coelomocytes of exposed earthworms. Luukkonen et al. (2009) reported a continuous-wave 872-MHz RFR increased chemically-induced DNA strand breaks and free radicals in human neuroblastoma cells, whereas a GSM-modulated 872-MHz field had no significant effect. Zhang et al. (2008) found that gene expression in rat neurons is more sensitive to intermittent than continuous exposure to a 1.8 GHz-RFR. López-Martín et al. (2009)

found that GSM and unmodulated RFR caused different effects on c-Fos gene expression in the rat brain. Regarding cell-type specificity, Nylund and Leszczynski (2006) and Remondini et al. (2006) reported different patterns of gene expression in different types of cells after exposure to RFR. Zhao et al. (2007) found than neurons are more sensitive to a 1.9 GHz cell phone radiation than astrocytes. Schwarz et al. (2008) reported DNA strand breaks and micronucleus formation in human fibroblasts, but not in lymphocytes, after exposure to a 1950-MHz UMTS field. Furthermore, Xu et al (2013) found DNA damages in some cell types and not in others after exposure to 1800-MHz RFR. Valbonesi et at. (2014) reported that HSP70 expression and MAPK signaling pathways in PC12 cells were affected by GSM-217 Hz signal and not by CW or GSM-talk signals. In ELF-EM research, Giorgi et al. (2011) found that DNA transposition in E. coli was *decreased* after exposure to a sinusoidal magnetic field and *increased* after exposure to a pulsed magnetic field. Kim et al. (2012) described DNA strand breaks in human fibroblasts after exposure to ELF magnetic field. They found that the pattern of changes depended on the eddy current and Lorentz force in the field. Nahab et al. (2007) reported that a square-continuous ELF magnetic field was more effective than sinusoidal-continuous or pulsed field in inducing sister chromatid exchange in human lymphocytes. These findings underscore the complicity of interaction of EMF with biological tissues and may partially explain why effects were observed in some studies and not others. It is essential to understand why and how certain wave-characteristics of an EMF are more effective than other characteristics in causing biological effects, and why certain types of cells are more susceptible to the effect of EMF? That there are different biological effects elicited by different EMF wave characteristics is critical proof for the existence of nonthermal effects.

6. Many biological/health effects have been reported in cells and animals after exposure to EMFs in both the ELF and RF ranges. (Sixty-five percent of the RFR papers and 82% of the ELF-EMF papers in the publication list below reported effects.) It is highly dishonest for a scientist to summarily deny the existence of biological effects of EMF. A biological effect of EMF can be detrimental to health, but can also be turned into a beneficial means for the treatment of human diseases. Denying any effects hampers the development of electromagnetic treatments for diseases. Examples of possible clinical uses of EMF are: Alzheimer's disease (Arendash GW, Sanchez-Ramos J, Mori T, Mamcarz M, Lin X, Runfeldt M, Wang L, Zhang G, Sava V, Tan J, Cao C. Electromagnetic field treatment protects against and reverses cognitive impairment in Alzheimer's disease mice. J Alzheimers Dis. 19(1):191-210, 2010); Parkinson's disease (Wang Z, Che PL, Du J, Ha B, Yarema KJ. Static magnetic field exposure reproduces cellular effects of the Parkinson's disease drug candidate ZM241385. PLoS One. 5(11):e13883, 2010); bone regeneration (Lee HM, Kwon UH, Kim H, Kim HJ, Kim B, Park JO, Moon ES, Moon SH. Pulsed eltromagnetic field stimulates cellular proliferation in human intervertebral disc cells. Yonsei Med. J. 51(6):954-959, 2010); cancer treatment (Costa FP, de Oliveira AC, Meirelles R, Machado MC, Zanesco T, Surjan R, Chammas MC, de Souza Rocha M, Morgan D, Cantor A, Zimmerman J, Brezovich I, Kuster N, Barbault A, Pasche B.

Treatment of advanced hepatocellular carcinoma with very low levels of amplitude-modulated electromagnetic fields. Br. J. Cancer. 105(5):640-648, 2011), and tissue regeneration (Gaetani R, Ledda M, Barile L, Chimenti I, De Carlo F, Forte E, Ionta V, Giuliani L, D'Emilia E, Frati G, Miraldi F, Pozzi D, Messina E, Grimaldi S, Giacomello A, Lisi A. Differentiation of human adult cardiac stem cells exposed to extremely low-frequency electromagnetic fields. Cardiovasc. Res. 82(3):411-420, 2009).

7. It must be pointed out that, consistent with previous research, not very much of the cellular and animal genetic research data directly indicate that EMF (both RF and ELF EMF) is a carcinogen. However, the data show that EMF can possibly alter genetic functions and thus it is advisable that one should limit one's exposure to EMF.

References and abstracts

Below is a key to abbreviations used throughout the following list of abstracts for recent papers published since 2006 and serve as my comments to help the reader quickly identify the significance of each work. The summary sentences by each author are underlined. The list is divided into RF effects papers, and ELF effects papers.

(E- effect observed; NE- no effect observed) (LE- long term exposure; GT- genotoxic effect, e.g., DNA damage, micronucleus formation, chromosome alterations; GE- gene expression; HU- human study; OX- oxidative effects, i.e., involvement of free radicals and oxidative enzymes; IA- interaction with other factors to cause genetic effects; DE- effects on developing animals; RP- reproduction, e.g., sperm damage; EH- compared with electro-hypersensitive subjects; WS- waveform specific effect, e.g., modulation and frequency; CS- cell type specific effect).

An update on the research on genetic effects of radiofrequency/cell phone radiation

(E) Agarwal A, Desai NR, Makker K, Varghese A, Mouradi R, Sabanegh E, Sharma R. Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study. Fertil Steril 92 1318-1325, 2009. (GT, RP, OX)

OBJECTIVE: To evaluate effects of cellular phone radiofrequency electromagnetic waves (RF-EMW) during talk mode on unprocessed (neat) ejaculated human semen. DESIGN: Prospective pilot study. SETTING: Center for reproductive medicine laboratory in tertiary hospital setting. SAMPLES: Neat semen samples from normal healthy donors (n = 23) and infertile patients (n = 9). INTERVENTION(S): After liquefaction, neat semen samples were divided into two aliquots. One aliquot (experimental) from each patient was exposed to cellular phone radiation (in talk mode) for 1 h, and the second aliquot (unexposed) served as the control sample under identical conditions. MAIN OUTCOME MEASURE(S): Evaluation of sperm parameters (motility, viability), reactive oxygen species (ROS), total antioxidant capacity (TAC) of semen, ROS-TAC score, and sperm DNA damage. RESULT(S): Samples exposed to RF-EMW showed a significant decrease in

sperm motility and viability, increase in ROS level, and decrease in ROS-TAC score. Levels of TAC and DNA damage showed no significant differences from the unexposed group. CONCLUSION(S): Radiofrequency electromagnetic waves emitted from cell phones may lead to oxidative stress in human semen. We speculate that keeping the cell phone in a trouser pocket in talk mode may negatively affect spermatozoa and impair male fertility.

(E) Atasoy HI, Gunal MY, Atasoy P, Elgun S, Bugdayci G. Immunohistopathologic demonstration of deleterious effects on growing rat testes of radiofrequency waves emitted from conventional Wi-Fi devices.J Pediatr Urol. 2012 Mar 30. [Epub ahead of print] (GT, OX, LE, RP)

OBJECTIVE: To investigate effects on rat testes of radiofrequency radiation emitted from indoor Wi-Fi Internet access devices using 802.11.g wireless standards. METHODS: Ten Wistar albino male rats were divided into experimental and control groups, with five rats per group. Standard wireless gateways communicating at 2.437 GHz were used as radiofrequency wave sources. The experimental group was exposed to radiofrequency energy for 24 h a day for 20 weeks. The rats were sacrificed at the end of the study. Intracardiac blood was sampled for serum 8-hydroxy-2'-deoxyguanosine levels. Testes were removed and examined histologically and immunohistochemically. Testis tissues were analyzed for malondialdehyde levels and prooxidant-antioxidant enzyme activities. RESULTS: We observed significant increases in serum 8-hydroxy-2'-deoxyguanosine levels and 8-hydroxyguanosine staining in the testes of the experimental group indicating DNA damage due to exposure ($p < 0.05$). We also found decreased levels of catalase and glutathione peroxidase activity in the experimental group, which may have been due to radiofrequency effects on enzyme activity ($p < 0.05$). CONCLUSIONS: These findings raise questions about the safety of radiofrequency exposure from Wi-Fi Internet access devices for growing organisms of reproductive age, with a potential effect on both fertility and the integrity of germ cells.

(E) Atlı Şekeroğlu Z, Akar A, Sekeroğlu V. Evaluation of the cytogenotoxic damage in immature and mature rats exposed to 900 MHz radio frequency electromagnetic fields. Int J Radiat Biol. 89(11):985-992, 2013. [Epub ahead of print] (GT, DE, LE)

Abstract Purpose: One of the most important issues regarding radio frequency electromagnetic fields (RF-EMF) is their effect on genetic material. Therefore, we investigated the cytogenotoxic effects of 900 MHz radio frequency electromagnetic fields (RF-EMF) and the effect of a recovery period after exposure to RF-EMF on bone marrow cells of immature and mature rats. Materials and methods: The immature and mature rats in treatment groups were exposed to RF-EMF for 2 h/day for 45 days. Average electrical field values for immature and mature rats were 28.1±4.8 V/m and 20.0±3.2 V/m, respectively. Whole-body specific absorption rate (SAR) values for immature and mature rats were in the range of 0.38-0.78 W/kg, and 0.31-0.52 W/kg during the 45 days, respectively. Two recovery groups were kept for 15 days after RF-EMF exposure. Results: Significant differences were observed in chromosome aberrations (CA), micronucleus (MN) frequency, mitotic index (MI) and ratio of polychromatic erythrocytes (PCE) in all

treatment and recovery groups. The cytogenotoxic damage in immature rats was statistically higher than the mature rats. The recovery period did not reduce the damage to the same extent as the corresponding control groups. Conclusions: The exposure of RF-EMF leads to cytotoxic and genotoxic damage in immature and mature rats. More sensitive studies are required to elucidate the possible carcinogenic risk of EMF exposure in humans, especially children.

(E) Avendaño C, Mata A, Sanchez Sarmiento CA, Doncel GF. Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation. FertilSteril 97:39-45, 2012. (GT, RP)

OBJECTIVE: To evaluate the effects of laptop computers connected to local area networks wirelessly (Wi-Fi) on human spermatozoa. DESIGN: Prospective in vitro study. SETTING: Center for reproductive medicine. PATIENT(S): Semen samples from 29 healthy donors. INTERVENTION(S): Motile sperm were selected by swim up. Each sperm suspension was divided into two aliquots. One sperm aliquot (experimental) from each patient was exposed to an internet-connected laptop by Wi-Fi for 4 hours, whereas the second aliquot (unexposed) was used as control, incubated under identical conditions without being exposed to the laptop. MAIN OUTCOME MEASURE(S): Evaluation of sperm motility, viability, and DNA fragmentation. RESULT(S): Donor sperm samples, mostly normozoospermic, exposed ex vivo during 4 hours to a wireless internet-connected laptop showed a significant decrease in progressive sperm motility and an increase in sperm DNA fragmentation. Levels of dead sperm showed no significant differences between the two groups. CONCLUSION(S): To our knowledge, this is the first study to evaluate the direct impact of laptop use on human spermatozoa. Ex vivo exposure of human spermatozoa to a wireless internet-connected laptop decreased motility and induced DNA fragmentation by a nonthermal effect. We speculate that keeping a laptop connected wirelessly to the internet on the lap near the testes may result in decreased male fertility. Further in vitro and in vivo studies are needed to prove this contention.

(E) Baohong Wang, Jiliang H, Lifen J, Deqiang L, Wei Z, Jianlin L, Hongping D. Studying the synergistic damage effects induced by 1.8 GHz radiofrequency field radiation (RFR) with four chemical mutagens on human lymphocyte DNA using comet assay in vitro. Mutat Res 578:149-57, 2005. (GT, IA)

The aim of this investigation was to study the synergistic DNA damage effects in human lymphocytes induced by 1.8GHz radiofrequency field radiation (RFR, SAR of 3W/kg) with four chemical mutagens, i.e. mitomycin C (MMC, DNA crosslinker), bleomycin (BLM, radiomimetic agent), methyl methanesulfonate (MMS, alkylating agent), and 4-nitroquinoline-1-oxide (4NQO, UV-mimetic agent). The DNA damage of lymphocytes exposed to RFR and/or with chemical mutagens was detected at two incubation time (0 or 21h) after treatment with comet assay in vitro. Three combinative exposure ways were used. Cells were exposed to RFR and chemical mutagens for 2 and 3h, respectively. Tail length (TL) and tail moment (TM) were utilized as DNA damage indexes. The results showed no difference of DNA damage indexes between RFR group and control group at 0 and 21h incubation after exposure ($P>0.05$). There were significant

difference of DNA damage indexes between MMC group and RFR+MMC co-exposure group at 0 and 21h incubation after treatment (P<0.01). Also the significant difference of DNA damage indexes between 4NQO group and RFR+4NQO co-exposure group at 0 and 21h incubation after treatment was observed (P<0.05 or P<0.01). The DNA damage in RFR+BLM co-exposure groups and RFR+MMS co-exposure groups was not significantly increased, as compared with corresponding BLM and MMS groups (P>0.05). The experimental results indicated 1.8GHz RFR (SAR, 3W/kg) for 2h did not induce the human lymphocyte DNA damage effects in vitro, but could enhance the human lymphocyte DNA damage effects induced by MMC and 4NQO. The synergistic DNA damage effects of 1.8GHz RFR with BLM or MMS were not obvious.

(E) Baohong W, Lifen J, Lanjuan L, Jianlin L, Deqiang L, Wei Z, Jiliang H.Evaluating the combinative effects on human lymphocyte DNA damage induced by ultraviolet ray C plus 1.8GHz microwaves using comet assay in vitro. Toxicology. 232(3):311-316, 2007. (GT, IA)

The objective of this study was to observe whether 1.8GHz microwaves (MW) (SAR, 3 W/kg) exposure can influence human lymphocyte DNA damage induced by ultraviolet ray C (UVC). The lymphocytes, which were from three young healthy donors, were exposed to 254 nm UVC at the doses of 0.25, 0.5, 0.75, 1.0, 1.5 and 2.0 J m(-2), respectively. The lymphocytes were irradiated by 1.8GHz MW (SAR, 3 W/kg) for 0, 1.5 and 4 h. The combinative exposure of UVC plus MW was conducted. The treated cells were incubated for 0, 1.5 and 4 h. Finally, comet assay was used to measure DNA damage of above treated lymphocytes. The results indicated that the difference of DNA damage induced between MW group and control group was not significant (P>0.05). The MTLs induced by UVC were 1.71+/-0.09, 2.02+/-0.08, 2.27+/-0.17, 2.27+/-0.06, 2.25+/-0.12, 2.24+/-0.11 microm, respectively, which were significantly higher than that (0.96+/-0.05 microm) of control (P<0.01). MTLs of some sub-groups in combinative exposure groups at 1.5-h incubation were significantly lower that those of corresponding UVC sub-groups (P<0.01 or P<0.05). However, MTLs of some sub-groups in combinative exposure groups at 4-h incubation were significantly higher that those of corresponding UVC sub-groups (P<0.01 or P<0.05). In this experiment it was found that 1.8GHz (SAR, 3 W/kg) MW exposure for 1.5 and 4 h did not enhance significantly human lymphocyte DNA damage, but could reduce and increase DNA damage of human lymphocytes induced by UVC at 1.5-h and 4-h incubation, respectively.

(E) Belyaev IY, Hillert L, Protopopova M, Tamm C, Malmgren LO, Persson BR, Selivanova G, Harms-Ringdahl M. 915 MHz microwaves and 50 Hz magnetic field affect chromatin conformation and 53BP1 foci in human lymphocytes from hypersensitive and healthy persons. Bioelectromagnetics 26:173-184, 2005. (GT, EH)

We used exposure to microwaves from a global system for mobile communication (GSM) mobile phone (915 MHz, specific absorption rate (SAR) 37 mW/kg) and power frequency magnetic field (50 Hz, 15 muT peak value) to investigate the response of lymphocytes from healthy subjects and from persons reporting hypersensitivity to electromagnetic field (EMF). The hypersensitive and healthy donors were matched by gender and age and the data were

analyzed blind to treatment condition. The changes in chromatin conformation were measured with the method of anomalous viscosity time dependencies (AVTD). 53BP1 protein, which has been shown to colocalize in foci with DNA double strand breaks (DSBs), was analyzed by immunostaining in situ. Exposure at room temperature to either 915 MHz or 50 Hz resulted in significant condensation of chromatin, shown as AVTD changes, which was similar to the effect of heat shock at 41 degrees C. No significant differences in responses between normal and hypersensitive subjects were detected. Neither 915 MHz nor 50 Hz exposure induced 53BP1 foci. On the contrary, a distinct decrease in background level of 53BP1 signaling was observed upon these exposures as well as after heat shock treatments. This decrease correlated with the AVTD data and may indicate decrease in accessibility of 53BP1 to antibodies because of stress-induced chromatin condensation. Apoptosis was determined by morphological changes and by apoptotic fragmentation of DNA as analyzed by pulsed-field gel electrophoresis (PFGE). No apoptosis was induced by exposure to 50 Hz and 915 MHz microwaves. In conclusion, 50 Hz magnetic field and 915 MHz microwaves under specified conditions of exposure induced comparable responses in lymphocytes from healthy and hypersensitive donors that were similar but not identical to stress response induced by heat shock.

(E) Belyaev IY, Koch CB, Terenius O, Roxstrom-Lindquist K, Malmgren LO, H Sommer W, Salford LG, Persson BR. Exposure of rat brain to 915 MHz GSM microwaves induces changes in gene expression but not double stranded DNA breaks or effects on chromatin conformation. Bioelectromagnetics 27:295-306, 2006. (GE)

We investigated whether exposure of rat brain to microwaves (MWs) of global system for mobile communication (GSM) induces DNA breaks, changes in chromatin conformation and in gene expression. An exposure installation was used based on a test mobile phone employing a GSM signal at 915 MHz, all standard modulations included, output power level in pulses 2 W, specific absorption rate (SAR) 0.4 mW/g. Rats were exposed or sham exposed to MWs during 2 h. After exposure, cell suspensions were prepared from brain samples, as well as from spleen and thymus. For analysis of gene expression patterns, total RNA was extracted from cerebellum. Changes in chromatin conformation, which are indicative of stress response and genotoxic effects, were measured by the method of anomalous viscosity time dependencies (AVTD). DNA double strand breaks (DSBs) were analyzed by pulsed-field gel electrophoresis (PFGE). Effects of MW exposure were observed on neither conformation of chromatin nor DNA DSBs. Gene expression profiles were obtained by Affymetrix U34 GeneChips representing 8800 rat genes and analyzed with the Affymetrix Microarray Suite (MAS) 5.0 software. In cerebellum from all exposed animals, 11 genes were upregulated in a range of 1.34-2.74 fold and one gene was downregulated 0.48-fold ($P < .0025$). The induced genes encode proteins with diverse functions including neurotransmitter regulation, blood-brain barrier (BBB), and melatonin production. The data shows that GSM MWs at 915 MHz did not induce PFGE-detectable DNA double stranded breaks or changes in chromatin conformation, but affected expression of genes in rat brain cells

(E) Belyaev IY, Markovà E, Hillert L, Malmgren LO, Persson BR. Microwaves from UMTS/GSM mobile phones induce long-lasting inhibition of 53BP1/gamma-H2AX DNA repair foci in human lymphocytes. Bioelectromagnetics 30:129-41, 2009. (GT, EH)

We have recently described frequency-dependent effects of mobile phone microwaves (MWs) of global system for mobile communication (GSM) on human lymphocytes from persons reporting hypersensitivity to electromagnetic fields and healthy persons. Contrary to GSM, universal global telecommunications system (UMTS) mobile phones emit wide-band MW signals. Hypothetically, UMTS MWs may result in higher biological effects compared to GSM signal because of eventual "effective" frequencies within the wideband. Here, we report for the first time that UMTS MWs affect chromatin and inhibit formation of DNA double-strand breaks co-localizing 53BP1/gamma-H2AX DNA repair foci in human lymphocytes from hypersensitive and healthy persons and confirm that effects of GSM MWs depend on carrier frequency. Remarkably, the effects of MWs on 53BP1/gamma-H2AX foci persisted up to 72 h following exposure of cells, even longer than the stress response following heat shock. The data are in line with the hypothesis that the type of signal, UMTS MWs, may have higher biological efficiency and possibly larger health risk effects compared to GSM radiation emissions. No significant differences in effects between groups of healthy and hypersensitive subjects were observed, except for the effects of UMTS MWs and GSM-915 MHz MWs on the formation of the DNA repair foci, which were different for hypersensitive ($P < 0.02$[53BP1]//0.01[gamma-H2AX]) but not for control subjects ($P > 0.05$). The non-parametric statistics used here did not indicate specificity of the differences revealed between the effects of GSM and UMTS MWs on cells from hypersensitive subjects and more data are needed to study the nature of these differences.

(NE) Bourthoumieu S, Joubert V, Marin B, Collin A, Leveque P, Terro F, Yardin C. Cytogenetic studies in human cells exposed in vitro to GSM-900 MHz radiofrequency radiation using R-banded karyotyping. Radiat Res 174:712-718, 2010. (GT)

It is important to determine the possible effects of exposure to radiofrequency (RF) radiation on the genetic material of cells since damage to the DNA of somatic cells may be linked to cancer development or cell death and damage to germ cells may lead to genetic damage in next and subsequent generations. The objective of this study was to investigate whether exposure to radiofrequency radiation similar to that emitted by mobile phones of second-generation standard Global System for Mobile Communication (GSM) induces genotoxic effects in cultured human cells. The cytogenetic effects of GSM-900 MHz (GSM-900) RF radiation were investigated using R-banded karyotyping after in vitro exposure of human cells (amniotic cells) for 24 h. The average specific absorption rate (SAR) was 0.25 W/kg. The exposures were carried out in wire-patch cells (WPCs) under strictly controlled conditions of temperature. The genotoxic effect was assessed immediately or 24 h after exposure using four different samples. One hundred metaphase cells were analyzed per assay. Positive controls were provided by using bleomycin. We found no direct cytogenetic effects of GSM-900 either 0 h or 24 h after exposure. To the best of our knowledge, our work is the first to study genotoxicity using

complete R-banded karyotyping, which allows visualizing all the chromosomal rearrangements, either numerical or structural.

(NE) Bourthoumieu S, Terro F, Leveque P, Collin A, Joubert V, Yardin C. Aneuploidy studies in human cells exposed in vitro to GSM-900 MHz radiofrequency radiation using FISH. Int J Radiat Biol 87:400-408, 2011. (GT)

PURPOSE: Since previous research found an increase in the rate of aneuploidies in human lymphocytes exposed to radiofrequencies, it seems important to perform further studies. The objective of this study was then to investigate whether the exposure to RF (radiofrequency) radiation similar to that emitted by mobile phones of a second generation standard, i.e., Global System for Mobile communication (GSM) may induce aneuploidy in cultured human cells. MATERIALS AND METHODS: The potential induction of genomic instability by GSM-900 MHz radiofrequency (GSM-900) was investigated after in vitro exposure of human amniotic cells for 24 h to average-specific absorption rates (SAR) of 0.25, 1, 2 and 4 W/kg in the temperature range of 36.3-39.7°C. The exposures were carried out in a wire-patch cell (WPC). The rate of aneuploidy of chromosomes 11 and 17 was determined by interphase FISH (Fluorescence In Situ Hybridisation) immediately after independent exposure of three different donors for 24 h. At least 100 interphase cells were analysed per assay. RESULTS: No significant change in the rate of aneuploidy of chromosomes 11 and 17 was found following exposure to GSM-900 for 24 h at average SAR up to 4 W/kg. CONCLUSION: Our study did not show any in vitro aneuploidogenic effect of GSM using FISH and is not in agreement with the results of previous research.

(NE) Bourthoumieu S, Magnaudeix A, Terro F, Leveque P, Collin A, Yardin C. Study of p53 expression and post-transcriptional modifications after GSM-900 radiofrequency exposure of human amniotic cells. Bioelectromagnetics. 2012 Jul 5. doi: 10.1002/bem.21744. [Epub ahead of print] (GE)

The potential effects of radiofrequency (RF) exposure on the genetic material of cells are very important to determine since genome instability of somatic cells may be linked to cancer development. In response to genetic damage, the p53 protein is activated and can induce cell cycle arrest allowing more time for DNA repair or elimination of damaged cells through apoptosis. The objective of this study was to investigate whether the exposure to RF electromagnetic fields, similar to those emitted by mobile phones of the second generation standard, Global System for Mobile Communications (GSM), may induce expression of the p53 protein and its activation by post-translational modifications in cultured human cells. The potential induction of p53 expression and activation by GSM-900 was investigated after in vitro exposure of human amniotic cells for 24 h to average specific absorption rates (SARs) of 0.25, 1, 2, and 4 W/kg in the temperature range of 36.3-39.7 °C. The exposures were carried out using a wire-patch cell (WPC) under strictly controlled conditions of temperature. Expression and activation of p53 by phosphorylation at serine 15 and 37 were studied using Western blot assay immediately after three independent exposures of cell cultures provided from three different donors. Bleomycin-exposed cells were used as a positive control. According to our results, no

significant changes in the expression and activation of the p53 protein by phosphorylation at serine 15 and 37 were found following exposure to GSM-900 for 24 h at average SARs up to 4 W/kg in human embryonic cells.

(E) Burlaka A, Tsybulin O, Sidorik E, Lukin S, Polishuk V, Tsehmistrenko S, Yakymenko I. Overproduction of free radical species in embryonal cells exposed to low intensity radiofrequency radiation. Exp Oncol. 35(3):219-225, 2013. (GT, LE, DE, OX)

Aim: Long-term exposure of humans to low intensity radiofrequency electromagnetic radiation (RF-EMR) leads to a statistically significant increase in tumor incidence. Mechanisms of such the effects are unclear, but features of oxidative stress in living cells under RF-EMR exposure were previously reported. Our study aims to assess a production of initial free radical species, which lead to oxidative stress in the cell. Materials and Methods: Embryos of Japanese quails were exposed in ovo to extremely low intensity RF-EMR of GSM 900 MHz (0.25 μW/cm2) during 158-360 h discontinuously (48 c - ON, 12 c - OFF) before and in the initial stages of development. The levels of superoxide (O2·-), nitrogen oxide (NO·), thiobarbituric acid reactive substances (TBARS), 8-oxo-2'-deoxyguanosine (8-oxo-dG) and antioxidant enzymes' activities were assessed in cells/tissues of 38-h, 5- and 10-day RF-EMR exposed and unexposed embryos. Results: The exposure resulted in a significant persistent overproduction of superoxide and nitrogen oxide in embryo cells during all period of analyses. As a result, significantly increased levels of TBARS and 8-oxo-dG followed by significantly decreased levels of superoxide dismutase and catalase activities were developed in the exposed embryo cells. Conclusion: Exposure of developing quail embryos to extremely low intensity RF-EMR of GSM 900 MHz during at least one hundred and fifty-eight hours leads to a significant overproduction of free radicals/reactive oxygen species and oxidative damage of DNA in embryo cells. These oxidative changes may lead to pathologies up to oncogenic transformation of cells.

(E) Buttiglione M, Roca L, Montemurno E, Vitiello F, Capozzi V, Cibelli G. Radiofrequency radiation (900 MHz) induces Egr-1 gene expression and affects cell-cycle control in human neuroblastoma cells. J Cell Physiol. 213(3):759-767, 2007. (GE)

Many environmental signals, including ionizing radiation and UV rays, induce activation of Egr-1 gene, thus affecting cell growth and apoptosis. The paucity and the controversial knowledge about the effect of electromagnetic fields (EMF) exposure of nerve cells prompted us to investigate the bioeffects of radiofrequency (RF) radiation on SH-SY5Y neuroblastoma cells. The effect of a modulated RF field of 900 MHz, generated by a wire patch cell (WPC) antenna exposure system on Egr-1 gene expression, was studied as a function of time. Short-term exposures induced a transient increase in Egr-1 mRNA level paralleled with activation of the MAPK subtypes ERK1/2 and SAPK/JNK. The effects of RF radiations on cell growth rate and apoptosis were also studied. Exposure to RF radiation had an anti-proliferative activity in SH-

SY5Y cells with a significant effect observed at 24 h. RF radiation impaired cell cycle progression, reaching a significant G2-M arrest. In addition, the appearance of the sub-G1 peak, a hallmark of apoptosis, was highlighted after a 24-h exposure, together with a significant decrease in mRNA levels of Bcl-2 and survivin genes, both interfering with signaling between G2-M arrest and apoptosis. Our results provide evidence that exposure to a 900 MHz-modulated RF radiation affect both Egr-1 gene expression and cell regulatory functions, involving apoptosis inhibitors like Bcl-2 and survivin, thus providing important insights into a potentially broad mechanism for controlling in vitro cell viability.

(E) Cam ST, Seyhan N. Single-strand DNA breaks in human hair root cells exposed to mobile phone radiation. Int J Radiat Biol 88(5):420-424, 2012 (GT, HU)

Purpose: To analyze the short term effects of radiofrequency radiation (RFR) exposure on genomic deoxyribonucleic acid (DNA) of human hair root cells. Subjects and methods: Hair samples were collected from 8 healthy human subjects immediately before and after using a 900-MHz GSM (Global System for Mobile Communications) mobile phone for 15 and 30 minutes. Single-strand DNA breaks of hair root cells from the samples were determined using the 'comet assay'. Results: The data showed that talking on a mobile phone for 15 or 30 minutes significantly increased ($p < .05$) single-strand DNA breaks in cells of hair roots close to the phone. Comparing the 15-min and 30-min data using the paired t-test also showed that significantly more damages resulted after 30 minutes than after 15 minutes of phone use. Conclusions: A short-term exposure (15 and 30 minutes) to RFR (900-MHz) from a mobile phone caused a significant increase in DNA single-strand breaks in human hair root cells located around the ear which is used for the phone calls.

(E) Campisi A, Gulino M, Acquaviva R, Bellia P, Raciti G, Grasso R, Musumeci F, Vanella A, Triglia A. Reactive oxygen species levels and DNA fragmentation on astrocytes in primary culture after acute exposure to low intensity microwave electromagnetic field. Neurosci Lett 473:52-55. 2010. (GT, OX, WS)

The exposure of primary rat neocortical astroglial cell cultures to acute electromagnetic fields (EMF) in the microwave range was studied. Differentiated astroglial cell cultures at 14 days in vitro were exposed for 5, 10, or 20 min to either 900 MHz continuous waves or 900 MHz waves modulated in amplitude at 50 Hz using a sinusoidal waveform and 100% modulation index. The strength of the electric field (rms value) at the sample position was 10V/m. No change in cellular viability evaluated by MTT test and lactate dehydrogenase release was observed. A significant increase in ROS levels and DNA fragmentation was found only after exposure of the astrocytes to modulated EMF for 20 min. No evident effects were detected when shorter time intervals or continuous waves were used. The irradiation conditions allowed the exclusion of any possible thermal effect. Our data demonstrate, for the first time, that even acute exposure to low intensity EMF induces ROS production and DNA fragmentation in astrocytes in primary cultures, which also represent the principal target of modulated EMF. Our findings also suggest the hypothesis that the effects could be due to hyperstimulation of the glutamate receptors, which play a crucial role in acute and chronic brain damage. Furthermore, the results show the

importance of the amplitude modulation in the interaction between EMF and neocortical astrocytes.

(E) 1 **Cervellati F, Valacchi G, Lunghi L, Fabbri E, Valbonesi P, Marci R, Biondi C, Vesce F. 17-β-estradiol counteracts the effects of high frequency electromagnetic fields on trophoblastic connexins and integrins. Oxid Med Cell Longev. 2013;2013:280850. doi: 10.1155/2013/280850. (GE)**

We investigated the effect of high-frequency electromagnetic fields (HF-EMFs) and 17-β-estradiol on connexins (Cxs), integrins (Ints), and estrogen receptor (ER) expression, as well as on ultrastructure of trophoblast-derived HTR-8/SVneo cells. HF-EMF, 17-β-estradiol, and their combination induced an increase of Cx40 and Cx43 mRNA expression. HF-EMF decreased Int alpha1 and β 1 mRNA levels but enhanced Int alpha5 mRNA expression. All the Ints mRNA expressions were increased by 17-β-estradiol and exposure to both stimuli. ER-β mRNA was reduced by HF-EMF but augmented by 17-β-estradiol alone or with HF-EMF. ER-β immunofluorescence showed a cytoplasmic localization in sham and HF-EMF exposed cells which became nuclear after treatment with hormone or both stimuli. Electron microscopy evidenced a loss of cellular contact in exposed cells which appeared counteracted by 17-β-estradiol. We demonstrate that 17-β-estradiol modulates Cxs and Ints as well as ER-β expression induced by HF-EMF, suggesting an influence of both stimuli on trophoblast differentiation and migration.

(NE) Chang SK, Choi JS, Gil HW, Yang JO, Lee EY, Jeon YS, Lee ZW, Lee M, Hong MY, Ho Son T, Hong SY. Genotoxicity evaluation of electromagnetic fields generated by 835-MHz mobile phone frequency band. Eur J Cancer Prev 14:175-179, 2005. (GT, IA) (Some interaction effects with chemicals are reported in this paper.)

It is still unclear whether the exposure to electromagnetic fields (EMFs) generated by mobile phone radiation is directly linked to cancer. We examined the biological effects of an EMF at 835 MHz, the most widely used communication frequency band in Korean CDMA mobile phone networks, on bacterial reverse mutation (Ames assay) and DNA stability (in vitro DNA degradation). In the Ames assay, tester strains alone or combined with positive mutagen were applied in an artificial mobile phone frequency EMF generator with continuous waveform at a specific absorption rate (SAR) of 4 W/kg for 48 h. In the presence of the 835-MHz EMF radiation, incubation with positive mutagen 4-nitroquinoline-1-oxide and cumene hydroxide further increased the mutation rate in Escherichia coli WP2 and TA102, respectively, while the contrary results in Salmonella typhimurium TA98 and TA1535 treated with 4-nitroquinoline-1-oxide and sodium azide, respectively, were shown as antimutagenic. However, these mutagenic or co-mutagenic effects of 835-MHz radiation were not significantly repeated in other relevant strains with same mutation type. In the DNA degradation test, the exposure to 835-MHz EMF did not change the rate of degradation observed using plasmid pBluescriptSK(+) as an indicator.

Thus, we suggest that 835-MHz EMF under the conditions of our study neither affected the reverse mutation frequency nor accelerated DNA degradation in vitro.

(NE) Chauhan V, Mariampillai A, Bellier PV, Qutob SS, Gajda GB, Lemay E, Thansandote A, McNamee JP. Gene expression analysis of a human lymphoblastoma cell line exposed in vitro to an intermittent 1.9 GHz pulse-modulated radiofrequency field. Radiat Res. 165(4):424-429, 2006. (GE)

This study was designed to determine whether radiofrequency (RF) fields of the type used for wireless communications could elicit a cellular stress response. As general indicators of a cellular stress response, we monitored changes in proto-oncogene and heat-shock protein expression. Exponentially growing human lymphoblastoma cells (TK6) were exposed to 1.9 GHz pulse-modulated RF fields at average specific absorption rates (SARs) of 1 and 10 W/kg. Perturbations in the expression levels of the proto-oncogenes FOS, JUN and MYC after exposure to sham and RF fields were assessed by real-time RT-PCR. In addition, the transcript levels of the cellular stress proteins HSP27 and inducible HSP70 were also monitored. We demonstrated that transcript levels of these genes in RF-field-exposed cells showed no significant difference in relation to the sham treatment group. However, concurrent positive (heat-shock) control samples displayed a significant elevation in the expression of HSP27, HSP70, FOS and JUN. Conversely, the levels of MYC mRNA were found to decline in the positive (heat-shock) control. In conclusion, our study found no evidence that the 1.9 GHz RF-field exposure caused a general stress response in TK6 cells under our experimental conditions.

(NE) Chauhan V, Mariampillai A, Gajda GB, Thansandote A, McNamee JP. Analysis of proto-oncogene and heat-shock protein gene expression in human derived cell-lines exposed in vitro to an intermittent 1.9 GHz pulse-modulated radiofrequency field. Int J Radiat Biol. 82(5):347-354, 2006. (GE)

Purpose: Several studies have reported that radiofrequency (RF) fields, as emitted by mobile phones, may cause changes in gene expression in cultured human cell-lines. The current study was undertaken to evaluate this possibility in two human-derived immune cell-lines.Materials and methods: HL-60 and Mono-Mac-6 (MM6) cells were individually exposed to intermittent (5 min on, 10 min off) 1.9 GHz pulse-modulated RF fields at a average specific absorption rate (SAR) of 1 and 10 W/kg at 37 +/- 0.5 degrees C for 6 h. Concurrent negative and positive (heat-shock for 1 h at 43 degrees C) controls were conducted with each experiment. Immediately following RF field exposure (T = 6 h) and 18 h post-exposure (T = 24 h), cell pellets were collected from each of the culture dishes and analyzed for transcript levels of proto-oncogenes (c-jun, c-myc and c-fos) and the stress-related genes (heat shock proteins (HSP) HSP27 and HSP70B) by quantitative reverse transcriptase polymerase chain reaction (RT-PCR).Results: No significant effects were observed in mRNA expression of HSP27, HSP70, c-jun, c-myc or c-fos between the sham and RF-exposed groups, in either of the two cell-lines. However, the positive

(heat-shock) control group displayed a significant elevation in the expression of HSP27, HSP70, c-fos and c-jun in both cell-lines at T = 6 and 24 h, relative to the sham and negative control groups.Conclusion: This study found no evidence that exposure of cells to non-thermalizing levels of 1.9 GHz pulse-modulated RF fields can cause any detectable change in stress-related gene expression.

(NE) Chauhan V, Qutob SS, Lui S, Mariampillai A, Bellier PV, Yauk CL, Douglas GR, Williams A, McNamee JP. Analysis of gene expression in two human-derived cell lines exposed in vitro to a 1.9 GHz pulse-modulated radiofrequency field. Proteomics. 7(21):3896-3905, 2007. (GE)

There is considerable controversy surrounding the biological effects of radiofrequency (RF) fields, as emitted by mobile phones. Previous work from our laboratory has shown no effect related to the exposure of 1.9 GHz pulse-modulated RF fields on the expression of 22,000 genes in a human glioblastoma-derived cell-line (U87MG) at 6 h following a 4 h RF field exposure period. As a follow-up to this study, we have now examined the effect of RF field exposure on the possible expression of late onset genes in U87MG cells after a 24 h RF exposure period. In addition, a human monocyte-derived cell-line (Mono-Mac-6, MM6) was exposed to intermittent (5 min ON, 10 min OFF) RF fields for 6 h and then gene expression was assessed immediately after exposure and at 18 h postexposure. Both cell lines were exposed to 1.9 GHz pulse-modulated RF fields for 6 or 24 h at specific absorption rates (SARs) of 0.1-10.0 W/kg. In support of our previous results, we found no evidence that nonthermal RF field exposure could alter gene expression in either cultured U87MG or MM6 cells, relative to nonirradiated control groups. However, exposure of both cell-lines to heat-shock conditions (43 degrees C for 1 h) caused an alteration in the expression of a number of well-characterized heat-shock proteins.

(E) Chavdoula ED, Panagopoulos DJ, Margaritis LH. Comparison of biological effects between continuous and intermittent exposure to GSM-900-MHz mobile phone radiation: detection of apoptotic cell-death features. Mutat Res 700:51-61, 2010. (RP, LE, GT)

In the present study we used a 6-min daily exposure of dipteran flies, Drosophila melanogaster, to GSM-900 MHz (Global System for Mobile Telecommunications) mobile phone electromagnetic radiation (EMR), to compare the effects between the continuous and four different intermittent exposures of 6min total duration, and also to test whether intermittent exposure provides any cumulative effects on the insect's reproductive capacity as well as on the induction of apoptotic cell death. According to our previous experiments, a 6-min continuous exposure per day for five days to GSM-900 MHz and DCS-1800 MHz (Digital Cellular System) mobile phone radiation, brought about a large decrease in the insect's reproductive capacity, as defined by the number of F pupae. This decrease was found to be non thermal and correlated with an increased percentage of induced fragmented DNA in the egg chambers' cells at early- and mid-oogenesis. In the present experiments we show that intermittent exposure also decreases the reproductive capacity and alters the actin cytoskeleton network of the egg chambers, another known aspect of cell death that was not investigated in previous experiments, and that the effect is also due to DNA fragmentation. Intermittent exposures with

10-min intervals between exposure sessions proved to be almost equally effective as continuous exposure of the same total duration, whereas longer intervals between the exposures seemed to allow the organism the time required to recover and partly overcome the above-mentioned effects of the GSM exposure.

(E) Chen G, Lu D, Chiang H, Leszczynski D, Xu Z. Using model organism Saccharomyces cerevisiae to evaluate the effects of ELF-MF and RF-EMF exposure on global gene expression. Bioelectromagnetics. 33(7):550-560, 2012 . (GE)

The potential health hazard of exposure to electromagnetic fields (EMF) continues to cause public concern. However, the possibility of biological and health effects of exposure to EMF remains controversial and their biophysical mechanisms are unknown. In the present study, we used Saccharomyces cerevisiae to identify genes responding to extremely low frequency magnetic fields (ELF-MF) and to radiofrequency EMF (RF-EMF) exposures. The yeast cells were exposed for 6 h to either 0.4 mT 50 Hz ELF-MF or 1800 MHz RF-EMF at a specific absorption rate of 4.7 W/kg. Gene expression was analyzed by microarray screening and confirmed using real-time reverse transcription-polymerase chain reaction (RT-PCR). We were unable to confirm microarray-detected changes in three of the ELF-MF responsive candidate genes using RT-PCR ($P > 0.05$). On the other hand, out of the 40 potential RF-EMF responsive genes, only the expressions of structural maintenance of chromosomes 3 (SMC3) and aquaporin 2 (AQY2 (m)) were confirmed, while three other genes, that is, halotolerance protein 9 (HAL9), yet another kinase 1 (YAK1) and one function-unknown gene (open reading frame: YJL171C), showed opposite changes in expression compared to the microarray data ($P < 0.05$). In conclusion, the results of this study suggest that the yeast cells did not alter gene expression in response to 50 Hz ELF-MF and that the response to RF-EMF is limited to only a very small number of genes. The possible biological consequences of the gene expression changes induced by RF-EMF await further investigation. 1

(E) De Iuliis GN, Newey RJ, King BV, Aitken RJ. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. PLoS One 4:e6446, 2009. (GT, OX, RP)

BACKGROUND: In recent times there has been some controversy over the impact of electromagnetic radiation on human health. The significance of mobile phone radiation on male reproduction is a key element of this debate since several studies have suggested a relationship between mobile phone use and semen quality. The potential mechanisms involved have not been established, however, human spermatozoa are known to be particularly vulnerable to oxidative stress by virtue of the abundant availability of substrates for free radical attack and the lack of cytoplasmic space to accommodate antioxidant enzymes. Moreover, the induction of oxidative stress in these cells not only perturbs their capacity for fertilization but also contributes to sperm DNA damage. The latter has, in turn, been linked with poor fertility, an increased incidence of miscarriage and morbidity in the offspring, including childhood cancer. In light of these associations, we have analyzed the influence of RF-EMR on the cell biology of

human spermatozoa in vitro. PRINCIPAL FINDINGS: Purified human spermatozoa were exposed to radio-frequency electromagnetic radiation (RF-EMR) tuned to 1.8 GHz and covering a range of specific absorption rates (SAR) from 0.4 W/kg to 27.5 W/kg. In step with increasing SAR, motility and vitality were significantly reduced after RF-EMR exposure, while the mitochondrial generation of reactive oxygen species and DNA fragmentation were significantly elevated ($P<0.001$). Furthermore, we also observed highly significant relationships between SAR, the oxidative DNA damage bio-marker, 8-OH-dG, and DNA fragmentation after RF-EMR exposure. CONCLUSIONS: RF-EMR in both the power density and frequency range of mobile phones enhances mitochondrial reactive oxygen species generation by human spermatozoa, decreasing the motility and vitality of these cells while stimulating DNA base adduct formation and, ultimately DNA fragmentation. These findings have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and wellbeing of their offspring.

(E) Del Vecchio G, Giuliani A, Fernandez M, Mesirca P, Bersani F, Pinto R, Ardoino L, Lovisolo GA, Giardino L, Calzà L. Continuous exposure to 900MHz GSM-modulated EMF alters morphological maturation of neural cells. Neurosci Lett. 455(3):173-177, 2009. (GE, DE)

The effects of radiofrequency electromagnetic field (RF-EMF) exposure on neuronal phenotype maturation have been studied in two different in vitro models: murine SN56 cholinergic cell line and rat primary cortical neurons. The samples were exposed at a dose of 1W/kg at 900 MHz GSM modulated. The phenotype analysis was carried out at 48 and 72 h (24 and 48 h of SN56 cell line differentiation) or at 24, 72, 120 h (2, 4 and 6 days in vitro for cortical neurons) of exposure, on live and immunolabeled neurons, and included the morphological study of neurite emission, outgrowth and branching. Moreover, cortical neurons were studied to detect alterations in the expression pattern of cytoskeleton regulating factors, e.g. beta-thymosin, and of early genes, e.g. c-Fos and c-Jun through real-time PCR on mRNA extracted after 24h exposure to EMF. We found that RF-EMF exposure reduced the number of neurites generated by both cell systems, and this alteration correlates to increased expression of beta-thymosin mRNA.

(E) Deshmukh PS, Megha K, Banerjee BD, Ahmed RS, Chandna S, Abegaonkar MP, Tripathi AK. Detection of Low Level Microwave Radiation Induced Deoxyribonucleic Acid Damage Vis-à-vis Genotoxicity in Brain of Fischer Rats. Toxicol Int. 20(1):19-24, 2013. (GT, LE)

BACKGROUND: Non-ionizing radiofrequency radiation has been increasingly used in industry, commerce, medicine and especially in mobile phone technology and has become a matter of serious concern in present time. OBJECTIVE: The present study was designed to investigate the possible deoxyribonucleic acid (DNA) damaging effects of low-level microwave radiation in brain of Fischer rats. MATERIALS AND METHODS: Experiments were performed on male Fischer rats exposed to microwave radiation for 30 days at three different frequencies: 900, 1800 and 2450 MHz. Animals were divided into 4 groups: Group I (Sham exposed): Animals not exposed to microwave radiation but kept under same conditions as that of other groups, Group II: Animals exposed to microwave radiation at frequency 900 MHz at specific absorption rate (SAR) 5.953 × 10(-4) W/kg, Group III: Animals exposed to 1800 MHz at SAR 5.835 × 10(-4) W/kg and Group IV: Animals exposed to 2450 MHz at SAR 6.672 × 10(-4) W/kg. At the end of the exposure period animals were sacrificed immediately and DNA damage in brain tissue was assessed using alkaline comet assay. RESULTS: In the present study, we demonstrated DNA damaging effects of low level microwave radiation in brain. CONCLUSION: We concluded that low SAR microwave radiation exposure at these frequencies may induce DNA strand breaks in brain tissue.

(E) Engelmann JC, Deeken R, Müller T, Nimtz G, Roelfsema MR, Hedrich R. Is gene activity in plant cells affected by UMTS-irradiation? A whole genome approach. Adv Appl Bioinform Chem. 1:71-83, 2008. (GE)

Mobile phone technology makes use of radio frequency (RF) electromagnetic fields transmitted through a dense network of base stations in Europe. Possible harmful effects of RF fields on humans and animals are discussed, but their effect on plants has received little attention. In search for physiological processes of plant cells sensitive to RF fields, cell suspension cultures of Arabidopsis thaliana were exposed for 24 h to a RF field protocol representing typical microwave exposition in an urban environment. mRNA of exposed cultures and controls was used to hybridize Affymetrix-ATH1 whole genome microarrays. Differential expression analysis revealed significant changes in transcription of 10 genes, but they did not exceed a fold change of 2.5. Besides that 3 of them are dark-inducible, their functions do not point to any known responses of plants to environmental stimuli. The changes in transcription of these genes were compared with published microarray datasets and revealed a weak similarity of the microwave to light treatment experiments. Considering the large changes described in published experiments, it is questionable if the small alterations caused by a 24 h continuous microwave exposure would have any impact on the growth and reproduction of whole plants.

(E) Esmekaya MA, Aytekin E, Ozgur E, Güler G, Ergun MA, Omeroğlu S, Seyhan N. Mutagenic and morphologic impacts of 1.8GHz radiofrequency radiation on human peripheral blood lymphocytes (hPBLs) and possible protective role of pre-treatment with Ginkgo biloba (EGb 761). Sci Total Environ. 410-411:59-64, 2011. (GT, OX)

The mutagenic and morphologic effects of 1.8GHz Global System for Mobile Communications (GSM) modulated RF (radiofrequency) radiation alone and in combination with Ginkgo biloba (EGb 761) pre-treatment in human peripheral blood lymphocytes (hPBLs) were investigated in this study using Sister Chromatid Exchange (SCE) and electron microscopy. Cell viability was assessed with 3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide (MTT) reduction assay. The lymphocyte cultures were exposed to GSM modulated RF radiation at 1.8GHz for 6, 8, 24 and 48h with and without EGb 761. We observed morphological changes in pulse-modulated RF radiated lymphocytes. Longer exposure periods led to destruction of organelle and nucleus structures. Chromatin change and the loss of mitochondrial crista occurred in cells exposed to RF for 8h and 24h and were more pronounced in cells exposed for 48h. Cytoplasmic lysis and destruction of membrane integrity of cells and nuclei were also seen in 48h RF exposed cells. There was a significant increase ($p<0.05$) in SCE frequency in RF exposed lymphocytes compared to sham controls. EGb 761 pre-treatment significantly decreased SCE from RF radiation. RF radiation also inhibited cell viability in a time dependent manner. The inhibitory effects of RF radiation on the growth of lymphoctes were marked in longer exposure periods. EGb 761 pre-treatment significantly increased cell viability in RF+EGb 761 treated groups at 8 and 24h when compared to RF exposed groups alone. The results of our study showed that RF radiation affects cell morphology, increases SCE and inhibits cell proliferation. However, EGb 761 has a protective role against RF induced mutagenity. We concluded that RF radiation induces chromosomal damage in hPBLs but this damage may be reduced by EGb 761 pre-treatment.

(NE) Falzone N, Huyser C, Franken DR, Leszczynski D. Mobile phone radiation does not induce pro-apoptosis effects in human spermatozoa. Radiat Res 174:169-176, 2010. (GT, OX)

Abstract Recent reports suggest that mobile phone radiation may diminish male fertility. However, the effects of this radiation on human spermatozoa are largely unknown. The present study examined effects of the radiation on induction of apoptosis-related properties in human spermatozoa. Ejaculated, density-purified, highly motile human spermatozoa were exposed to mobile phone radiation at specific absorption rates (SARs) of 2.0 and 5.7 W/kg. At various times after exposure, flow cytometry was used to examine caspase 3 activity, externalization of phosphatidylserine (PS), induction of DNA strand breaks, and generation of reactive oxygen species. Mobile phone radiation had no statistically significant effect on any of the parameters studied. This suggests that the impairment of fertility reported in some studies was not caused by the induction of apoptosis in spermatozoa.

(E) Ferreira AR, Knakievicz T, de Bittencourt Pasquali MA, Gelain DP, Dal-Pizzol F, Fernandez CE, de Almeida de Salles AA, Ferreira HB, Moreira JC. Ultra high frequency-electromagnetic field irradiation during pregnancy leads to an increase in erythrocytes micronuclei incidence in rat offspring. Life Sci 80: 43-50, 2006. (GT, OX, LE, DE)

Mobile telephones and their base stations are an important ultra high frequency-electromagnetic field (UHF-EMF) source and their utilization is increasing all over the world. Epidemiological studies suggested that low energy UHF-EMF emitted from a cellular telephone

may cause biological effects, such as DNA damage and changes on oxidative metabolism. An in vivo mammalian cytogenetic test, the micronucleus (MN) assay, was used to investigate the occurrence of chromosomal damage in erythrocytes from rat offspring exposed to a non-thermal UHF-EMF from a cellular phone during their embryogenesis; the irradiated group showed a significant increase in MN occurrence. In order to investigate if UHF-EMF could also alter oxidative parameters in the peripheral blood and in the liver - an important hematopoietic tissue in rat embryos and newborns - we also measured the activity of antioxidant enzymes, quantified total sulfhydryl content, protein carbonyl groups, thiobarbituric acid-reactive species and total non-enzymatic antioxidant defense. No significant differences were found in any oxidative parameter of offspring blood and liver. The average number of pups in each litter has also not been significantly altered. Our results suggest that, under our experimental conditions, UHF-EMF is able to induce a genotoxic response in hematopoietic tissue during the embryogenesis through an unknown mechanism.

(NE) Finnie JW, Cai Z, Blumbergs PC, Manavis J, Kuchel TR. Expression of the immediate early gene, c-fos, in fetal brain after whole of gestation exposure of pregnant mice to global system for mobile communication microwaves. Pathology. 38(4):333-335, 2006. (GE, DE)

AIMS: To study immediate early gene, c-fos, expression as a marker of neural stress after whole of gestation exposure of the fetal mouse brain to mobile telephone-type radiofrequency fields. METHODS: Using a purpose-designed exposure system at 900 MHz, pregnant mice were given a single, far-field, whole body exposure at a specific absorption rate of 4 W/kg for 60 min/day from day 1 to day 19 of gestation. Pregnant control mice were sham-exposed or freely mobile in a cage without further restraint. Immediately prior to parturition on gestational day 19, fetal heads were collected, fixed in 4% paraformaldehyde and paraffin embedded. Any stress response in the brain was detected by c-fos immunohistochemistry in the cerebral cortex, basal ganglia, thalamus, hippocampus, midbrain, cerebellum and medulla. RESULTS: c-fos expression was of limited, but consistent, neuroanatomical distribution and there was no difference in immunoreactivity between exposed and control brains. CONCLUSION: In this animal model, no stress response was detected in the fetal brain using c-fos immunohistochemistry after whole of gestation exposure to mobile telephony.

(E) Franzellitti S, Valbonesi P, Ciancaglini N, Biondi C, Contin A, Bersani F, Fabbri E. Transient DNA damage induced by high-frequency electromagnetic fields (GSM 1.8 GHz) in the human trophoblast HTR-8/SVneo cell line evaluated with the alkaline comet assay. Mutat Res 683(1-2):35-42, 2010. (GT, WS)

One of the most controversial issue regarding high-frequency electromagnetic fields (HF-EMF) is their putative capacity to affect DNA integrity. This is of particular concern due to the increasing use of HF-EMF in communication technologies, including mobile phones. Although epidemiological studies report no detrimental effects on human health, the possible disturbance generated by HF-EMF on cell physiology remains controversial. In addition, the question remains as to whether cells are able to compensate their potential effects. We have previously reported that a 1-h exposure to amplitude-modulated 1.8 GHz sinusoidal waves

(GSM-217 Hz, SAR=2 W/kg) largely used in mobile telephony did not cause increased levels of primary DNA damage in human trophoblast HTR-8/SVneo cells. Nevertheless, further investigations on trophoblast cell responses after exposure to GSM signals of different types and durations were considered of interest. In the present work, HTR-8/SVneo cells were exposed for 4, 16 or 24h to 1.8 GHz continuous wave (CW) and different GSM signals, namely GSM-217 Hz and GSM-Talk (intermittent exposure: 5 min field on, 10 min field off). The alkaline comet assay was used to evaluate primary DNA damages and/or strand breaks due to uncompleted repair processes in HF-EMF exposed samples. The amplitude-modulated signals GSM-217 Hz and GSM-Talk induced a significant increase in comet parameters in trophoblast cells after 16 and 24h of exposure, while the un-modulated CW was ineffective. However, alterations were rapidly recovered and the DNA integrity of HF-EMF exposed cells was similar to that of sham-exposed cells within 2h of recovery in the absence irradiation. Our data suggest that HF-EMF with a carrier frequency and modulation scheme typical of the GSM signal may affect the DNA integrity.

(E) Furtado-Filho OV, Borba JB, Dallegrave A, Pizzolato TM, Henriques JA, Moreira JC, Saffi J. Effect of 950 MHz UHF electromagnetic radiation on biomarkers of oxidative damage, metabolism of UFA and antioxidants in the livers of young rats of different ages. Int J Radiat Biol. 2013 Jul 25. [Epub ahead of print] (LE, GT, OX)

Purpose: To assess the effect of 950 MHz ultra-high-frequency electromagnetic radiation (UHF EMR) on biomarkers of oxidative damage, as well as to verify the concentration of unsaturated fatty acids (UFA) and the expression of the catalase in the livers of rats of different ages. Materials and methods: Twelve rats were equally divided into two groups as controls (CR) and exposed (ER), for each age (0, 6, 15 and 30 days). Radiation exposure lasted half an hour per day for up to 51 days (21 days of gestation and 6, 15 or 30 days of life outside the womb). The specific absorption rate (SAR) ranged from 1.3-1.0 W/kg. The damage to lipids, proteins and DNA was verified by thiobarbituric acid reactive substances (TBARS), protein carbonyls and comets, respectively. UFA were determined by gas chromatography with a flame ionization detector. The expression of catalase was by Western blotting. Results: The neonates had low levels of TBARS and concentrations of UFA after exposure. There was no age difference in the accumulation of protein carbonyls for any age. The DNA damage of ER 15 or 30 days was different. The exposed neonates exhibited lower expression of catalase. Conclusions: 950 MHz UHF EMR does not cause oxidative stress (OS), and it is not genotoxic to the livers of neonates or those of 6 and 15 day old rats, but it changes the concentrations of polyunsaturated fatty acid (PUFA) in neonates. For rats of 30 days, no OS, but it is genotoxic to the livers of ER to total body irradiation.

(E) Gajski G, Garaj-Vrhovac V. Radioprotective effects of honeybee venom (Apismellifera) against 915-MHz microwave radiation-induced DNA damage in wistar rat lymphocytes: in vitro study. Int J Toxicol 28:88-98, 2009. (GT, OX)

The aim of this study is to investigate the radioprotective effect of bee venom against DNA damage induced by 915-MHz microwave radiation (specific absorption rate of 0.6 W/kg) in

Wistar rats. Whole blood lymphocytes of Wistar rats are treated with 1 microg/mL bee venom 4 hours prior to and immediately before irradiation. Standard and formamidopyrimidine-DNA glycosylase (Fpg)-modified comet assays are used to assess basal and oxidative DNA damage produced by reactive oxygen species. Bee venom shows a decrease in DNA damage compared with irradiated samples. Parameters of Fpg-modified comet assay are statistically different from controls, making this assay more sensitive and suggesting that oxidative stress is a possible mechanism of DNA damage induction. Bee venom is demonstrated to have a radioprotective effect against basal and oxidative DNA damage. Furthermore, bee venom is not genotoxic and does not produce oxidative damage in the low concentrations used in this study.

(E) Gandhi G, Anita, Genetic damage in mobile phone users: some preliminary findings. Ind J Hum Genet 11:99-104, 2005. (GT, HU)

BACKGROUND: The impact of microwave (MW)/radio frequency radiation (RFR) on important biological parameters is probably more than a simply thermal one. Exposure to radio frequency (RF) signals generated by the use of cellular telephones have increased dramatically and reported to affect physiological, neurological, cognitive and behavioural changes and to induce, initiate and promote carcinogenesis. Genotoxicity of RFR has also been reported in various test systems after in vitro and/or in vivo exposure but none in mobile phone users. AIMS: In the present study, DNA and chromosomal damage investigations were carried out on the peripheral blood lymphocytes of individuals using mobile phones, being exposed to MW frequency ranging from 800 to 2000 MHz. METHODS: DNA damage was assessed using the single cell gel electrophoresis assay and aneugenic and clastogenic damage by the in vivo capillary blood micronucleus test (MNT) in a total of 24 mobile phone users. RESULTS: Mean comet tail length (26.76 ± 0.054 mm; 39.75% of cells damaged) in mobile phone users was highly significant from that in the control group. The in vivo capillary blood MNT also revealed highly significant (0.25) frequency of micronucleated (MNd) cells. CONCLUSIONS: These results highlight a correlation between mobile phone use (exposure to RFR) and genetic damage and require interim public health actions in the wake of widespread use of mobile telephony.

(E) Gandhi G, Singh P. Cytogenetic damage in mobile phone users: preliminary data. Int J Hum Genet 5:259-265, 2005. (GT, HU)

Mobile telephones, sometimes called cellular (cell) phones or handies, are now an integral part of modern life. The mobile phone handsets are low-powered radiofrequency transmitters, emitting maximum powers in the range of 0.2 to 0.6 watts. Scientific concenrns have increased sufficiently over the possible hazard to health from using cell phones. The reported adverse health effects include physiological, behavioural and cognitive changes as well as tumour formation and genetic damage. However findings are controversial and no consensus exists. Genotoxicity has been observed either in lower organisms or in vitro studies. The aim of the present study hence was to detect any cytogenertic damage in mobile phone users by analysing short term peripheral lymphocyte cultures for chromosomal aberrations and the buccal mucosal cells for micronuclei (aneugenicity and clastogenicity). The results revealed increased

number of micronucleated buccal cells and cytological abnormalities in cultured lymphocytes indicating the genotoxic response from mobile phone use.

(E) Garaj-Vrhovac V, Gajski G, Pažanin S, Sarolić A, Domijan AM, Flajs D, Peraica M. Assessment of cytogenetic damage and oxidative stress in personnel occupationally exposed to the pulsed microwave radiation of marine radar equipment. Int J Hyg Environ Health. 4(1):59-65, 2011. (GT, HU, OX)

Due to increased usage of microwave radiation, there are concerns of its adverse effect in today's society. Keeping this in view, study was aimed at workers occupationally exposed to pulsed microwave radiation, originating from marine radars. Electromagnetic field strength was measured at assigned marine radar frequencies (3 GHz, 5.5 GHz and 9.4 GHz) and corresponding specific absorption rate values were determined. Parameters of the comet assay and micronucleus test were studied both in the exposed workers and in corresponding unexposed subjects. Differences between mean tail intensity (0.67 vs. 1.22) and moment (0.08 vs. 0.16) as comet assay parameters and micronucleus test parameters (micronuclei, nucleoplasmic bridges and nuclear buds) were statistically significant between the two examined groups, suggesting that cytogenetic alterations occurred after microwave exposure. Concentrations of glutathione and malondialdehyde were measured spectrophotometrically and using high performance liquid chromatography. The glutathione concentration in exposed group was significantly lower than in controls (1.24 vs. 0.53) whereas the concentration of malondialdehyde was significantly higher (1.74 vs. 3.17), indicating oxidative stress. Results suggests that pulsed microwaves from working environment can be the cause of genetic and cell alterations and that oxidative stress can be one of the possible mechanisms of DNA and cell damage.

(E) Guler G, Tomruk A, Ozgur E, Seyhan N.The effect of radiofrequency radiation on DNA and lipid damage in non-pregnant and pregnant rabbits and their newborns. Gen Physiol Biophys 29:59-66, 2010. (GT, OX, LE, DE)

The concerns of people on possible adverse health effects of radiofrequency radiation (RFR) generated from mobile phones as well as their supporting transmitters (base stations) have increased markedly. RFR effect on oversensitive people, such as pregnant women and their developing fetuses, and older people is another source of concern that should be considered. In this study, oxidative DNA damage and lipid peroxidation levels in the brain tissue of pregnant and non-pregnant New Zealand White rabbits and their newborns exposed to RFR were investigated. Thirteen-month-old rabbits were studied in four groups as non-pregnant-control, non-pregnant-RFR exposed, pregnant-control and pregnant-RFR exposed. They were exposed to RFR (1800 MHz GSM; 14 V/m as reference level) for 15 min/day during 7 days. Malondialdehyde (MDA) and 8-hydroxy-2'-deoxyguanosine (8-OHdG) levels were analyzed. MDA and 8-OHdG levels of non-pregnant and pregnant-RFR exposed animals significantly increased with respect to controls ($p < 0.001$, Mann-Whitney test). No difference was found in the newborns ($p > 0.05$, Mann-Whitney). There exist very few experimental studies on the

effects of RFR during pregnancy. It would be beneficial to increase the number of these studies in order to establish international standards for the protection of pregnant women from RFR.

(E) Güler G, Tomruk A, Ozgur E, Sahin D, Sepici A, Altan N, Seyhan N. The effect of radiofrequency radiation on DNA and lipid damage in female and male infant rabbits. Int J Radiat Biol. 88(4):367-373, 2012. (LE, GT, OX, DE)

PURPOSE: We aimed to design a prolonged radiofrequency (RF) radiation exposure and investigate in an animal model, possible bio-effects of RF radiation on the ongoing developmental stages of children from conception to childhood. **MATERIALS AND METHODS:** A total of 72 New Zealand female and male white rabbits aged one month were used. Females were exposed to RF radiation for 15 min/day during 7 days, whereas males were exposed to the same level of radiation for 15 min/day during 14 days. Thirty-six female and 36 male infant rabbits were randomly divided into four groups: Group I [Intrauterine (IU) exposure (-); Extrauterine (EU) exposure (-)]: Sham exposure which means rabbits were exposed to 1800 MHz Global System for Mobile Telecommunication (GSM)-like RF signals neither in the IU nor in the EU periods. Group II [IU exposure (-); EU exposure (+)]: Infant rabbits were exposed to 1800 MHz GSM-like RF signals when they reached one month of age. Group III [IU exposure (+); EU exposure (-)]: Infant rabbits were exposed to 1800 MHz GSM-like RF signals in the IU period (between 15th and 22nd days of the gestational period). Group IV [IU exposure (+); EU exposure (+)]: Infant rabbits were exposed to 1800 MHz GSM-like RF signals both in the IU period (between 15th and 22nd days of the gestational period) and in the EU period when they reached one month of age. Biochemical analysis for lipid peroxidation and DNA damage were carried out in the livers of all rabbits. **RESULTS:** Lipid peroxidation levels in the liver tissues of female and male infant rabbits increased under RF radiation exposure. Liver 8-hydroxy-2'-deoxyguanosine (8-OHdG) levels of female rabbits exposed to RF radiation were also found to increase when compared with the levels of non-exposed infants. However, there were no changes in liver 8-OHdG levels of male rabbits under RF exposure. **CONCLUSION:** Consequently, it can be concluded that GSM-like RF radiation may induce biochemical changes by increasing free radical attacks to structural biomolecules in the rabbit as an experimental animal model.

(NE) Gurbuz N, Sirav B, Yuvaci HU, Turhan N, Coskun ZK, Seyhan N. Is there any possible genotoxic effect in exfoliated bladder cells of rat under the exposure of 1800 MHz GSM-like modulated radio frequency radiation (RFR)? Electromagn Biol Med. 29(3):98-104, 2010. (LE, GT)

People are exposed to many carcinogenic and mutagenic chemicals in their everyday lives. These include antineoplastic drugs, Polycyclic aromatic hydrocarbons (PAH)s, aromatic amines, nitrosamines, metals, and electromagnetic radiation. Based on the state of knowledge acquired during the last 50 years of research on possible biological effects of electromagnetic fields (EMF), the majority of the scientific community is convinced that exposure to EMF below the existing security limits does not cause a risk to the health of the general public. However, this

position is questioned by others, who are of the opinion that the available research data are contradictory or inconsistent and, therefore, unreliable. In this study, we aimed to investigate if there is any effect of 1800 MHz GSM modulated radio frequency radiation (RFR) on the number of micronucleus in exfoliated bladder cells of rat which will be informative about the genotoxic damage. Exposure period was 20 min/day, 5 days/week during a month. Six female Wistar rats were used for two groups: Group I (n=6): controls; Group II (n=6): 1.8 GHz exposed animals. 1800 MHz RFR did not showed a significant MN frequencies in rat bladder cells when compared with the control group (p>0.05). 1800 MHz RFR-exposed animals did not produce any genotoxic effect when compared with the control group (p>0.05). Kinetic studies are important for any biomarker, especially those in which tissue differentiation and maturation processes will heavily influence the time between induction of damage and collection of damaged cells for micronucleus analysis.

(NE) Gurbuz N, Sirav B, Colbay M, Yetkin I, Seyhan N. No genotoxic effect in exfoliated bladder cells of rat under the exposure of 1800 and 2100-MHz radio frequency radiation. Electromagn Biol Med. 2013 Nov 27. [Epub ahead of print] (GT, LE)

Abstract In this study, we aimed to investigate the effects of 1800 and 2100 MHz Radio Frequency (RF) radiation on the number of micronucleus (MN) in exfoliated bladder cells of rat which shows the genotoxic damage. Exposure period was 30 min/day, 6 days/week for a month and two months exposure periods. Thirty male wistar albino rats were used for five groups: Group I (n = 6): 1800 MHz RF exposed animals for one month, Group II (n = 6): 2100 MHz RF exposed animals for one month, Group III (n = 6): 2100 MHz RF exposed for two months, Group IV (n = 6): control group for one month, Group V (n = 6): control group for two months. Rats of the control groups were housed in their home cages during the entire experimental period without subjecting to any experimental manipulation. 1800 and 2100 MHz RF exposures did not result in any significant MN frequencies in rat bladder cells with respect to the control groups (p > 0.05). There was no statistically significant difference between 2100 MHz RF exposed groups, either. Further studies are needed to demonstrate if there is any genotoxic effect, micronucleus formation in other tissues of rats.

(NE) Hansteen IL, Lågeide L, Clausen KO, Haugan V, Svendsen M, Eriksen JG, Skiaker R, Hauger E, Vistnes AI, Kure EH. Cytogenetic effects of 18.0 and 16.5 GHz microwave radiation on human lymphocytes in vitro. Anticancer Res 29:2885-2892, 2009. (GT, IA, WS)

BACKGROUND: There are few cell studies on the direct genotoxic effects of microwave radiation. In this study, cytogenetic effects of microwave radiation alone or in combination with mitomycin C (MMC) were investigated. MATERIALS AND METHODS: Lymphocytes from two smoking and four non-smoking donors were exposed for 53 hours in vitro to 1.0 W/m continuous-wave radiation at 18.0 GHz or 10 W/m pulsed-wave at 16.5 GHz, alone or in combination with MMC. DNA synthesis and repair were inhibited in vitro in some cultures. RESULTS: No synergistic effect was observed in cells exposed to combinations of microwave radiation and in vitro exposure to MMC, or to cells pre-exposed in vivo to tobacco smoke. For

the 16.5 GHz pulsed exposure, a non-significant trend consisting of an increase in aberration frequencies with microwave radiation was shown for the DNA synthesis and repair inhibited cultures both with and without MMC. CONCLUSION: Neither 18.0 GHz continuous-wave nor 16.5 GHz pulsed-wave exposure to human lymphocytes in vitro induced statistically significant increases in chromosomal aberration frequencies. 16.5 GHz pulsed-wave exposure requires further documentation before a true negative conclusion can be drawn.

(NE) Hansteen IL, Clausen KO, Haugan V, Svendsen M, Svendsen MV, Eriksen JG, Skiaker R, Hauger E, Lågeide L, Vistnes AI, Kure EH. Cytogenetic effects of exposure to 2.3 GHz radiofrequency radiation on human lymphocytes in vitro. Anticancer Res 29:4323-4330, 2009. (GT, IA)

BACKGROUND: No previous in vitro studies have tested radio frequency radiation for at least one full cell cycle in culture. The aim was to test if exposure used in mobile phones and wireless network technologies would induce DNA damage in cultured human lymphocytes with and without a known clastogen. MATERIALS AND METHODS: Lymphocytes from six donors were exposed to 2.3 GHz, 10 W/m continuous waves, or 2.3 GHz, 10 W/m pulsed waves (200 Hz pulse frequency, 50% duty cycle). Mitomycin C was added to half of the cultures. DNA synthesis and repair were inhibited in one experiment. RESULTS: No statistically significant differences were observed between control and exposed cultures. A weak trend for more chromosomal damage with the interaction of pulsed fields with mitomycin C compared to a constant field was observed. CONCLUSION: Exposure during the whole cell cycle in inhibited cultures did not resulted in significant differences in chromosomal aberrations as compared to controls.

(E) Hekmat A, Saboury AA, Moosavi-Movahedi AA. The toxic effects of mobile phone radiofrequency (940MHz) on the structure of calf thymus DNA. Ecotoxicol Environ Saf. 2012 Nov 16. pii: S0147-6513(12)00368-5. doi: 10.1016/j.ecoenv.2012.10.016. [Epub ahead of print] (GT)

Currently, the biological effects of nonionizing electromagnetic fields (EMFs) including radiofrequency (RF) radiation have been the subject of numerous experimental and theoretical studies. The aim of this study is to evaluate the possible biological effects of mobile phone RF (940MHz, 15V/m and SAR=40mW/kg) on the structure of calf thymus DNA (ct DNA) immediately after exposure and 2h after 45min exposure via diverse range of spectroscopic instruments. The UV-vis and circular dichroism (CD) experiments depict that mobile phone EMFs can remarkably cause disturbance on ct DNA structure. In addition, the DNA samples, immediately after exposure and 2h after 45min exposure, are relatively thermally unstable compared to the DNA solution, which was placed in a small shielded box (unexposed ct DNA). Furthermore, the exposed DNA samples (the DNA samples that were exposed to 940MHz EMF) have more fluorescence emission when compared with the unexposed DNA, which may have occurred attributable to expansion of the exposed DNA structure. The results of dynamic light scattering (DLS) and zeta potential experiments demonstrate that RF-EMFs lead to increment in the surface charge and size of DNA. The structure of DNA immediately after exposure is not significantly different from the DNA sample 2h after 45min exposure. In other words, the EMF-

induced conformational changes are irreversible. Collectively, our results reveal that 940MHz can alter the structure of DNA. The displacement of electrons in DNA by EMFs may lead to conformational changes of DNA and DNA disaggregation. Results from this study could have an important implication on the health effects of RF-EMFs exposure. In addition, this finding could proffer a novel strategy for the development of next generation of mobile phone.

(NE) Hintzsche H, Stopper H. Micronucleus frequency in buccal mucosa cells of mobile phone users. Toxicol Lett. 193(1):124-130, 2010. (GT, HU)

Mobile phones are being used extensively throughout the world, with more than four billion accounts existing in 2009. This technology applies electromagnetic radiation in the microwave range. Health effects of this radiation have been subject of debate for a long time, both within the scientific community and within the general public. This study investigated the effect of mobile phone use on genomic instability of the human oral cavity's mucosa cells. 131 Individuals donated buccal mucosa cells extracted by slightly scraping the oral cavity with a cotton swab. Every participant filled out a questionnaire about mobile phone use including duration of weekly use, overall period of exposure and headset usage. 13 Individuals did not use mobile phones at all, 85 reported using the mobile phone for three hours per week or less, and 33 reported use of more than three hours per week. Additionally, information on age, gender, body weight, smoking status, medication and nutrition was retrieved. For staining of the cells a procedure using alpha-tubulin-antibody and chromomycin A(3) was applied. Micronuclei and other markers were evaluated in 1000 cells per individual at the microscope. A second scorer counted another 1000 cells, resulting in 2000 analyzed cells per individual. Mobile phone use did not lead to a significantly increased frequency of micronuclei.

(NE) Hintzsche H, Jastrow C, Kleine-Ostmann T, Schrader T, Stopper H. 900 MHz radiation does not induce micronucleus formation in different cell types. Mutagenesis. 27(4):477-483, 2012 . (GT)

The exposure of the population to non-ionising electromagnetic radiation is still increasing, mainly due to mobile communication. Whether low-intensity electromagnetic fields can cause other effects apart from heating has been a subject of debate. One of the effects, which were proposed to be caused by mobile phone radiation, is the occurrence of mitotic disturbances. The aim of this study was to investigate possible consequences of these mitotic disturbances as manifest genomic damage, i.e. micronucleus induction. Cells were irradiated at a frequency of 900 MHz, which is located in one of the main frequency bands applied for mobile communication. Two cell types were used, HaCaT cells as human cells and A(L) cells (human-hamster hybrid cells), in which mitotic disturbances had been reported to occur. After different post-exposure incubation periods, cells were fixed and micronucleus frequencies were evaluated. Both cell types did not show any genomic damage after exposure. To adapt the protocol for the micronucleus test into the direction of the protocol for mitotic disturbances, the post-exposure incubation period was reduced and exposure time was extended to one cell cycle length. This did not result in any increase of the genomic damage. In conclusion,

micronucleus induction was not observed as a consequence of exposure to non-ionising radiation, even though this agent was reported to cause mitotic disturbances under similar experimental conditions.

(NE) Hirose H, Sakuma N, Kaji N, Suhara T, Sekijima M, Nojima T, Miyakoshi J. Phosphorylation and gene expression of p53 are not affected in human cells exposed to 2.1425 GHz band CW or W-CDMA modulated radiation allocated to mobile radio base stations. Bioelectromagnetics 27:494-504, 2006. (GT)

A large-scale in vitro study focusing on low-level radiofrequency (RF) fields from mobile radio base stations employing the International Mobile Telecommunication 2000 (IMT-2000) cellular system was conducted to test the hypothesis that modulated RF fields induce apoptosis or other cellular stress response that activate p53 or the p53-signaling pathway. First, we evaluated the response of human cells to microwave exposure at a specific absorption rate (SAR) of 80 mW/kg, which corresponds to the limit of the average whole-body SAR for general public exposure defined as a basic restriction by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. Second, we investigated whether continuous wave (CW) and wideband code division multiple access (W-CDMA) modulated signal RF fields at 2.1425 GHz induced apoptosis or any signs of stress. Human glioblastoma A172 cells were exposed to W-CDMA radiation at SARs of 80, 250, and 800 mW/kg, and CW radiation at 80 mW/kg for 24 or 48 h. Human IMR-90 fibroblasts from fetal lungs were exposed to both W-CDMA and CW radiation at a SAR of 80 mW/kg for 28 h. Under the RF field exposure conditions described above, no significant differences in the percentage of apoptotic cells were observed between the test groups exposed to RF signals and the sham-exposed negative controls, as evaluated by the Annexin V affinity assay. No significant differences in expression levels of phosphorylated p53 at serine 15 or total p53 were observed between the test groups and the negative controls by the bead-based multiplex assay. Moreover, microarray hybridization and real-time RT-PCR analysis showed no noticeable differences in gene expression of the subsequent downstream targets of p53 signaling involved in apoptosis between the test groups and the negative controls. Our results confirm that exposure to low-level RF signals up to 800 mW/kg does not induce p53-dependent apoptosis, DNA damage, or other stress response in human cells.

(NE) Hirose H, Sakuma N, Kaji N, Nakayama K, Inoue K, Sekijima M, Nojima T, Miyakoshi J. Mobile phone base station-emitted radiation does not induce phosphorylation of Hsp27. Bioelectromagnetics 28:99-108, 2007. (GE)

An in vitro study focusing on the effects of low-level radiofrequency (RF) fields from mobile radio base stations employing the International Mobile Telecommunication 2000 (IMT-2000) cellular system was conducted to test the hypothesis that modulated RF fields act to induce phosphorylation and overexpression of heat shock protein hsp27. First, we evaluated the responses of human cells to microwave exposure at a specific absorption rate (SAR) of 80 mW/kg, which corresponds to the limit of the average whole-body SAR for general public exposure defined as a basic restriction in the International Commission on Non-Ionizing

Radiation Protection (ICNIRP) guidelines. Second, we investigated whether continuous wave (CW) and Wideband Code Division Multiple Access (W-CDMA) modulated signal RF fields at 2.1425 GHz induced activation or gene expression of hsp27 and other heat shock proteins (hsps). Human glioblastoma A172 cells were exposed to W-CDMA radiation at SARs of 80 and 800 mW/kg for 2-48 h, and CW radiation at 80 mW/kg for 24 h. Human IMR-90 fibroblasts from fetal lungs were exposed to W-CDMA at 80 and 800 mW/kg for 2 or 28 h, and CW at 80 mW/kg for 28 h. Under the RF field exposure conditions described above, no significant differences in the expression levels of phosphorylated hsp27 at serine 82 (hsp27[pS82]) were observed between the test groups exposed to W-CDMA or CW signal and the sham-exposed negative controls, as evaluated immediately after the exposure periods by bead-based multiplex assays. Moreover, no noticeable differences in the gene expression of hsps were observed between the test groups and the negative controls by DNA Chip analysis. Our results confirm that exposure to low-level RF field up to 800 mW/kg does not induce phosphorylation of hsp27 or expression of hsp gene family.

(NE) Huang TQ, Lee MS, Oh E, Zhang BT, Seo JS, Park WY. Molecular responses of Jurkat T-cells to 1763 MHz radiofrequency radiation.Int J RadiatBiol 84:734-741, 2008. (GT, GE)

PURPOSE: The biological effects of exposure to mobile phone emitted radiofrequency (RF) radiation are the subject of intense study, yet the hypothesis that RF exposure is a potential health hazard remains controversial. In this paper, we monitored cellular and molecular changes in Jurkat human T lymphoma cells after irradiating with 1763 MHz RF radiation to understand the effect on RF radiation in immune cells. MATERIALS AND METHODS: Jurkat T-cells were exposed to RF radiation to assess the effects on cell proliferation, cell cycle progression, DNA damage and gene expression. Jurkat cells were exposed to 1763 MHz RF radiation at 10 W/kg specific absorption rate (SAR) and compared to sham exposed cells. RESULTS: RF exposure did not produce significant changes in cell numbers, cell cycle distributions, or levels of DNA damage. In genome-wide analysis of gene expressions, there were no genes changed more than two-fold upon RF-radiation while ten genes change to 1.3 approximately 1.8-fold. Among ten genes, two cytokine receptor genes such as chemokine (C-X-C motif) receptor 3 (CXCR3) and interleukin 1 receptor, type II (IL1R2) were down-regulated upon RF radiation, but they were not directly related to cell proliferation or DNA damage responses. CONCLUSION: These results indicate that the alterations in cell proliferation, cell cycle progression, DNA integrity or global gene expression was not detected upon 1763 MHz RF radiation under 10 W/kg SAR for 24 h to Jurkat T cells.

(NE) Huang TQ, Lee MS, Oh EH, Kalinec F, Zhang BT, Seo JS, Park WY. Characterization of biological effect of 1763 MHz radiofrequency exposure on auditory hair cells.Int J Radiat Biol 84:909-915, 2008. (GT, GE)

Purpose: Radiofrequency (RF) exposure at the frequency of mobile phones has been reported not to induce cellular damage in in vitro and in vivo models. We chose HEI-OC1 immortalized mouse auditory hair cells to characterize the cellular response to 1763 MHz RF exposure, because auditory cells could be exposed to mobile phone frequencies. Materials and methods:

Cells were exposed to 1763 MHz RF at a 20 W/kg specific absorption rate (SAR) in a code division multiple access (CDMA) exposure chamber for 24 and 48 h to check for changes in cell cycle, DNA damage, stress response, and gene expression. Results: Neither of cell cycle changes nor DNA damage was detected in RF-exposed cells. The expression of heat shock proteins (HSP) and the phosphorylation of mitogen-activated protein kinases (MAPK) did not change, either. We tried to identify any alteration in gene expression using microarrays. Using the Applied Biosystems 1700 full genome expression mouse microarray, we found that only 29 genes (0.09% of total genes examined) were changed by more than 1.5-fold on RF exposure. Conclusion: From these results, we could not find any evidence of the induction of cellular responses, including cell cycle distribution, DNA damage, stress response and gene expression, after 1763 MHz RF exposure at an SAR of 20 W/kg in HEI-OC1 auditory hair cells.

(E) Jiang B, Nie J, Zhou Z, Zhang J, Tong J, Cao Y. Adaptive response in mice exposed to 900 MHz radiofrequency fields: primary DNA damage. PLoS One. 7(2):e32040, 2012. (LE, GT, IA)

The phenomenon of adaptive response (AR) in animal and human cells exposed to ionizing radiation is well documented in scientific literature. We have examined whether such AR could be induced in mice exposed to non-ionizing radiofrequency fields (RF) used for wireless communications. Mice were pre-exposed to 900 MHz RF at 120 µW/cm(2) power density for 4 hours/day for 1, 3, 5, 7 and 14 days and then subjected to an acute dose of 3 Gy γ-radiation. The primary DNA damage in the form of alkali labile base damage and single strand breaks in the DNA of peripheral blood leukocytes was determined using the alkaline comet assay. The results indicated that the extent of damage in mice which were pre-exposed to RF for 1 day and then subjected to γ-radiation was similar and not significantly different from those exposed to γ-radiation alone. However, mice which were pre-exposed to RF for 3, 5, 7 and 14 days showed progressively decreased damage and was significantly different from those exposed to γ-radiation alone. Thus, the data indicated that RF pre-exposure is capable of inducing AR and suggested that the pre-exposure for more than 4 hours for 1 day is necessary to elicit such AR.

(NE) Juutilainen J, Heikkinen P, Soikkeli H, Mäki-Paakkanen J. Micronucleus frequency in erythrocytes of mice after long-term exposure to radiofrequency radiation. Int J Radiat Biol. 83(4):213-220, 2007. (LE, GT)

PURPOSE: The aim of the study was to investigate genotoxicity of long-term exposure to radiofrequency (RF) electromagnetic fields by measuring micronuclei in erythrocytes. The blood samples were collected in two animal studies evaluating possible cocarcinogenic effects of RF fields. METHODS: In study A, female CBA/S mice were exposed for 78 weeks (1.5 h/d, 5 d/week) to either a continuous 902.5 MHz signal similar to that emitted by analog NMT (Nordic Mobile Telephone) phones at a whole-body specific absorption rate (SAR) of 1.5 W/kg, or to a pulsed 902.4 MHz signal similar to that of digital GSM (Global System for Mobile Communications) phones at 0.35 W/kg. A third group was sham-exposed, and a fourth group served as cage controls. All but the cage control animals were exposed to 4 Gy of x-rays during three first weeks of the experiment. In study B, female transgenic mice (line K2) and their

nontransgenic littermates were exposed for 52 weeks (1.5 h/d, 5 d/week). Two digital mobile phone signals, GSM and DAMPS (Digital Advanced Mobile Phone System), were used at 0.5 W/kg. All but the cage-control animals were exposed 3 times per week to an ultraviolet radiation dose of 1.2 MED (minimum erythema dose). RESULTS AND CONCLUSIONS: The results did not show any effects of RF fields on micronucleus frequency in polychromatic or normochromatic erythrocytes. The results were consistent in two mouse strains (and in a transgenic variant of the second strain), after 52 or 78 weeks of exposure, at three SAR levels relevant to human exposure from mobile phones, and for three different mobile signals.

(E) Karaca E, Durmaz B, Altug H, Yildiz T, Guducu C, Irgi M, Koksal MG, Ozkinay F, Gunduz C, Cogulu O. The genotoxic effect of radiofrequency waves on mouse brain. J Neurooncol 106:53-58, 2012. (GT, GE)

Erratum: J Neurooncol 2012 May;107:665.

Concerns about the health effects of radiofrequency (RF) waves have been raised because of the gradual increase in usage of cell phones, and there are scientific questions and debates about the safety of those instruments in daily life. The aim of this study is to evaluate the genotoxic effects of RF waves in an experimental brain cell culture model. Brain cell cultures of the mice were exposed to 10.715 GHz with specific absorbtion rate (SAR) 0.725 W/kG signals for 6 h in 3 days at 25°C to check for the changes in the micronucleus (MNi) assay and in the expression of 11 proapoptotic and antiapoptotic genes. It was found that MNi rate increased 11-fold and STAT3 expression decreased 7-fold in the cell cultures which were exposed to RF. Cell phones which spread RF may damage DNA and change gene expression in brain cells.

(E) Kesari KK, Behari J. Fifty-gigahertz Microwave exposure effect of radiations on rat brain. Appl Biochem Biotechnol 158:126-139, 2009. (GT, OX, LE)

The object of this study is to investigate the effects of 50-GHz microwave radiation on the brain of Wistar rats. Male rats of the Wistar strain were used in the study. Animals of 60-day age were divided into two groups-group 1, sham-exposed, and group 2, experimental (microwave-exposed). The rats were housed in a temperature-controlled room (25 degrees C) with constant humidity (40-50%) and received food and water ad libitum. During exposure, rats were placed in Plexiglas cages with drilled ventilation holes and kept in an anechoic chamber. The animals were exposed for 2 h a day for 45 days continuously at a power level of 0.86 muW/cm with nominal specific absorption rate 8.0 x 10(-4) w/kg. After the exposure period, the rats were killed and homogenized, and protein kinase C (PKC), DNA double-strand break, and antioxidant enzyme activity [superoxides dismutase (SOD), catalase, and glutathione peroxidase (GPx)] were estimated in the whole brain. Result shows that the chronic exposure to these radiations causes DNA double-strand break (head and tail length, intensity and tail migration) and a significant decrease in GPx and SOD activity ($p = <0.05$) in brain cells, whereas catalase activity shows significant increase in the exposed group of brain samples as compared with control ($p = <0.001$). In addition to these, PKC decreased significantly in whole brain and hippocampus ($p <$

0.05). All data are expressed as mean +/- standard deviation. We conclude that these radiations can have a significant effect on the whole brain.

(E) Kesari KK, Behari J, Kumar S. Mutagenic response of 2.45 GHz radiation exposure on rat brain. Int J Radiat Biol 86:334-343, 2010. (GT, OX, LE)

Purpose: To investigate the effect of 2.45 GHz microwave radiation on rat brain of male wistar strain. Material and methods: Male rats of wistar strain (35 days old with 130 +/- 10 g body weight) were selected for this study. Animals were divided into two groups: Sham exposed and experimental. Animals were exposed for 2 h a day for 35 days to 2.45 GHz frequency at 0.34 mW/cm power density. The whole body specific absorption rate (SAR) was estimated to be 0.11 W/Kg. Exposure took place in a ventilated Plexiglas cage and kept in anechoic chamber in a far field configuration from the horn antenna. After the completion of exposure period, rats were sacrificed and the whole brain tissue was dissected and used for study of double strand DNA (Deoxyribonucleic acid) breaks by micro gel electrophoresis and the statistical analysis was carried out using comet assay (IV-2 version software). Thereafter, antioxidant enzymes and histone kinase estimation was also performed. Results: A significant increase was observed in comet head ($P < 0.002$), tail length ($P < 0.0002$) and in tail movement ($P < 0.0001$) in exposed brain cells. An analysis of antioxidant enzymes glutathione peroxidase ($P < 0.005$), and superoxide dismutase ($P < 0.006$) showed a decrease while an increase in catalase ($P < 0.006$) was observed. A significant decrease ($P < 0.023$) in histone kinase was also recorded in the exposed group as compared to the control (sham-exposed) ones. One-way analysis of variance (ANOVA) method was adopted for statistical analysis. Conclusion: The study concludes that the chronic exposure to these radiations may cause significant damage to brain, which may be an indication of possible tumour promotion (Behari and Paulraj 2007).

(E) Khalil AM, Gagaa M, Alshamali A. 8-Oxo-7, 8-dihydro-2'-deoxyguanosine as a biomarker of DNA damage by mobile phone radiation. Hum ExpToxicol 31(7):734-740, 2012. (GT, OX)

We examined the effect of exposure to mobile phone 1800 MHz radio frequency radiation (RFR) upon the urinary excretion of 8-oxo-7, 8-dihydro-2'-deoxyguanosine (8-oxodG), one major form of oxidative DNA damage, in adult male Sprague-Dawley rats. Twenty-four rats were used in three independent experiments (RFR exposed and control, 12 rats, each). The animals were exposed to RFR for 2 h from Global System for Mobile Communications (GSM) signal generator with whole-body-specific absorption rate of 1.0 W/kg. Urine samples were collected from the rat while housed in a metabolic cage during the exposure period over a 4-h period at 0.5, 1.0, 2.0 and 4.0 h from the beginning of exposure. In the control group, the signal generator was left in the turn-off position. The creatinine-standardized concentrations of 8-oxodG were measured. With the exception of the urine collected in the last half an hour of exposure, significant elevations were noticed in the levels of 8-oxodG in urine samples from rats exposed to RFR when compared to control animals. Significant differences were seen overall across time points of urine collection with a maximum at 1 h after exposure, suggesting repair of the DNA lesions leading to 8-oxodG formation.

(E) Kim JY, Hong SY, Lee YM, Yu SA, Koh WS, Hong JR, Son T, Chang SK, Lee M.In vitro assessment of clastogenicity of mobile-phone radiation (835 MHz) using the alkaline comet assay and chromosomal aberration test. Environ Toxicol 23:319-327, 2008. (GT, IA)

Recently we demonstrated that 835-MHz radiofrequency radiation electromagnetic fields (RF-EMF) neither affected the reverse mutation frequency nor accelerated DNA degradation in vitro. Here, two kinds of cytogenetic endpoints were further investigated on mammalian cells exposed to 835-MHz RF-EMF (the most widely used communication frequency band in Korean CDMA mobile phone networks) alone and in combination with model clastogens: in vitro alkaline comet assay and in vitro chromosome aberration (CA) test. No direct cytogenetic effect of 835-MHz RF-EMF was found in the in vitro CA test. The combined exposure of the cells to RF-EMF in the presence of ethylmethanesulfonate (EMS) revealed a weak and insignificant cytogenetic effect when compared to cells exposed to EMS alone in CA test. Also, the comet assay results to evaluate the ability of RF-EMF alone to damage DNA were nearly negative, although showing a small increase in tail moment. However, the applied RF-EMF had potentiation effect in comet assay when administered in combination with model clastogens (cyclophosphamide or 4-nitroquinoline 1-oxide). Thus, our results imply that we cannot confidently exclude any possibility of an increased risk of genetic damage, with important implications for the possible health effects of exposure to 835-MHz electromagnetic fields.

(E) Kumar S, Kesari KK, Behari J. Evaluation of genotoxic effects in male Wistar rats following microwave exposure. Indian J Exp Biol 48:586-592, 2010. (GT, OX)

Wistar rats (70 days old) were exposed for 2 h a day for 45 days continuously at 10 GHz [power density 0.214 mW/cm2, specific absorption rate (SAR) 0.014 W/kg] and 50 GHz (power density 0.86 microW/cm2, SAR 8.0 x10(-4) W/kg). Micronuclei (MN), reactive oxygen species (ROS), and antioxidant enzymes activity were estimated in the blood cells and serum. These radiations induce micronuclei formation and significant increase in ROS production. Significant changes in the level of serum glutathione peroxidase, superoxide dismutase and catalase were observed in exposed group as compared with control group. It is concluded that microwave exposure can be affective at genetic level. This may be an indication of tumor promotion, which comes through the overproduction of reactive oxygen species.

(E) Lakshmi NK, Tiwari R, Bhargava SC, Ahuja YR. Investigations on DNA damage and frequency of micronuclei in occupational exposure to electromagnetic fields (EMFs) emitted from video display terminals (VDTs). Gen MolBiol 33, 154-158, 2010. (GT, HU, LE)

The potential effect of electromagnetic fields (EMFs) emitted from video display terminals (VDTs) to elicit biological response is a major concern for the public. The software professionals are subjected to cumulative EMFs in their occupational environments. This study was undertaken to evaluate DNA damage and incidences of micronuclei in such professionals. To the best of our knowledge, the present study is the first attempt to carry out cytogenetic investigations on assessing bioeffects in personal computer users. The study subjects (n = 138) included software professionals using VDTs for more than 2 years with age, gender,

socioeconomic status matched controls (n = 151). DNA damage and frequency of micronuclei were evaluated using alkaline comet assay and cytochalasin blocked micronucleus assay respectively. Overall DNA damage and incidence of micronuclei showed no significant differences between the exposed and control subjects. With exposure characteristics, such as total duration (years) and frequency of use (minutes/day) sub-groups were assessed for such parameters. Although cumulative frequency of use showed no significant changes in the DNA integrity of the classified sub-groups, the long-term users (> 10 years) showed higher induction of DNA damage and increased frequency of micronuclei and micro nucleated cells.

(E) Liu C, Duan W, Xu S, Chen C, He M, Zhang L, Yu Z, Zhou Z. Exposure to 1800 MHz radiofrequency electromagnetic radiation induces oxidative DNA base damage in a mouse spermatocyte-derived cell line. Toxicol Lett 218(1): 2-9, 2013a. (GT, OX, RP)

Whether exposure to radiofrequency electromagnetic radiation (RF-EMR) emitted from mobile phones can induce DNA damage in male germ cells remains unclear. In this study, we conducted a 24 h intermittent exposure (5 min on and 10 min off) of a mouse spermatocyte-derived GC-2 cell line to 1800 MHz Global System for Mobile Communication (GSM) signals in GSM-Talk mode at specific absorption rates (SAR) of 1 W/kg, 2 W/kg or 4 W/kg. Subsequently, through the use of formamidopyrimidine DNA glycosylase (FPG) in a modified comet assay, we determined that the extent of DNA migration was significantly increased at a SAR of 4 W/kg. Flow cytometry analysis demonstrated that levels of the DNA adduct 8-oxoguanine (8-oxoG) were also increased at a SAR of 4 W/kg. These increases were concomitant with similar increases in the generation of reactive oxygen species (ROS); these phenomena were mitigated by co-treatment with the antioxidant α-tocopherol. However, no detectable DNA strand breakage was observed by the alkaline comet assay. Taking together, these findings may imply the novel possibility that RF-EMR with insufficient energy for the direct induction of DNA strand breaks may produce genotoxicity through oxidative DNA base damage in male germ cells.

(E) Liu C, Gao P, Xu SC, Wang Y, Chen CH, He MD, Yu ZP, Zhang L, Zhou Z. Mobile phone radiation induces mode-dependent DNA damage in a mouse spermatocyte-derived cell line: a protective role of melatonin. Int J Radiat Biol. 2013b Aug 19. [Epub ahead of print] (GT, OX, RP)

Purpose: To evaluate whether exposure to mobile phone radiation (MPR) can induce DNA damage in male germ cells. Materials and methods: A mouse spermatocyte-derived GC-2 cell line was exposed to a commercial mobile phone handset once every 20 minutes in standby, listen, dialed or dialing modes for 24 h. DNA damage was determined using an alkaline comet assay. Results: The levels of DNA damage were significantly increased following exposure to MPR in the listen, dialed and dialing modes. Moreover, there were significantly higher increases in the dialed and dialing modes than in the listen mode. Interestingly, these results were consistent with the radiation intensities of these modes. However, the DNA damage effects of

MPR in the dialing mode were efficiently attenuated by melatonin pretreatment. Conclusions: These results regarding mode-dependent DNA damage have important implications for the safety of inappropriate mobile phone use by males of reproductive age and also suggest a simple preventive measure, keeping our body from mobile phones as far away as possible, not only during conversations but during "dialed" and "dialing" operation modes as well. Since the "dialed" mode is actually part of the standby mode, mobile phones should be kept at a safe distance from our body even during standby operation. Furthermore, the protective role of melatonin suggests that it may be a promising pharmacological candidate for preventing mobile phone use-related reproductive impairments.

(E) Lixia S, Yao K, Kaijun W, Deqiang L, Huajun H, Xiangwei G, Baohong W, Wei Z, Jianling L, Wei W. Effects of 1.8GHz radiofrequency field on DNA damage and expression of heat shock protein 70 in human lens epithelial cells. Mutat Res 602(1-2):135-42, 2006. (GT, GE)

To investigate the DNA damage, expression of heat shock protein 70 (Hsp70) and cell proliferation of human lens epithelial cells (hLEC) after exposure to the 1.8GHz radiofrequency field (RF) of a global system for mobile communications (GSM). An Xc-1800 RF exposure system was used to employ a GSM signal at 1.8GHz (217Hz amplitude-modulated) with the output power in the specific absorption rate (SAR) of 1, 2 and 3W/kg. After 2h exposure to RF, the DNA damage of hLEC was accessed by comet assay at five different incubation times: 0, 30, 60, 120 and 240min, respectively. Western blot and RT-PCR were used to determine the expression of Hsp70 in hLECs after RF exposure. The proliferation rate of cells was evaluated by bromodeoxyuridine incorporation on days 0, 1 and 4 after exposure. The results show that the difference of DNA-breaks between the exposed and sham-exposed (control) groups induced by 1 and 2W/kg irradiation were not significant at any incubation time point ($P>0.05$). The DNA damage caused by 3W/kg irradiation was significantly increased at the times of 0 and 30min after exposure ($P<0.05$), a phenomenon that could not be seen at the time points of 60, 120 or 240min ($P>0.05$). Detectable mRNA as well as protein expression of Hsp70 was found in all groups. Exposure at SARs of 2 and 3W/kg for 2h exhibited significantly increased Hsp70 protein expression ($P<0.05$), while no change in Hsp70 mRNA expression could be found in any of the groups ($P>0.05$). No difference of the cell proliferation rate between the sham-exposed and exposed cells was found at any exposure dose tested ($P>0.05$). The results indicate that exposure to non-thermal dosages of RF for wireless communications can induce no or repairable DNA damage and the increased Hsp70 protein expression in hLECs occurred without change in the cell proliferation rate. The non-thermal stress response of Hsp70 protein increase to RF exposure might be involved in protecting hLEC from DNA damage and maintaining the cellular capacity for proliferation.

(E) López-Martín E, Bregains J, Relova-Quinteiro JL, Cadarso-Suárez C, Jorge-Barreiro FJ, Ares-Pena FJ. The action of pulse-modulated GSM radiation increases regional changes in brain activity and c-Fos expression in cortical and subcortical areas in a rat model of picrotoxin-induced seizure proneness. J Neurosci Res. 87(6):1484-1499, 2009. (AS, GE, WS, IA)

The action of the pulse-modulated GSM radiofrequency of mobile phones has been suggested as a physical phenomenon that might have biological effects on the mammalian central nervous system. In the present study, GSM-exposed picrotoxin-pretreated rats showed differences in clinical and EEG signs, and in c-Fos expression in the brain, with respect to picrotoxin-treated rats exposed to an equivalent dose of unmodulated radiation. Neither radiation treatment caused tissue heating, so thermal effects can be ruled out. The most marked effects of GSM radiation on c-Fos expression in picrotoxin-treated rats were observed in limbic structures, olfactory cortex areas and subcortical areas, the dentate gyrus, and the central lateral nucleus of the thalamic intralaminar nucleus group. Nonpicrotoxin-treated animals exposed to unmodulated radiation showed the highest levels of neuronal c-Fos expression in cortical areas. These results suggest a specific effect of the pulse modulation of GSM radiation on brain activity of a picrotoxin-induced seizure-proneness rat model and indicate that this mobile-phone-type radiation might induce regional changes in previous preexcitability conditions of neuronal activation.

(E) Luukkonen J, Hakulinen P, Mäki-Paakkanen J, Juutilainen J, Naarala J. Enhancement of chemically induced reactive oxygen species production and DNA damage in human SH-SY5Y neuroblastoma cells by 872MHz radiofrequency radiation. Mutat Res 662:54-58, 2009. (GT, OX, WS)

The objective of the study was to investigate effects of 872 MHz radiofrequency (RF) radiation on intracellular reactive oxygen species (ROS) production and DNA damage at a relatively high SAR value (5W/kg). The experiments also involved combined exposure to RF radiation and menadione, a chemical inducing intracellular ROS production and DNA damage. The production of ROS was measured using the fluorescent probe dichlorofluorescein and DNA damage was evaluated by the Comet assay. Human SH-SY5Y neuroblastoma cells were exposed to RF radiation for 1h with or without menadione. Control cultures were sham exposed. Both continuous waves (CW) and a pulsed signal similar to that used in global system for mobile communications (GSM) mobile phones were used. Exposure to the CW RF radiation increased DNA breakage ($p<0.01$) in comparison to the cells exposed only to menadione. Comparison of the same groups also showed that ROS level was higher in cells exposed to CW RF radiation at 30 and 60 min after the end of exposure ($p<0.05$ and $p<0.01$, respectively). No effects of the GSM signal were seen on either ROS production or DNA damage. The results of the present study suggest that 872MHz CW RF radiation at 5W/kg might enhance chemically induced ROS production and thus cause secondary DNA damage. However, there is no known mechanism that would explain such effects from CW RF radiation but not from GSM modulated RF radiation at identical SAR.

(NE) Luukkonen J, Juutilainen J, Naarala J. Combined effects of 872 MHz radiofrequency radiation and ferrous chloride on reactive oxygen species production and DNA damage in human SH-SY5Y neuroblastoma cells. Bioelectromagnetics 31:417-424, 2010. (GT, OX)

The aim of the present study was to investigate possible cooperative effects of radiofrequency (RF) radiation and ferrous chloride (FeCl) on reactive oxygen species (ROS) production and DNA

damage. In order to test intracellular ROS production as a possible underlying mechanism of DNA damage, we applied the fluorescent probe DCFH-DA. Integrity of DNA was quantified by alkaline comet assay. The exposures to 872 MHz RF radiation were conducted at a specific absorption rate (SAR) of 5 W/kg using continuous waves (CW) or a modulated signal similar to that used in Global System for Mobile Communications (GSM) phones. Four groups were included: Sham exposure (control), RF radiation, Chemical treatment, Chemical treatment, and RF radiation. In the ROS production experiments, human neuroblastoma (SH-SY5Y) cells were exposed to RF radiation and 10 microg/ml FeCl for 1 h. In the comet assay experiments, the exposure time was 3 h and an additional chemical (0.015% diethyl maleate) was used to make DNA damage level observable. The chemical treatments resulted in statistically significant responses, but no effects from either CW or modulated RF radiation were observed on ROS production, DNA damage or cell viability.

(NE) Maes A, Van Gorp U, Verschaeve L. Cytogenetic investigation of subjects professionally exposed to radiofrequency radiation. Mutagenesis 21:139-42, 2006. (GT, IA)

Nowadays, virtually everybody is exposed to radiofrequency radiation (RFR) from mobile phone base station antennas or other sources. At least according to some scientists, this exposure can have detrimental health effects. We investigated cytogenetic effects in peripheral blood lymphocytes from subjects who were professionally exposed to mobile phone electromagnetic fields in an attempt to demonstrate possible RFR-induced genetic effects. These subjects can be considered well suited for this purpose as their RFR exposure is 'normal' though rather high, and definitely higher than that of the 'general population'. The alkaline comet assay, sister chromatid exchange (SCE) and chromosome aberration tests revealed no evidence of RFR-induced genetic effects. Blood cells were also exposed to the well known chemical mutagen mitomycin C in order to investigate possible combined effects of RFR and the chemical. No cooperative action was found between the electromagnetic field exposure and the mutagen using either the comet assay or SCE test.

(E) Manti L, Braselmann H, Calabrese ML, Massa R, Pugliese M, Scampoli P, Sicignano G, Grossi G. Effects of modulated microwave radiation at cellular telephone frequency (1.95 GHz) on X-ray-induced chromosome aberrations in human lymphocytes in vitro. Radiat Res 169:575-583, 2008. (GT, IA)

The case for a DNA-damaging action produced by radiofrequency (RF) signals remains controversial despite extensive research. With the advent of the Universal Mobile Telecommunication System (UMTS) the number of RF-radiation-exposed individuals is likely to escalate. Since the epigenetic effects of RF radiation are poorly understood and since the potential modifications of repair efficiency after exposure to known cytotoxic agents such as ionizing radiation have been investigated infrequently thus far, we studied the influence of UMTS exposure on the yield of chromosome aberrations induced by X rays. Human peripheral blood lymphocytes were exposed in vitro to a UMTS signal (frequency carrier of 1.95 GHz) for 24 h at 0.5 and 2.0 W/kg specific absorption rate (SAR) using a previously characterized waveguide system. The frequency of chromosome aberrations was measured on metaphase

spreads from cells given 4 Gy of X rays immediately before RF radiation or sham exposures by fluorescence in situ hybridization. Unirradiated controls were RF-radiation- or sham-exposed. No significant variations due to the UMTS exposure were found in the fraction of aberrant cells. However, the frequency of exchanges per cell was affected by the SAR, showing a small but statistically significant increase of 0.11 exchange per cell compared to 0 W/kg SAR. We conclude that, although the 1.95 GHz signal (UMTS modulated) does not exacerbate the yield of aberrant cells caused by ionizing radiation, the overall burden of X-ray-induced chromosomal damage per cell in first-mitosis lymphocytes may be enhanced at 2.0 W/kg SAR. Hence the SAR may either influence the repair of X-ray-induced DNA breaks or alter the cell death pathways of the damage response.

(E) Mazor R, Korenstein-Ilan A, Barbul A, Eshet Y, Shahadi A, Jerby E, Korenstein R. Increased levels of numerical chromosome aberrations after in vitro exposure of human peripheral blood lymphocytes to radiofrequency electromagnetic fields for 72 hours. Radiat Res. 169(1):28-37, 2008. (GT)

We investigated the effects of 72 h in vitro exposure of 10 human lymphocyte samples to radiofrequency electromagnetic fields (800 MHz, continuous wave) on genomic instability. The lymphyocytes were exposed in a specially designed waveguide resonator at specific absorption rates (SARs) of 2.9 and 4.1 W/kg in a temperature range of 36-37 degrees C. The induced aneuploidy of chromosomes 1, 10, 11 and 17 was determined by interphase FISH using semi-automated image analysis. We observed increased levels of aneuploidy depending on the chromosome studied as well as on the level of exposure. In chromosomes 1 and 10, there was increased aneuploidy at the higher SAR, while for chromosomes 11 and 17, the increases were observed only for the lower SAR. Multisomy (chromosomal gains) appeared to be the primary contributor to the increased aneuploidy. The effect of temperature on the level of aneuploidy was examined over the range of 33.5-40 degrees C for 72 h with no statistically significant difference in the level of aneuploidy compared to 37 degrees C. These findings suggest the possible existence of an athermal effect of RF radiation that causes increased levels of aneuploidy. These results contribute to the assessment of potential health risks after continuous chronic exposure to RF radiation at SARs close to the current levels set by ICNIRP guidelines.

(E) Nikolova T, Czyz J, Rolletschek A, Blyszczuk P, Fuchs J, Jovtchev G, Schuderer J, Kuster N, Wobus AM. Electromagnetic fields affect transcript levels of apoptosis-related genes in embryonic stem cell-derived neural progenitor cells. ASEB J 19(12):1686-1688, 2005. (GT, GE)

Mouse embryonic stem (ES) cells were used as an experimental model to study the effects of electromagnetic fields (EMF). ES-derived nestin-positive neural progenitor cells were exposed to extremely low frequency EMF simulating power line magnetic fields at 50 Hz (ELF-EMF) and to radiofrequency EMF simulating the Global System for Mobile Communication (GSM) signals at 1.71 GHz (RF-EMF). Following EMF exposure, cells were analyzed for transcript levels of cell cycle regulatory, apoptosis-related, and neural-specific genes and proteins; changes in

proliferation; apoptosis; and cytogenetic effects. Quantitative RT-PCR analysis revealed that ELF-EMF exposure to ES-derived neural cells significantly affected transcript levels of the apoptosis-related bcl-2, bax, and cell cycle regulatory "growth arrest DNA damage inducible" GADD45 genes, whereas mRNA levels of neural-specific genes were not affected. RF-EMF exposure of neural progenitor cells resulted in down-regulation of neural-specific Nurr1 and in up-regulation of bax and GADD45 mRNA levels. Short-term RF-EMF exposure for 6 h, but not for 48 h, resulted in a low and transient increase of DNA double-strand breaks. No effects of ELF- and RF-EMF on mitochondrial function, nuclear apoptosis, cell proliferation, and chromosomal alterations were observed. We may conclude that EMF exposure of ES-derived neural progenitor cells transiently affects the transcript level of genes related to apoptosis and cell cycle control. However, these responses are not associated with detectable changes of cell physiology, suggesting compensatory mechanisms at the translational and posttranslational level.

(E) Nittby H, Widegren B, Krogh M, Grafström G, Berlin H, Rehn G, Eberhardt JL, Malmgren L, Persson BRR, Salford L. Exposure to radiation from global system for mobile communications at 1,800 MHz significantly changes gene expression in rat hippocampus and cortex. Environmentalist 28(4), 458-465, 2008. (GE)

We have earlier shown that radio frequency electromagnetic fields can cause significant leakage of albumin through the blood–brain barrier of exposed rats as compared to non-exposed rats, and also significant neuronal damage in rat brains several weeks after a 2 h exposure to a mobile phone, at 915 MHz with a global system for mobile communications (GSM) frequency modulation, at whole-body specific absorption rate values (SAR) of 200, 20, 2, and 0.2 mW/kg. We have now studied whether 6 h of exposure to the radiation from a GSM mobile test phone at 1,800 MHz (at a whole-body SAR-value of 13 mW/kg, corresponding to a brain SAR-value of 30 mW/kg) has an effect upon the gene expression pattern in rat brain cortex and hippocampus—areas where we have observed albumin leakage from capillaries into neurons and neuronal damage. Microarray analysis of 31,099 rat genes, including splicing variants, was performed in cortex and hippocampus of 8 Fischer 344 rats, 4 animals exposed to global system for mobile communications electromagnetic fields for 6 h in an anechoic chamber, one rat at a time, and 4 controls kept as long in the same anechoic chamber without exposure, also in this case one rat at a time. Gene ontology analysis (using the gene ontology categories biological processes, molecular functions, and cell components) of the differentially expressed genes of the exposed animals versus the control group revealed the following highly significant altered gene categories in both cortex and hippocampus: extracellular region, signal transducer activity, intrinsic to membrane, and integral to membrane. The fact that most of these categories are connected with membrane functions may have a relation to our earlier observation of albumin transport through brain capillaries.

(E) Nylund R, Leszczynski D. Mobile phone radiation causes changes in gene and protein expression in human endothelial cell lines and the response seems to be genome- and proteome-dependent. Proteomics 6:4769-4780, 2006. (GE, CS)

We have examined in vitro cell response to mobile phone radiation (900 MHz GSM signal) using two variants of human endothelial cell line: EA.hy926 and EA.hy926v1. Gene expression changes were examined in three experiments using cDNA Expression Arrays and protein expression changes were examined in ten experiments using 2-DE and PDQuest software. Obtained results show that gene and protein expression were altered, in both examined cell lines, in response to one hour mobile phone radiation exposure at an average specific absorption rate of 2.8 W/kg. However, the same genes and proteins were differently affected by the exposure in each of the cell lines. This suggests that the cell response to mobile phone radiation might be genome- and proteome-dependent. Therefore, it is likely that different types of cells and from different species might respond differently to mobile phone radiation or might have different sensitivity to this weak stimulus. Our findings might also explain, at least in part, the origin of discrepancies in replication studies between different laboratories.

(E) Panagopoulos DJ, Chavdoula ED, Nezis IP, Margaritis LH. Cell death induced by GSM 900-MHz and DCS 1800-MHz mobile telephony radiation. Mutat Res 626:69-78, 2007. (GT, RP)

In the present study, the TUNEL (Terminal deoxynucleotidetransferasedUTP Nick End Labeling) assay - a well known technique widely used for detecting fragmented DNA in various types of cells - was used to detect cell death (DNA fragmentation) in a biological model, the early and mid stages of oogenesis of the insect Drosophila melanogaster. The flies were exposed in vivo to either GSM 900-MHz (Global System for Mobile telecommunications) or DCS 1800-MHz (Digital Cellular System) radiation from a common digital mobile phone, for few minutes per day during the first 6 days of their adult life. The exposure conditions were similar to those to which a mobile phone user is exposed, and were determined according to previous studies of ours [D.J Panagopoulos, A. Karabarbounis, L.H. Margaritis, Effect of GSM 900-MHz mobile phone radiation on the reproductive capacity of D. melanogaster, Electromagn. Biol Med 23 (2004) 29-43; D.J Panagopoulos, N. Messini, A. Karabarbounis, A.L. Philippetis, L.H. Margaritis, Radio frequency electromagnetic radiation within "safety levels" alters the physiological function of insects, in: P. Kostarakis, P. Stavroulakis (Eds.), Proceedings of the Millennium International Workshop on Biological Effects of Electromagnetic Fields, Heraklion, Crete, Greece, October 17-20, 2000, pp. 169-175, ISBN: 960-86733-0-5; D.J Panagopoulos, L.H. Margaritis, Effects of electromagnetic fields on the reproductive capacity of D. melanogaster, in: P. Stavroulakis (Ed.), Biological Effects of Electromagnetic Fields, Springer, 2003, pp. 545-578], which had shown a large decrease in the oviposition of the same insect caused by GSM radiation. Our present results suggest that the decrease in oviposition previously reported, is due to degeneration of large numbers of egg chambers after DNA fragmentation of their constituent cells, induced by both types of mobile telephony radiation. Induced cell death is recorded for the first time, in all types of cells constituting an egg chamber (follicle cells, nurse cells and the oocyte) and in all stages of the early and mid-oogenesis, from germarium to stage 10, during which programmed cell death does not physiologically occur. Germarium and stages 7-8 were found to be the most sensitive developmental stages also in response to electromagnetic stress induced by the GSM and DCS fields and, moreover, germarium was found to be even more sensitive than stages 7-8.

(NE) Paparini A, Rossi P, Gianfranceschi G, Brugaletta V, Falsaperla R, De Luca P, Romano Spica V. No evidence of major transcriptional changes in the brain of mice exposed to 1800 MHz GSM signal. Bioelectromagnetics. 29(4):312-323, 2008. (GE)

To analyze possible effects of microwaves on gene expression, mice were exposed to global system for mobile communication (GSM) 1800 MHz signal for 1 h at a whole body SAR of 1.1 W/kg. Gene expression was studied in the whole brain, where the average SAR was 0.2 W/kg, by expression microarrays containing over 22,600 probe sets. Comparison of data from sham and exposed animals showed no significant difference in gene expression modulation. However, when less stringent constraints were adopted to analyze microarray results, 75 genes were found to be modulated following exposure. Forty-two probes showed fold changes ranging from 1.5 to 2.8, whereas 33 were down-regulated from 0.67- to 0.29-fold changes, but these differences in gene expression were not confirmed by real-time PCR. Under these specific limited conditions, no consistent indication of gene expression modulation in whole mouse brain was found associated to GSM 1800 MHz exposure.

(E) Paulraj R, Behari J. Single strand DNA breaks in rat brain cells exposed to microwave radiation. Mutat Res 596:76-80, 2006. (GT, LE)

This investigation concerns with the effect of low intensity microwave (2.45 and 16.5GHz, SAR 1.0 and 2.01W/kg, respectively) radiation on developing rat brain. Wistar rats (35 days old, male, six rats in each group) were selected for this study. These animals were exposed for 35 days at the above mentioned frequencies separately in two different exposure systems. After the exposure period, the rats were sacrificed and the whole brain tissue was dissected and used for study of single strand DNA breaks by micro gel electrophoresis (comet assay). Single strand DNA breaks were measured as tail length of comet. Fifty cells from each slide and two slides per animal were observed. One-way ANOVA method was adopted for statistical analysis. This study shows that the chronic exposure to these radiations cause statistically significant ($p<0.001$) increase in DNA single strand breaks in brain cells of rat.

(E) Pesnya DS, Romanovsky AV. Comparison of cytotoxic and genotoxic effects of plutonium-239 alpha particles and mobile phone GSM 900 radiation in the Allium cepa test. Mutat Res. 2012 Oct 8. pii: S1383-5718(12)00291-4. doi: 10.1016/j.mrgentox.2012.08.010. [Epub ahead of print] (GT)

The goal of this study was to compare the cytotoxic and genotoxic effects of plutonium-239 alpha particles and GSM 900 modulated mobile phone radiation in the Allium cepa test. Three groups of bulbs were exposed to mobile phone radiation during 0 (sham), 3 and 9hours. A positive control group was treated during 20 min with plutonium-239 alpha-radiation. Mitotic abnormalities, chromosome aberrations, micronuclei and mitotic index were analyzed. Exposure to alpha-radiation from plutonium-239 and exposure to modulated radiation from mobile phone during 3 and 9h significantly increased the mitotic index. GSM 900 mobile phone radiation as well as alpha-radiation from plutonium-239 induced both clastogenic and

aneugenic effects. However, the aneugenic activity of mobile phone radiation was more pronounced. After 9 hours of exposure to mobile phone radiation, polyploid cells, three-groups metaphases, amitoses and some unspecified abnormalities were detected, which were not registered in the other experimental groups. Importantly, GSM 900 mobile phone radiation increased the mitotic index, the frequency of mitotic and chromosome abnormalities, and the micronucleus frequency in a time-dependent manner. Due to its sensitivity, the Allium cepa test can be recommended as a useful cytogenetic assay to assess cytotoxic and genotoxic effects of radiofrequency electromagnetic fields.

(NE) Qutob SS, Chauhan V, Bellier PV, Yauk CL, Douglas GR, Berndt L, Williams A, Gajda GB, Lemay E, Thansandote A, McNamee JP. Microarray gene expression profiling of a human glioblastoma cell line exposed in vitro to a 1.9 GHz pulse-modulated radiofrequency field. Radiat Res 165:636-644, 2006. (GE)

The widespread use of mobile phones has led to public concerns about the health effects associated with exposure to radiofrequency (RF) fields. The paramount concern of most persons relates to the potential of these fields to cause cancer. Unlike ionizing radiation, RF fields used for mobile telecommunications (800-1900 MHz) do not possess sufficient energy to directly damage DNA. Most rodent bioassay and in vitro genotoxicity/mutation studies have reported that RF fields at non-thermal levels have no direct mutagenic, genotoxic or carcinogenic effects. However, some evidence has suggested that RF fields may cause detectable postexposure changes in gene expression. Therefore, the purpose of this study was to assess the ability of exposure to a 1.9 GHz pulse-modulated RF field for 4 h at specific absorption rates (SARs) of 0.1, 1.0 and 10.0 W/kg to affect global gene expression in U87MG glioblastoma cells. We found no evidence that non-thermal RF fields can affect gene expression in cultured U87MG cells relative to the nonirradiated control groups, whereas exposure to heat shock at 43 degrees C for 1 h up-regulated a number of typical stress-responsive genes in the positive control group. Future studies will assess the effect of RF fields on other cell lines and on gene expression in the mouse brain after in vivo exposure.

(E) Remondini D, Nylund R, Reivinen J, Poulletier de Gannes F, Veyret B, Lagroye I, Haro E, Trillo MA, Capri M, Franceschi C, Schlatterer K, Gminski R, Fitzner R, Tauber R, Schuderer J, Kuster N, Leszczynski D, Bersani F, Maercker C. Gene expression changes in human cells after exposure to mobile phone microwaves. Proteomics 6:4745-4754, 2006. (GE, CS)

Possible biological effects of mobile phone microwaves were investigated in vitro. In this study, which was part of the 5FP EU project REFLEX (Risk Evaluation of Potential Environmental Hazards From Low-Energy Electromagnetic Field Exposure Using Sensitive in vitro Methods), six human cell types, immortalized cell lines and primary cells, were exposed to 900 and 1800 MHz. RNA was isolated from exposed and sham-exposed cells and labeled for transcriptome analysis on whole-genome cDNA arrays. The results were evaluated statistically using bioinformatics techniques and examined for biological relevance with the help of different databases. NB69 neuroblastoma cells, T lymphocytes, and CHME5 microglial cells did not show significant changes in gene expression. In EA.hy926 endothelial cells, U937 lymphoblastoma cells, and HL-

60 leukemia cells we found between 12 and 34 up- or down-regulated genes. Analysis of the affected gene families does not point towards a stress response. However, following microwave exposure, some but not all human cells might react with an increase in expression of genes encoding ribosomal proteins and therefore up-regulating the cellular metabolism.

(NE) Ros-Llor I, Sanchez-Siles M, Camacho-Alonso F, Lopez-Jornet P. Effect of mobile phones on micronucleus frequency in human exfoliated oral mucosal cells. Oral Dis. 18:786-792, 2012. (GT)

Objective: In the last two decades, the use of mobile phones has increased enormously all over the world. The controversy regarding whether radiofrequency (RF) fields exert effects upon biological systems is a concern for the general population. An evaluation is made of DNA damage and cytokinetic defects, proliferative potential, and cell death because of RF radiation emitted by mobile phones in healthy young users. Study design: This cohort study was carried out in 50 Caucasian mobile phone users. We collected two cell samples from each subject (a total of 100 cell samples), corresponding to the right and left cheek mucosa, respectively. Case histories and personal information were assessed, including age, gender, body height and weight, history of cancer, smoking and alcohol consumption, exposure to chemical carcinogens or radiation, and dietary habits. Sampling comprised cell collection from both cheeks with a cytobrush, centrifugation, slide preparation, fixation, and staining, followed by fluorescent microscopic analysis. A total of 2000 exfoliated cells were screened for nuclear abnormalities, especially micronucleus. Results: No statistically significant changes were recorded in relation to age, gender, body mass index, or smoking status. A comparison of the results vs the control area according to the side of the face on which the mobile phone was placed, and in relation to the duration of exposure (years) to mobile phone radiation in the total 100 samples, yielded no significant differences. Conclusions: No genotoxic effects because of RF exposure were observed in relation to any of the study parameters.

(NE) Sakuma N, Komatsubara Y, Takeda H, Hirose H, Sekijima M, Nojima T, Miyakoshi J. DNA strand breaks are not induced in human cells exposed to 2.1425 GHz band CW and W-CDMA modulated radiofrequency fields allocated to mobile radio base stations. Bioelectromagnetics 27:51-57, 2006. (CT)

We conducted a large-scale in vitro study focused on the effects of low level radiofrequency (RF) fields from mobile radio base stations employing the International Mobile Telecommunication 2000 (IMT-2000) cellular system in order to test the hypothesis that modulated RF fields may act as a DNA damaging agent. First, we evaluated the responses of human cells to microwave exposure at a specific absorption rate (SAR) of 80 mW/kg, which corresponds to the limit of the average whole body SAR for general public exposure defined as a basic restriction in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. Second, we investigated whether continuous wave (CW) and Wideband Code Division Multiple Access (W-CDMA) modulated signal RF fields at 2.1425 GHz induced different levels of DNA damage. Human glioblastoma A172 cells and normal human IMR-90

fibroblasts from fetal lungs were exposed to mobile communication frequency radiation to investigate whether such exposure produced DNA strand breaks in cell culture. A172 cells were exposed to W-CDMA radiation at SARs of 80, 250, and 800 mW/kg and CW radiation at 80 mW/kg for 2 and 24 h, while IMR-90 cells were exposed to both W-CDMA and CW radiations at a SAR of 80 mW/kg for the same time periods. Under the same RF field exposure conditions, no significant differences in the DNA strand breaks were observed between the test groups exposed to W-CDMA or CW radiation and the sham exposed negative controls, as evaluated immediately after the exposure periods by alkaline comet assays. Our results confirm that low level exposures do not act as a genotoxicant up to a SAR of 800 mW/kg.

(NE) Sakurai T, Kiyokawa T, Narita E, Suzuki Y, Taki M, Miyakoshi J. Analysis of gene expression in a human-derived glial cell line exposed to 2.45 GHz continuous radiofrequency electromagnetic fields. J Radiat Res. 52(2):185-192, 2011. (GE)

The increasing use of mobile phones has aroused public concern regarding the potential health risks of radiofrequency (RF) fields. We investigated the effects of exposure to RF fields (2.45 GHz, continuous wave) at specific absorption rate (SAR) of 1, 5, and 10 W/kg for 1, 4, and 24 h on gene expression in a normal human glial cell line, SVGp12, using DNA microarray. Microarray analysis revealed 23 assigned gene spots and 5 non-assigned gene spots as prospective altered gene spots. Twenty-two genes out of the 23 assigned gene spots were further analyzed by reverse transcription-polymerase chain reaction to validate the results of microarray, and no significant alterations in gene expression were observed. Under the experimental conditions used in this study, we found no evidence that exposure to RF fields affected gene expression in SVGp12 cells.

(NE) Sannino A, Di Costanzo G, Brescia F, Sarti M, Zeni O, Juutilainen J, Scarfi MR. Human fibroblasts and 900 MHz radiofrequency radiation: evaluation of DNA damage after exposure and co-exposure to 3-Chloro-4-(dichloromethyl)-5-Hydroxy-2(5h)-furanone (MX). Radiat Res 171:743-751, 2009. (NT, IA)

Abstract Sannino, A., Di Costanzo, G., Brescia, F., Sarti, M., Zeni, O., Juutilainen, J and Scarfi, M. R. Human Fibroblasts and 900 MHz Radiofrequency Radiation: Evaluation of DNA Damage after Exposure and Co-exposure to 3-Chloro-4-(dichloromethyl)-5-Hydroxy-2(5h)-furanone (MX). Radiat Res 171, 743-751 (2009). The aim of this study was to investigate DNA damage in human dermal fibroblasts from a healthy subject and from a subject affected by Turner's syndrome that were exposed for 24 h to radiofrequency (RF) radiation at 900 MHz. The RF-radiation exposure was carried out alone or in combination with 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX), a well-known environmental mutagen and carcinogen produced during the chlorination of drinking water. Turner's syndrome fibroblasts were also exposed for a shorter time (1 h). A signal similar to that emitted by Global System for Mobile Communications (GSM) mobile phones was used at a specific absorption rate of 1 W/kg under strictly controlled conditions of temperature and dosimetry. To evaluate DNA damage after RF-radiation exposure alone, the alkaline comet assay and the cytokinesis-block micronucleus assay were used. In the

combined-exposure experiments, MX was given at a concentration of 25 microM for 1 h immediately after the RF-radiation exposure, and the effects were evaluated by the alkaline comet assay. The results revealed no genotoxic and cytotoxic effects from RF radiation alone in either cell line. As expected, MX treatment induced an increase in DNA migration in the comet assay, but no enhancement of the MX-induced DNA damage was observed in the cells exposed to RF radiation.

(E) Schwarz C, Kratochvil E, Pilger A, Kuster N, Adlkofer F, Rüdiger HW. Radiofrequency electromagnetic fields (UMTS, 1,950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes. Int Arch Occup Environ Health 81:755-767, 2008. (GT, CS)

OBJECTIVE: Universal Mobile Telecommunication System (UMTS) was recently introduced as the third generation mobile communication standard in Europe. This was done without any information on biological effects and genotoxic properties of these particular high-frequency electromagnetic fields. This is discomforting, because genotoxic effects of the second generation standard Global System for Mobile Communication have been reported after exposure of human cells in vitro. METHODS: Human cultured fibroblasts of three different donors and three different short-term human lymphocyte cultures were exposed to 1,950 MHz UMTS below the specific absorption rate (SAR) safety limit of 2 W/kg. The alkaline comet assay and the micronucleus assay were used to ascertain dose and time-dependent genotoxic effects. Five hundred cells per slide were visually evaluated in the comet assay and comet tail factor (CTF) was calculated. In the micronucleus assay 1,000 binucleated cells were evaluated per assay. The origin of the micronuclei was determined by fluorescence labeled anticentromere antibodies. All evaluations were performed under blinded conditions. RESULTS: UMTS exposure increased the CTF and induced centromere-negative micronuclei (MN) in human cultured fibroblasts in a dose and time-dependent way. Incubation for 24 h at a SAR of 0.05 W/kg generated a statistically significant rise in both CTF and MN ($P = 0.02$). At a SAR of 0.1 W/kg the CTF was significantly increased after 8 h of incubation ($P = 0.02$), the number of MN after 12 h ($P = 0.02$). No UMTS effect was obtained with lymphocytes, either unstimulated or stimulated with Phytohemagglutinin. CONCLUSION: UMTS exposure may cause genetic alterations in some but not in all human cells in vitro.

(E) Sekeroğlu V, Akar A, Sekeroğlu ZA. Cytotoxic and genotoxic effects of high-frequency electromagnetic fields (GSM 1800 MHz) on immature and mature rats. Ecotoxicol Environ Saf. 80:140-144, 2012. (LE, GT, DE)

We investigated the cytogenotoxic effects of high frequency electromagnetic fields (HF-EMF) for 45 day and the effect of a recovery period of 15 day after exposure to EMF on bone marrow cells of immature and mature rats. The animals in treatment groups were exposed to 1800 MHz EMF at SAR of 0.37 W/kg and 0.49 W/kg for 2h/day for 45 day. Two recovery groups were kept for a recovery period of 15 day without EMF after exposure to HF-EMF. Two control groups for both immature and mature rats were also included. Significant differences were also observed in chromosome aberrations (CA), micronucleus (MN) frequency, mitotic index (MI) and ratio of

polychromatic erythrocytes (PCEs) in all treatment groups. The cytogenotoxic damage was more remarkable in immature rats and, the recovery period did not improve this damage in immature rats. Because much higher and irreversible cytogenotoxic damage was observed in immature rats than in mature rats, further studies are needed to understand effects of EMF on DNA damage and DNA repair, and to determine safe limits for environment and human, especially for children.

(NE) Sekijima M, Takeda H, Yasunaga K, Sakuma N, Hirose H, Nojima T, Miyakoshi J. 2-GHz band CW and W-CDMA modulated radiofrequency fields have no significant effect on cell proliferation and gene expression profile in human cells. J Radiat Res. 51(3):277-284, 2010. (GE)

We investigated the mechanisms by which radiofrequency (RF) fields exert their activity, and the changes in both cell proliferation and the gene expression profile in the human cell lines, A172 (glioblastoma), H4 (neuroglioma), and IMR-90 (fibroblasts from normal fetal lung) following exposure to 2.1425 GHz continuous wave (CW) and Wideband Code Division Multiple Access (W-CDMA) RF fields at three field levels. During the incubation phase, cells were exposed at the specific absorption rates (SARs) of 80, 250, or 800 mW/kg with both CW and W-CDMA RF fields for up to 96 h. Heat shock treatment was used as the positive control. No significant differences in cell growth or viability were observed between any test group exposed to W-CDMA or CW radiation and the sham-exposed negative controls. Using the Affymetrix Human Genome Array, only a very small (< 1%) number of available genes (ca. 16,000 to 19,000) exhibited altered expression in each experiment. The results confirm that low-level exposure to 2.1425 GHz CW and W-CDMA RF fields for up to 96 h did not act as an acute cytotoxicant in either cell proliferation or the gene expression profile. These results suggest that RF exposure up to the limit of whole-body average SAR levels as specified in the ICNIRP guidelines is unlikely to elicit a general stress response in the tested cell lines under these conditions.

(E) Souza LD, Cerqueira ED, Meireles JR. Assessment of nuclear abnormalities in exfoliated cells from the oral epithelium of mobile phone users. Electromagn Biol Med. 2013 May 28. [Epub ahead of print] (GE, HU)

Abstract Transmission and reception of mobile telephony signals take place through electromagnetic wave radiation, or electromagnetic radiofrequency fields, between the mobile terminal and the radio base station. Based on reports in the literature on adverse effects from exposure to this type of radiation, the objective of this study was to evaluate the genotoxic and cytotoxic potential of such exposure, by means of the micronucleus test on exfoliated cells from the oral epithelium. The sample included 45 individuals distributed in 3 groups according to the amount of time in hours per week (t) spent using mobile phones: group I, $t > 5$ h; group II, $t > 1$ h and ≤ 5 h; and group III, $t \leq 1$ h. Cells from the oral mucosa were analyzed to assess the numbers of micronuclei, broken egg structures and degenerative nuclear abnormalities

indicative of apoptosis (condensed chromatin, karyorrhexis and pyknosis) or necrosis (karyolysis in addition to these changes). The occurrences of micronuclei and degenerative nuclear abnormalities did not differ between the groups, but the number of broken egg (structures that may be associated with gene amplification) was significantly greater in the individuals in group I ($p < 0.05$).

(NE) Speit G, Schütz P, Hoffmann H. Genotoxic effects of exposure to radiofrequency electromagnetic fields (RF-EMF) in cultured mammalian cells are not independently reproducible. Mutat Res. 626(1-2):42-47, 2007. (GT)

Conflicting results have been published regarding the induction of genotoxic effects by exposure to radiofrequency electromagnetic fields (RF-EMF). Using the comet assay, the micronucleus test and the chromosome aberration test with human fibroblasts (ES1 cells), the EU-funded "REFLEX" project (Risk Evaluation of Potential Environmental Hazards From Low Energy Electromagnetic Field Exposure Using Sensitive in vitro Methods) reported clearly positive effects for various exposure conditions. Because of the ongoing discussion on the biological significance of the effects observed, it was the aim of the present study to independently repeat the results using the same cells, the same equipment and the same exposure conditions. We therefore exposed ES1 cells to RF-EMF (1800 MHz; SAR 2 W/kg, continuous wave with intermittent exposure) for different time periods and then performed the alkaline (pH>13) comet assay and the micronucleus test (MNT). For both tests, clearly negative results were obtained in independently repeated experiments. We also performed these experiments with V79 cells, a sensitive Chinese hamster cell line that is frequently used in genotoxicity testing, and also did not measure any genotoxic effect in the comet assay and the MNT. Appropriate measures of quality control were considered to exclude variations in the test performance, failure of the RF-EMF exposure or an evaluation bias. The reasons for the difference between the results reported by the REFLEX project and our experiments remain unclear.

(NE) Stronati L, Testa A, Moquet J, Edwards A, Cordelli E, Villani P, Marino C, Fresegna AM, Appolloni M, Lloyd D. 935 MHz cellular phone radiation. An in vitro study of genotoxicity in human lymphocytes. Int J Radiat Biol 82:339-346, 2006. (GT, IA)

Purpose: The possibility of genotoxicity of radiofrequency radiation (RFR) applied alone or in combination with x-rays was investigated in vitro using several assays on human lymphocytes. The chosen specific absorption rate (SAR) values are near the upper limit of actual energy absorption in localized tissue when persons use some cellular telephones. The purpose of the combined exposures was to examine whether RFR might act epigenetically by reducing the fidelity of repair of DNA damage caused by a well-characterized and established mutagen.Methods: Blood specimens from 14 donors were exposed continuously for 24 h to a Global System for Mobile Communications (GSM) basic 935 MHz signal. The signal was applied at two SAR; 1 and 2 W/Kg, alone or combined with a 1-min exposure to 1.0 Gy of 250 kVp x-rays given immediately before or after the RFR. The assays employed were the alkaline comet

technique to detect DNA strand breakage, metaphase analyses to detect unstable chromosomal aberrations and sister chromatid exchanges, micronuclei in cytokinesis-blocked binucleate lymphocytes and the nuclear division index to detect alterations in the speed of in vitro cell cycling.Results: By comparison with appropriate sham-exposed and control samples, no effect of RFR alone could be found for any of the assay endpoints. In addition RFR did not modify any measured effects of the x-radiation. Conclusions: This study has used several standard in vitro tests for chromosomal and DNA damage in Go human lymphocytes exposed in vitro to a combination of x-rays and RFR. It has comprehensively examined whether a 24-h continuous exposure to a 935 MHz GSM basic signal delivering SAR of 1 or 2 W/Kg is genotoxic per se or whether, it can influence the genotoxicity of the well-established clastogenic agent; x-radiation. Within the experimental parameters of the study in all instances no effect from the RFR signal was observed.

(E) Sun LX, Yao K, He JL, Lu DQ, Wang KJ, Li HW.[Effect of acute exposure to microwave from mobile phone on DNA damage and repair of cultured human lens epithelial cells in vitro.] Zhonghua Lao Dong Wei Sheng Zhi Ye Bing ZaZhi. 24:465-467, 2006. [Article in Chinese] (GT)

OBJECTIVE: To investigate the DNA damage of human lens epithelial cells (LECs) caused by acute exposure to low-power 217 Hz modulated 1.8 GHz microwave radiation and DNA repair. METHODS: Cultured LECs were exposed to 217 Hz modulated 1.8 GHz microwave radiation at SAR (specific absorption rate) of 0, 1, 2, 3 and 4 W/kg for 2 hours in an sXc-1800 incubator and irradiate system. The DNA single strand breaks were detected with comet assay in sham-irradiated cells and irradiated cells incubated for varying periods: 0, 30, 60, 120 and 240 min after irradiation. Images of comets were digitized and analyzed using an Imagine-pro plus software, and the indexes used in this study were tail length (TL) and tail moment (TM). RESULTS: The difference in DNA-breaks between the exposure and sham exposure groups induced by 1 and 2 W/kg irradiation was not significant at every detect time ($P > 0.05$). As for the dosage of 3 and 4 W/kg there was difference in both groups immediately after irradiation ($P < 0.01$). At the time of 30 min after irradiation the difference went on at both group ($P < 0.01$). However, the difference disappeared after one hour's incubation in 3 W/kg group ($P > 0.05$), and existed in 4 W/kg group. CONCLUSION: No or repairable DNA damage was observed after 2 hour irradiation of 1.8 GHz microwave on LECs when SAR </= 3 W/kg. The DNA damages caused by 4 W/kg irradiation were irreversible.

(E) Tiwari R, Lakshmi NK, Surender V, Rajesh AD, Bhargava SC, Ahuja YR. Combinative exposure effect of radio frequency signals from CDMA mobile phones and aphidicolin on DNA integrity. Electromagn Biol Med 27:418-425, 2008. (GT, IA)

The aim of present study is to assess DNA integrity on the effect of exposure to a radio frequency (RF) signal from Code Division Multiple Access (CDMA) mobile phones. Whole blood samples from six healthy male individuals were exposed for RF signals from a CDMA mobile phone for 1 h. Alkaline comet assay was performed to assess the DNA damage. The combinative exposure effect of the RF signals and APC at two concentrations on DNA integrity was studied. DNA repair efficiency of the samples was also studied after 2 h of exposure. The RF

signals and APC (0.2 microg/ml) alone or in synergism did not have any significant DNA damage as compared to sham exposed. However, univariate analysis showed that DNA damage was significantly different among combinative exposure of RF signals and APC at 0.2 microg/ml ($p < 0.05$) and at 2 microg/ml ($p < 0.02$). APC at 2 microg/ml concentration also showed significant damage levels ($p < 0.05$) when compared to sham exposed. DNA repair efficiency also varied in a significant way in combinative exposure sets ($p < 0.05$). From these results, it appears that the repair inhibitor APC enhances DNA breaks at 2 microg/ml concentration and that the damage is possibly repairable. Thus, it can be inferred that the in vitro exposure to RF signals induces reversible DNA damage in synergism with APC.

(E) Tkalec M, Stambuk A, Srut M, Malarić K, Klobučar GI. Oxidative and genotoxic effects of 900MHz electromagnetic fields in the earthworm Eisenia fetida. Ecotoxicol Environ Saf. 90:7-12, 2013. (GT, OX, WS)

Accumulating evidence suggests that exposure to radiofrequency electromagnetic field (RF-EMF) can have various biological effects. In this study the oxidative and genotoxic effects were investigated in earthworms Eisenia fetida exposed in vivo to RF-EMF at the mobile phone frequency (900MHz). Earthworms were exposed to the homogeneous RF-EMF at field levels of 10, 23, 41 and 120Vm(-1) for a period of 2h using a Gigahertz Transversal Electromagnetic (GTEM) cell. At the field level of 23Vm(-1) the effect of longer exposure (4h) and field modulation (80% AM 1kHz sinusoidal) was investigated as well. All exposure treatments induced significant genotoxic effect in earthworms coelomocytes detected by the Comet assay, demonstrating DNA damaging capacity of 900MHz electromagnetic radiation. Field modulation additionally increased the genotoxic effect. Moreover, our results indicated the induction of antioxidant stress response in terms of enhanced catalase and glutathione reductase activity as a result of the RF-EMF exposure, and demonstrated the generation of lipid and protein oxidative damage. Antioxidant responses and the potential of RF-EMF to induce damage to lipids, proteins and DNA differed depending on the field level applied, modulation of the field and duration of E. fetida exposure to 900MHz electromagnetic radiation. Nature of detected DNA lesions and oxidative stress as the mechanism of action for the induction of DNA damage are discussed.

(E) Tomruk A, Guler G, Dincel AS. The influence of 1800 MHz GSM-like signals on hepatic oxidative DNA and lipid damage in nonpregnant, pregnant, and newly born rabbits. Cell Biochem Biophys 56:39-47, 2010. (GT, OX, DE, LE)

The aim of our study is to evaluate the possible biological effects of whole-body 1800 MHz GSM-like radiofrequency (RF) radiation exposure on liver oxidative DNA damage and lipid peroxidation levels in nonpregnant, pregnant New Zealand White rabbits, and in their newly borns. Eighteen nonpregnant and pregnant rabbits were used and randomly divided into four groups which were composed of nine rabbits: (i) Group I (nonpregnant control), (ii) Group II (nonpregnant-RF exposed), (iii) Group III (pregnant control), (iv) Group IV (pregnant-RF exposed). Newborns of the pregnant rabbits were also divided into two groups: (v) Group V

(newborns of Group III) and (vi) Group VI (newborns of Group III). 1800 MHz GSM-like RF radiation whole-body exposure (15 min/day for a week) was applied to Group II and Group IV. No significant differences were found in liver 8 OHdG/10 dG levels of exposure groups (Group II and Group IV) compared to controls (Group I and Group III). However, in Group II and Group IV malondialdehyde (MDA) and ferrous oxidation in xylenol orange (FOX) levels were increased compared to Group I ($P < 0.05$, Mann-Whitney). No significant differences were found in liver tissue of 8 OHdG/10 dG and MDA levels between Group VI and Group V ($P > 0.05$, Mann-Whitney) while liver FOX levels were found significantly increased in Group VI with respect to Group V ($P < 0.05$, Mann-Whitney). Consequently, the whole-body 1800 MHz GSM-like RF radiation exposure may lead to oxidative destruction as being indicators of subsequent reactions that occur to form oxygen toxicity in tissues.

(E) Trivino Pardo JC, Grimaldi S, Taranta M, Naldi I, Cinti C. Microwave electromagnetic field regulates gene expression in T-lymphoblastoid leukemia CCRF-CEM cell line exposed to 900 MHz. Electromagn Biol Med. 31(1):1-18, 2012. (GE)

Electric, magnetic, and electromagnetic fields are ubiquitous in our society, and concerns have been expressed regarding possible adverse effects of these exposures. Research on Extremely Low-Frequency (ELF) magnetic fields has been performed for more than two decades, and the methodology and quality of studies have improved over time. Studies have consistently shown increased risk for childhood leukemia associated with ELF magnetic fields. There are still inadequate data for other outcomes. More recently, focus has shifted toward Radio Frequencies (RF) exposures from mobile telephony. There are no persuasive data suggesting a health risk, but this research field is still immature with regard to the quantity and quality of available data. This technology is constantly changing and there is a need for continued research on this issue. To investigate whether exposure to high-frequency electromagnetic fields (EMF) could induce adverse health effects, we cultured acute T-lymphoblastoid leukemia cells (CCRF-CEM) in the presence of 900 MHz MW-EMF generated by a transverse electromagnetic (TEM) cell at short and long exposure times. We evaluated the effect of high-frequency EMF on gene expression and we identified functional pathways influenced by 900 MHz MW-EMF exposure.

(E) Trosić I, Pavicić I, Milković-Kraus S, Mladinić M, Zeljezić D. Effect of electromagnetic radiofrequency radiation on the rats' brain, liver and kidney cells measured by comet assay. Coll Antropol 35:1259-1264, 2011. (GT)

The goal of study was to evaluate DNA damage in rat's renal, liver and brain cells after in vivo exposure to radiofrequency/microwave (Rf/Mw) radiation of cellular phone frequencies range. To determine DNA damage, a single cell gel electrophoresis/comet assay was used. Wistar rats (male, 12 week old, approximate body weight 350 g) (N = 9) were exposed to the carrier frequency of 915 MHz with Global System Mobile signal modulation (GSM), power density of 2.4 W/m2, whole body average specific absorption rate SAR of 0.6 W/kg. The animals were irradiated for one hour/day, seven days/week during two weeks period. The exposure set-up

was Gigahertz Transversal Electromagnetic Mode Cell (GTEM--cell). Sham irradiated controls (N = 9) were apart of the study. The body temperature was measured before and after exposure. There were no differences in temperature in between control and treated animals. Comet assay parameters such as the tail length and tail intensity were evaluated. In comparison with tail length in controls (13.5 +/- 0.7 microm), the tail was slightly elongated in brain cells of irradiated animals (14.0 +/- 0.3 microm). The tail length obtained for liver (14.5 +/- 0.3 microm) and kidney (13.9 +/- 0.5 microm) homogenates notably differs in comparison with matched sham controls (13.6 +/- 0.3 microm) and (12.9 +/- 0.9 microm). Differences in tail intensity between control and exposed animals were not significant. The results of this study suggest that, under the experimental conditions applied, repeated 915 MHz irradiation could be a cause of DNA breaks in renal and liver cells, but not affect the cell genome at the higher extent compared to the basal damage.

(NE) Valbonesi P, Franzellitti S, Piano A, Contin A, Biondi C, Fabbri E. Evaluation of HSP70 Expression and DNA damage in cells of a human trophoblast cell line exposed to 1.8 GHz amplitude-modulated radiofrequency fields. Radiat Res 169:270-279, 2008. (GT, GE)

The aim of this study was to determine whether high-frequency electromagnetic fields (EMFs) could induce cellular effects. The human trophoblast cell line HTR-8/SVneo was used as a model to evaluate the expression of proteins (HSP70 and HSC70) and genes (HSP70A, B, C and HSC70) of the HSP70 family and the primary DNA damage response after nonthermal exposure to pulse-modulated 1817 MHz sinusoidal waves (GSM-217 Hz; 1 h; SAR of 2 W/kg). HSP70 expression was significantly enhanced by heat, which was applied as the prototypical stimulus. The HSP70A, B and C transcripts were differentially expressed under basal conditions, and they were all significantly induced above basal levels by thermal stress. Conversely, HSC70 protein and gene expression was not influenced by heat. Exposing HTR-8/SVneo cells to high-frequency EMFs did not change either HSP70 or HSC70 protein or gene expression. A significant increase in DNA strand breaks was caused by exposure to HO, which was used as a positive stimulus; however, no effect was observed after exposure of cells to high-frequency EMFs. Overall, no evidence was found that a 1-h exposure to GSM-217 Hz induced a HSP70-mediated stress response or primary DNA damage in HTR-8/SVneo cells. Nevertheless, further investigations on trophoblast cell responses after exposure to GSM signals of different types and durations are needed.

(E) Valbonesi P, Franzellitti S, Bersani F, Contin A, Fabbri E. Effects of the exposure to intermittent 1.8 GHz radio frequency electromagnetic fields on HSP70 expression and MAPK signaling pathways in PC12 cells. Int J Radiat Biol. 2014 Feb 11. [Epub ahead of print] (GE, WS)

Purpose: We previously reported effects on heat shock protein 70 (HSP70) mRNA expression, a cytoprotective protein induced under stressful condition, in human trophoblast cells exposed to amplitude-modulated Global System for Mobile Communication (GSM) signals. In the present work the same experimental conditions were applied to the rat PC12 cells, in order to assess the stress responses mediated by HSP70 and by the Mitogen Activated Protein Kinases (MAPK) in neuronal-like cells, an interesting model to study possible effects of mobile phone

frequencies exposure. Materials and methods: HSP70 gene expression level was evaluated by reverse transcriptase polymerase chain reaction, HSP70 protein expression and MAPK phosphorylation were assessed by Western blotting. PC12 cells were exposed for 4, 16 or 24 h to 1.8 GHz continuous wave signal (CW, carrier frequency without modulation) or to two different GSM modulation schemes, GSM-217Hz and GSM-Talk (which generates temporal changes between two different GSM signals, active during talking or listening phases respectively, thus simulating a typical conversation). Specific adsorption rate (SAR) was 2 W/kg. Results: After PC12 cells exposure to the GSM-217Hz signal for 16 or 24 h, HSP70 transcription significantly increased, whereas no effect was observed in cells exposed to the CW or GSM-Talk signals. HSP70 protein expression and three different MAPK signaling pathways were not affected by the exposure to any of the three different 1.8 GHz signals. Conclusion: The positive effect on HSP70 mRNA expression, observed only in cells exposed to the GSM-217Hz signal, is a repeatable response previously reported in human trophoblast cells and now confirmed in PC12 cells. Further investigations towards a possible role of 1.8 GHz signal modulation are therefore advisable.

(NE) Verschaeve L, Heikkinen P, Verheyen G, Van Gorp U, Boonen F, Vander Plaetse F, Maes A, Kumlin T, Maki-Paakkanen J, Puranen L, Juutilainen J. Investigation of co-genotoxic effects of radiofrequency electromagnetic fields in vivo. Radiat Res 165:598-607, 2006. (GT, LE, IA)

We investigated the possible combined genotoxic effects of radiofrequency (RF) electromagnetic fields (900 MHz, amplitude modulated at 217 Hz, mobile phone signal) with the drinking water mutagen and carcinogen 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX). Female rats were exposed to RF fields for a period of 2 years for 2 h per day, 5 days per week at average whole-body specific absorption rates of 0.3 or 0.9 W/kg. MX was given in the drinking water at a concentration of 19 mug/ml. Blood samples were taken at 3, 6 and 24 months of exposure and brain and liver samples were taken at the end of the study (24 months). DNA damage was assessed in all samples using the alkaline comet assay, and micronuclei were determined in erythrocytes. We did not find significant genotoxic activity of MX in blood and liver cells. However, MX induced DNA damage in rat brain. Co-exposures to MX and RF radiation did not significantly increase the response of blood, liver and brain cells compared to MX exposure only. In conclusion, this 2-year animal study involving long-term exposures to RF radiation and MX did not provide any evidence for enhanced genotoxicity in rats exposed to RF radiation.

(NE) Vijayalaxmi. Cytogenetic studies in human blood lymphocytes exposed in vitro to 2.45 GHz or 8.2 GHz radiofrequency radiation. Radiat Res 166, 532–538, 2006. (GT)

Peripheral blood samples collected from healthy human volunteers were exposed in vitro to 2.45 GHz or 8.2 GHz pulsed-wave radiofrequency (RF) radiation. The net forward power, average power density, mean specific absorption rate, and the temperature maintained during the 2-h exposure of the cells to 2.45 GHz or 8.2 GHz were, respectively, 21 W or 60 W, 5 mW/cm2 or 10 mW/cm2, 2.13 W/kg or 20.71 W/kg, and 36.9 ± 0.1°C or 37.5 ± 0.2°C. Aliquots of the same blood samples that were either sham-exposed or exposed in vitro to an acute dose

of 1.5 Gy γ radiation were used as unexposed and positive controls, respectively. Cultured lymphocytes were examined to determine the extent of cytogenetic damage assessed from the incidence of chromosomal aberrations and micronuclei. Under the conditions used to perform the experiments, the levels of damage in RF-radiation-exposed and sham-exposed lymphocytes were not significantly different. Also, there were no significant differences in the response of unstimulated lymphocytes and lymphocytes stimulated with phytohemagglutinin when exposed to 8.2 GHz RF radiation. In contrast, the positive control cells that had been subjected to γ irradiation exhibited significantly more damage than RF-radiation- and sham-exposed lymphocytes.

(NE) Waldmann P, Bohnenberger S, Greinert R, Hermann-Then B, Heselich A, Klug SJ, Koenig J, Kuhr K, Kuster N, Merker M, Murbach M, Pollet D, Schadenboeck W, Scheidemann-Wesp U, Schwab B, Volkmer B, Weyer V, Blettner M. Influence of GSM Signals on Human Peripheral Lymphocytes: Study of Genotoxicity. Radiat Res. 2013 Jan 14. [Epub ahead of print] (GT)

Exposure to radiofrequency (RF) electromagnetic fields (EMF) is continuously increasing worldwide. Yet, conflicting results of a possible genotoxic effect of RF EMF continue to be discussed. In the present study, a possible genotoxic effect of RF EMF (GSM, 1,800 MHz) in human lymphocytes was investigated by a collaboration of six independent institutes (institutes a, b, c, d, e, h). Peripheral blood of 20 healthy, nonsmoking volunteers of two age groups (10 volunteers 16-20 years old and 10 volunteers 50-65 years old) was taken, stimulated and intermittently exposed to three specific absorption rates (SARs) of RF EMF (0.2 W/kg, 2 W/kg, 10 W/kg) and sham for 28 h (institute a). The exposures were performed in a setup with strictly controlled conditions of temperature and dose, and randomly and automatically determined waveguide SARs, which were designed and periodically maintained by ITIS (institute h). Four genotoxicity tests with different end points were conducted (institute a): chromosome aberration test (five types of structural aberrations), micronucleus test, sister chromatid exchange test and the alkaline comet assay (Olive tail moment and % DNA). To demonstrate the validity of the study, positive controls were implemented. The genotoxicity end points were evaluated independently by three laboratories blind to SAR information (institute c = laboratory 1; institute d = laboratory 2; institute e = laboratory 3). Statistical analysis was carried out by institute b. Methods of primary statistical analysis and rules to adjust for multiple testing were specified in a statistical analysis plan based on a data review before unblinding. A linear trend test based on a linear mixed model was used for outcomes of comet assay and exact permutation test for linear trend for all other outcomes. It was ascertained that only outcomes with a significant SAR trend found by at least two of three analyzing laboratories indicated a substantiated suspicion of an exposure effect. On the basis of these specifications, none of the nine end points tested for SAR trend showed a significant and reproducible exposure effect. Highly significant differences between sham exposures and positive controls were detected by each analyzing laboratory, thus validating the study. In conclusion, the results show no evidence of a genotoxic effect induced by RF EMF (GSM, 1,800 MHz).

(E) Wu W, Yao K, Wang KJ, Lu DQ, He JL, Xu LH, Sun WJ. [Blocking 1800 MHz mobile phone radiation-induced reactive oxygen species production and DNA damage in lens epithelial cells by noise magnetic fields.]Zhejiang Da XueXueBao Yi Xue Ban 37:34-38, 2008. [Article in Chinese] (GT, IA, OX)

OBJECTIVE: To investigate whether the exposure to the electromagnetic noise can block reactive oxygen species (ROS) production and DNA damage of lens epithelial cells induced by 1800 MHz mobile phone radiation. METHODS: The DCFH-DA method and comet assay were used respectively to detect the intracellular ROS and DNA damage of cultured human lens epithelial cells induced by 4 W/kg 1800 MHz mobile phone radiation or/and 2microT electromagnetic noise for 24 h intermittently. RESULT: 1800 MHz mobile phone radiation at 4 W/kg for 24 h increased intracellular ROS and DNA damage significantly ($P<0.05$). However, the ROS level and DNA damage of mobile phone radiation plus noise group were not significant enhanced ($P>0.05$) as compared to sham exposure group. Conclusion: Electromagnetic noise can block intracellular ROS production and DNA damage of human lens epithelial cells induced by 1800 MHz mobile phone radiation.

(E) Xu S, Zhong M, Zhang L, Zhou Z, Zhang W, Wang Y, Wang X, Li M, Chen Y, Chen C, He M, Zhang G, Yu Z. Exposure to 1800 MHz radiofrequency radiation induces oxidative damage to mitochondrial DNA in primary cultured neurons. Brain Res 1311:189-196. 2010. (GT, OX)

Increasing evidence indicates that oxidative stress may be involved in the adverse effects of radiofrequency (RF) radiation on the brain. Because mitochondrial DNA (mtDNA) defects are closely associated with various nervous system diseases and mtDNA is highly susceptible to oxidative stress, the purpose of this study was to determine whether radiofrequency radiation can cause oxidative damage to mtDNA. In this study, we exposed primary cultured cortical neurons to pulsed RF electromagnetic fields at a frequency of 1800 MHz modulated by 217 Hz at an average special absorption rate (SAR) of 2 W/kg. At 24h after exposure, we found that RF radiation induced a significant increase in the levels of 8-hydroxyguanine (8-OHdG), a common biomarker of DNA oxidative damage, in the mitochondria of neurons. Consistent with this finding, the copy number of mtDNA and the levels of mitochondrial RNA (mtRNA) transcripts showed an obvious reduction after RF exposure. Each of these mtDNA disturbances could be reversed by pretreatment with melatonin, which is known to be an efficient in the brain. Together, these results suggested that 1800 MHz RF radiation could cause oxidative damage to mtDNA in primary cultured neurons. Oxidative damage to mtDNA may account for the neurotoxicity of RF radiation in the brain.

(E) Xu S, Chen G, Chen C, Sun C, Zhang D, Murbach M, Kuster N, Zeng Q, Xu Z. Cell Type-Dependent Induction of DNA Damage by 1800 MHz Radiofrequency Electromagnetic Fields Does Not Result in Significant Cellular Dysfunctions. PLoS One. 8(1):e54906, 2013. (GT, CS)

BACKGROUND: Although IARC clarifies radiofrequency electromagnetic fields (RF-EMF) as possible human carcinogen, the debate on its health impact continues due to the inconsistent results. Genotoxic effect has been considered as a golden standard to determine if an

environmental factor is a carcinogen, but the currently available data for RF-EMF remain controversial. As an environmental stimulus, the effect of RF-EMF on cellular DNA may be subtle. Therefore, more sensitive method and systematic research strategy are warranted to evaluate its genotoxicity. **OBJECTIVES:** To determine whether RF-EMF does induce DNA damage and if the effect is cell-type dependent by adopting a more sensitive method γH2AX foci formation; and to investigate the biological consequences if RF-EMF does increase γH2AX foci formation. **METHODS:** Six different types of cells were intermittently exposed to GSM 1800 MHz RF-EMF at a specific absorption rate of 3.0 W/kg for 1 h or 24 h, then subjected to immunostaining with anti-γH2AX antibody. The biological consequences in γH2AX-elevated cell type were further explored with comet and TUNEL assays, flow cytometry, and cell growth assay. **RESULTS:** Exposure to RF-EMF for 24 h significantly induced γH2AX foci formation in Chinese hamster lung cells and Human skin fibroblasts (HSFs), but not the other cells. However, RF-EMF-elevated γH2AX foci formation in HSF cells did not result in detectable DNA fragmentation, sustainable cell cycle arrest, cell proliferation or viability change. RF-EMF exposure slightly but not significantly increased the cellular ROS level. **CONCLUSIONS:** RF-EMF induces DNA damage in a cell type-dependent manner, but the elevated γH2AX foci formation in HSF cells does not result in significant cellular dysfunctions.

(NE) Yadav AS, Sharma MK. Increased frequency of micronucleated exfoliated cells among humans exposed in vivo to mobile telephone radiations. Mutat Res.650(2):175-180, 2008. (LE, GT, HU)

The health concerns have been raised following the enormous increase in the use of wireless mobile telephones throughout the world. This investigation had been taken, with the motive to find out whether mobile phone radiations cause any in vivo effects on the frequency of micronucleated exfoliated cells in the exposed subjects. A total of 109 subjects including 85 regular mobile phone users (exposed) and 24 non-users (controls) had participated in this study. Exfoliated cells were obtained by swabbing the buccal-mucosa from exposed as well as sex-age-matched controls. One thousand exfoliated cells were screened from each individual for nuclear anomalies including micronuclei (MN), karyolysis (KL), karyorrhexis (KH), broken egg (BE) and binucleated (BN) cells. The average daily duration of exposure to mobile phone radiations is 61.26 min with an overall average duration of exposure in term of years is 2.35 years in exposed subjects along with the 9.84+/-0.745 micronucleated cells (MNCs) and 10.72+/-0.889 total micronuclei (TMN) as compared to zero duration of exposure along with average 3.75+/-0.774 MNC and 4.00+/-0.808 TMN in controls. The means are significantly different in case of MNC and TMN at 0.01% level of significance. The mean of KL in controls is 13.17+/-2.750 and in exposed subjects is 13.06+/-1.793. The value of means of KH in exposed subjects (1.84+/-0.432) is slightly higher than in controls (1.42+/-0.737). Mean frequency of broken egg is found to be more in exposed subjects (0.65+/-0.276) as compared to controls (0.50+/-0.217). Frequency of presence of more than one nucleus in a cell (binucleated) is also higher in exposed (2.72+/-0.374) in comparison to controls (0.67+/-0.231). Although there is a slight increase in mean frequency of KH, BE and BN in exposed subjects but the difference is not

found statistically significant. Correlation between 0-1, 1-2, 2-3 and 3-4 years of exposure and the frequency of MNC and TMN has been calculated and found to be positively correlated.

(E) Yan JG, Agresti M, Zhang LL, Yan Y, Matloub HS. Upregulation of specific mRNA levels in rat brain after cell phone exposure. Electromagn Biol Med. 27(2):147-154, 2008. (LE, GE)

Adult Sprague-Dawley rats were exposed to regular cell phones for 6 h per day for 126 days (18 weeks). RT-PCR was used to investigate the changes in levels of mRNA synthesis of several injury-associated proteins. Calcium ATPase, Neural Cell Adhesion Molecule, Neural Growth Factor, and Vascular Endothelial Growth Factor were evaluated. The results showed statistically significant mRNA up-regulation of these proteins in the brains of rats exposed to cell phone radiation. These results indicate that relative chronic exposure to cell phone microwave radiation may result in cumulative injuries that could eventually lead to clinically significant neurological damage.

(E) Yao K, Wu W, Wang K, Ni S, Ye P, Yu Y, Ye J, Sun L. Electromagnetic noise inhibits radiofrequency radiation-induced DNA damage and reactive oxygen species increase in human lens epithelial cells. Mol Vis 14:964-969, 2008. (GT, IA, OX)

PURPOSE: The goal of this study was to investigate whether superposing of electromagnetic noise could block or attenuate DNA damage and intracellular reactive oxygen species (ROS) increase of cultured human lens epithelial cells (HLECs) induced by acute exposure to 1.8 GHz radiofrequency field (RF) of the Global System for Mobile Communications (GSM). METHODS: An sXc-1800 RF exposure system was used to produce a GSM signal at 1.8 GHz (217 Hz amplitude-modulated) with the specific absorption rate (SAR) of 1, 2, 3, and 4 W/kg. After 2 h of intermittent exposure, the ROS level was assessed by the fluorescent probe, 2',7'-dichlorodihydrofluorescein diacetate (DCFH-DA). DNA damage to HLECs was examined by alkaline comet assay and the phosphorylated form of histone variant H2AX (gammaH2AX) foci formation assay. RESULTS: After exposure to 1.8 GHz RF for 2 h, HLECs exhibited significant intracellular ROS increase in the 2, 3, and 4 W/kg groups. RF radiation at the SAR of 3 W/kg and 4 W/kg could induce significant DNA damage, examined by alkaline comet assay, which was used to detect mainly single strand breaks (SSBs), while no statistical difference in double strand breaks (DSBs), evaluated by gammaH2AX foci, was found between RF exposure (SAR: 3 and 4 W/kg) and sham exposure groups. When RF was superposed with 2 muT electromagnetic noise could block RF-induced ROS increase and DNA damage. CONCLUSIONS: DNA damage induced by 1.8 GHz radiofrequency field for 2 h, which was mainly SSBs, may be associated with the increased ROS production. Electromagnetic noise could block RF-induced ROS formation and DNA damage.

(NE) Yildirim MS, Yildirim A, Zamani AG, Okudan N. Effect of mobile phone station on micronucleus frequency and chromosomal aberrations in human blood cells. Genet Couns. 21(2):243-251, 2010. (HU, LE, GT)

The use of mobile telephones has rapidly increased worldwide as well as the number of mobile phone base stations that lead to rise low level radiofrequency emissions which may in turn have possible harm for human health. The national radiation protection board has published the known effects of radio waves exposure on humans living close to mobile phone base stations. However, several studies have claimed that the base station has detrimental effects on different tissues. In this study, we aimed to evaluate the effects of mobile phone base stations on the micronucleus (MN) frequency and chromosomal aberrations on blood in people who were living around mobile phone base stations and healthy controls. Frequency of MN and chromosomal aberrations in study and control groups was 8.96 +/- 3.51 and 6.97 +/- 1.52 (p: 0.16); 0.36 +/- 0.31 and 0.75 +/- 0.61 (p: 0.07), respectively. Our results show that there was not a significant difference of MN frequency and chromosomal aberrations between the two study groups. The results claim that cellular phones and their base stations do not produce important carcinogenic changes.

(E) Zalata, A., A. Z. El-Samanoudy, D. Shaalan, Y. El-Baiomy, and T. Mostafa. In vitro effect of cell phone radiation on motility, DNA fragmentation and clusterin gene expression of sperm. Int J Fertil Steril, In Press. Published online ahead of print. (GT, GE, RP)

Background: Use of cellular phones that emits radiofrequency electromagnetic field (RF-EMF) has been increased exponentially and became a part of everyday life. This study aimed to investigate the effects of RF-EMF radiation emitted from cellular phones on sperm motility variables, sperm DNA fragmentation and clusterin (CLU) gene expression. Materials and Methods: 124 semen samples were grouped into; normozoospermia (N, n=26), asthenozoospermia (A, n=32), asthenoteratozoospermia (AT, n=31) and oligoasthenoteratozoospermia (OAT, n=35). Semen samples were divided into two aliquots; samples not exposed to cell phone and samples exposed to cell phone radiation (850 MHz, maximum power < 1 watt; SAR 1.46 W/kg at 10 cm distance) for 1 hr. Before and immediately after exposure both aliquots were subjected to assessment of sperm motility, acrosin activity, sperm DNA fragmentation and CLU gene expression. Statistical differences were analyzed using paired t-student test for comparisons where P< 0.05 was set as significant. Results: There was significant decrease in sperm motility, sperm linear velocity, sperm linearity index, sperm acrosin activity and significant increase in sperm DNA fragmentation percent, CLU gene expression and CLU protein levels in the exposed semen samples to RF-EMF compared with non- exposed samples in OAT > AT > A > N groups (P<0.05).
Conclusions: Cell phone emissions have a negative impact on exposed sperm motility indices, sperm acrosin activity, sperm DNA fragmentation and CLU gene expression especially in OAT cases.

(NE) Zeni O, Schiavoni A, Perrotta A, Forigo D, Deplano M, Scarfi MR. Evaluation of genotoxic effects in human leukocytes after in vitro exposure to 1950 MHz UMTS radiofrequency field. Bioelectromagnetics 29:177-184, 2008. (GT)

In the present study the third generation wireless technology of the Universal Mobile Telecommunication System (UMTS) signal was investigated for the induction of genotoxic effects in human leukocytes. Peripheral blood from six healthy donors was used and, for each donor, intermittent exposures (6 min RF on, 2 h RF off) at the frequency of 1950 MHz were conducted at a specific absorption rate of 2.2 W/kg. The exposures were performed in a transverse electro magnetic (TEM) cell hosted in an incubator under strictly controlled conditions of temperature and dosimetry. Following long duration intermittent RF exposures (from 24 to 68 h) in different stages of the cell cycle, micronucleus formation was evaluated by applying the cytokinesis block micronucleus assay, which also provides information on cell division kinetics. Primary DNA damage (strand breaks/alkali labile sites) was also investigated following 24 h of intermittent RF exposures, by applying the alkaline single cell gel electrophoresis (SCG)/comet assay. Positive controls were included by treating cell cultures with Mitomycin-C and methylmethanesulfonate for micronucleus and comet assays, respectively. The results obtained indicate that intermittent exposures of human lymphocytes in different stages of cell cycle do not induce either an increase in micronucleated cells, or change in cell cycle kinetics; moreover, 24 h intermittent exposures also fail to affect DNA structure of human leukocytes soon after the exposures, likely indicating that repairable DNA damage was not induced.

(E) Zhang DY, Xu ZP, Chiang H, Lu DQ, Zeng QL. [Effects of GSM 1800 MHz radiofrequency electromagnetic fields on DNA damage in Chinese hamster lung cells.] Zhonghua Yu Fang Yi XueZaZhi 40:149-152, 2006. [Article in Chinese] (GT)

OBJECTIVE: To study the effects of GSM 1800 MHz radiofrequency electromagnetic fields (RF EMF) on DNA damage in Chinese hamster lung (CHL) cells. METHODS: The cells were intermittently exposed or sham-exposed to GSM 1800 MHz RF EMF (5 minutes on/10 minutes off) at a special absorption rate (SAR) of 3.0 W/kg for 1 hour or 24 hours. Meanwhile, cells exposed to 2-acetaminofluorene, a DNA damage agent, at a final concentration of 20 mg/L for 2 hours were used as positive control. After exposure, cells were fixed by using 4% paraformaldehyde and processed for phosphorylated form of H2AX (gammaH2AX) immunofluorescence measurement. The primary antibody used for immunofluorescence was mouse monoclonal antibody against gammaH2AX and the secondary antibody was fluorescein isothiocyanate (FITC)-conjugated goat anti-mouse IgG. Nuclei were counterstained with 4, 6-diamidino-2-phenylindole (DAPI). The gammaH2AX foci and nuclei were visualized with an Olympus AX70 fluorescent microscope. Image Pro-Plus software was used to count the gammaH2AX foci in each cell. For each exposure condition, at least 50 cells were selected to detect gammaH2AX foci. Cells were classified as positive when more than five foci were detected. The percentage of gammaH2AX foci positive cells was adopted as the index of DNA damage. RESULTS: The percentage of gammaH2AX foci positive cell of 1800 MHz RF EMF exposure for 24 hours (37.9 +/- 8.6)% or 2-acetylaminofluorene exposure (50.9 +/- 9.4)% was

significantly higher compared with the sham-exposure (28.0 +/- 8.4)%. However, there was no significant difference between the sham-exposure and RF EMF exposure for 1 hour (31.8 +/- 8.7)%. CONCLUSION: 1800 MHz RF EMF (SAR, 3.0 W/kg) for 24 hours might induce DNA damage in CHL cells.

(E) Zhang SZ, Yao GD, Lu DQ, Chiang H, Xu ZP. [Effect of 1.8 GHz radiofrequency electromagnetic fields on gene expression of rat neurons]. Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 26(8):449-452, 2008. [Article in Chinese] (GE, WS)

OBJECTIVE: To investigate the changes of gene expression in rat neuron induced by 1.8 GHz radiofrequency electromagnetic fields (RF EMF) to screen for RF EMF-responsive genes and the effect of different exposure times and modes on the gene expression in neuron. METHODS: Total RNA was extracted immediately and purified from the primary culture of neurons after intermittent exposed or sham-exposed to a frequency of 1.8 GHz RF EMF for 24 hours at an average special absorption rate (SAR) of 2 W/kg. Affymetrix Rat Neurobiology U34 array was applied to investigate the changes of gene expression in rat neuron. Differentially expressed genes (Egr-1, Mbp and Plp) were further confirmed by semi-quantitative revere transcription polymerase chain reaction (RT PCR). The expression levels of Egr-1, Mbp and Plp were observed at different exposure times (6, 24 h) and modes (intermittent and continuous exposure). RESULTS: Among 1200 candidate genes, 24 up-regulated and 10 down-regulated genes were found by using Affymetrix microarray suite software 5.0 which are associated with multiple cellular functions (cytoskeleton, signal transduction pathway, metabolism, etc.) after functional classification. Under 24 h and 6 h intermittent exposure, Egr-1 and Plp in experiment groups showed statistic significance ($P < 0.05$) compared with the control groups, while expression of Mbp did not change significantly ($P > 0.05$). After 24 h continuous exposure, Egr-1 and Mbp in experiment groups showed statistic significance ($P < 0.05$) compared with the control group, while expression of Plp did not change significantly ($P > 0.05$). Under the same exposure mode 6 h, expression of all the 3 genes did not change significantly. Different times (6, 24 h) and modes (intermittent and continuous exposure) of exposure exerted remarkable different influences on the expression of Egr-1, Mbp, Plp genes ($P < 0.01$). CONCLUSION: The changes of many genes transcription were involved in the effect of 1.8 GHz RF EMF on rat neurons; Down-regulation of Egr-1 and up-regulation of Mbp, Plp indicated the negative effects of RF EMF on neurons; The effect of RF intermittent exposure on gene expression was more obvious than that of continuous exposure; The effect of 24 h RF exposure (both intermittent and continuous) on gene expression was more obvious than that of 6 h (both intermittent and continuous).

(E) Zhao R, Zhang S, Xu Z, Ju L, Lu D, Yao G. Studying gene expression profile of rat neuron exposed to 1800MHz radiofrequency electromagnetic fields with cDNA microassay. Toxicology 235:167-175, 2007. (GE)

A widespread use of mobile phone (MP) evokes a growing concern for their possible adverse effects on human, especially the brain. Gene expression is a unique way of characterizing how cells and organism adapt to changes in the external environment, so the aim of this investigation was to determine whether 1800 MHz radiofrequency electromagnetic fields (RF

EMF) can influence the gene expression of neuron. Affymetrix Rat Neurobiology U34 array was applied to investigate the changes of gene expression in rat neuron after exposed to the pulsed RF EMF at a frequency of 1800 MHz modulated by 217 Hz which is commonly used in MP. Among 1200 candidate genes, 24 up-regulated genes and 10 down-regulated genes were identified after 24-h intermittent exposure at an average special absorption rate (SAR) of 2 W/kg, which are associated with multiple cellular functions (cytoskeleton, signal transduction pathway, metabolism, etc.) after functional classification. The results were further confirmed by quantitative real-time polymerase chain reaction (RT PCR). The present results indicated that the gene expression of rat neuron could be altered by exposure to RF EMF under our experimental conditions.

(E) Zhao TY, Zou SP, Knapp PE. Exposure to cell phone radiation up-regulates apoptosis genes in primary cultures of neurons and astrocytes. Neurosci Lett. 412(1):34-38, 2007. (GE, CS)

The health effects of cell phone radiation exposure are a growing public concern. This study investigated whether expression of genes related to cell death pathways are dysregulated in primary cultured neurons and astrocytes by exposure to a working Global System for Mobile Communication (GSM) cell phone rated at a frequency of 1900MHz. Primary cultures were exposed to cell phone emissions for 2h. We used array analysis and real-time RT-PCR to show up-regulation of caspase-2, caspase-6 and Asc (apoptosis associated speck-like protein containing a card) gene expression in neurons and astrocytes. Up-regulation occurred in both "on" and "stand-by" modes in neurons, but only in "on" mode in astrocytes. Additionally, astrocytes showed up-regulation of the Bax gene. The effects are specific since up-regulation was not seen for other genes associated with apoptosis, such as caspase-9 in either neurons or astrocytes, or Bax in neurons. The results show that even relatively short-term exposure to cell phone radiofrequency emissions can up-regulate elements of apoptotic pathways in cells derived from the brain, and that neurons appear to be more sensitive to this effect than astrocytes.

(E) Zhijian C, Xiaoxue L, Yezhen L, Shijie C, Lifen J, Jianlin L, Deqiang L, Jiliang H. Impact of 1.8-GHz radiofrequency radiation (RFR) on DNA damage and repair induced by doxorubicin in human B-cell lymphoblastoid cells. Mutat Res. 695(1-2):16-21, 2010. (GT, IA)

In the present in vitro study, a comet assay was used to determine whether 1.8-GHz radiofrequency radiation (RFR, SAR of 2W/kg) can influence DNA repair in human B-cell lymphoblastoid cells exposed to doxorubicin (DOX) at the doses of 0microg/ml, 0.05microg/ml, 0.075microg/ml, 0.10microg/ml, 0.15microg/ml and 0.20microg/ml. The combinative exposures to RFR with DOX were divided into five categories. DNA damage was detected at 0h, 6h, 12h, 18h and 24h after exposure to DOX via the comet assay, and the percent of DNA in the tail (% tail DNA) served as the indicator of DNA damage. The results demonstrated that (1) RFR could not directly induce DNA damage of human B-cell lymphoblastoid cells; (2) DOX could significantly induce DNA damage of human B-cell lymphoblastoid cells with the dose-effect relationship, and there were special repair characteristics of DNA damage induced by DOX; (3)

E-E-E type (exposure to RFR for 2h, then simultaneous exposure to RFR and DOX, and exposure to RFR for 6h, 12h, 18h and 24h after exposure to DOX) combinative exposure could obviously influence DNA repair at 6h and 12h after exposure to DOX for four DOX doses (0.075microg/ml, 0.10microg/ml, 0.15microg/ml and 0.20microg/ml) in human B-cell lymphoblastoid cells.

(NE) Zhijian C, Xiaoxue L, Yezhen L, Deqiang L, Shijie C, Lifen J, Jianlin L, Jiliang H. Influence of 1.8-GHz (GSM) radiofrequency radiation (RFR) on DNA damage and repair induced by X-rays in human leukocytes in vitro. Mutat Res. 677(1-2):100-104, 2009. (GT, IA)

In the present study, the in vitro comet assay was used to determine whether 1.8-GHz radiofrequency radiation (RFR) can influence DNA repair in human leukocytes exposed to X-rays. The specific energy absorption rate (SAR) of 2 W/kg (the current European safety limit) was applied. The leukocytes from four young healthy donors were intermittently exposed to RFR for 24 h (fields on for 5 min, fields off for 10 min), and then irradiated with X-rays at doses of 0.25, 0.5, 1.0 and 2.0 Gy. DNA damage to human leukocytes was detected using the comet assay at 0, 15, 45, 90, 150 and 240 min after exposure to X-rays. Using the comet assay, the percent of DNA in the tail (% tail DNA) served as the indicator of DNA damage; the DNA repair percentage (DRP) served as the indicator of the DNA repair speed. The results demonstrated that (1) the DNA repair speeds of human leukocytes after X-ray exposure exhibited individual differences among the four donors; (2) the intermittent exposures of 1.8-GHz RFR at the SAR of 2 W/kg for 24 h did not directly induce DNA damage or exhibit synergistic effects with X-rays on human leukocytes.

(NE) Ziemann C, Brockmeyer H, Reddy SB, Vijayalaxmi, Prihoda TJ, Kuster N, Tillmann T, Dasenbrock C. Absence of genotoxic potential of 902 MHz (GSM) and 1747 MHz (DCS) wireless communication signals: In vivo two-year bioassay in B6C3F1 mice. Int J Radiat Biol. 85(5):454-464, 2009. (GT, LE)

PURPOSE: The aim of the present investigation was to determine the incidence of micronuclei in peripheral blood erythrocytes of B6C3F1 mice that had been chronically exposed to radiofrequencies (RF) used for mobile communication. MATERIALS AND METHODS: 'Ferris wheels' were used to expose tube-restrained male and female mice to simulated environmental RF signals of the Global System for Mobile Communications (GSM, 902 MHz) or Digital Cellular System (DCS, 1747 MHz). RF signals were applied to the mice for 2 hours/day on 5 days/week for two years, at maximal whole-body-averaged specific absorption rates of 0.4, 1.3, and 4.0 W/kg body weight. Concurrent sham-exposed mice, cage controls, and positive controls injected with mitomycin C were included in this investigation. At necropsy, peripheral blood smears were prepared, and coded slides were stained using May-Grunwald-Giemsa or acridine orange. The incidence of micronuclei was recorded for each mouse in 2000 polychromatic and 2000 normochromatic erythrocytes. RESULTS: There were no significant differences in the frequency of micronuclei between RF-exposed, sham-exposed, and cage control mice, irrespective of the staining/counting method used. Micronuclei were, however, significantly increased in polychromatic erythrocytes of the positive control mice. CONCLUSIONS: In conclusion, the data did not indicate RF-induced genotoxicity in mice after two years of exposure.

Update on genetic effects of extremely-low frequency electromagnetic fields

(NE) Albert GC, McNamee JP, Marro L, Bellier PV, Prato FS, Thomas AW. Assessment of genetic damage in peripheral blood of human volunteers exposed (whole-body) to a 200 muT, 60 Hz magnetic field. Int J Radiat Biol. 85(2):144-152, 2009. (GT, IA)

AIM: To investigate the extent of damage in nucleated cells in peripheral blood of healthy human volunteers exposed to a whole-body 60 Hz, 200 microT magnetic field. **MATERIALS AND METHODS:** In this study, 10 male and 10 female healthy human volunteers received a 4 h whole-body exposure to a 200 microT, 60 Hz magnetic field. In addition, five males and five females were treated in a similar fashion, but were exposed to sham conditions. For each subject, a blood sample was obtained prior to the exposure period and aliquots were used as negative- (pre-exposure) and positive- [1.5 Gray (Gy) (60)Cobalt ((60)Co) gamma-irradiation] controls. At the end of the 4 h exposure period, a second blood sample was obtained. The extent of DNA damage was assessed in peripheral human blood leukocytes from all samples using the alkaline comet assay. To detect possible clastogenic effects, the incidence of micronuclei was assessed in phytohemagglutinin (PHA)-stimulated lymphocytes using the cytokinesis-block micronucleus assay. **RESULTS:** There was no evidence of either increased DNA damage, as indicated by the alkaline comet assay, or increased incidence of micronuclei (MN) in the magnetic field exposed group. However, an in vitro exposure of 1.5 Gy gamma-irradiation caused a significant increase in both DNA damage and MN induction. **CONCLUSIONS:** <u>This study found no evidence that an acute, whole-body exposure to a 200 microT, 60 Hz magnetic field for 4 hours could cause DNA damage in human blood.</u>

(E) Alcaraz M, Olmos E, Alcaraz-Saura M, Achel DG, Castillo J. Effect of long-term 50 Hz magnetic field exposure on the micronucleated polychromatic erythrocytes of mice. Electromagn Biol Med. 2013 Jun 19. [Epub ahead of print] (GT)

Abstract In recent years extremely low-frequency magnetic fields (ELF-EMF) have become widely used in human activities, leading to an increased chance of exposure to ELF-EMF. There are few reports on in vivo mammalian genotoxic effects using micronucleus (MN) assays, which generally have been used as a short-term screening system. We analyzed the possible genotoxic effect induced by long-term exposure (7, 14, 21, 28 d) of a 50 Hz ELM-MF to mice by measuring the increase in frequency of micronucleated polychromatic erythrocyte in their bone marrow (MNPCEs) and we compared it with that induced by 50 cGy of X-rays. Subsequently, we tried to reduce this chromosomal damage by administering four antioxidants substances with radioprotective capacities: dimethyl sulfoxide (DMSO), 6-n-propyl-2-thiouracil (PTU), grape-procyanidins (P) and citrus flavonoids extract (CE). The increase in micronucleated cells was higher in both physical treatments (Control < ELF-EMF ($p < 0.01$) <X-rays ($p > 0.001$)); however,

the antioxidant substances only showed a genoprotective capacity against the damage induced by ionizing radiation (Ci > PTU = DMSO ($p < 0.001$) >P = CE ($p < 0.001$). The 50 Hz ELM-MF increased MNPCEs in mouse bone marrow, expressing a genotoxic capacity. Administration of antioxidant substances with radioprotective capacities known to act through the elimination of free radicals did not diminish the genotoxic effect induced by ELM-MF.

(E) Balamuralikrishnan B, Balachandar V, Kumar SS, Stalin N, Varsha P, Devi SM, Arun M, Manikantan P, Venkatesan C, Sasikala K, Dharwadkar SN. Evaluation of Chromosomal Alteration in Electrical Workers Occupationally Exposed to Low Frequency of Electro Magnetic Field (EMFs) in Coimbatore Population, India. Asian Pac J Cancer Prev. 13(6):2961-2966, 2012. (HU, LE, GT)

Extremely low frequency electromagnetic fields (EMFs) have been classified as possibly carcinogenic to humans by the International Agency for Research on Cancer. An increased number of chromosomal alterations in peripheral lymphocytes are correlated with elevated incidence of cancer. The aim of the present study was to assess occupationally induced chromosomal damage in EMF workers exposed to low levels of radiation. We used conventional metaphase chromosome aberration (CA) analysis and the micronucleus (MN) assay as biological indicators of nonionizing radiation exposure. In the present study totally 70 subjects were selected including 50 exposed and 20 controls. Informed written consent was obtained from all participants and the study was performed in accordance with the Declaration of Helsinki and the approval of the local ethical committee. A higher degree of CA and MN was observed in exposed subjects compared to controls, the frequency of CA being significantly enhanced with long years of exposure ($P<0.05$). Moreover increase in CA and MN with age was noted in both exposed subjects and controls, but was significantly greater in the former. The results of this study demonstrated that a significant induction of cytogenetic damage in peripheral lymphocytes of workers occupationally exposed to EMFs in electric transformer and distribution stations. In conclusion, our findings suggest that EMFs possess genotoxic capability, as measured by CA and MN assays; CA analysis appeared more sensitive than other cytogenetic end-points. It can be concluded that chronic occupational exposure to EMFs may lead to an increased risk of genetic damage among electrical workers.

(E) Belyaev IY, Hillert L, Protopopova M, Tamm C, Malmgren LO, Persson BR, Selivanova G, Harms-Ringdahl M. 915 MHz microwaves and 50 Hz magnetic field affect chromatin conformation and 53BP1 foci in human lymphocytes from hypersensitive and healthy persons. Bioelectromagnetics 26:173-184, 2005. (GT, EH)

We used exposure to microwaves from a global system for mobile communication (GSM) mobile phone (915 MHz, specific absorption rate (SAR) 37 mW/kg) and power frequency magnetic field (50 Hz, 15 muT peak value) to investigate the response of lymphocytes from healthy subjects and from persons reporting hypersensitivity to electromagnetic field (EMF). The hypersensitive and healthy donors were matched by gender and age and the data were

analyzed blind to treatment condition. The changes in chromatin conformation were measured with the method of anomalous viscosity time dependencies (AVTD). 53BP1 protein, which has been shown to colocalize in foci with DNA double strand breaks (DSBs), was analyzed by immunostaining in situ. Exposure at room temperature to either 915 MHz or 50 Hz resulted in significant condensation of chromatin, shown as AVTD changes, which was similar to the effect of heat shock at 41 degrees C. No significant differences in responses between normal and hypersensitive subjects were detected. Neither 915 MHz nor 50 Hz exposure induced 53BP1 foci. On the contrary, a distinct decrease in background level of 53BP1 signaling was observed upon these exposures as well as after heat shock treatments. This decrease correlated with the AVTD data and may indicate decrease in accessibility of 53BP1 to antibodies because of stress-induced chromatin condensation. Apoptosis was determined by morphological changes and by apoptotic fragmentation of DNA as analyzed by pulsed-field gel electrophoresis (PFGE). No apoptosis was induced by exposure to 50 Hz and 915 MHz microwaves. In conclusion, 50 Hz magnetic field and 915 MHz microwaves under specified conditions of exposure induced comparable responses in lymphocytes from healthy and hypersensitive donors that were similar but not identical to stress response induced by heat shock.

(E) Borhani N, Rajaei F, Salehi Z, Javadi A. Analysis of DNA fragmentation in mouse embryos exposed to an extremely low-frequency electromagnetic field. Electromagn Biol Med. 30(4):246-252, 2011. (GT, DE, LE)

Effects of extremely low-frequency electromagnetic fields (ELF-EMFs) on DNA damage in biological systems are still a matter of dispute. The aim of the present study was to investigate the possible effect of electromagnetic field exposure on DNA fragmentation in cells (blastomers) of mouse blastocysts. Eighty female NMRI mice were randomly divided into 2 groups of 40 animals each. The control group was left unexposed whereas the animals in the EMF-group were exposed to a 50-Hz EMF at 0.5 mT 4 h per day, 6 days a week for a duration of 2 weeks. After the 8(th) day of exposure, the female mice in both groups were superovulated (with injections of pregnant mare serum gonadotropin and human chorionic gonadotropin) and then mated overnight. At approximately 4 days after mating (102 h after the human chorionic gonadotropin treatment), blastocysts were obtained by flushing the uterus horns. The mean numbers of pregnant mice, blastocysts after flushing, blastomers within the blastocysts, and the DNA fragmentation index following staining in both groups were compared using statistical methods (SPSS, the Chi-square test, the Student's t-test and the Mann-Whitney U-test, $P < 0.05$). The results showed that the mean number of blastocysts after flushing was significantly decreased in the EMF-group compared to that of the control group ($P < 0.03$). The DNA fragmentation index was significantly increased in the EMF-group compared to control (10.53% vs. 7.14%; $P < 0.001$). However, there was no significant difference in the mean numbers of blastomers and numbers of pregnant mice between the EMF-exposed and control group. Our findings indicate that the EMF exposure in preimplantation stage could have detrimental effects on female mouse fertility and embryo development by decreasing the number of blastocysts and increasing the blastocysts DNA fragmentation.

(E) Bułdak RJ, Polaniak R, Bułdak L, Zwirska-Korczala K, Skonieczna M, Monsiol A, Kukla M, Duława-Bułdak A, Birkner E. Short-term exposure to 50 Hz ELF-EMF alters the cisplatin-induced oxidative response in AT478 murine squamous cell carcinoma cells. Bioelectromagnetics. 2012 Apr 25. doi: 10.1002/bem.21732. [Epub ahead of print] (GT, IA, OX)

The aim of this study was to assess the influence of cisplatin and an extremely low frequency electromagnetic field (ELF-EMF) on antioxidant enzyme activity and the lipid peroxidation ratio, as well as the level of DNA damage and reactive oxygen species (ROS) production in AT478 carcinoma cells. Cells were cultured for 24 and 72 h in culture medium with cisplatin. Additionally, the cells were irradiated with 50 Hz/1 mT ELF-EMF for 16 min using a solenoid as a source of the ELF-EMF. The amount of ROS, superoxide dismutase (SOD) isoenzyme activity, glutathione peroxidase (GSH-Px) activity, DNA damage, and malondialdehyde (MDA) levels were assessed. Cells that were exposed to cisplatin exhibited a significant increase in ROS and antioxidant enzyme activity. The addition of ELF-EMF exposure to cisplatin treatment resulted in decreased ROS levels and antioxidant enzyme activity. A significant reduction in MDA concentrations was observed in all of the study groups, with the greatest decrease associated with treatment by both cisplatin and ELF-EMF. Cisplatin induced the most severe DNA damage; however, when cells were also irradiated with ELF-EMF, less DNA damage occurred. Exposure to ELF-EMF alone resulted in an increase in DNA damage compared to control cells. ELF-EMF lessened the effects of oxidative stress and DNA damage that were induced by cisplatin; however, ELF-EMF alone was a mild oxidative stressor and DNA damage inducer. We speculate that ELF-EMF exerts differential effects depending on the exogenous conditions. This information may be of value for appraising the pathophysiologic consequences of exposure to ELF-EMF.

(E) Calabrò E, Condello S, Magazù S, Ientile, R. Static and 50 Hz electromagnetic fields effects on human neuronal-like cells vibration bands in the mid-infrared region. J Electromagnetic Analysis and Applications 3(2) 69-78, 2011. (GT)

Human neuronal-like cells were exposed to static and 50 Hz electromagnetic fields at the intensities of 2 mT and 1 mT, respectively. The effects of exposure were investigated in the mid-infrared region by means of Fourier self deconvolution spectroscopic analysis. After exposure of 3 hours to static and 50 Hz electromagnetic fields, the vibration bands of CH2 methilene group increased significantly after both exposures, suggesting a relative increase of lipid related to conformational changes in the cell membrane due to electromagnetic fields. In addition, PO2-stretching phosphate bands decreased after both exposures, suggesting that alteration in DNA/RNA can be occurred. In particular, exposure of 3 hours to 50 Hz electromagnetic fields produced significant increases in β-sheet contents in amide I, and around the 1740 cm^{-1} band assigned to non-hydrogen-bonded ester carbonyl stretching mode, that can be related to unfolding processes of proteins structure and cells death. Further exposure up to 18 hours to static magnetic field produced an increase in β-sheet contents as to α-helix components of amide I region, as well.

(E) Celikler S, Aydemir N, Vatan O, Kurtuldu S, Bilaloglu R. A biomonitoring study of genotoxic risk to workers of transformers and distribution line stations. Int J Environ Health Res. 19(6):421-430, 2009. (GT, HU)

A cytogenetic monitoring study was carried out on a group of workers from transformer and distribution line stations in the Bursa province of Turkey, to investigate the genotoxic risk of occupational exposure to extremely low frequency electric (ELF) and magnetic fields (EMF). Cytogenetic analysis, namely chromosomal aberrations (CAs) and micronucleus (MN) tests were performed on a strictly selected group of 55 workers and compared to 17 controls. CA and MN frequencies in electrical workers appeared significantly higher than in controls ($p < 0.001$, 0.05, respectively). The frequency of CA in exposed groups were significantly enhanced with the years of exposure ($p < 0.01$). The effect of smoking on the level of CA and MN was not significant in the control and exposure groups. The results of this study demonstrated that a significant induction of cytogenetic damage in peripheral lymphocytes of workers engaged to occupational exposure to ELMF in electric transformer and distribution stations.

(E) Chen GD, Lu DQ, Jiang H, Xu ZP.[Effects of 50 Hz magnetic fields on gene expression in MCF-7 cells]. Zhejiang Da Xue Xue Bao Yi Xue Ban. 37(1):15-22, 2008. [Article in Chinese] **(GT, GE)**

OBJECTIVE: To investigate whether 50 Hz magnetic fields (MF) can change the gene expression profile in MCF-7 cells and to screen MF responsive genes. **METHODS:** In vitro cultured MCF-7 cells were continuously exposed or sham-exposed to 0.4 mT of 50 Hz MF for 24 hours. Affymetrix Human Genome Genechips (U133A) were applied to analyze gene expression profiles in MF exposed and sham-exposed MCF-7 cells and the data were processed with Genechip data analysis software MAS 5.0 and DMT 3.0. Real-time RT-PCR assay was employed to examine the differentially expressed genes. **RESULT:** Thirty differentially expressed genes were screened with 100 % consistency change calls in the MF exposed MCF-7 cells. Six independent real-time RT-PCR analyses showed that SCNN1A, METTL3 and GPR137B were slightly but statistically significantly changed in MCF-7 cells after exposure to 50 Hz MF ($P<0.05$), while other analyzed genes exhibited slight up-and down-fluctuations in expressions and no increase or decrease in each gene expression reached statistical significance ($P>0.05$). **CONCLUSION:** The present study identified three 50 Hz MF responsive genes in MCF-7 cells and the biological consequences of expression changes in these MF responsive genes need to be further investigated.0.4 mT 50 Hz MF exposure for longer duration might induce DNA double-strand breaks in human lens epithelial cells in vitro.

(NE) Chen G, Lu D, Chiang H, Leszczynski D, Xu Z. Using model organism Saccharomyces cerevisiae to evaluate the effects of ELF-MF and RF-EMF exposure on global gene expression. Bioelectromagnetics. 33(7):550-560, 2012. (GE)

The potential health hazard of exposure to electromagnetic fields (EMF) continues to cause public concern. However, the possibility of biological and health effects of exposure to EMF remains controversial and their biophysical mechanisms are unknown. In the present study, we used Saccharomyces cerevisiae to identify genes responding to extremely low frequency magnetic fields (ELF-MF) and to radiofrequency EMF (RF-EMF) exposures. The yeast cells were exposed for 6 h to either 0.4 mT 50 Hz ELF-MF or 1800 MHz RF-EMF at a specific absorption rate of 4.7 W/kg. Gene expression was analyzed by microarray screening and confirmed using real-time reverse transcription-polymerase chain reaction (RT-PCR). We were unable to confirm microarray-detected changes in three of the ELF-MF responsive candidate genes using RT-PCR ($P > 0.05$). On the other hand, out of the 40 potential RF-EMF responsive genes, only the expressions of structural maintenance of chromosomes 3 (SMC3) and aquaporin 2 (AQY2 (m)) were confirmed, while three other genes, that is, halotolerance protein 9 (HAL9), yet another kinase 1 (YAK1) and one function-unknown gene (open reading frame: YJL171C), showed opposite changes in expression compared to the microarray data ($P < 0.05$). In conclusion, the results of this study suggest that the yeast cells did not alter gene expression in response to 50 Hz ELF-MF and that the response to RF-EMF is limited to only a very small number of genes. The possible biological consequences of the gene expression changes induced by RF-EMF await further investigation.

(E) Cho S, Lee Y, Lee S, Choi YJ, Chung HW. Enhanced cytotoxic and genotoxic effects of gadolinium following ELF-EMF irradiation in human lymphocytes. Drug Chem Toxicol. 2014 Jan 30. [Epub ahead of print] (GT, IA)

Gadolinium (Gd) and its chelated derivatives are widely utilized for various industrial and medical purposes, particularly as a contrast agent for magnetic resonance imaging (MRI). There are many studies of Gd nephrotoxicity and neurotoxicity, whereas research on cyto- and genotoxicity in normal human lymphocytes is scarce. It is important to investigate the effect of extremely low-frequency electromagnetic fields (ELF-EMF) on Gd toxicity, as patients are co-exposed to Gd and ELF-EMF generated by MRI scanners. We investigated the cytotoxicity and genotoixcity of Gd and the possible enhancing effect of ELF-EMF on Gd toxicity in cultured human lymphocytes by performing a micronuclei (MN) assay, trypan blue dye exclusion, single cell gel electrophoresis, and apoptosis analyses using flow cytometry. Isolated lymphocytes were exposed to 0.2-1.2 mM of Gd only or in combination with a 60-Hz ELF-EMF of 0.8-mT field strength. Exposing human lymphocytes to Gd resulted in a concentration- and time-dependent decrease in cell viability and an increase in MN frequency, single strand DNA breakage, apoptotic cell death, and ROS production. ELF-EMF (0.8 mT) exposure also increased cell death, MN frequency, olive tail moment, and apoptosis induced by Gd treatment alone. These results suggest that Gd induces DNA damage and apoptotic cell death in human lymphocytes and that ELF-EMF enhances the cytotoxicity and genotoxicity of Gd.

(E) Cho YH, Jeon HK, Chung HW. Effects of extremely low-frequency electromagnetic fields on delayed chromosomal instability induced by bleomycin in normal human fibroblast cells. J Toxicol Environ Health A. 70(15-16):1252-1258, 2007. (GT, IA)

This study was carried out to examine the interaction of extremely low-frequency electromagnetic fields (ELF-EMF) on delayed chromosomal instability by bleomycin (BLM) in human fibroblast cells. A micronucleus-centromere assay using DNA probes for chromosomes 1 and 4 was performed and a 60-Hz ELF-EMF of 0.8 mT field strength was applied either alone or with BLM throughout the culture period. The frequencies of micronuclei (MN) and aneuploidy were analyzed at 28, 88, and 240 h after treatment with BLM. The coexposure of cells to BLM and ELF-EMF led to a significant increase in the frequencies of MN and aneuploidy compared to the cells treated with BLM alone. No difference was observed between field-exposed and sham-exposed control cells. The frequency of MN induced by BLM was increased at 28 h, and further analysis showed a persistent increase up to 240 h, but the new levels were not significantly different from the level at 28 h. BLM increased the frequencies of aneuploidy at 28, 88, and 240 h, and significantly higher frequency of aneuploidy was observed in the cells analyzed at 240 h compared to the cells examined at 28 h. No interaction of ELF-EMF on delayed chromosomal instability by BLM was observed. Our results suggest that ELF-EMF enhances the cytotoxicity of BLM. BLM might induce delayed chromosomal instability, but no effect of ELF-EMF was observed on the BLM-induced delayed chromosomal instability in fibroblast cells.

(E) Collard JF, Lazar C, Nowé A, Hinsenkamp M. Statistical validation of the acceleration of the differentiation at the expense of the proliferation in human epidermal cells exposed to extremely low frequency electric fields. Prog Biophys Mol Biol. 111(1):37-45, 2013. (GE)

An acceleration of differentiation at the expense of proliferation is observed in our previous publications and in the literature after exposure of various biological models to low frequency and low-amplitude electric and electromagnetic fields. This observation is related with a significant modification of genes expression. We observed and compared over time this modification. This study use microarray data obtained on epidermis cultures harvested from human abdominoplasty exposed to ELF electric fields. This protocol is repeated with samples collected on three different healthy patients. The sampling over time allows comparison of the effect of the stimulus at a given time with the evolution of control group. After 4 days, we observed a significant difference of the genes expression between control (D4C) and stimulated (D4S) ($p < 0.05$). On the control between day 4 and 7, we observed another group of genes with significant difference ($p < 0.05$) in their expression. We identify the common genes between these two groups and we select from them those expressing no difference between stimulate at 4 days (D4S) and control after 7 days (D7C). The same analysis was performed with D4S-D4C-D12C and D7S-D7C-D12C. The lists of genes which follow this pattern show acceleration in their expressions under stimulation appearing on control at a later time. In this list, genes such as DKK1, SPRR3, NDRG4, and CHEK1 are involved in cell proliferation or differentiation. Numerous

other genes are also playing a function in mitosis, cell cycle or in the DNA replication transcription and translation.[1]

(E) Cuccurazzu B, Leone L, Podda MV, Piacentini R, Riccardi E, Ripoli C, Azzena GB, Grassi C. Exposure to extremely low-frequency (50 Hz) electromagnetic fields enhances adult hippocampal neurogenesis in C57BL/6 mice. Exp Neurol. 226(1):173-182, 2010. (LE, GE, DE)

Throughout life, new neurons are continuously generated in the hippocampus, which is therefore a major site of structural plasticity in the adult brain. We recently demonstrated that extremely low-frequency electromagnetic fields (ELFEFs) promote the neuronal differentiation of neural stem cells in vitro by up-regulating Ca(v)1-channel activity. The aim of the present study was to determine whether 50-Hz/1 mT ELFEF stimulation also affects adult hippocampal neurogenesis in vivo, and if so, to identify the molecular mechanisms underlying this action and its functional impact on synaptic plasticity. ELFEF exposure (1 to 7 h/day for 7 days) significantly enhanced neurogenesis in the dentate gyrus (DG) of adult mice, as documented by increased numbers of cells double-labeled for 5-bromo-deoxyuridine (BrdU) and double cortin. Quantitative RT-PCR analysis of hippocampal extracts revealed significant ELFEF exposure-induced increases in the transcription of pro-neuronal genes (Mash1, NeuroD2, Hes1) and genes encoding Ca(v)1.2 channel α(1C) subunits. Increased expression of NeuroD1, NeuroD2 and Ca(v)1 channels was also documented by Western blot analysis. Immunofluorescence experiments showed that, 30 days after ELFEF stimulation, roughly half of the newly generated immature neurons had survived and become mature dentate granule cells (as shown by their immunoreactivity for both BrdU and NeuN) and were integrated into the granule cell layer of the DG. Electrophysiological experiments demonstrated that the new mature neurons influenced hippocampal synaptic plasticity, as reflected by increased long-term potentiation. Our findings show that ELFEF exposure can be an effective tool for increasing in vivo neurogenesis, and they could lead to the development of novel therapeutic approaches in regenerative medicine.

(E) Di Campli E, Di Bartolomeo S, Grande R, Di Giulio M, Cellini L. Effects of extremely low-frequency electromagnetic fields on Helicobacter pylori biofilm. Curr Microbiol. 60(6):412-418, 2010. (GE)

The aim of this work was to investigate the effects of exposure to extremely low-frequency electromagnetic fields (ELF-EMF) both on biofilm formation and on mature biofilm of Helicobacter pylori. Bacterial cultures and 2-day-old biofilm of H. pylori ATCC 43629 were exposed to ELF-EMF (50 Hz frequency-1 mT intensity) for 2 days to assess their effect on the cell adhesion and on the mature biofilm detachment, respectively. All the exposed cultures and the respective sham exposed controls were studied for: the cell viability status, the cell morphological analysis, the biofilm mass measurement, the genotypic profile, and the luxS and amiA gene expression. The ELF-EMF acted on the bacterial population during the biofilm formation displaying significant differences in cell viability, as well as, in morphotypes

measured by the prevalence of spiral forms (58.41%) in respect to the controls (33.14%), whereas, on mature biofilm, no significant differences were found when compared to the controls. The measurement of biofilm cell mass was significantly reduced in exposed cultures in both examined experimental conditions. No changes in DNA patterns were recorded, whereas a modulation in amiA gene expression was detected. An exposure to ELF-EMF of H. pylori biofilm induces phenotypic changes on adhering bacteria and decreases the cell adhesion unbalancing the bacterial population therefore reducing the H. pylori capability to protect itself.

(E) Dominici L, Villarini M, Fatigoni C, Monarca S, Moretti M. Genotoxic hazard evaluation in welders occupationally exposed to extremely low-frequency magnetic fields (ELF-MF). Int J Hyg Environ Health. 215(1):68-75, 2011. (GT, HU)

Electric arc welding is known to involve considerable exposure to extremely low-frequency magnetic fields (ELF-MF). A cytogenetic monitoring study was carried out in a group of welders to investigate the genotoxic risk of occupational exposure to ELF-MF. This study assessed individual occupational exposure to ELF-MF using a personal magnetic-field dosimeter, and the cytogenetic effects were examined by comparing micronuclei (MN) and sister chromatid exchange (SCE) frequencies in the lymphocytes of the exposed workers with those of non-exposed control subjects (blood donors) matched for age and smoking habit. Cytogenetic analyses were carried out on 21 workers enrolled from two different welding companies in Central Italy and compared to 21 controls. Some differences between the groups were observed on analysis of SCE and MN, whereas replication indices in the exposed were found not to differ from the controls. In particular, the exposed group showed a significantly higher frequency of MN (group mean±SEM: 6.10±0.39) compared to the control group (4.45±0.30). Moreover, the increase in MN is associated with a proportional increase in ELF-MF exposure levels with a dose-response relationship. A significant decrease in SCE frequency was observed in exposed subjects (3.73±0.21) compared to controls (4.89±0.12). The hypothesis of a correlation between genotoxic assays and ELF-MF exposure value was partially supported, especially as regards MN assay. Since these results are derived from a small-scale pilot study, a larger scale study should be undertaken.

(E) Du XG, Xu SS, Chen Q, Lu DQ, Xu ZP, Zeng QL. [Effects of 50 Hz magnetic fields on DNA double-strand breaks in human lens epithelial cells]. Zhejiang Da Xue Xue Bao Yi Xue Ban. 37(1):9-14, 2008. [Article in Chinese] (GT)

OBJECTIVE: To investigate the effects of 50 Hz magnetic fields (MF) on DNA double-strand breaks in human lens epithelial cells (hLECs). **METHODS:** The cultured human lens epithelial cells were exposed to 0.4 mT 50 Hz MF for 2 h, 6 h, 12 h, 24 h and 48 h. Cells exposed to 4-nitroquinoline-1-oxide, a DNA damage agent, at a final concentration of 0.1 micromol/L for 1 h were used as positive controls.After exposure, cells were fixed with 4 % paraformaldehyde and for H2AX (gamma H2AX) immunofluorescence measurement. gamma H2AX foci were detected at least 200 cells for each sample. Cells were classified as positive when more than three foci per cell were observed. Mean values of foci per cell and percentage of foci positive cells were

adopted as indexes of DNA double-strand breaks. **RESULT:** The mean value of foci per cell and the percentage of gamma H2AX foci positive cells in 50 Hz MF exposure group for 24 h were (2.93 +/-0.43) and (27.88 +/-2.59)%, respectively, which were significantly higher than those of sham-exposure group [(1.77 +/-0.37) and (19.38+/-2.70)%, P <0.05], and the mean value of foci per cell and the percentage of gamma H2AX foci positive cells in 50 Hz MF exposure group for 48 h were (3.14 +/-0.35) and (31.00 +/-3.44)%, which were significantly higher than those of sham-exposure group (P <0.01). However there was no significant difference between 50 Hz MF exposure groups for 2 h, 6 h, 12 h and sham-exposure group for above two indexes (P >0.05). **CONCLUSION:** 0.4 mT 50 Hz MF exposure for longer duration might induce DNA double-strand breaks in human lens epithelial cells in vitro.

(E) El-Bialy NS, Rageh MM. Extremely low-frequency magnetic field enhances the therapeutic efficacy of low-dose cisplatin in the treatment of Ehrlich carcinoma. Biomed Res Int. 2013;2013:189352. doi: 10.1155/2013/189352. Epub 2013 Jan 14. (GT, IA)

The present study examines the therapeutic efficacy of the administration of low-dose cisplatin (cis) followed by exposure to extremely low-frequency magnetic field (ELF-MF), with an average intensity of 10 mT, on Ehrlich carcinoma in vivo. The cytotoxic and genotoxic actions of this combination were studied using comet assay, mitotic index (MI), and the induction of micronucleus (MN). Moreover, the inhibition of tumor growth was also measured. Treatment with cisplatin and ELF-MF (group A) increased the number of damaged cells by 54% compared with 41% for mice treated with cisplatin alone (group B), 20% for mice treated by exposure to ELF-MF (group C), and 9% for the control group (group D). Also the mitotic index decreased significantly for all treated groups (P < 0.001). The decrement percent for the treated groups (A, B, and C) were 70%, 65%, and 22%, respectively, compared with the control group (D). Additionally, the rate of tumor growth at day 12 was suppressed significantly (P < 0.001) for groups A, B, and C with respect to group (D). These results suggest that ELF-MF enhanced the cytotoxic activity of cisplatin and potentiate the benefit of using a combination of low-dose cisplatin and ELF-MF in the treatment of Ehrlich carcinoma.

(E) Erdal N, Gürgül S, Celik A. Cytogenetic effects of extremely low frequency magnetic field on Wistar rat bone marrow. Mutat Res. 630(1-2):69-77, 2007. (GT, LE)

In this study, the genotoxic and cytotoxic potential of extremely low frequency magnetic fields (ELF-MF) was investigated in Wistar rat tibial bone marrow cells, using the chromosomal aberration (CA) and micronucleus (MN) test systems. In addition to these test systems, we also investigated the mitotic index (MI), and the ratio of polychromatic erythrocytes (PCEs) to normochromatic erythrocytes (NCEs). Wistar rats were exposed to acute (1 day for 4h) and long-term (4h/day for 45 days) to a horizontal 50Hz, 1mT uniform magnetic field generated by a Helmholtz coil system. Mitomycin C (MMC, 2mg/kg BW) was used as positive control. Results obtained by chromosome analysis do not show any statistically significant differences between the negative control and both acute and long-term ELF-MF exposed samples. When comparing the group mean CA of long-term exposure with the negative control and acute exposure, the

group mean of the long-term exposed group was higher, but this was not statistically significant. However, the mean micronucleus frequency of the longer-term exposed group was considerably higher than the negative control and acutely exposed groups. This difference was statistically significant ($p<0.01$). The results of the MI in bone marrow showed that the averages of both A-MF and L-MF groups significantly decreased when compared to those in the negative control ($p<0.001$ and $p<0.01$, respectively). No significant differences were found between the group mean MI of A-MF exposure with L-MF. We found that the average of PCEs/NCEs ratios of A-MF exposed group was significantly lower than the negative control and L-MF exposed groups ($p<0.001$ and $p<0.01$, respectively). In addition, the group mean of the PCEs/NCEs ratios of L-MF was significantly lower than negative control ($p<0.01$). We also found that the MMC treated group showed higher the number of CA and the frequency of MN formation when compared to those in all other each groups (p-values of all each groups <0.01) and also MMC treated group showed lower MI and the PCEs/NCEs ratios when compared to those in all other each groups (p-values of all groups <0.01). These observations indicate the in vivo suspectibility of mammals to the genotoxicity potential of ELF-MF.

(E) Fedrowitz M, Löscher W. Gene expression in the mammary gland tissue of female Fischer 344 and Lewis rats after magnetic field exposure (50 Hz, 100 µT) for 2 weeks. Int J Radiat Biol. 88(5):425-429, 2012. (GE, LE) See also: Fedrowitz M, Hass R, Löscher W. Effects of 50 Hz magnetic field exposure on the stress marker α-amylase in the rat mammary gland. Int J Radiat Biol. 88(7):556-564, 2012.

PURPOSE: The issue of whether exposure to environmental power-frequency magnetic fields (MF) has impact on breast cancer development still remains equivocal. Previously, we observedrat strain differences in the MF response of breast tissue, so that the genetic background plays a role in MF effects. The present experiment aimed to elucidate candidate genes involved in MF effects by comparison of MF-susceptible Fischer 344 (F344) rats and MF-insensitive Lewis rats. **MATERIALS AND METHODS:** Female F344 and Lewis rats were exposed to MF (50 Hz, 100 µT) for two weeks, and a whole genome microarray analysis in the mammary gland tissue was performed. **RESULTS:** A remarkably decreased α-amylase gene expression, decreases in carbonic anhydrase 6 and lactoperoxidase, both relevant for pH regulation, and an increased gene expression of cystatin E/M, a tumor suppressor, were observed in MF-exposed F344, but not in Lewis rats. **CONCLUSION:** The MF-exposed F344 breast tissue showed alterations in gene expression, which were absent in Lewis and may therefore be involved in the MF-susceptibility of F344. Notably α-amylase might serve as a promising target to study MF effects, because first experiments indicate that MF exposure alters the functionality of this enzyme in breast tissue.

(E) Focke F, Schuermann D, Kuster N, Schär P. DNA fragmentation in human fibroblasts under extremely low frequency electromagnetic field exposure. Mutat Res. 683(1-2):74-83, 2010. (GT)

Extremely low frequency electromagnetic fields (ELF-EMFs) were reported to affect DNA integrity in human cells with evidence based on the Comet assay. These findings were heavily debated for two main reasons; the lack of reproducibility, and the absence of a plausible scientific rationale for how EMFs could damage DNA. Starting out from a replication of the relevant experiments, we performed this study to clarify the existence and explore origin and nature of ELF-EMF induced DNA effects. Our data confirm that intermittent (but not continuous) exposure of human primary fibroblasts to a 50 Hz EMF at a flux density of 1 mT induces a slight but significant increase of DNA fragmentation in the Comet assay, and we provide first evidence for this to be caused by the magnetic rather than the electric field. Moreover, we show that EMF-induced responses in the Comet assay are dependent on cell proliferation, suggesting that processes of DNA replication rather than the DNA itself may be affected. Consistently, the Comet effects correlated with a reduction of actively replicating cells and a concomitant increase of apoptotic cells in exposed cultures, whereas a combined Fpg-Comet test failed to produce evidence for a notable contribution of oxidative DNA base damage. Hence, ELF-EMF induced effects in the Comet assay are reproducible under specific conditions and can be explained by minor disturbances in S-phase processes and occasional triggering of apoptosis rather than by the generation of DNA damage.

(E) Frisch P, Li GC, McLeod K, Laramee CB. Induction of heat shock gene expression in RAT1 primary fibroblast cells by ELF electric fields. Bioelectromagnetics. 34(5):405-413, 2013. (GE)

Recent studies have demonstrated that the Ku70 gene fragment can be placed in the anti-sense orientation under the control of a heat-inducible heat shock protein 70 (HSP70) promoter and activated through heat shock exposure. This results in attenuation of the Ku70 protein expression, inhibiting cellular repair processes, and sensitizing the transfected cells to exposures such as the ionizing radiation exposures used clinically. However, achieving the tissue temperatures necessary to thermally induce the HSP70 response presents significant limitations to the clinical application of this strategy. Previous findings suggest an alternative approach to inducing a heat shock response, specifically through the use of extremely low frequency (ELF) electrical field stimulation. To further pursue this approach, we investigated HSP70 responses in transfected rat primary fibroblast (RAT1) cells exposed to 10 Hz electric fields at intensities of 20-500 V/m. We confirmed that low frequency electric fields can induce HSP70 heat shock expression, with peak responses obtained at 8 h following a 2 h field exposure. However, the approximate threefold increase in expression is substantially lower than that obtained using thermal stimulation, raising questions of the clinical utility of the response.

(E) Giorgi G, Marcantonio P, Bersani F, Gavoçi E, Del Re B. Effect of extremely low frequency magnetic field exposure on DNA transposition in relation to frequency, wave shape and exposure time. Int J Radiat Biol. 87(6):601-608, 2011. (GT, WS)

PURPOSE: To examine the effect of extremely low frequency magnetic field (ELF-MF) exposure on transposon (Tn) mobility in relation to the exposure time, the frequency and the wave shape

of the field applied. **MATERIALS AND METHODS:** Two Escherichia coli model systems were used: (1) Cells unable to express β-galactosidase (LacZ(-)), containing a mini-transposon Tn10 element able to give ability to express β-galactosidase (LacZ(+)) upon its transposition; therefore in these cells transposition activity can be evaluated by analysing LacZ(+) clones; (2) cells carrying Fertility plasmid (F(+)), and a Tn5 element located on the chromosome; therefore in these cells transposition activity can be estimated by a bacterial conjugation assay. Cells were exposed to sinusoidal (SiMF) or pulsed-square wave (PMF) magnetic fields of various frequencies (20, 50, 75 Hz) and for different exposure times (15 and 90 min). **RESULTS:** Both mini-Tn10 and Tn5 transposition decreased under SiMF and increased under PMF, as compared to sham exposure control. No significant difference was found between frequencies and between exposure times. **CONCLUSIONS:** ELF-MF exposure affects transposition activity and the effects critically depend on the wave shape of the field, but not on the frequency and the exposure time, at least in the range observed.

(E) Heredia-Rojas JA, Rodríguez de la Fuente AO, Alcocer González JM, Rodríguez-Flores LE, Rodríguez-Padilla C, Santoyo-Stephano MA, Castañeda-Garza E, Taméz-Guerra RS. Effect of 60 Hz magnetic fields on the activation of hsp70 promoter in cultured INER-37 and RMA E7 cells. In Vitro Cell Dev Biol Anim. 46(9):758-63, 2010. (GE)

It has been reported that 50-60 Hz magnetic fields (MF) with flux densities ranging from microtesla to millitesla are able to induce heat shock factor or heat shock proteins in various cells. In this study, we investigated the effect of 60 Hz sinusoidal MF at 8 and 80 μT on the expression of the luciferase gene contained in a plasmid labeled as electromagnetic field-plasmid (pEMF). This gene construct contains the specific sequences previously described for the induction of hsp70 expression by MF, as well as the reporter for the luciferase gene. The pEMF vector was transfected into INER-37 and RMA E7 cell lines that were later exposed to either MF or thermal shock (TS). Cells that received the MF or TS treatments and their controls were processed according to the luciferase assay system for evaluate luciferase activity. An increased luciferase gene expression was observed in INER-37 cells exposed to MF and TS compared with controls ($p < 0.05$), but MF exposure had no effect on the RMA E7 cell line.

(NE) Huwiler SG, Beyer C, Fröhlich J, Hennecke H, Egli T, Schürmann D, Rehrauer H, Fischer HM. Genome-wide transcription analysis of Escherichia coli in response to extremely low-frequency magnetic fields. Bioelectromagnetics. 2012 Feb 13. doi: 10.1002/bem.21709. [Epub ahead of print] (GE)

The widespread use of electricity raises the question of whether or not 50 Hz (power line frequency in Europe) magnetic fields (MFs) affect organisms. We investigated the transcription of Escherichia coli K-12 MG1655 in response to extremely low-frequency (ELF) MFs. Fields generated by three signal types (sinusoidal continuous, sinusoidal intermittent, and power line intermittent; all at 50 Hz, 1 mT) were applied and gene expression was monitored at the transcript level using an Affymetrix whole-genome microarray. Bacterial cells were grown continuously in a chemostat (dilution rate D = 0.4 h(-1)) fed with glucose-limited minimal

medium and exposed to 50 Hz MFs with a homogenous flux density of 1 mT. For all three types of MFs investigated, neither bacterial growth (determined using optical density) nor culturable counts were affected. Likewise, no statistically significant change (fold-change > 2, $P \leq 0.01$) in the expression of 4,358 genes and 714 intergenic regions represented on the gene chip was detected after MF exposure for 2.5 h (1.4 generations) or 15 h (8.7 generations). Moreover, short-term exposure (8 min) to the sinusoidal continuous and power line intermittent signal neither affected bacterial growth nor showed evidence for reliable changes in transcription. In conclusion, our experiments did not indicate that the different tested MFs (50 Hz, 1 mT) affected the transcription of E. coli.

(NE) Jin YB, Kang GY, Lee JS, Choi JI, Lee JW, Hong SC, Myung SH, Lee YS. Effects on micronuclei formation of 60-Hz electromagnetic field exposure with ionizing radiation, hydrogen peroxide, or c-Myc overexpression. Int J Radiat Biol. 88(4):374-380, 2012. (GT, IA)

PURPOSE: Epidemiological studies have demonstrated a possible correlation between exposure to extremely low-frequency magnetic fields (ELF-MF) and cancer. However, this correlation has yet to be definitively confirmed by epidemiological studies. The principal objective of this study was to assess the effects of 60 Hz magnetic fields in a normal cell line system, and particularly in combination with various external factors, via micronucleus (MN) assays. **MATERIALS AND METHODS:** Mouse embryonic fibroblast NIH3T3 cells and human lung fibroblast WI-38 cells were exposed for 4 h to a 60 Hz, 1 mT uniform magnetic field with or without ionizing radiation (IR, 2 Gy), H(2)O(2) (100 µM) and cellular myelocytomatosis oncogene (c-Myc) activation. **RESULTS:** The results obtained showed no significant differences between the cells exposed to ELF-MF alone and the unexposed cells. Moreover, no synergistic effects were observed when ELF-MF was combined with IR, H(2)O(2), and c-Myc activation. **CONCLUSIONS:** Our results demonstrate that ELF-MF did not enhance MN frequency by IR, H(2)O(2) and c-Myc activation.

(NE) Jin YB, Choi SH, Lee JS, Kim JK, Lee JW, Hong SC, Myung SH, Lee YS. Absence of DNA damage after 60-Hz electromagnetic field exposure combined with ionizing radiation, hydrogen peroxide, or c-Myc overexpression. Radiat Environ Biophys. 2013 Dec 5. [Epub ahead of print] (GT, IA)

The principal objective of this study was to assess the DNA damage in a normal cell line system after exposure to 60 Hz of extremely low frequency magnetic field (ELF-MF) and particularly in combination with various external factors, via comet assays. NIH3T3 mouse fibroblast cells, WI-38 human lung fibroblast cells, L132 human lung epithelial cells, and MCF10A human mammary gland epithelial cells were exposed for 4 or 16 h to a 60-Hz, 1 mT uniform magnetic field in the presence or absence of ionizing radiation (IR, 1 Gy), H_2O_2 (50 µM), or c-Myc oncogenic activation. The results obtained showed no significant differences between the cells exposed to ELF-MF alone and the unexposed cells. Moreover, no synergistic or additive effects were observed after 4 or 16 h of pre-exposure to 1 mT ELF-MF or simultaneous exposure to ELF-MF combined with IR, H_2O_2, or c-Myc activation.

(E) Jouni FJ, Abdolmaleki P, Ghanati F. Oxidative stress in broad bean (Vicia faba L.) induced by static magnetic field under natural radioactivity. Mutat Res. 741(1-2):116-121, 2012. (LE, GT, OX, IA)

The investigation was performed to evaluate the influence of the static magnetic field on oxidative stress in Vicia faba cultivated in soil from high background natural radioactivity in Iran. Soil samples were collected from Ramsar, Iran where the annual radiation absorbed dose from background radiation is substantially higher than 20 mSv/year. The soil samples were then divided into 2 separate groups including high and low natural radioactivity. The plants were continuously exposed to static magnetic field of 15 mT for 8 days, each 8h/day. The results showed that in the plants cultivated in soils with high background natural radioactivity and low background natural radioactivity the activity of antioxidant enzymes as well as flavonoid content were lower than those of the control. Treatment of plants with static magnetic field showed similar results in terms of lowering of antioxidant defense system and increase of peroxidation of membrane lipids. Accumulation of ROS also resulted in chromosomal aberration and DNA damage. This phenomenon was more pronounced when a combination of natural radiation and treatment with static magnetic field was applied. The results suggest that exposure to static magnetic field causes accumulation of reactive oxygen species in V. faba and natural radioactivity of soil exaggerates oxidative stress.

(E) Kim J, Ha CS, Lee HJ, Song K. Repetitive exposure to a 60-Hz time-varying magnetic field induces DNA double-strand breaks and apoptosis in human cells. Biochem Biophys Res Commun. 400(4):739-744, 2010. (GT)

We investigated the effects of extremely low frequency time-varying magnetic fields (MFs) on human normal and cancer cells. Whereas a single exposure to a 60-Hz time-varying MF of 6 mT for 30min showed no effect, repetitive exposure decreased cell viability. This decrease was accompanied by phosphorylation of γ-H2AX, a common DNA double-strand break (DSB) marker, and checkpoint kinase 2 (Chk2), which is critical to the DNA damage checkpoint pathway. In addition, repetitive exposure to a time-varying MF of 6 mT for 30 min every 24 h for 3 days led to p38 activation and induction of apoptosis in cancer and normal cells. Therefore, these results demonstrate that repetitive exposure to MF with extremely low frequency can induce DNA DSBs and apoptosis through p38 activation. These results also suggest the need for further evaluation of the effects of repetitive exposure to environmental time-varying MFs on human health.

(E) Kim J, Yoon Y, Yun S, Park GS, Lee HJ, Song K. Time-varying magnetic fields of 60 Hz at 7 mT induce DNA double-strand breaks and activate DNA damage checkpoints without apoptosis. Bioelectromagnetics. 33(5):383-393, 2012. (GT, WS)

The potential genotoxic effect of a time-varying magnetic field (MF) on human cells was investigated. Upon continuous exposure of human primary fibroblast and cervical cancer cells to a 60 Hz MF at 7 mT for 10-60 min, no significant change in cell viability was observed.

However, deoxyribonucleic acid (DNA) double-strand breaks (DSBs) were detected, and the DNA damage checkpoint pathway was activated in these cells without programmed cell death (called apoptosis). The exposure of human cells to a 60 Hz MF did not induce intracellular reactive oxygen species (ROS) production, suggesting that the observed DNA DSBs are not directly caused by ROS. We also compared the position and time dependency of DNA DSBs with numerical simulation of MFs. The Lorentz force and eddy currents in these experiments were numerically calculated to investigate the influence of each factor on DNA DSBs. The DNA DSBs mainly occurred at the central region, where the MF was strongest, after a 30-min exposure. After 90 min, however, the amount of DNA DSBs increased rapidly in the outer regions, where the eddy current and Lorentz force were strong.

(NE) Kirschenlohr H, Ellis P, Hesketh R, Metcalfe J. Gene Expression Profiles in White Blood Cells of Volunteers Exposed to a 50 Hz Electromagnetic Field. Radiat Res. 178(3): 138-149, 2012. (GE, HU)

Consistent and independently replicated laboratory evidence to support a causative relationship between environmental exposure to extremely low-frequency electromagnetic fields (EMFs) at power line frequencies and the associated increase in risk of childhood leukemia has not been obtained. In particular, although gene expression responses have been reported in a wide variety of cells, none has emerged as robust, widely replicated effects. DNA microarrays facilitate comprehensive searches for changes in gene expression without a requirement to select candidate responsive genes. To determine if gene expression changes occur in white blood cells of volunteers exposed to an ELF-EMF, each of 17 pairs of male volunteers age 20-30 was subjected either to a 50 Hz EMF exposure of 62.0 ± 7.1 μT for 2 h or to a sham exposure (0.21 ± 0.05 μT) at the same time (11:00 a.m. to 13:00 p.m.). The alternative regime for each volunteer was repeated on the following day and the two-day sequence was repeated 6 days later, with the exception that a null exposure (0.085 ± 0.01 μT) replaced the sham exposure. Five blood samples (10 ml) were collected at 2 h intervals from 9:00 to 17:00 with five additional samples during the exposure and sham or null exposure periods on each study day. RNA samples were pooled for the same time on each study day for the group of 17 volunteers that were subjected to the ELF-EMF exposure/sham or null exposure sequence and were analyzed on Illumina microarrays. Time courses for 16 mammalian genes previously reported to be responsive to ELF-EMF exposure, including immediate early genes, stress response, cell proliferation and apoptotic genes were examined in detail. No genes or gene sets showed consistent response profiles to repeated ELF-EMF exposures. A stress response was detected as a transient increase in plasma cortisol at the onset of either exposure or sham exposure on the first study day. The cortisol response diminished progressively on subsequent exposures or sham exposures, and was attributable to mild stress associated with the experimental protocol.

(E) Koyama S, Sakurai T, Nakahara T, Miyakoshi J. Extremely low frequency (ELF) magnetic fields enhance chemically induced formation of apurinic/apyrimidinic (AP) sites in A172 cells. Int J Radiat Biol. 84(1):53-59, 2008. (GT, IA)

PURPOSE: To detect the effects of extremely low frequency (ELF) magnetic fields, the number of apurinic/apyrimidinic (AP) sites in human glioma A172 cells was measured following exposure to ELF magnetic fields. **MATERIALS AND METHODS:** The cells were exposed to an ELF magnetic field alone, to genotoxic agents (methyl methane sulfonate (MMS) and hydrogen peroxide (H2O2)) alone, or to an ELF magnetic field with the genotoxic agents. After exposure, DNA was extracted, and the number of AP sites was measured. **RESULTS:** There was no difference in the number of AP sites between cells exposed to an ELF magnetic field and sham controls. With MMS or H2O2 alone, the number of AP sites increased with longer treatment times. Exposure to an ELF magnetic field in combination with the genotoxic agents increased AP-site levels compared with the genotoxic agents alone. **CONCLUSIONS:** Our results suggest that the number of AP sites induced by MMS or H2O2 is enhanced by exposure to ELF magnetic fields at 5 millitesla (mT). This may occur because such exposure can enhance the activity or lengthen the lifetime of radical pairs.

(E) Lee JW, Kim MS, Kim YJ, Choi YJ, Lee Y, Chung HW. Genotoxic effects of 3 T magnetic resonance imaging in cultured human lymphocytes. Bioelectromagnetics. 32(7):535-542, 2011. (GT)

The clinical and preclinical use of high-field intensity (HF, 3 T and above) magnetic resonance imaging (MRI) scanners have significantly increased in the past few years. However, potential health risks are implied in the MRI and especially HF MRI environment due to high-static magnetic fields, fast gradient magnetic fields, and strong radiofrequency electromagnetic fields. In this study, the genotoxic potential of 3 T clinical MRI scans in cultured human lymphocytes in vitro was investigated by analyzing chromosome aberrations (CA), micronuclei (MN), and single-cell gel electrophoresis. Human lymphocytes were exposed to electromagnetic fields generated during MRI scanning (clinical routine brain examination protocols: three-channel head coil) for 22, 45, 67, and 89 min. We observed a significant increase in the frequency of single-strand DNA breaks following exposure to a 3 T MRI. In addition, the frequency of both CAs and MN in exposed cells increased in a time-dependent manner. The frequencies of MN in lymphocytes exposed to complex electromagnetic fields for 0, 22, 45, 67, and 89 min were 9.67, 11.67, 14.67, 18.00, and 20.33 per 1000 cells, respectively. Similarly, the frequencies of CAs in lymphocytes exposed for 0, 45, 67, and 89 min were 1.33, 2.33, 3.67, and 4.67 per 200 cells, respectively. These results suggest that exposure to 3 T MRI induces genotoxic effects in human lymphocytes.

(E) Leone L, Fusco S, Mastrodonato A, Piacentini R, Barbati SA, Zaffina S, Pani G, Podda MV, Grassi C. Epigenetic Modulation of Adult Hippocampal Neurogenesis by Extremely Low-Frequency Electromagnetic Fields. Mol Neurobiol. 2014 Feb 16. [Epub ahead of print] (GE)

Throughout life, adult neurogenesis generates new neurons in the dentate gyrus of hippocampus that have a critical role in memory formation. Strategies able to stimulate this endogenous process have raised considerable interest because of their potential use to treat neurological disorders entailing cognitive impairment. We previously reported that mice

exposed to extremely low-frequency electromagnetic fields (ELFEFs) showed increased hippocampal neurogenesis. Here, we demonstrate that the ELFEF-dependent enhancement of hippocampal neurogenesis improves spatial learning and memory. To gain insights on the molecular mechanisms underlying ELFEFs' effects, we extended our studies to an in vitro model of neural stem cells (NSCs) isolated from the hippocampi of newborn mice. We found that ELFEFs enhanced proliferation and neuronal differentiation of hippocampal NSCs by regulation of epigenetic mechanisms leading to pro-neuronal gene expression. Upon ELFEF stimulation of NSCs, we observed a significant enhancement of expression of the pro-proliferative gene hairy enhancer of split 1 and the neuronal determination genes NeuroD1 and Neurogenin1. These events were preceded by increased acetylation of H3K9 and binding of the phosphorylated transcription factor cAMP response element-binding protein (CREB) on the regulatory sequence of these genes. Such ELFEF-dependent epigenetic modifications were prevented by the Ca_v1-channel blocker nifedipine, and were associated with increased occupancy of CREB-binding protein (CBP) to the same loci within the analyzed promoters. Our results unravel the molecular mechanisms underlying the ELFEFs' ability to improve endogenous neurogenesis, pointing to histone acetylation-related chromatin remodeling as a critical determinant. These findings could pave the way to the development of novel therapeutic approaches in regenerative medicine.

(E) Li SS, Zhang ZY, Yang CJ, Lian HY, Cai P. Gene expression and reproductive abilities of male Drosophila melanogaster subjected to ELF-EMF exposure. Mutat Res. 758(1-2):95-103, 2013. (GE, LE, RP)

Extremely low frequency electromagnetic field (ELF-EMF) exposure is attracting increased attention as a possible disease-inducing factor. The in vivo effects of short-term and long-term ELF-EMF exposure on male Drosophila melanogaster were studied using transcriptomic analysis for preliminary screening and QRT-PCR for further verification. Transcriptomic analysis indicated that 439 genes were up-regulated and 874 genes were down-regulated following short-term exposures and that 514 genes were up-regulated and 1206 genes were down-regulated following long-term exposures (expression >2- or <0.5-fold, respectively). In addition, there are 238 up-regulated genes and 598 down-regulated genes in the intersection of short-term and long-term exposure (expression >2- or <0.5-fold). The DEGs (differentially expressed genes) in D. melanogaster following short-term exposures were involved in metabolic processes, cytoskeletal organization, mitotic spindle organization, cell death, protein modification and proteolysis. Long-term exposure let to changes in expression of genes involved in metabolic processes, response to stress, mitotic spindle organization, aging, cell death and cellular respiration. In the intersection of short-term and long-term exposure, a series of DEGs were related to apoptosis, aging, immunological stress and reproduction. To check the ELF-EMF effects on reproduction, some experiments on male reproduction ability were performed. Their results indicated that short-term ELF-EMF exposure may decrease the reproductive ability of males, but long-term exposures had no effect on reproductive ability. Down-regulation of ark gene in the exposed males suggests that the decrease in reproductive capacity may be induced by the effects of ELF-EMF exposure on spermatogenesis through the

caspase pathway. QRT-PCR analysis confirmed that jra, ark and decay genes were down regulated in males exposed for 1 Generation (1G) and 72 h, which suggests that apoptosis may be inhibited in vivo. ELF-EMF exposure may have accelerated cell senescence, as suggested by the down-regulation of both cat and jra genes and the up-regulation of hsp22 gene. Up-regulation of totA and hsp22 genes during exposure suggests that exposed flies might induce an in vivo immune response to counter the adverse effects encountered during ELF-EMF exposure. Down-regulation of cat genes suggests that the partial oxidative protection system might be restrained, especially during short-term exposures. This study demonstrates the bioeffects of ELF-EMF exposure and provides evidence for understanding the in vivo mechanisms of ELF-EMF exposure on male D. melanogaster.

(E) Lupke M, Frahm J, Lantow M, Maercker C, Remondini D, Bersani F, Simkó M. Gene expression analysis of ELF-MF exposed human monocytes indicating the involvement of the alternative activation pathway. Biochim Biophys Acta. 1763(4):402-12, 2006. (GE)

This study focused on the cell activating capacity of extremely low frequency magnetic fields (ELF-MF) on human umbilical cord blood-derived monocytes. Our results confirm the previous findings of cell activating capacity of ELF-MF (1.0 mT) in human monocytes, which was detected as an increased ROS release. Furthermore, gene expression profiling (whole-genome cDNA array Human Unigene RZPD-2) was performed to achieve a comprehensive view of involved genes during the cell activation process after 45 min ELF-MF exposure. Our results indicate the alteration of 986 genes involved in metabolism, cellular physiological processes, signal transduction and immune response. Significant regulations could be analyzed for 5 genes (expression >2- or <0.5-fold): IL15RA (Interleukin 15 receptor, alpha chain), EPS15R (Epidermal growth factor receptor pathway substrate 15 - like 1), DNMT3A (Hypothetical protein MGC16121), DNMT3A (DNA (cytosine-5) methyltransferase 3 alpha), and one gene with no match to known genes, DKFZP586J1624. Real-time RT-PCR analysis of the kinetic of the expression of IL15RA, and IL10RA during 45 min ELF-MF exposure indicates the regulation of cell activation via the alternative pathway, whereas the delayed gene expression of FOS, IL2RA and the melatonin synthesizing enzyme HIOMT suggests the suppression of inflammatory processes. Accordingly, we suggest that ELF-MF activates human monocytes via the alternative pathway.

(E) Luukkonen J, Liimatainen A, Höytö A, Juutilainen J, Naarala J. Pre-exposure to 50 Hz magnetic fields modifies menadione-induced genotoxic effects in human SH-SY5Y neuroblastoma cells. PLoS One. 2011 Mar 23;6(3):e18021. (GT, IA)

BACKGROUND: Extremely low frequency (ELF) magnetic fields (MF) are generated by power lines and various electric appliances. They have been classified as possibly carcinogenic by the International Agency for Research on Cancer, but a mechanistic explanation for carcinogenic effects is lacking. A previous study in our laboratory showed that pre-exposure to ELF MF altered cancer-relevant cellular responses (cell cycle arrest, apoptosis) to menadione-induced DNA damage, but it did not include endpoints measuring actual genetic damage. In the present

study, we examined whether pre-exposure to ELF MF affects chemically induced DNA damage level, DNA repair rate, or micronucleus frequency in human SH-SY5Y neuroblastoma cells. **METHODOLOGY/PRINCIPAL FINDINGS:** Exposure to 50 Hz MF was conducted at 100 µT for 24 hours, followed by chemical exposure for 3 hours. The chemicals used for inducing DNA damage and subsequent micronucleus formation were menadione and methyl methanesulphonate (MMS). Pre-treatment with MF enhanced menadione-induced DNA damage, DNA repair rate, and micronucleus formation in human SH-SY5Y neuroblastoma cells. Although the results with MMS indicated similar effects, the differences were not statistically significant. No effects were observed after MF exposure alone. **CONCLUSIONS:** The results confirm our previous findings showing that pre-exposure to MFs as low as 100 µT alters cellular responses to menadione, and show that increased genotoxicity results from such interaction. The present findings also indicate that complementary data at several chronological points may be critical for understanding the MF effects on DNA damage, repair, and post-repair integrity of the genome.

(E) Luukkonen J, Liimatainen A, Juutilainen J, Naarala J. Induction of genomic instability, oxidative processes, and mitochondrial activity by 50Hz magnetic fields in human SH-SY5Y neuroblastoma cells. Mutat Res. 760:33-41, 2014. (GT, OX, IA)

Epidemiological studies have suggested that exposure to 50Hz magnetic fields (MF) increases the risk of childhood leukemia, but there is no mechanistic explanation for carcinogenic effects. In two previous studies we have observed that a 24-h pre-exposure to MF alters cellular responses to menadione-induced DNA damage. The aim of this study was to investigate the cellular changes that must occur already during the first 24h of exposure to MF, and to explore whether the MF-induced changes in DNA damage response can lead to genomic instability in the progeny of the exposed cells. In order to answer these questions, human SH-SY5Y neuroblastoma cells were exposed to a 50-Hz, 100-µT MF for 24h, followed by 3-h exposure to menadione. The main finding was that MF exposure was associated with increased level of micronuclei, used as an indicator of induced genomic instability, at 8 and 15d after the exposures. Other delayed effects in MF-exposed cells included increased mitochondrial activity at 8d, and increased reactive oxygen species (ROS) production and lipid peroxidation at 15d after the exposures. Oxidative processes (ROS production, reduced glutathione level, and mitochondrial superoxide level) were affected by MF immediately after the exposure. In conclusion, the present results suggest that MF exposure disturbs oxidative balance immediately after the exposure, which might explain our previous findings on MF altered cellular responses to menadione-induced DNA damage. Persistently elevated levels of micronuclei were found in the progeny of MF-exposed cells, indicating induction of genomic instability.

(E) Ma Q, Deng P, Zhu G, Liu C, Zhang L, Zhou Z, Luo X, Li M, Zhong M, Yu Z, Chen C, Zhang Y. Extremely low-frequency electromagnetic fields affect transcript levels of neuronal

differentiation-related genes in embryonic neural stem cells. PLoS One. 2014 Mar 3;9(3):e90041. doi: 10.1371/journal.pone.0090041. eCollection 2014. (GE)

Previous studies have reported that extremely low-frequency electromagnetic fields (ELF-EMF) can affect the processes of brain development, but the underlying mechanism is largely unknown. The proliferation and differentiation of embryonic neural stem cells (eNSCs) is essential for brain development during the gestation period. To date, there is no report about the effects of ELF-EMF on eNSCs. In this paper, we studied the effects of ELF-EMF on the proliferation and differentiation of eNSCs. Primary cultured eNSCs were treated with 50 Hz ELF-EMF; various magnetic intensities and exposure times were applied. Our data showed that there was no significant change in cell proliferation, which was evaluated by cell viability (CCK-8 assay), DNA synthesis (Edu incorporation), average diameter of neurospheres, cell cycle distribution (flow cytometry) and transcript levels of cell cycle related genes (P53, P21 and GADD45 detected by real-time PCR). When eNSCs were induced to differentiation, real-time PCR results showed a down-regulation of Sox2 and up-regulation of Math1, Math3, Ngn1 and Tuj1 mRNA levels after 50 Hz ELF-EMF exposure (2 mT for 3 days), but the percentages of neurons (Tuj1 positive cells) and astrocytes (GFAP positive cells) were not altered when detected by immunofluorescence assay. Although cell proliferation and the percentages of neurons and astrocytes differentiated from eNSCs were not affected by 50 Hz ELF-EMF, the expression of genes regulating neuronal differentiation was altered. In conclusion, our results support that 50 Hz ELF-EMF induce molecular changes during eNSCs differentiation, which might be compensated by post-transcriptional mechanisms to support cellular homeostasis.

(E) Mairs RJ, Hughes K, Fitzsimmons S, Prise KM, Livingstone A, Wilson L, Baig N, Clark AM, Timpson A, Patel G, Folkard M, Angerson WJ, Boyd M. Microsatellite analysis for determination of the mutagenicity of extremely low-frequency electromagnetic fields and ionising radiation in vitro. Mutat Res. 626(1-2):34-41, 2007. (GT, IA)

Extremely low-frequency electromagnetic fields (ELF-EMF) have been reported to induce lesions in DNA and to enhance the mutagenicity of ionising radiation. However, the significance of these findings is uncertain because the determination of the carcinogenic potential of EMFs has largely been based on investigations of large chromosomal aberrations. Using a more sensitive method of detecting DNA damage involving microsatellite sequences, we observed that exposure of UVW human glioma cells to ELF-EMF alone at a field strength of 1 mT (50 Hz) for 12 h gave rise to 0.011 mutations/locus/cell. This was equivalent to a 3.75-fold increase in mutation induction compared with unexposed controls. Furthermore, ELF-EMF increased the mutagenic capacity of 0.3 and 3 Gy gamma-irradiation by factors of 2.6 and 2.75, respectively. These results suggest not only that ELF-EMF is mutagenic as a single agent but also that it can potentiate the mutagenicity of ionising radiation. Treatment with 0.3 Gy induced more than 10 times more mutations per unit dose than irradiation with 3 Gy, indicating hypermutability at low dose.

(E) Mariucci G, Villarini M, Moretti M, Taha E, Conte C, Minelli A, Aristei C, Ambrosini MV.

Brain DNA damage and 70-kDa heat shock protein expression in CD1 mice exposed to extremely low frequency magnetic fields. Int J Radiat Biol. 86(8):701-710, 2010. (GT, LE)

PURPOSE: The question of whether exposure to extremely low frequency magnetic fields (ELF-MF), may contribute to cerebral cancer and neurodegeneration is of current interest. In this study we investigated whether exposure to ELF-MF (50 Hz-1 mT) harms cerebral DNA and induces expression of 70-kDa heat shock protein (hsp70). **MATERIALS AND METHODS:** CD1 mice were exposed to a MF (50 Hz-1 mT) for 1 or 7 days (15 h/day) and sacrificed either at the end of exposure or after 24 h. Unexposed and sham-exposed mice were used as controls. Mouse brains were dissected into cerebral cortex-striatum, hippocampus and cerebellum to evaluate primary DNA damage and hsp70 gene expression. Food intake, weight gain, and motor activity were also evaluated. **RESULTS:** An increase in primary DNA damage was detected in all cerebral areas of the exposed mice sacrificed at the end of exposure, as compared to controls. DNA damage, as can be evaluated by the comet assay, appeared to be repaired in mice sacrificed 24 h after a 7-day exposure. Neither a short (15 h) nor long (7 days) MF-exposure induced hsp70 expression, metabolic and behavioural changes. **CONCLUSIONS:** These results indicate that in vivo ELF-MF induce reversible brain DNA damage while they do not elicit the stress response.

(E) Markkanen A, Juutilainen J, Naarala J. Pre-exposure to 50 Hz magnetic fields modifies menadione-induced DNA damage response in murine L929 cells. Int J Radiat Biol. 84(9):742-751, 2008. (IA)

PURPOSE: Effects on DNA damage response were investigated in murine L929 cells exposed to 50 Hz magnetic fields (MF) with or without ultraviolet B (UVB, wavelength 280-320 nm) radiation or menadione (MQ). **MATERIALS AND METHODS:** Cells were exposed to MF at 100 or 300 microT combined with MQ (150 microM, 1 hour) or UVB radiation (160 J/m(2)) using various exposure schedules. The samples were stained with propidium iodide (PI) and analysed by flow cytometer for cell cycle stages. Apoptotic cells were defined as sub G(1) events. **RESULTS:** In cells first exposed to 100 microT MF for 24 h, the response to subsequent MQ treatment was significantly altered so that the proportion of sub G(1) cells was decreased and the proportion of cells in the G(2)/M phase was increased. When a 300 microT MF was used, also the proportion of cells in the G(1) phase was decreased. MF exposures after MQ treatment did not alter responses to MQ. No effects were found from MF exposure alone or from MF combined with UVB radiation. **CONCLUSIONS:** The results strengthen previous findings suggesting that pre-exposure to MF can alter cellular responses to other agents, and indicate that MF as low as 100 microT has measurable impacts on cancer-relevant cellular processes such as DNA-damage.

(NE) Mizuno K, Narita E, Yamada M, Shinohara N, Miyakoshi J. ELF magnetic fields do not affect cell survival and DNA damage induced by ultraviolet B. Bioelectromagnetics. 35(2):108-115, 2014. (GT, IA)

We investigated whether extremely low frequency (ELF) magnetic field exposure has modification effects on cell survival after ultraviolet B (UV-B) irradiation and on repair process of DNA damage induced by UV-B irradiation in WI38VA13 subcloned 2RA and XP2OS(SV) cells. The ELF magnetic field exposure was conducted using a Helmholtz coil-based system that was designed to generate a sinusoidal magnetic field at 5 mT and 60 Hz. Cell survival was assessed by WST assay after UV-B irradiation at 20-80 J/m(2) , ELF magnetic field exposure for 24 h, followed by incubation for 48 h. DNA damage was assessed by quantification of cyclobutane pyrimidine dimer formation and 6-4 photoproduct formation using ELISA after UV-B irradiation at 20-80 J/m(2) followed by ELF magnetic field exposure for 24 h. No significant changes were observed in cell survival between ELF magnetic field and sham exposures. Similarly, DNA damage induced by UV-B irradiation did not change significantly following ELF magnetic field exposure. Our results suggest that ELF magnetic field exposure at 5 mT does not have modification effect on cell survival after UV-B irradiation and on repair process of DNA damage induced by UV-B irradiation.

(E) Nikolova T, Czyz J, Rolletschek A, Blyszczuk P, Fuchs J, Jovtchev G, Schuderer J, Kuster N, Wobus AM. Electromagnetic fields affect transcript levels of apoptosis-related genes in embryonic stem cell-derived neural progenitor cells. ASEB J 19(12):1686-1688, 2005. (GT, GE)

Mouse embryonic stem (ES) cells were used as an experimental model to study the effects of electromagnetic fields (EMF). ES-derived nestin-positive neural progenitor cells were exposed to extremely low frequency EMF simulating power line magnetic fields at 50 Hz (ELF-EMF) and to radiofrequency EMF simulating the Global System for Mobile Communication (GSM) signals at 1.71 GHz (RF-EMF). Following EMF exposure, cells were analyzed for transcript levels of cell cycle regulatory, apoptosis-related, and neural-specific genes and proteins; changes in proliferation; apoptosis; and cytogenetic effects. Quantitative RT-PCR analysis revealed that ELF-EMF exposure to ES-derived neural cells significantly affected transcript levels of the apoptosis-related bcl-2, bax, and cell cycle regulatory "growth arrest DNA damage inducible" GADD45 genes, whereas mRNA levels of neural-specific genes were not affected. RF-EMF exposure of neural progenitor cells resulted in down-regulation of neural-specific Nurr1 and in up-regulation of bax and GADD45 mRNA levels. Short-term RF-EMF exposure for 6 h, but not for 48 h, resulted in a low and transient increase of DNA double-strand breaks. No effects of ELF- and RF-EMF on mitochondrial function, nuclear apoptosis, cell proliferation, and chromosomal alterations were observed. We may conclude that EMF exposure of ES-derived neural progenitor cells transiently affects the transcript level of genes related to apoptosis and cell cycle control. However, these responses are not associated with detectable changes of cell physiology, suggesting compensatory mechanisms at the translational and posttranslational level.

(NE) Okudan N, Celik I, Salbacak A, Cicekcibasi AE, Buyukmumcu M, Gökbel H. Effects of long-term 50 Hz magnetic field exposure on the micro nucleated polychromatic erythrocyte and blood lymphocyte frequency and argyrophilic nucleolar organizer regions in lymphocytes of mice. Neuro Endocrinol Lett. 31(2):208-214, 2010. (GT)

OBJECTIVES: We aimed to investigate the effects of weak extremely low frequency electromagnetic fields (ELF-EMFs) on the nucleus size, the silver staining nucleolar organizer regions (AgNORs), the frequency of micro nucleated peripheral blood lymphocytes (MPBLs) and the micro nucleated polychromatic erythrocytes (MPCEs).**METHODS:** One hundred and twenty Swiss albino mice were equally divided into 6 groups. The study groups were exposed to 1, 2, 3, 4 and 5 microT 50 Hz-EMFs for 40 days. Micronucleus number (MN) per PBL was determined. **RESULTS:** ELF-EMF exposure caused a nonlinear decline of nucleus area. A sharp drop occurred in AgNOR area of 1 microT group, and following it gained an insignificantly higher level than that of the control group. The field did not change mean AgNOR numbers per nucleus of the groups. Relative AgNOR area had the highest level in 1 microT-exposure group, and the level was quite similar to that of the 5 microT-exposure group. The remaining groups had significantly lower values quite similar to that of the control level. The field exposure at any intensity did not affect significantly the frequency of either MPBLs or MPCEs. The number of MN per PBL in the 4 and 5 microT-exposure groups were significantly higher than those of the lower intensity exposure groups. The males in 4 microT-exposure group displayed the highest MN number per PBL, whereas values changed in a nonlinear manner. **CONCLUSIONS:** The results of the present study suggest that </=5 microT intensities of 50 Hz EMFs did not cause genotoxic effect on the mouse.

(E) Panagopoulos DJ, Karabarbounis A, Lioliousis C. ELF alternating magnetic field decreases reproduction by DNA damage induction. Cell Biochem Biophys. 67(2):703-16, 2013. (LE, GT, RP)

In the present experiments, the effect of 50-Hz alternating magnetic field on Drosophila melanogaster reproduction was studied. Newly eclosed insects were separated into identical groups of ten males and ten females and exposed to three different intensities of the ELF magnetic field (1, 11, and 21 G) continuously during the first 5 days of their adult lives. The reproductive capacity was assessed by the number of F1 pupae according to a well-defined protocol of ours. The magnetic field was found to decrease reproduction by up to 4.3%. The effect increased with increasing field intensities. The decline in reproductive capacity was found to be due to severe DNA damage (DNA fragmentation) and consequent cell death induction in the reproductive cells as determined by the TUNEL assay applied during early and mid-oogenesis (from germarium to stage 10) where physiological apoptosis does not occur. The increase in DNA damage was more significant than the corresponding decrease in reproductive capacity (up to ~7.5%). The TUNEL-positive signal denoting DNA fragmentation was observed exclusively at the two most sensitive developmental stages of oogenesis: the early and mid-oogenesis checkpoints (i.e. region 2a/2b of the germarium and stages 7-8 just before the onset of vitellogenesis)-in contrast to exposure to microwave radiation of earlier work of ours in which the DNA fragmentation was induced at all developmental stages of early and mid-oogenesis. Moreover, the TUNEL-positive signal was observed in all three types of egg chamber cells, mainly in the nurse and follicle cells and also in the oocyte, in agreement with the microwave exposure of our earlier works. According to previous reports, cell death induction in the oocyte was observed only in the case of microwave exposure and not after exposure to

other stress factors as toxic chemicals or food deprivation. Now it is also observed for the first time after ELF magnetic field exposure. Finally, in contrast to microwave exposure of previous experiments of ours in which the germarium checkpoint was found to be more sensitive than stage 7-8, in the magnetic field exposure of the present experiments the mid-oogenesis checkpoint was found to be more sensitive than the germarium.

(E) Rageh MM, El-Gebaly RH, El-Bialy NS. Assessment of genotoxic and cytotoxic hazards in brain and bone marrow cells of newborn rats exposed to extremely low-frequency magnetic field. J Biomed Biotechnol. 2012;2012:716023. (LE, GT, DE, OX)

The present study aimed to evaluate the association between whole body exposure to extremely low frequency magnetic field (ELF-MF) and genotoxic , cytotoxic hazards in brain and bone marrow cells of newborn rats. Newborn rats (10 days after delivery) were exposed continuously to 50 Hz, 0.5 mT for 30 days. The control group was treated as the exposed one with the sole difference that the rats were not exposed to magnetic field. Comet assay was used to quantify the level of DNA damage in isolated brain cells. Also bone marrow cells were flushed out to assess micronucleus induction and mitotic index. Spectrophotometric methods were used to measure the level of malondialdehyde (MDA) and the activity of glutathione (GSH) and superoxide dismutase (SOD). The results showed a significant increase in the mean tail moment indicating DNA damage in exposed group ($P < 0.01$, 0.001, 0.0001). Moreover ELF-MF exposure induced a significant ($P < 0.01$, 0.001) four folds increase in the induction of micronucleus and about three folds increase in mitotic index ($P < 0.0001$). Additionally newborn rats exposed to ELF-MF showed significant higher levels of MDA and SOD ($P < 0.05$). Meanwhile ELF-MF failed to alter the activity of GSH. In conclusion, the present study suggests an association between DNA damage and ELF-MF exposure in newborn rats.

(E) Reyes-Guerrero G, Guzmán C, García DE, Camacho-Arroyo I, Vázquez-García M. Extremely low-frequency electromagnetic fields differentially regulate estrogen receptor-alpha and -beta expression in the rat olfactory bulb. Neurosci Lett. 471(2):109-13, 2010. (GE)

Recently, the effects of extremely low-frequency electromagnetic fields (ELF EMF) on biological systems have been extensively investigated. In this report, the influence of ELF EMF on olfactory bulb (OB) estrogen receptor-alpha (ER alpha) mRNA and -beta (ER beta) mRNA expression was studied by RT-PCR in adult female and male rats. Results reveal for the first time that ELF EMF exerted a biphasic effect on female OB ER beta mRNA gene expression, which increased during diestrous and decreased during estrous. We did not observe any influence of ELF EMF on female OB ER alpha mRNA expression. Our data demonstrate a fluctuating pattern of ER-alpha and -beta mRNA expression in the female OB throughout the phases of the estrous cycle in non-ELF EMF-exposed animals. Thus the highest ER alpha expression was observed in diestrous and the lowest in proestrous. The pattern of ER beta mRNA was less variable, the lowest expression was observed in diestrous. ER-alpha mRNA and -beta mRNA expression level in the male OB did not exhibit any variation either in ELF EMF-exposed or non-ELF EMF-exposed

animals. In summary, ELF EMF modulate ER beta gene expression in the OB of female adult rats but not in males.

(E) Ruiz-Gómez MJ, Sendra-Portero F, Martínez-Morillo M. Effect of 2.45 mT sinusoidal 50 Hz magnetic field on Saccharomyces cerevisiae strains deficient in DNA strand breaks repair. Int J Radiat Biol. 86(7):602-611, 2010. (GT)

PURPOSE: To investigate whether extremely-low frequency magnetic field (MF) exposure produce alterations in the growth, cell cycle, survival and DNA damage of wild type (wt) and mutant yeast strains. **MATERIALS AND METHODS:** wt and high affinity DNA binding factor 1 (hdf1), radiation sensitive 52 (rad52), rad52 hdf1 mutant Saccharomyces cerevisiae strains were exposed to 2.45 mT, sinusoidal 50 Hz MF for 96 h. MF was generated by a pair of Helmholtz coils. During this time the growth was monitored by measuring the optical density at 600 nm and cell cycle evolution were analysed by microscopic morphological analysis. Then, yeast survival was assayed by the drop test and DNA was extracted and electrophoresed. **RESULTS:** A significant increase in the growth was observed for rad52 strain (P = 0.005, Analysis of Variance [ANOVA]) and close to significance for rad52 hdf1 strain (P = 0.069, ANOVA). In addition, the surviving fraction values obtained for MF-exposed samples were in all cases less than for the controls, being the P value obtained for the whole set of MF-treated strains close to significance (P = 0.066, Student's t-test). In contrast, the cell cycle evolution and the DNA pattern obtained for wt and the mutant strains were not altered after exposure to MF. **CONCLUSIONS:** The data presented in the current report show that the applied MF (2.45 mT, sinusoidal 50 Hz, 96 h) induces alterations in the growth and survival of S. cerevisiae strains deficient in DNA strand breaks repair. In contrast, the MF treatment does not induce alterations in the cell cycle and does not cause DNA damage.

(E) Sarimov R, Alipov ED, Belyaev IY. Fifty hertz magnetic fields individually affect chromatin conformation in human lymphocytes: dependence on amplitude, temperature, and initial chromatin state. Bioelectromagnetics. 32(7):570-579, 2011. (GT)

Effects of magnetic field (MF) at 50 Hz on chromatin conformation were studied by the method of anomalous viscosity time dependence (AVTD) in human lymphocytes from two healthy donors. MF within the peak amplitude range of 5-20 μT affected chromatin conformation. These MF effects differed significantly between studied donors, and depended on magnetic flux density and initial condensation of chromatin. While the initial state of chromatin was rather stable in one donor during one calendar year of measurements, the initial condensation varied significantly in cells from another donor. Both this variation and the MF effect depended on temperature during exposure. Despite these variations, the general rule was that MF condensed the relaxed chromatin and relaxed the condensed chromatin. Thus, in this study we show that individual effects of 50 Hz MF exposure at peak amplitudes within the range of 5-20 μT may be observed in human lymphocytes in dependence on the initial state of chromatin and temperature.

(E) Tiwari R, Lakshmi NK, Bhargava SC, Ahuja YR. Epinephrine, DNA integrity and oxidative stress in workers exposed to extremely low-frequency electromagnetic fields (ELF-EMFs) at 132 kV substations. Electromagn Biol Med. 2014 Jan 24. [Epub ahead of print] (LE, GT, HU, OX)

There is apprehension about widespread use of electrical and electromagnetic gadgets which are supposed to emit electromagnetic radiations. Reports are controversy. These electromagnetic fields (EMFs) have considerable effect on endocrine system of exposed subjects. This study was focused to assess the possible bioeffects of extremely low-frequency (ELF)-EMFs on epinephrine level, DNA damage and oxidative stress in subjects occupationally exposed to 132 kV high-voltage substations. The blood sample of 142 exposed subjects and 151 non-exposed individuals was analyzed. Plasma epinephrine was measured by enzyme-linked immunosorbent assay, DNA damage was studied by alkaline comet assay along with oxidative stress. Epinephrine levels of sub-groups showed mean concentration of 75.22 ± 1.46, 64.43 ± 8.26 and 48.47 ± 4.97 for high, medium and low exposed groups, respectively. DNA damage ranged between 1.69 µm and 9.91 µm. The oxidative stress levels showed significant increase. The individuals employed in the live-line procedures were found to be vulnerable for EM stress with altered epinephrine concentrations, DNA damage and increased oxidative stress.

(E) Udroiu I, Cristaldi M, Ieradi LA, Bedini A, Giuliani L, Tanzarella C. Clastogenicity and aneuploidy in newborn and adult mice exposed to 50 Hz magnetic fields. Int J Radiat Biol. 82(8):561-567, 2006. (GT, DE, LE)

PURPOSE: To detect possible clastogenic and aneugenic properties of a 50 Hz, 650 muT magnetic field. **MATERIALS AND METHODS:** The micronucleus test with CREST (Calcinosis, Raynaud's phenomenon, Esophageal dismotility, Sclerodactility, Telangectasia) antibody staining was performed on liver and peripheral blood sampled from newborn mice exposed to an ELF (Extremely Low Frequency) magnetic field during the whole intra-uterine life (21 days), and on bone marrow and peripheral blood sampled from adult mice exposed to the same magnetic field for the same period. **RESULTS:** Data obtained in newborn mice show a significant increase in micronuclei frequencies. In absolute terms, most of the induced micronuclei were CREST-negative (i.e., formed by a chromosome fragment). However, in relative terms, ELF exposure caused a two-fold increase in CREST-negative micronuclei and a four-fold increase in CREST-positive micronuclei (i.e., formed by a whole chromosome). No significant effect was recorded on exposed adults. **CONCLUSIONS:** These findings suggest the need for investigation of aneugenic properties of ELF magnetic fields in order to establish a possible relationship to carcinogenesis.

(NE) Verschaeve L, Anthonissen R, Grudniewska M, Wudarski J, Gevaert L, Maes A. Genotoxicity investigation of ELF-magnetic fields in Salmonella typhimurium with the sensitive SOS-based VITOTOX test. Bioelectromagnetics. 32(7):580-584, 2011. (GT, IA)

We performed a genotoxicity investigation of extremely low-frequency (ELF) magnetic fields (MFs, 50 Hz, 100 and 500 µT, 1 and 2 h exposure) alone and in combination with known chemical mutagens using the VITOTOX test. This test is a very sensitive reporter assay of Salmonella typhimurium bacteria based on the SOS response. Our study showed that ELF-MFs do not induce SOS-based mutagenicity in S. typhimurium bacteria and do not show any synergetic effect when combined with chemical mutagens.

(E) Villarini M, Ambrosini MV, Moretti M, Dominici L, Taha E, Piobbico D, Gambelunghe C, Mariucci G. Brain hsp70 expression and DNA damage in mice exposed to extremely low frequency magnetic fields: a dose-response study. Int J Radiat Biol. 89(7):562-570, 2013. (LE, GT)

Purpose: To determine whether a dose-response relationship exists among exposure to extremely low frequency magnetic fields (ELF-MF) at different densities and 70-kDa heat shock protein (hsp70) expression and DNA damage in mouse brain. Materials and Methods: Male CD1 mice were exposed to ELF-MF (50 Hz; 0.1, 0.2, 1 or 2 mT) for 7 days (15 hours/day) and sacrificed either at the end of exposure or after 24 h. Hsp70 expression was determined in cerebral cortex-striatum, hippocampus and cerebellum by real-time reverse-transcriptase polymerase chain reaction (RT-PCR) and western blot analysis. Primary DNA damage was evaluated in the same tissues by comet assay. Sham-exposed mice were used as controls. Results: No changes in both hsp70 mRNA and corresponding protein occurred following exposure to ELF-MF, except for a weak increase in the mRNA in hippocampus of exposed mice to 0.1 mT ELF-MF. Only mice exposed to 1 or 2 mT and sacrificed immediately after exposure presented DNA strand breaks higher than controls in all the cerebral areas; such DNA breakage reverted to baseline in the mice sacrificed 24 h after exposure. Conclusions: These data show that high density ELF-MF only induce reversible brain DNA damage while they do not affect hsp70 expression.

(E) Wahab MA, Podd JV, Rapley BI, Rowland RE. Elevated sister chromatid exchange frequencies in dividing human peripheral blood lymphocytes exposed to 50 Hz magnetic fields. Bioelectromagnetics. 28(4):281-288, 2007. (GT, WS)

The in vitro cytomolecular technique, sister chromatid exchange (SCE), was applied to test the clastogenic potentiality of extremely low frequency (ELF) electromagnetic fields (EMFs) on human peripheral blood lymphocytes (HPBLs). SCE frequencies were scored in dividing peripheral blood lymphocytes (PBLs) from six healthy male blood donors in two rounds of experiments, R1 and R2, to determine reproducibility. Lymphocyte cultures in the eight experiments conducted in each round were exposed to 50 Hz sinusoidal (continuous or pulsed) or square (continuous or pulsed) MFs at field strengths of 1 microT or 1 mT for 72 h. A significant increase in the number of SCEs/cell in the grouped experimental conditions compared to the controls was observed in both rounds. The highest SCE frequency in R1 was 10.03 for a square continuous field, and 10.39 for a square continuous field was the second

highest frequency in R2. DNA crosslinking at the replication fork is proposed as a model which could explain the mechanistic link between ELF EMF exposure and increased SCE frequency.

(E) Wang Z, Sarje A, Che PL, Yarema KJ. Moderate strength (0.23-0.28 T) static magnetic fields (SMF) modulate signaling and differentiation in human embryonic cells. BMC Genomics. 10:356, 2009. (GE)

BACKGROUND: Compelling evidence exists that magnetic fields modulate living systems. To date, however rigorous studies have focused on identifying the molecular-level biosensor (e.g., radical ion pairs or membranes) or on the behavior of whole animals leaving a gap in understanding how molecular effects are translated into tissue-wide and organism-level responses. This study begins to bridge this gulf by investigating static magnetic fields (SMF) through global mRNA profiling in human embryonic cells coupled with software analysis to identify the affected signaling pathways. **RESULTS:** Software analysis of gene expression in cells exposed to 0.23-0.28 T SMF showed that nine signaling networks responded to SMF; of these, detailed biochemical validation was performed for the network linked to the inflammatory cytokine IL-6. We found the short-term (<24 h) activation of IL-6 involved the coordinate up-regulation of toll-like receptor-4 (TLR4) with complementary changes to NEU3 and ST3GAL5 that reduced ganglioside GM3 in a manner that augmented the activation of TLR4 and IL-6. Loss of GM3 also provided a plausible mechanism for the attenuation of cellular responses to SMF that occurred over longer exposure periods. Finally, SMF-mediated responses were manifest at the cellular level as morphological changes and biochemical markers indicative of pre-oligodendrocyte differentiation. **CONCLUSION:** This study provides a framework describing how magnetic exposure is transduced from a plausible molecular biosensor (lipid membranes) to cell-level responses that include differentiation toward neural lineages. In addition, SMF provided a stimulus that uncovered new relationships - that exist even in the absence of magnetic fields - between gangliosides, the time-dependent regulation of IL-6 signaling by these glycosphingolipids, and the fate of embryonic cells.

(NE) Williams PA, Ingebretsen RJ, Dawson RJ. 14.6 mT ELF magnetic field exposure yields no DNA breaks in model system Salmonella, but provides evidence of heat stress protection. Bioelectromagnetics. 27(6):445-450, 2006. (GT)

In this study, we demonstrate that common extremely low frequency magnetic field (MF) exposure does not cause DNA breaks in this Salmonella test system. The data does, however, provide evidence that MF exposure induces protection from heat stress. Bacterial cultures were exposed to MF (14.6 mT 60 Hz field, cycled 5 min on, 10 min off for 4 h) and a temperature-matched control. Double- and single-stranded DNA breaks were assayed using a recombination event counter. After MF or control exposure they were grown on indicator plates from which recombination events can be quantified and the frequency of DNA strand breaks deduced. The effect of MF was also monitored using a recombination-deficient mutant (recA). The results showed no significant increase in recombination events and strand breaks due to MF. Evidence of heat stress protection was determined using a cell viability assay that compared the survival rates of MF exposed and control cells after the administration of a 10 min 53 degrees C heat

stress. The control cells exhibited nine times more cell mortality than the MF exposed cells. This Salmonella system provides many mutants and genetic tools for further investigation of this phenomenon.

(E) Yokus B, Akdag MZ, Dasdag S, Cakir DU, Kizil M. Extremely low frequency magnetic fields cause oxidative DNA damage in rats. Int J Radiat Biol. 84(10):789-795, 2008. (GT)

PURPOSE: To detect the genotoxic effects of extremely low frequency (ELF) -magnetic fields (MF) on oxidative DNA base modifications [8-hydroxyguanine (8-OH-Gua), 2,6-diamino-4-hydroxy-5-formamidopyrimidine (FapyGua) and 4,6-diamino-5-formamidopyrimidine (FapyAde)] in rat leucocytes, measured following exposure to ELF-MF. **MATERIALS AND METHODS:** After exposure to ELF-MF (50 Hz, 100 and 500 microT, for 2 hours/day during 10 months), DNA was extracted, and measurement of DNA lesions was achieved by gas chromatography/mass spectrometry (GC/MS) and liquid chromatography/mass spectrometry (LC/MS). **RESULTS:** Levels of FapyAde, FapyGua and 8OHdG in DNA were increased by both 100 microT and 500 microT ELF-MF as compared to a cage-control and a sham group; however, statistical significance was observed only in the group exposed to 100 microT. **CONCLUSION:** This is the first study to report that ELF-MF exposure generates oxidatively induced DNA base modifications which are mutagenic in mammalian cells, such as FapyGua, FapyAde and 8-OH-Gua, in vivo. This may explain previous studies showing DNA damage and genomic instability. These findings support the hypothesis that chronic exposure to 50-Hz MF may be potentially genotoxic. However, the intensity of ELF-MF has an important influence on the extent of DNA damage.

(E) Yoon HE, Lee JS, Myung SH, Lee YS. Increased γ-H2AX by exposure to a 60-Hz magnetic fields combined with ionizing radiation, but not hydrogen peroxide, in non-tumorigenic human cell lines. Int J Radiat Biol. 2014 Jan 28. [Epub ahead of print] (GT, IA)

Purpose: Genotoxic effects have been considered the gold standard to determine if an environmental factor is a carcinogen, but the currently available data for extremely low frequency time-varying magnetic fields (ELF-MFs) remain controversial. As an environmental stimulus, the effect of ELF-MF on cellular DNA may be subtle. Therefore, a more sensitive method and systematic research strategy are warranted to evaluate genotoxicity. Materials and methods: We investigated the effect of ELF-MFs in combination with ionizing radiation (IR) or H_2O_2 on the DNA damage response of expression of phosphorylated H2AX (γ-H2AX) and production of γ-H2AX foci in non-tumorigenic human cell systems consisting of human lung fibroblast WI38 cells and human lung epithelial L132 cells. Results: Exposure to a 60-Hz, 2 mT ELF-MFs for 6 h produced increased γ-H2AX expression, as well as γ-H2AX foci production, a common DNA double-strand break (DSB) marker. However, exposure to a 1 mT ELF-MFs did not have the same effect. Moreover, 2 mT ELF-MFs exposure potentiated the expression of γ-H2AX and γ-H2AX foci production when combined with IR, but not when combined with H_2O_2. Conclusions: ELF-MFs could affect the DNA damage response and, in combination with different stimuli, provide different effects on γ-H2AX.

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Use of mobile phones and cordless phones is associated with increased risk for glioma and acoustic neuroma

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Abstract

The International Agency for Research on Cancer (IARC) at WHO evaluation of the carcinogenic effect of RF-EMF on humans took place during a 24–31 May 2011 meeting at Lyon in France. The Working Group consisted of 30 scientists and categorised the radiofrequency electromagnetic fields from mobile phones, and from other devices that emit similar non-ionising electromagnetic fields (RF-EMF), as Group 2B, i.e., a 'possible', human carcinogen. The decision on mobile phones was based mainly on the Hardell group of studies from Sweden and the IARC Interphone study. We give an overview of current epidemiological evidence for an increased risk for brain tumours including a meta-analysis of the Hardell group and Interphone results for mobile phone use. Results for cordless phones are lacking in Interphone. The meta-analysis gave for glioma in the most exposed part of the brain, the temporal lobe, odds ratio (OR) = 1.71, 95% confidence interval (CI) = 1.04–2.81 in the ≥10 years (>10 years in the Hardell group) latency group. Ipsilateral mobile phone use ≥1640 h in total gave OR = 2.29, 95% CI = 1.56–3.37. The results for meningioma were OR = 1.25, 95% CI = 0.31–4.98 and OR = 1.35, 95% CI = 0.81–2.23, respectively. Regarding acoustic neuroma ipsilateral mobile phone use in the latency group ≥10 years gave OR = 1.81, 95% CI = 0.73–4.45. For ipsilateral cumulative use ≥1640 h OR = 2.55, 95% CI = 1.50–4.40 was obtained. Also use of cordless phones increased the risk for glioma and acoustic neuroma in the Hardell group studies. Survival of patients with glioma was analysed in the Hardell group studies yielding in the >10 years latency period hazard ratio (HR) = 1.2, 95% CI = 1.002–1.5 for use of wireless phones. This increased HR was based on results for astrocytoma WHO grade IV (glioblastoma multiforme). Decreased HR was found for low-grade astrocytoma, WHO grades I–II, which might be caused by RF-EMF exposure leading to tumour-associated symptoms and earlier detection and surgery with better prognosis. Some studies show increasing incidence of brain tumours whereas other studies do not. It is concluded that one should be careful using incidence data to dismiss results in analytical epidemiology. The IARC carcinogenic classification does not seem to have had any significant impact on governments' perceptions of their responsibilities to protect public health from this widespread source of radiation.

Keywords: Brain tumour; Glioma; Meningioma; Acoustic neuroma; Wireless phones; Incidence; Adolescent risk; CEFALO; Danish cohort

1. Introduction

On 31 May 2011 the International Agency for Research on Cancer (IARC) at WHO categorised the radiofrequency electromagnetic fields (RF-EMF) from mobile phones, and from other devices that emit similar non-ionising electromagnetic fields, as a Group 2B, i.e., a 'possible', human carcinogen [1,2]. Nine years earlier IARC had also classified extremely low frequency (ELF) magnetic field as Group 2B carcinogen [3].

The IARC evaluation of the carcinogenic effect of RF-EMF on humans took place during a 24–31 May 2011 meeting at Lyon in France. The Working Group consisted of 30 scientists representing four areas: 'animal cancer studies', 'epidemiology', 'exposure' and 'mechanistic and other relevant data'. The expert groups initially prepared a written draft prior to the IARC meeting. Further work was done in the expert groups and a final agreement, sentence by sentence, was obtained during plenary sessions with all experts participating.

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The IARC decision on mobile phones was based mainly on two sets of case-control human studies; the Hardell group of studies from Sweden and the IARC Interphone study. Both provided complementary and supportive results on positive associations between two types of brain tumours; glioma and acoustic neuroma, and exposure to RF-EMF from wireless phones.

The final IARC decision was confirmed by voting of 29 scientists (one not present). A large majority of participants voted to classify RF-EMF radiation as 'possibly carcinogenic' to humans, Group 2B. The decision was also based on occupational studies.

In this paper an up-to-date review of the evidence of an association between use of wireless phones and brain tumours is presented. The Nordic countries were among the first countries in the world to widely adopt wireless telecommunications technology. Analogue phones (NMT; Nordic Mobile Telephone System) were introduced in the early 1980s using both 450 and 900 Megahertz (MHz) frequencies. NMT 450 was used in Sweden from 1981 but closed down on 31 December 2007, NMT 900 operated during 1986–2000.

The digital system (GSM; Global System for Mobile Communication) using dual band, 900 and 1800 MHz, started to operate in 1991 and dominates now the market. The third generation of mobile phones, 3G or UMTS (Universal Mobile Telecommunication System), using 1900/2100 MHz RF fields has been introduced worldwide in recent years, in Sweden in 2003. Currently the fourth generation, 4G (Terrestrial 3G), operating at 800/2600 MHz and Trunked Radio Communication (TETRA 380–400 MHz) are being established in Sweden and elsewhere. Nowadays mobile phones are used more than landline phones in Sweden (http://www.pts.se/upload/Rapporter/Tele/2011/sv-telemarknad-halvar-2011-pts-er-2011-21.pdf). Worldwide, an estimate of 5.9 billion mobile phone subscriptions was reported at the end of 2011 by the International Telecommunication Union (ITU; http://www.itu.int/ITU-D/ict/facts/2011/material/ICTFactsFigures2011.pdf). Many users are children and adolescents, which is of special concern regarding potential health effects.

Desktop cordless phones (DECT) have been used in Sweden since 1988, first using analogue 800–900 MHz RF fields, but since early 1990s using a digital 1900 MHz system. The cordless phones are becoming more common than traditional landlines. Also these phones emit RF-EMF radiation similar to that of mobile phones. Thus, it is also necessary to consider the usage of cordless phones along with mobile phones, when human health risks are evaluated. It should be noted that the usual cordless base stations emit RF-EMF continuously. They are often installed in offices close to the person using a cordless phone handset or in homes even in bedrooms next to the head of a sleeping person.

The real increase in use and exposure to electromagnetic fields from wireless phones (mobile phones and cordless phones) in most countries has occurred since the end of the 1990s. When used they emit RF-EMFs. The GSM phones and to a lesser extent the cordless phones emit also ELF-EMF from the battery when used [4,5]. The brain is the main target organ during use of the handheld phone [6]. Thus, fear of an increased risk for brain tumours has dominated the debate during the last one or two decades. While RF-EMFs do not have sufficient energy to break chemical bonds like ionising radiation, at least not directly, they can nevertheless have harmful effects on biological tissues. Plausible biological mechanisms for these effects include impairment of DNA repair mechanisms and epigenetic changes to DNA.

Primary brain tumours (central nervous system; CNS) constitute of a heterogeneous group of neoplasms divided into two major groups; malignant and benign. They are of different histological types depending on tissue of origin with different growth patterns, molecular markers, anatomical localisations, and age and gender distributions. The clinical appearance, treatment and prognosis are quite different depending on tumour type.

Ionising radiation is an established risk factor for primary brain tumours [7], but there are no well-established environmental causes. Higher socio-economic status tends to be related to higher incidence and some rare inherited cancer syndromes account for a small fraction of tumours [7]. Familial aggregation of glioma has been reported. In a large study 77% more glioma cases than expected were reported among family members [8].

The purpose of this article is to give a comprehensive review of the association between use of mobile and cordless phones and brain tumours, primarily based on the results of the major publications in this field. We include the Hardell group papers and the WHO Interphone study [9–11]. Also some additional analyses of the risk for brain tumours based on these results are given. Some early studies not part of these two major study groups are also included. More discussion of the results and responses, agreements and disagreements of the findings for the Hardell group and Interphone studies can be found elsewhere [12]. In addition, this review includes studies published after the IARC evaluation in May 2011.

2. Materials and methods

The PubMed database (www.ncbi.nlm.nih.gov) was used for an up-dated search of published studies in this area using mobile/cellular/cordless telephone and brain tumour/neoplasm/acoustic neuroma/meningioma/glioma as searching terms. Personal knowledge of published studies was also used in order to get as comprehensive a review as possible. All of the authors have long experience in this research area and have published the pioneer studies indicating an association between use of wireless phones and certain types of brain tumours. They represent different supportive areas of competence such as oncology, cancer epidemiology, statistics and physics.

Table 1
Summary of studies on the use of mobile phones and brain tumour risk.

Study	Years; study type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
Hardell et al. [15,16] Sweden	1994–1996; Case-control	20–80 years	Brain tumours ($n = 209$)	78	OR 0.98 (0.69–1.41)	Analogue and digital mobile phone use
				34	OR 1.07 (0.64–1.80)	*Ipsilateral* mobile phone use
				16	OR 1.20 (0.56–2.59)	>10 year latency, analogue mobile phone use
Muscat et al. [17] USA	1994–1998; Case-control	18–80 years	Brain tumours ($n = 469$)	66	OR 0.8 (0.6–1.2)	Mean duration of mobile phone use 2.8 years
			Neuorepithelioma ($n = 35$)	14	OR 2.1 (0.9–4.7)	

2.1. Statistical methods

All analyses in the Hardell group studies were done using StataSE 10.1 (Stata/SE 10.1 for Windows; StataCorp., College Station TX). Odds ratios (OR) and 95% confidence intervals (CI) were calculated using unconditional logistic regression analysis. Further details can be found in the publications.

Meta-analyses were performed on use of mobile phones in the Hardell group [13,14] and Interphone group [9,10] studies. No duplicate data from different articles published by the same group of authors were included. Model was chosen based on test for heterogeneity in the overall ($\geq$10 years and $\geq$1640 h) groups. In the analysis of survival of patients with glioma, Cox proportional hazards model was used to calculate hazard ratios (HR) and corresponding 95% confidence intervals. Follow-up time was counted from the date of diagnosis to the date of death or until May 30, 2012 for living cases.

3. Results

3.1. Brain tumours overall

The first study by Hardell et al. [15,16] included cases and controls during 1994–1996 in parts of Sweden and was the first published study on this issue. Only living cases diagnosed during 1994–1996 were included. Two controls were selected to each case from the Population Registry. In total 209 (90%) of the cases and 425 (91%) of the controls that met the inclusion criteria answered the mailed questionnaire. Overall no association between mobile phone use and brain tumours was found. A slightly increased, but not statistically significant, risk was found for analogue phone (NMT) use and for a latency period greater than 10 years, OR = 1.20, 95% CI = 0.56–2.59, Table 1.

Exposure to the radiation from the phones is generally higher in the temporal lobe, the part of the brain that is near to the ear [6]. For tumours located in the temporal, occipital or temporoparietal lobe areas of the brain an increased risk was found for ipsilateral exposure, that is the telephone was mostly used on the same side of the head as the tumour appeared, yielding OR = 2.42, 95% CI = 0.97–6.05 [16]. This was the first study in the world that indicated an association between use of mobile phones and an increased risk for brain tumours. However, all results were based on low numbers of exposed subjects and different histopathological types of brain tumours so no firm conclusions could be drawn. Furthermore, this first study did not include use of cordless phones.

Muscat et al. [17] studied patients with malignant brain tumours from five different hospitals in USA, Table 1. Controls were hospital patients. Data from 469 (82%) cases and 422 (90%) controls were available. Overall no association was found, OR for handheld cellular phones was 0.8, 95% CI = 0.6–1.2, but the mean duration of use was short, only 2.8 years for cases and 2.7 years for controls. For neuroepithelioma OR = 2.1, 95% CI = 0.9–4.7, was reported. The study was inconclusive since no data were available on long-term users ($\geq$10 years latency period). Some support of an association was obtained since of 41 evaluable tumours, 26 occurred at the side of the head mostly used during calls and 15 on the contralateral side.

3.2. Glioma

Glioma is the most common malignant brain tumour and represents about 60% of all central nervous system tumours. The most common glioma subtype is astrocytoma. Astrocytic tumours are divided in two groups depending on the malignant potential; low-grade (WHO grades I–II) and high-grade (WHO grades III–IV). Low-grade astrocytoma has a relatively favourable prognosis, whereas survival is shorter for patients with high-grade glioma. Glioblastoma multiforme (WHO grade IV) accounts for 60–75% of all astrocytoma. The peak incidence is between 45 and 75 years of age with median survival less than one year [18].

In the study by Hardell et al. [15] analysis of the cases with astrocytoma produced OR = 1.09, 95% CI = 0.64–1.84 ($n = 36$ cases), Table 2. OR increased further for ipsilateral exposure for right sided tumours, OR = 1.30, 95% CI = 0.54–3.13 ($n = 13$ cases), whereas no association was

Table 2
Summary of studies on the use of wireless phones and glioma risk.

Study	Years; study type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
Hardell et al. [15] Sweden	1994–1996; Case-control	20–80 years	Astrocytoma WHO grade I–IV ($n = 94$)	36	OR 1.09 (0.64–1.84)	Analogue and digital mobile phone use
				13	OR 1.30 (0.54–3.13)	*Ipsilateral* mobile phone use, *right* sided tumours
				3	OR 0.35 (0.07–1.81)	*Ipsilateral* mobile phone use, *left* sided tumours
Inskip et al. [19] USA	1994–1998; Case-control	≥18 years	Glioma ($n = 489$)	11	OR 0.6 (0.3–1.4)	≥5 years of mobile phone use
Auvinen et al. [20] Finland	1996; Case-control, register based	20–69 years	Glioma ($n = 198$)	Not given	OR 1.5 (1.0–2.4)	Analogue and digital mobile phone "ever" use
				25	OR 2.1 (1.3–3.4)	Analogue mobile phone "ever" used
				11	OR 2.4 (1.2–5.1)	Analogue mobile phone use, 1–2 years
				11	OR 2.0 (1.0–4.1)	Analogue mobile phone use, >2 years
Hardell et al. [26–28] Carlberg, Hardell [29] Sweden	1997–2003; Case-control	20–80 years	Glioma ($n = 1148$)	123	OR 2.5 (1.8–3.3)	>10 year latency, mobile phone
				57	OR 2.9 (1.8–4.7)	>10 year latency, mobile phone, *ipsilateral*, only living
				50	OR 2.6 (1.7–4.1)	>10 year latency, *mobile phone only*
				45	OR 1.7 (1.1–2.6)	>10 year latency, cordless phone
				20	OR 3.8 (1.8–8.1)	>10 year latency, cordless phone, *ipsilateral*, only living
				9	OR 1.2 (0.5–2.9)	>10 year latency, *cordless phone only*; >5–10 year latency OR 1.9 (1.3–2.9; $n = 55$)
				150	OR 2.1 (1.6–2.8)	>10 year latency, wireless phone (mobile and cordless phone)
			Astrocytoma, high grade ($n = 820$)	102	OR 3.0 (2.1–4.2)	>10 year latency, mobile phone
				47	OR 3.9 (2.3–6.6)	>10 year latency, mobile phone, ipsilateral, only living
				37	OR 2.8 (1.7–4.6)	>10 year latency, *mobile phone only*
				36	OR 2.0 (1.2–3.2)	>10 year latency, cordless phone
				15	OR 5.5 (2.3–13)	>10 year latency, cordless phone, ipsilateral, only living
				6	OR 0.9 (0.3–2.6)	>10 year latency, *cordless phone only*; >5–10 year latency OR 2.4 (1.6–3,7; $n = 44$)
				121	OR 2.5 (1.8–3.4)	>10 year latency, wireless phone (mobile and cordless phone)
Interphone Study Group [9] 13 countries; Australia, Canada, Denmark, Finland, France, UK, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Glioma ($n = 2708$)	1666	OR 0.81 (0.70–0.94)	Regular use of mobile phone in the past ≥1 year

				210	OR 1.40 (1.03–1.89)	Cumulative hours mobile phone ≥1640 h
				78	OR 1.87 (1.09–3.22)	Cumulative hours mobile phone ≥1640 h, tumours in *temporal lobe*
				100	OR 1.96 (1.22–3.16)	Cumulative hours mobile phone ≥1640 h, *ipsilateral* mobile phone use
Interphone Study Group [9] Appendix 2	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Glioma (n = 1211)	460	OR 1.68 (1.16–2.41)	Restricted to *ever regular use* time since start 2–4 years; 1–1.9 years as reference entity
				468	OR 1.54 (1.06–2.22)	Restricted to *ever regular use* time since start 5–9 years; 1–1.9 years as reference entity
				190	OR 2.18 (1.43–3.31)	Restricted to *ever regular use* time since start 10+ years; 1–1.9 years as reference entity
				160	OR 1.82 (1.15–2.89)	Restricted to *ever regular use* ≥1640 h, <5 h as reference entity

seen for astrocytoma in the left hemisphere and ipsilateral exposure, OR = 0.35, 95% CI = 0.07–1.81 (n = 3 cases).

The study by Inskip et al. [19] from USA had few long-term users of mobile phones. Only 11 cases with glioma, 6 with meningioma and 5 with acoustic neuroma had ≥5 years regular use. No subject had ≥10 years use. Of the hospital-based cases 92% participated. The study comprised 489 cases with glioma, 197 with meningioma and 96 with acoustic neuroma, and 799 (86%) hospital-based controls. Proxy interviews were necessary for 16% of the patients with glioma, 8% of the patients with meningioma, 3% of the patients with acoustic neuroma, and 3% of the controls. Overall no statistically significant associations were found, Table 2. Regarding different types of glioma OR = 1.8, 95% CI = 0.7–5.1 was found for anaplastic astrocytoma (WHO grade III). Regarding hospital-based interviews and use of proxy interviews, see discussion below in relation to the Interphone study.

A register based case-control study on brain and salivary gland tumours was performed in Finland [20]. All cases aged 20–69 years diagnosed in 1996 were included; 398 brain tumour cases and 34 salivary gland tumour cases. The duration of mobile phone use was short, for analogue users 2–3 years and for digital users less than one year. No association was found for salivary gland tumours. For glioma OR = 2.1, 95% CI = 1.3–3.4 was calculated for use of analogue phones, but no association was found for digital mobile phones, Table 2. When duration of use of analogue phones was used as a continuous variable an increased risk was found for glioma with OR = 1.2, 95% CI = 1.1–1.5 per year of use.

The Hardell group in Sweden studied the association between use of mobile and cordless phones and brain tumours diagnosed during 1997–2003. First, cases diagnosed during 1 January 1997 to 30 June 2000 were included. These results were published separately [21,22]. This was followed by the next study period, 1 July 2000 to 31 December 2003 [23,24]. The methods were the same including the same inclusion criteria and an identical questionnaire in both studies; see the publications for further details.

Both men and women aged 20–80 years at the time of diagnosis were included and all were alive at the time of inclusion in the study. They were reported from cancer registries with a brain tumour verified by histopathology. The Swedish Population Registry was used for identification of matched controls. The study included use of wireless phones (mobile and cordless phones), as well as asking questions on e.g., occupational exposures. Use of wireless phones was carefully assessed by a self-administered questionnaire supplemented over the phone. The ear that had mostly been used during calls with mobile phone and/or cordless phone was assessed by separate questions; >50% of the time for one side, or equally for both sides. This information was checked during the supplementary phone calls and finally also by a separate letter with good agreement between these three methods.

Tumour localisation for the cases was defined by using medical records including computer tomography (CT) and/or magnetic resonance imaging (MRI). The matched control was assigned the same side as the tumour of the respective case. Use of the wireless phone was defined as ipsilateral (≥50% of the time), or contralateral (<50% of the time) in relation to tumour side. Further details can be found in the publications.

In a review commissioned by the former Swedish Radiation Protection Agency (now called the Swedish Radiation Safety Authority) it was suggested that the exclusion of deceased cases was a source of bias in our studies [25]. As a response to that critique we performed a study on the cases with a malignant brain tumour that had died before inclusion in the case-control studies 1997–2003. These cases represented patients with a poor prognosis, mostly with astrocytoma WHO grade IV (glioblastoma multiforme). Controls were selected from the Death Registry in Sweden.

The study encompassed 464 cases and 464 controls that had died from a malignant disease and 463 controls with other causes of death. Exposure was assessed by a questionnaire sent to the next of kin to each deceased case and control. The questionnaire was similar as in previous studies.

This investigation confirmed the previous results of an association between mobile phones and malignant brain tumours [26].

The Hardell group has previously published pooled analysis of malignant brain tumours diagnosed during the period 1997–2003 [27]. These results were updated including also results for deceased cases with malignant brain tumours [28,29]. The results on use of wireless phones were based on 1251 cases with malignant brain tumour (response rate 85%) and 2438 controls (response rate 84%).

Most cases had glioma ($n = 1148$) so we present in the following results for that type of tumour. Latency was divided in three categories, >1–5 years, >5–10 years, and >10 years from first use of a wireless phone until diagnosis of glioma. Both use of mobile and cordless phone gave an increased risk overall, highest in the latency group >10 years, increasing further for ipsilateral use yielding for mobile phone OR = 2.9, 95% CI = 1.8–4.7 and for cordless phone OR = 3.8, 95% CI = 1.8–8.1, Table 2. Highest ORs were found in the >10 year latency group for total wireless phone use as well, OR = 2.1, 95% CI = 1.6–2.8 or a doubling of glioma risk.

OR increased statistically significant for glioma for cumulative use of wireless phones per 100 h; OR = 1.014, 95% CI = 1.008–1.019, and per year of latency; OR = 1.056, 95% CI = 1.037–1.075 [29]. Separate calculations of mobile phone and cordless phone use yielded similar results with statistically significant increasing risks.

It is common for a person to use both a mobile and a cordless phone. For only use of mobile phone OR increased for glioma with time since first use yielding for >10 years latency OR = 2.6, 95% CI = 1.7–4.1. For only cordless phone use highest risk was obtained in the >5–10 years latency time; OR = 1.9, 95% CI = 1.3–2.9. However, the calculations in the longest latency period were based on few subjects regarding cordless phone.

In Table 2 results are presented for high-grade astrocytoma ($n = 820$). The results are similar as for the whole glioma group. Low-grade glioma is less common and the results in this study were based on 132 cases. Ipsilateral use of mobile phone yielded in total OR = 1.8, 95% CI = 1.02–3.1 ($n = 39$ cases) and cordless phone OR = 1.7, 95% CI = 0.98–3.1 ($n = 34$ cases, data not in Table). Further results and discussion may be found elsewhere [29].

The Interphone study was conducted at 16 research centres in 13 countries during varying time periods between 2000 and 2004. It was an international collaboration on brain tumour risk and mobile phone use conducted under the guidance of IARC. The investigation was initiated by recommendations from several expert groups including one of the authors, Kjell Hansson Mild as a member of the EU group, to study possible health effects of exposure to RF-EMF [30,31]. It should be noted that there was no overlap of cases or controls between the Hardell group studies and the Swedish part of Interphone performed by another research group.

Some of the separate country analyses of the Interphone study produced contradictory results, as we have discussed elsewhere [13,32]. An increased risk for brain tumour was found in some studies and decreased risk in other studies. After several years of delay the overall Interphone results were finally published in May 2010 [9].

The study included 4301 glioma cases and the results were based on 2708 participating cases (response rate 64%, range by centre 36–92%). In total 14,354 potential controls were identified and interviews were completed with 7658 (53%, range 42–74%). The low participation rates in some centres may have created selection bias, see Hardell et al. [32].

Regular use of mobile phone in the past ≥1 year gave for glioma OR = 0.81, 95% CI = 0.70–0.94, Table 2. Subgroup analyses showed statistically significant increased risk in the highest exposure group, i.e., those with cumulative mobile phone use ≥1640 h, which corresponds to about half an hour of use per day for ten years, OR = 1.40, 95% CI = 1.03–1.89. The risk increased further for glioma in the temporal lobe yielding OR = 1.87, 95% CI = 1.09–3.22. In the same exposure category, cumulative use ≥1640 h and ipsilateral exposure produced OR = 1.96, 95% CI = 1.22–3.16 in total (no data given for temporal lobe).

In Appendix 2, available on the web [9] analysis was restricted to ever-regular users of mobile phones in the Interphone study. Cumulative call time ≥1640 h gave OR = 1.82, 95% CI = 1.15–2.89 compared with use <5 h. Time since start of regular use (latency) ≥10 years produced OR = 2.18, 95% CI = 1.43–3.31; reference entity 1–1.9 years.

The Interphone study group concluded: "*However, biases and errors limit the strength of the conclusions we can draw from these analyses and prevent a causal interpretation*." In an editorial accompanying the Interphone results the main conclusion of the Interphone results was described as "*both elegant and oracular. . .(which) tolerates diametrically*

opposite readings" [33]. They also pointed out several methodological reasons why the Interphone results were likely to have underestimated the risks, such as the short latency period since first exposures became widespread; less than 10% of the Interphone cases had more than 10 years exposure. "*None of the today's established carcinogens, including tobacco, could have been firmly identified as increasing risk in the first 10 years or so since first exposure*".

As has pointed our elsewhere [32] there were differences between the Hardell group studies and Interphone. Regarding age group the Hardell group studies included subjects aged 20–80 years, versus 30–59 years in Interphone. Furthermore use of cordless phones was not properly assessed, analysed or reported in Interphone. These differences have been discussed in detail by Hardell et al. [14]. Thus, it could be shown that restricting the age group to 30–59 years and considering subjects that used a cordless phone as unexposed in the Hardell group studies reduced the OR and produced results quite similar to Interphone, Table 3; see also Table 11 as discussed below. Latency time >10 years for glioma in the temporal lobe yielded OR = 1.40, 95% CI = 0.70–2.81 in the Hardell group studies and OR = 1.36, 95% CI = 0.88–2.11 in Interphone (latency ≥10 years). Unfortunately the Interphone study did not give results for glioma in the temporal lobe in the analyses in Appendix 2. Thus, excluding exposure to RF-EMFs from cordless phones as in the Interphone study, as well as excluding the younger and older subjects biased the ORs towards unity, which likely dilutes the ability to see health risks.

Most mobile phone users have not been using one single telephone. It is likely that they have changed their handset several times if they have been using a mobile phone for more than a few years. Many users have also been using different phone systems, such as analogue and digital, and many of them have also been using a cordless phone at home or at work. It is not clear how to combine the use of different phones with different power outputs, systems, frequencies and anatomical specific absorption rate (SAR) distributions into one exposure and dose measure. The difficulties lie in the fact that there is no generally accepted mechanism(s) between the electromagnetic fields emitted from the phone and the biological organism. This includes a mechanism by which RF-EMF exposure produces changes in DNA. The energy level associated with exposure is too low to cause direct DNA strand breaks and DNA cross links. However, DNA damages can be caused by cellular biochemical activities such as free radicals. Several studies indicate that RF-EMFs increase free radical activity in cells, as reviewed by Phillips et al. [34]. This process is probably mediated via the Fenton reaction. It should also be noted that possible biological effects might not have linear dose–response as indicated in some studies [35] and that the effects are depending on the carrier frequencies [36].

The different types of phones have different output power. We applied different weighting factors according to the mean output power of the phones using for analogue phones (NMT) = 1, GSM = 0.1 and cordless phones = 0.01. The cumulative time for use of the different phone types was multiplied with the respective weighting factor added into one score. The median score among the controls was used as the cut-off in the dose–response calculations. We applied this method for the study period 1 January 1997 to 30 June 2000 [21,22]. Somewhat higher ORs were obtained using the weighting factor, especially with a >10-year latency period, compared with calculations based on cumulative use only, but overall the results were similar [37]. This was explained by the fact that most subjects had used an analogue mobile phone with the weighting factor = 1, thus the weighting factor had little impact on the results.

A further issue is that there is a difference in the output power level from mobile phones between urban and rural areas. This is caused by adaptive power control (APC) in the cellular telephone and is regulated by the distance between base stations. Thus, in areas with a long distance between base stations, usually rural areas, the output power level is higher than in more densely populated areas; that is, urban areas, with a shorter distance between base stations. To further explore these circumstances we used the Swedish population register that contains information on present municipality for all residents. The municipalities are classified by Statistics Sweden into so called homogeneity regions, six categories depending on the population density, and the number of inhabitants in the nearest vicinity of the main city in that municipality. Thus, we used these official statistics for grouping of the subjects in urban or rural areas for the study period 1 January 1997 to 30 June 2000. For use of digital mobile phones (GSM) we found a clear effect of urban versus rural areas [38]. Living in rural areas yielded OR = 1.4, 95% CI = 0.98–2.0, increasing to 3.2, 95% CI = 1.2–8.4 with >5 year latency time for digital phones. The corresponding ORs for living in urban areas were 0.9, 95% CI = 0.8–1.2 and 0.9, 95% CI = 0.6–1.4, respectively. This effect was most obvious for malignant brain tumours.

Estimated RF-EMF dose from mobile phone use in the tumour area was associated with an increased risk of glioma in parts of the Interphone study [11]. OR increased with increasing total cumulative dose of specific energy (J/kg) absorbed at the estimated tumour centre for more than 7 years before diagnosis giving OR = 1.91, 95% CI = 1.05–3.47 (p trend = 0.01) in the highest quintile of exposure. A similar study based on less sound methods was later published by another part of the Interphone study group [39]. The results seemed to contradict the findings of Cardis et al. [11]. However, a different, less clear method was used. Only 42 cases had used mobile phone for more than 10 years and no analysis was made of the most exposed group with longest duration of use. Thus, this study is much less informative and less sophisticated than the one by Cardis et al. [11]. It should have been of great value to apply the method by Cardis et al. for the whole Interphone study.

Table 3
Comparison between Hardell group and Interphone using the same age group 30–59 years and excluding use of cordless phones.

Study	Years; study type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
Hardell et al. [14]	1997–2003; Case-control	30–59 years	Glioma ($n = 490$)	56	OR 1.79 (1.19–2.70)	>10 year latency, cordless phone among unexposed, age 30–59 years
				29	OR 1.75 (1.02–3.00)	Cumulative use ≥1640 h, cordless phone among unexposed, age 30–59 years
				20	OR 2.18 (1.09–4.35)	Cumulative use ≥1640 h, cordless phone among unexposed, age 30–59 years, *ipsilateral*
				8	OR 1.48 (0.57–3.87)	Cumulative use ≥1640 h, cordless phone among unexposed, age 30–59 years, *contralateral*
Interphone Study Group [9] 13 countries; Australia, Canada, Denmark, Finland, France, UK, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Glioma ($n = 2708$)	252	OR 0.98 (0.76–1.26)	Regular use of mobile phone in the past ≥1 year, latency ≥10 years
				210	OR 1.40 (1.03–1.89)	Cumulative hours mobile phone ≥1640 h
				100	OR 1.96 (1.22–3.16)	Cumulative hours mobile phone ≥1640 h, *ipsilateral*
				39	OR 1.25 (0.64–2.42)	Cumulative hours mobile phone ≥1640 h, *contralateral*
				160	OR 1.82 (1.15–2.89)	Restricted to *ever regular use* ≥1640 h, <5 h as reference entity, Appendix 2. Results for ipsilateral and contralateral use not reported.

Table 4
Use of mobile phones and glioma risk, meta-analysis of Hardell et al. [14] and Interphone [9]. Numbers of exposed cases (Ca) and controls (Co) are given.

	Hardell et al.		Interphone		Meta-analysis	
	Ca/Co	OR, CI	Ca/Co	OR, CI	Ca/Co	OR, CI
Latency ≥10 years						
-all	88/99	2.26 (1.60–3.19)	252/232	0.98 (0.76–1.26)	340/331	1.48 (0.65–3.35)
-ipsilateral	57/45	2.84 (1.82–4.44)	108/82	1.21 (0.82–1.80)	165/127	1.84 (0.80–4.25)
-contralateral	29/29	2.18 (1.24–3.85)	49/56	0.70 (0.42–1.15)	78/85	1.23 (0.40–3.73)
-temporal lobe	28/99	2.26 (1.32–3.86)	94/69	1.36 (0.88–2.11)	122/168	1.71 (1.04–2.81)
Cumulative use ≥1640 h						
-all	42/43	2.31 (1.44–3.70)	210/154	1.40 (1.03–1.89)	252/197	1.74 (1.07–2.83)
-ipsilateral	29/21	2.94 (1.60–5.41)	100/62	1.96 (1.22–3.16)	129/83	2.29 (1.56–3.37)
-contralateral	12/12	2.10 (0.90–4.90)	39/31	1.25 (0.64–2.42)	51/43	1.52 (0.90–2.57)
-temporal lobe	14/43	2.44 (1.21–4.95)	78/47	1.87 (1.09–3.22)	92/90	2.06 (1.34–3.17)

Random-effects model used for all meta-analyses, based on test for heterogeneity in the overall (≥10 years and ≥1640 h) groups.

3.3. Meta-analysis glioma

We performed a meta-analysis of glioma on use of mobile phones based on Hardell et al. [14] and Interphone Study Group [9]. Random-effects model was used based on test for heterogeneity in the overall (≥10 years and ≥1640 h) groups. The analysis was based on published results in Interphone since we do not have access to their database. Our results were recalculated to these groups of exposure. Thus, results can be found in Table 4 for latency ≥10 years, (>10 years in Hardell et al.), and cumulative use of mobile phone ≥1640 h. The meta-analysis yielded for mobile phone use OR = 1.71, 95% CI = 1.04–2.81 for glioma in the temporal lobe in the ≥10 years latency group. Ipsilateral mobile phone use ≥1640 h in total gave the highest risk, OR = 2.29, 95% CI = 1.56–3.37. Certainly the meta-analysis strengthens a causal association between use of mobile phones and glioma.

3.4. Meningioma

Meningioma is the most common benign brain tumour. It develops from the pia and arachnoid that covers the central nervous system. Meningioma is an encapsulated and well-demarked tumour. It is rarely malignant. More women than men develop meningioma.

In the first study by Hardell et al. [15] only 46 cases had meningioma. No increased risk was found overall; OR = 1.05, 95% CI = 0.49–2.27, Table 5. Only 16 cases had used a mobile phone. There was no pattern of increased risk for ipsilateral use, although the results were based on low numbers.

The US study by Inskip et al. [19] included 197 cases with meningioma. Regular mobile phone use produced OR = 0.8, 95% CI = 0.4–1.3, Table 5. The risk did not increase with average daily use, cumulative use, or duration of regular use. However, results for duration of regular use ≥5 years was based on only 6 exposed cases.

The Finnish register based case-control study on brain tumours by Auvinen et al. [20] included 129 cases with meningioma. Ever use of mobile phone gave OR = 1.1, 95% CI = 0.5–2.4, analogue phone use OR = 1.5, 95% CI = 0.6–3.5, Table 5. As discussed above the study was limited by short latency and exposure based on subscription information.

The Hardell group made a pooled analysis of benign brain tumours from the two case-control studies 1997–2003 as discussed above [40,41]. Regarding meningioma use of mobile phone gave OR = 1.1, 95% CI = 0.9–1.3, and cordless phone OR = 1.1, 95% CI = 0.9–1.4, Table 5. Using >10 year latency period OR increased; for mobile phone to OR = 1.5, 95% CI = 0.98–2.4, and for cordless phone to OR = 1.8, 95% CI = 1.01–3.2. Ipsilateral mobile phone use in the >10 years latency group yielded OR = 1.6, 95% CI = 0.9–2.9, and cordless phone OR = 3.0, 95% CI = 1.3–7.2. These results were based on rather low numbers of exposed cases, however.

In the Interphone study [9] a statistically significant decreased risk was found for meningioma for regular use of mobile phone, OR = 0.79, 95% CI = 0.68–0.91, Table 5. The risk increased somewhat with cumulative use ≥1640 h and ipsilateral mobile phone use to OR = 1.45, 95% CI = 0.80–2.61. The overall pattern of no association did not change if analysis was restricted to tumours in the temporal lobe or only to the group of ever-regular use.

3.5. Meta-analysis meningioma

Similarly as for glioma we performed meta-analysis of meningioma for use of mobile phone on the Hardell group and Interphone results, Table 6. Random-effects model was used in the ≥10 years group based on test for heterogeneity in the overall group. For analyses of ≥1640 h no heterogeneity was found in the heterogeneity test; random- and fixed effects models produced identical results. In summary no statistically significant decreased or increased risks were found. These results support the conclusion that up to latency ≥10 years or cumulative use ≥1640 h there is not a consistent pattern of an association between use of mobile phones and meningioma.

Table 5
Summary of studies on the use of wireless phones and meningioma risk.

Study	Years; study type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
Hardell et al. [15] Sweden	1994–1996; Case-control	20–80 years	Meningioma ($n = 46$)	16	OR 1.05 (0.49–2.27)	Analogue and digital mobile phone use
Inskip et al. [19] USA	1994–1998; Case-control	≥18 years	Meningioma ($n = 197$)	32	OR 0.8 (0.4–1.3)	Regular use
				6	OR 0.9 (0.3–2.7)	≥5 years of mobile phone use
Auvinen et al. [20] Finland	1996; Case-control, register based	20–69 years	Meningioma ($n = 129$)	Not given	OR 1.1 (0.5–2.4)	Analogue and digital mobile phone "ever" use
				8	OR 1.5 (0.6–3.5)	Analogue mobile phone "ever" used
				3	OR 1.6 (0.4–6.1)	Analogue mobile phone use, 1–2 years
				2	OR 1.0 (0.2–4.4)	Analogue mobile phone use, >2 years
Hardell et al. [40], Hardell, Carlberg [41] Sweden	1997–2003; Case-control	20–80 years	Meningioma ($n = 916$)	347	OR 1.1 (0.9–1.3)	>1 year latency, mobile phone use
				38	OR 1.5 (0.98–2.4)	>10 years latency of mobile phone use
				18	OR 1.6 (0.9–2.9)	>10 years latency of ipsilateral mobile phone use
				294	OR 1.1 (0.9–1.4)	>1 year latency, cordless phone use
				23	OR 1.8 (1.01–3.2)	>10 years latency of cordless phone use
				11	OR 3.0 (1.3–7.2)	>10 years latency of ipsilateral cordless phone use
Interphone Study Group [9] 13 countries; Australia, Canada, Denmark, Finland, France, UK, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Meningioma ($n = 2409$)	1262	OR 0.79 (0.68–0.91)	Regular use of mobile phone in the past ≥1 year
				130	OR 1.15 (0.81–1.62)	Cumulative hours mobile phone ≥1640 h
				21	OR 0.94 (0.31–2.86)	Cumulative hours mobile phone ≥1640 h, tumours in *temporal lobe*
				46	OR 1.45 (0.80–2.61)	Cumulative hours mobile phone ≥1640 h, *ipsilateral* mobile phone use
Interphone [9] Appendix 2			Meningioma ($n = 842$)	362	OR 0.90 (0.62–1.31)	Restricted to *ever regular use* time since start 2–4 years; 1–1.9 years as reference entity
				288	OR 0.75 (0.51–1.10)	Restricted to *ever regular use* time since start 5–9 years; 1–1.9 years as reference entity
				76	OR 0.86 (0.51–1.43)	Restricted to *ever regular use* time since start 10+ years; 1–1.9 years as reference entity
				96	OR 1.10 (0.65–1.85)	Restricted to *ever regular use* ≥1640 h, <5 h as reference entity

Table 6
Use of mobile phones and meningioma risk, meta-analysis of Hardell, Carlberg [41] and Interphone [9]. Numbers of exposed cases (Ca) and controls (Co) are given.

	Hardell et al.		Interphone		Meta-analysis	
	Ca/Co	OR, CI	Ca/Co	OR, CI	Ca/Co	OR, CI
Latency ≥10 years						
-all	38/99	1.52 (0.98–2.37)	110/112	0.83 (0.61–1.14)	148/211	1.10 (0.61–1.99)
-ipsilateral	18/45	1.59 (0.86–2.95)	40/42	0.88 (0.52–1.47)	58/87	1.16 (0.65–2.06)
-contralateral	12/29	1.57 (0.75–3.31)	20/25	0.58 (0.29–1.16)	32/54	0.95 (0.36–2.51)
-temporal lobe	10/99	2.46 (1.08–5.60)	12/12	0.60 (0.22–1.62)	22/111	1.25 (0.31–4.98)
Cumulative use ≥1640 h						
-all	10/43	0.85 (0.41–1.75)	130/107	1.15 (0.81–1.62)	140/150	1.09 (0.80–1.49)
-ipsilateral	6/21	1.11 (0.42–2.88)	46/35	1.45 (0.80–2.61)	52/56	1.35 (0.81–2.23)
-contralateral	3/12	0.98 (0.26–3.61)	28/28	0.62 (0.31–1.25)	31/40	0.69 (0.37–1.27)
-temporal lobe	1/43	0.52 (0.07–3.95)	21/14	0.94 (0.31–2.86)	22/57	0.82 (0.31–2.17)

Random-effects model used for meta-analyses of ≥10 years, based on test for heterogeneity in the overall group. For meta-analyses of ≥1640 h no heterogeneity was found; random- and fixed effects models produced identical results.

3.6. Acoustic neuroma

Acoustic neuroma or Vestibular Schwannoma is a benign tumour that is located in the eighth cranial nerve that leads from the inner ear to the brain. This tumour type does not undergo malignant transformation. It tends to be encapsulated and grows in relation to the auditory and vestibular portions of the nerve. It is a slow growing tumour in the auditory canal but grows gradually out into the cerebellopontine angle with potential compression of vital brain stem centres. Tinnitus and hearing problems are usual first symptoms of acoustic neuroma. Although neuroma is a benign tumour it causes persistent disabling symptoms after treatment such as loss of hearing and tinnitus that severely affect the daily life. The eighth cranial nerve is located close to the handheld wireless phone when used, so there is particular concern of an increased risk for neuroma development due to exposure to RF-EMF emissions during use of these devices.

In the first study by Hardell et al. [15] in Sweden only 13 cases had acoustic neuroma. Five cases reported use of mobile phone, only one with ipsilateral use. The numbers were too low to make meaningful interpretation of an association, Table 7.

Inskip et al. [19] included 96 cases with acoustic neuroma in their US case-control study. No increased risk was found for regular use of mobile phone, Table 7. Duration of regular use ≥5 years gave OR = 1.9, 95% CI = 0.6–5.9. This result was based on only 5 exposed cases and there were no results on long-term use. Furthermore only 1 case had cumulative use >500 h.

Muscat et al. [42] presented results from a hospital based case-control study on acoustic neuroma on 90 (100% response rate) patients and 86 (100%) controls. Mobile phone use 1–2 years gave OR = 0.5, 95% CI = 0.2–1.3 ($n = 7$ cases), increasing to OR = 1.7, 95% CI = 0.5–5.1 ($n = 11$ cases), in the group with 3–6 years use, Table 7. Average use among cases was 4.1 years and among controls 2.2 years.

The pooled analysis of the Hardell group studies yielded in total OR = 2.9, 95% CI = 2.0–4.3 for use of analogue mobile phone and OR = 1.5, 95% CI 1.1–2.1 for use of digital mobile phone [40]. Use of mobile phones gave for acoustic neuroma OR = 1.7, 95% CI = 1.2–2.3 increasing to OR = 2.9, 95% CI = 1.6–5.5 with >10 years latency period, Table 7. Ipsilateral use increased the risk further; in the >10 years latency group to OR = 3.0, 95% CI = 1.4–4.2 [41]. Cordless phone use gave OR = 1.5, 95% CI = 1.04–2.0 increasing to OR = 1.7, 95% CI = 1.2–2.5 for ipsilateral use.

A case-case study on acoustic neuroma was conducted in Japan [43]. The cases were identified during 2000–2006 at 22 participating neurosurgery departments. The diagnosis was based on histopathology or CT/MRI imaging. Of 1589 cases 816 (51%) agreed to participate and answered a mailed questionnaire. A total of 787 cases were included in the final analysis. Two datasets were analysed, one consisted of 362 cases without any tumour related symptoms 1 year before diagnosis, and another consisted of 593 cases without any symptoms 5 years before diagnosis. Cases with ipsilateral use were regarded as exposed and those with contralateral use were assumed to be unexposed and were used as the reference category. Overall no increased risk was found. However, for average daily call duration >20 min with reference date 1 year Risk Ratio (RR) = 2.74, 95% CI = 1.18–7.85 was found increasing to RR = 3.08, 95% CI = 1.47–7.41 with reference date 5 years before diagnosis, Table 7. Unfortunately no results were given for cumulative number of hours for use over the years. For cordless phones no increased risk was found but the analysis was not very informative.

In the Interphone study [10] 1121 (82%) acoustic neuroma cases participated, range 70–100% by centre. Of the controls 7658 (53%) completed the interviews, range 35–74% by centre. The final matched analysis (1:1 or 1:2) consisted of 1105 cases and 2145 controls. Overall no increased risk was found censoring exposure at one year or at 5 years before reference date, OR = 0.85, 95% CI = 0.69–1.04 and OR = 0.95, 95% CI = 0.77–1.17, respectively, Table 7.

Cumulative number of hours of ipsilateral mobile phone use ≥1640 h up to 1 year before reference date gave OR = 2.33, 95% CI = 1.23–4.40 and contralateral use

Table 7
Summary of studies on the use of wireless phones and acoustic neuroma risk.

Study	Years Study Type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
Hardell et al. [15] Sweden	1994–1996; Case-control	20–80 years	Acoustic neuroma ($n = 13$)	5	OR 0.78 (0.14–4.20)	>1 year latency of mobile phone use
Inskip et al. [19] USA	1994–1998; Case-control	≥18 years	Acoustic neuroma ($n = 96$)	22	OR 1.0 (0.5–1.9)	Regular mobile phone use
				5	OR 1.9 (0.6–5.9)	≥5 years of mobile phone use
Muscat et al. [42] USA	1997–1999; Case-control	≥18 years	Acoustic neuroma ($n = 90$)	11	OR 1.7 (0.5–5.1)	3–6 years of mobile phone use
Hardell et al. [40], Hardell, Carlberg [41] Sweden	1997–2003; Case-control	20–80 years	Acoustic neuroma ($n = 243$)	130	OR 1.7 (1.2–2.3)	>1 year latency of mobile phone use
				20	OR 2.9 (1.6–5.5)	>10 years latency of mobile phone use
				13	OR 3.0 (1.4–6.2)	>10 years of *ipsilateral* mobile phone use
				4	OR 1.3 (0.4–3.8)	>10 years latency of cordless phone use
				3	OR 2.3 (0.6–8.8)	>10 years latency of *ipsilateral* cordless phone use
Sato et al. [43] Japan	2000–2006; Case-case	All ages	Acoustic neuroma ($n = 787$)	97	RR 1.08 (0.93–1.28)	Mobile phone, reference date 1 year before diagnosis, *ipsilateral*
				86	RR 1.14 (0.96–1.40)	Mobile phone, reference date 5 years before diagnosis, *ipsilateral*
				18	RR 2.74 (1.18–7.85)	Mobile phone, reference date 1 year before diagnosis, average daily call duration >20 min, *ipsilateral*
				28	RR 3.08 (1.47–7.41)	Mobile phone, reference date 5 years before diagnosis, average daily call duration >20 min, *ipsilateral*
				45	RR 0.93 (0.79–1.14)	Cordless phone, reference date 1 year before diagnosis, *ipsilateral;* mobile phone non-users
				125	RR 1.02 (0.91–1.17)	Cordless phone, reference date 5 years before diagnosis, *ipsilateral;* mobile phone non-users
Interphone Study Group [10] 13 countries; Australia, Canada, Denmark, Finland, France, UK, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Acoustic neuroma ($n = 1105$)	643	OR 0.85 (0.69–1.04)	Mobile phone regular use up to 1 year before reference date

Interphone [10] 13 countries; Australia, Canada, Denmark, Finland, France, UK, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Acoustic neuroma ($n = 1105$)	304	OR 0.95 (0.77–1.17)	Mobile phone regular use up to 5 years before reference date
				77	OR 1.32 (0.88–1.97)	Cumulative hours mobile phone ≥1640 h up to 1 year before reference date
				36	OR 2.79 (1.51–5.16)	Cumulative hours mobile phone ≥1640 h up to 5 years before reference date
				47	OR 2.33 (1.23–4.40)	Cumulative hours mobile phone ≥1640 h up to 1 year before reference date; *ipsilateral* use
				27	OR 3.53 (1.59–7.82)	Cumulative hours mobile phone ≥1640 h up to 5 years before reference date; *ipsilateral* use
				37	OR 1.93 (1.10–3.38)	Cumulative hours mobile phone ≥1640 h in the past start ≥10 years before reference date
				28	OR 3.74 (1.58–8.83)	Cumulative hours mobile phone ≥1640 h in the past start ≥10 years before reference date, *ipsilateral*
				225	OR 1.41 (0.82–2.40)	Restricted to *ever regular use* time since start 2–4 years; 1–1.9 years as reference entity
				209	OR 1.38 (0.80–2.39)	Restricted to *ever regular use* time since start 5–9 years; 1–1.9 years as reference entity
				64	OR 1.08 (0.58–2.04)	Restricted to *ever regular use* time since start 10+ years; 1–1.9 years as reference entity
				72	OR 1.74 (0.90–3.36)	Restricted to *ever regular use* ≥1640 h, <5 h as reference entity

OR = 0.72, 95% CI = 0.34–1.53 for acoustic neuroma, Table 7 [10]. For cumulative number of hours of ipsilateral mobile phone use ≥1640 h up to 5 years before reference date OR = 3.53, 95% CI = 1.59–7.82, and for contralateral use OR = 1.69, 95% CI = 0.43–6.69 were obtained. The risk increased further for cumulative ipsilateral use ≥1640 h with start ≥10 years before reference date to OR = 3.74, 95% CI = 1.58–8.83. Contralateral use in that group yielded OR = 0.48, 95% CI = 0.12–1.94, however based on only 4 exposed cases and 9 exposed controls. Overall OR = 1.93, 95% CI = 1.10–3.38 was obtained for long-term use with start ≥10 years before reference date and cumulative call time ≥1640 h.

Similar analyses of the data as in Appendix 2 for glioma [9], yielded highest OR for acoustic neuroma in the shortest latency group, 2–4 years before reference date, OR = 1.41, 95% CI = 0.82–2.40 [10]. Lower OR was calculated in the ≥10 years group, OR = 1.08, 95% CI = 0.58–2.04. Somewhat higher risk than in total, OR = 1.32, 95% CI = 0.88–1.97, was found for cumulative mobile phone use ≥1640 h; OR = 1.74, 95% CI = 0.90–3.36, in this analysis restricted to only regular users. No results were given for ipsilateral use.

3.7. Meta-analysis acoustic neuroma

Table 8 shows results for use of mobile phone and the association with acoustic neuroma based on results by the Hardell group and Interphone study. Random-effects model was used based on test for heterogeneity in the overall (≥10 years and ≥1640 h) groups. The same exposure groups as in the meta-analyses of glioma and meningioma were used. For the latency group ≥10 years highest risk was obtained for ipsilateral use, OR = 1.81, 95% CI = 0.73–4.45. The risk increased further for cumulative use ≥1640 h yielding OR = 2.55, 95% CI = 1.50–4.40 for ipsilateral use. The meta-analysis strengthens a causal association between use of mobile phones and acoustic neuroma.

3.8. Other types of brain tumours

Results for other types of brain tumours from the Hardell group diagnosed during 1997–2003 included medulloblastoma ($n = 6$), ependymoma ($n = 19$) and other malignant types ($n = 46$). In total using >1 year latency time no statistically significant increased risk was found for mobile phone use, OR = 1.2, 95% CI = 0.7–2.1 for these tumour types grouped together [41]. However, with >10 years latency the risk increased to OR = 3.2, 95% CI = 1.2–8.8 in total; for ipsilateral use OR = 4.1, 95% CI = 1.03–16. For cordless phone use no statistically significant decreased or increased risk was found (data not in Table). For pituitary adenoma ($n = 34$) and other types of benign brain tumours ($n = 62$) no statistically significant associations were found overall. In the >10 year latency group ipsilateral mobile phone use gave OR = 4.7, 95% CI = 1.1–21 for benign tumours other than pituitary adenoma (central location in the brain and not included in these calculations) but based on only 4 exposed cases. Thus, several of the calculations were based on low numbers.

Takebayashi et al. [44] included 102 cases with pituitary adenoma in the Japanese part of Interphone from December 2000 to November 2004. The response rate was 76%; 102 out of 135 cases. Of the individually matched controls 208 (49%) of 421 participated. In the statistical analysis 161 controls were used to 101 cases; one case was excluded since not diagnosed within study period. Regular mobile phone use yielded OR = 0.90, 95% CI = 0.50–1.61. Cumulative length of use in years or cumulative call time in hours produced no pattern of an association and there was no statistically significant trend. The cut off for highest quartile of cumulative use was 560 h producing OR = 1.33, 95% CI = 0.58–3.09 ($n = 21$ cases, 27 controls exposed). Since pituitary adenoma is a centrally located tumour in the pituitary gland in sella turcica there was no laterality analysis.

In parallel with the Interphone study, pituitary tumours were studied in Southeast England using the same protocol [45]. The inclusion period was from December 2000 until February 2005. In total 506 eligible cases were identified. Of them 317 (63%) were interviewed and 291 (58%) included in the final analysis. Eligible controls from patient lists at general practitioners in the study region were 1464 subjects, and 630 (43%) were interviewed. Regular use of mobile phone gave OR = 0.9, 95% CI = 0.7–1.3. No statistically significant trend for the risk was found for lifetime use in years or cumulative use in hours. For ≥10 years since first use and ≥51 h of cumulative use (median number in that category) OR = 1.6, 95% CI = 0.8–3.6 ($n = 16$ cases, 23 controls exposed) was found.

3.9. Risks to children and adolescents

Children have smaller head and thinner skull bone than adults. Their brain tissue has also higher conductivity and these circumstances give higher absorption from RF-EMF than for adults [6,46,47]. The developing brain is more sensitive to toxins [48] and it is still developing until about 20 years of age [49]. Use of wireless phones is widespread among children and adolescents [50,51]. The greater absorption of RF energy per unit of time, the greater sensitivity of their brains, and their longer lifetimes with the risk to develop a brain tumour leaves children at a higher risk than adults from mobile phone radiation.

The Hardell group has published results for different age groups at the time of diagnosis [52] or age at first use of wireless phones [12,13,28]. Three age groups for first use of a wireless phone were used: <20 years, 20–49 years and 50–80 years. Highest risk for glioma was found for first use of mobile phone or cordless phone before the age of 20 years, Table 9. Thus, mobile phone yielded for glioma OR = 3.1, 95% CI = 1.4–6.7 and cordless phone OR 2.6, 95% CI = 1.2–5.5. The risk increased further for ipsilateral mobile phone use in the youngest age group to OR = 4.4,

Table 8
Use of mobile phones and acoustic neuroma risk, meta-analysis of Hardell, Carlberg [41] and Interphone [10]. Numbers of exposed cases (Ca) and controls (Co) are given.

	Hardell et al.		Interphone		Meta-analysis	
	Ca/Co	OR, CI	Ca/Co	OR, CI	Ca/Co	OR, CI
Latency ≥10 years						
-all	20/99	2.93 (1.57–5.46)	68/141	0.76 (0.52–1.11)	88/240	1.46 (0.39–5.47)
-ipsilateral	13/45	2.97 (1.42–6.21)	44/52	1.18 (0.69–2.04)	57/97	1.81 (0.73–4.45)
-contralateral	6/29	2.38 (0.89–6.35)	17/30	0.69 (0.33–1.42)	23/59	1.22 (0.37–4.11)
Cumulative use ≥1640 h						
-all	10/43	2.86 (1.33–6.14)	77/107	1.32 (0.88–1.97)	87/150	1.81 (0.86–3.81)
-ipsilateral	7/21	3.10 (1.21–7.95)	47/46	2.33 (1.23–4.40)	54/67	2.55 (1.50–4.40)
-contralateral	3/12	2.28 (0.60–8.71)	16/26	0.72 (0.34–1.53)	19/38	1.12 (0.37–3.34)

Random-effects model used for all meta-analyses, based on test for heterogeneity in the overall (≥10 years and ≥1640 h) groups.

95% CI = 1.3–15 for mobile phone use and to OR = 4.3, 95% CI = 1.4–13 for cordless phone use.

Also for acoustic neuroma the risk was highest in the youngest age group with OR = 5.0, 95% CI = 1.5–16 for use of mobile phone increasing to OR = 6.8, 95% CI = 1.4–34 for ipsilateral use. Only one case had first use of cordless phone before the age of 20, so no conclusions could be drawn for cordless phones. Regarding meningioma no clear pattern of age-dependent increased risk was seen.

There are few other studies on brain tumour risk for children from use of wireless phones. Mobikids is one study that is on-going. A multi-centre case-control study was conducted in Denmark, Sweden, Norway, and Switzerland, CEFALO [53]. It included children and adolescents aged 7–19 years and has been commented elsewhere in detail since serious methodological problems exist in the study design and interpretation of the results [54].

In CEFALO a statistically non-significant increased risk for brain tumours among regular users (one call per week for at least 6 months) of mobile phones was found; OR = 1.36, 95% CI = 0.92–2.02. This OR increased somewhat with cumulative duration of subscriptions and duration of calls [53]. No data for long-term use were given; the longest latency period was 5 years. Interestingly, further support of a true association was found in the results based on operator-recorded use for 62 cases and 101 controls, which for time since first subscription >2.8 years yielded a statistically significant OR of 2.15, 95% CI = 1.07–4.29, with a statistically significant trend ($p = 0.001$).

Use of cordless phones was not well assessed. The authors stated that such use was covered only in the first 3 years of use. No explanation was given for this most peculiar definition. Wireless phone use was not considered, that is use of both mobile phones and cordless phones as the relevant exposure category, as used by the Hardell group and adopted by IARC [1]. Instead Aydin et al. [53] included use of cordless phones in the 'unexposed' category when risk estimates were calculated for mobile phone use. Similarly, when use of cordless phones was analysed mobile phone use was regarded as 'no exposure'. Thus, an increased risk was potentially concealed.

The authors summarised that they "*did not observe that regular use of a mobile phone increased the risk for brain tumors in children and adolescents*." An editorial in the same journal accompanied that conclusion by stating

Table 9
Odds ratio (OR) and 95% confidence interval (CI) for glioma, meningioma and acoustic neuroma in different age groups for first use of the wireless phone [26–28,40]. Numbers of exposed cases (Ca) and controls (Co) are given. Adjustment was made for age, gender, SEI-code, year of diagnosis. For glioma adjustment was also made for vital status.

	Glioma ($n = 1148$)		Meningioma ($n = 916$)		Acoustic neuroma ($n = 243$)	
	Ca/Co	OR, CI	Ca/Co	OR, CI	Ca/Co	OR, CI
Wireless phone (mobile and cordless phone)	670/1267	1.3 (1.1–1.5)	461/1172	1.0 (0.9–1.2)	155/1172	1.5 (1.1–2.0)
<20 years old	25/27	2.3 (1.3–4.3)	6/27	1.0 (0.4–2.6)	5/27	2.4 (0.8–7.3)
20–49 years old	377/746	1.3 (1.1–1.6)	276/711	1.3 (1.02–1.6)	103/711	1.8 (1.2–2.6)
≥50 years old	268/494	1.3 (1.1–1.6)	179/434	0.9 (0.7–1.2)	47/434	1.3 (0.9–1.9)
Mobile phone	529/963	1.3 (1.1–1.6)	347/900	1.1 (0.9–1.3)	130/900	1.7 (1.2–2.3)
<20 years old	17/14	3.1 (1.4–6.7)	5/14	1.9 (0.6–5.6)	5/14	5.0 (1.5–16)
20–49 years old	315/581	1.4 (1.1–1.7)	210/555	1.3 (0.99–1.6)	86/555	2.0 (1.3–2.9)
≥50 years old	197/368	1.3 (1.01–1.6)	132/331	1.0 (0.8–1.3)	39/331	1.4 (0.9–2.2)
Cordless phone	402/762	1.3 (1.1–1.6)	294/701	1.1 (0.9–1.4)	96/701	1.5 (1.04–2.0)
<20 years old	16/16	2.6 (1.2–5.5)	2/16	0.5 (0.1–2.2)	1/16	0.7 (0.1–5.9)
20–49 years old	206/437	1.2 (0.9–1.5)	167/416	1.3 (0.98–1.6)	65/416	1.7 (1.1–2.5)
≥50 years old	180/309	1.4 (1.1–1.7)	125/269	1.1 (0.8–1.4)	30/269	1.3 (0.8–2.1)

that the study showed "*no increased risk of brain tumors in children and adolescents who are regular cell phone users*" [55]. This was echoed by a news release from the Karolinska Institute in Stockholm claiming that the results of no increased risk were 'reassuring' (http://ki.se/ki/jsp/polopoly.jsp?d=130&a=125250&l=en&newsdep=130). However, these statements go far beyond what the study really showed. In fact, the results indicate a moderately increased risk, in spite of low exposure, short latency period and limitations in study design and analyses. Aydin et al. discussed recall bias – that people tend to overestimate their number of calls – and interestingly they showed that controls overestimated their number of calls more than cases [56]. It was concluded that it was unlikely that a false positive result occurred in CEFALO and that the OR was underestimated for heavy users. Certainly the results in the article [53] cannot be used as reassuring evidence against an association, as discussed in our commentary [54].

3.10. Danish cohort study on mobile phone users

Ideally a cohort study on wireless phone users would be of substantial value. However, several problems exist to establish a cohort with high quality assessed exposure. For example use of both mobile phones and cordless phones vary over time and exposure to RF-EMF emissions also depends on several physical characteristics for different phone types. An attempt to establish a cohort of mobile phone users was made in Denmark in co-operation between the Danish Cancer Society and the International Epidemiology Institute (IEI), Rockville, MD, USA. It was financed by grants from two Danish telecom operation companies (TeleDenmark Mobil and Sonofon), IEI, and the Danish Cancer Society. The source of money for IEI has not been disclosed.

The first results from the Danish study on brain tumour risk among mobile phone subscribers were published in 2001 [57]. It included subjects from January 1, 1982 until December 31, 1995 identified from the computerised files of the two Danish operating companies, TeleDenmark Mobil and Sonofon. A total of 723,421 subscribers were initially identified but the final cohort consisted of only 58% of these subjects. Due to lack of names of individual users 200,507 corporate users were excluded. They were expected to be the heaviest users and such exclusion would underestimate any risk estimates. It should be noted that duration of subscription of a digital phone was at most ≥3 years ($n = 9$) and that two thirds of the subscriptions began in 1994 and 1995. In other words, the majority of the cohort members had two years or less of subscription time. This and other shortcomings in this cohort study have been discussed elsewhere in detail [58]. The Danish study was part of the IARC evaluation but it was concluded that the methods used could have resulted in considerable misclassification in exposure assessment [1].

The first update of the Danish study gave follow-up data until 2002 [59]. The median time since first subscription was this time 8.0 years. It was now stated that the cohort members were excluded from the reference population, which seems not to have been the case in the first publication. The Standardised Incidence Ratio (SIR) for glioma was close to unity, SIR = 1.01, 95% CI = 0.89–1.14. The highest SIR was found for glioma in the temporal lobe where RF-EMF exposure from a mobile phone would be highest, SIR = 1.21, 95% CI = 0.91–1.58 ($n = 54$ cases).

After the outcome of the IARC-evaluation was made public in June 2011 [1] two additional reports on the Danish cohort were soon published. Both were new up-dates of mobile phone subscribers and included more information on risk related to longer follow-up. One focused on acoustic neuroma [60] while the other gave results both for all cancers and separately for glioma and meningioma [61].

Approximately 2.9 million of the Danish population of 5.5 million in total was included in the record linkage study on acoustic neuroma [60]. Of the 2.9 million subjects 420,095 were mobile phone subscribers that started their subscription 1987–1995 and in accordance with the aim of the study had lasted for ≥11 years, i.e., 1998–2006 during which period the tumour cases were ascertained. No evidence of an increased risk was found for ≥11 years of subscription; adjusted Incidence Rate Ratio (IRR) was 0.87, 95% CI = 0.52–1.46.

The analysis of long-term exposure (≥11 years) was based on only 15 exposed cases with acoustic neuroma all of which were men. Analysis of tumour size was based on even fewer cases; 8 had a subscription for ≥11 years. As for the risk related to laterality Schüz et al. [60] compared the location of acoustic neuroma in long-term mobile phone subscribers with shorter use (<11 years) and non-subscribers to see if tumours occurred more frequently on the side which was assumed to be the mostly exposed. This assumption was based on ecological data from the prospective study, COSMOS, as proxy for laterality [62]. Due to these facts the argument of no laterality risk is not very impressive, especially when applied to only 15 exposed cases.

The fourth report on the Danish mobile phone cohort on tumours of the central nervous system showed no overall increased risk [61]. This was true also when restricted to the individuals with the longest mobile phone use, ≥13 years of assumed subscription.

This time the number of the cohort was reduced to 358,403 (49.5%) of the initially identified subscribers ($n = 723,421$). This number was also used in the study on acoustic neuroma [60]. The major additional exclusion ($n = 54,350$) was due to record linkage with the Danish so-called CANULI cohort on socioeconomic factors [63]. That register started 1990 and included subjects from the age of 30. Subscription holders aged 18–29 years were excluded from the mobile phone cohort; this was also the case for the third publication (acoustic neuroma), see above. Follow-up of cancer started at January 1, 1990, or at the age of 30 if occurred later, and ended December 31, 2007.

The study period was 1990–2007 [61] but the cohort was established during 1982–1995. Cancer cases before 1990 were disregarded since the CANULI cohort started in 1990.

The authors did not discuss the impact of the exclusion of these subscribers on the results. This exclusion would include the early users of analogue phones, which seem to have had higher emissions of RF-EMF than the later digital system. The authors themselves also stated the following in their discussion: "*. . .we found indications that early subscription holders before 1995 were in fact heavier users (based on outgoing calls) compared with all subscription holders in the years 1996–2002*." Analysis of any early effect in the group who used phones with the highest emissions was most likely hampered. Moreover, also the youngest users, aged 18–29 years that had previously been included, were now excluded from the cohort. The fully adjusted model had no substantial effect on the risk estimates, so results adjusted for age and calendar period should be possible also for the youngest users. The exclusion of young subscribers could be of importance since as discussed above studies have indicated highest risk in subjects that started the use of a mobile or cordless phone before the age of 20 [28,41].

Some of the many shortcomings of the Danish cohort study include: (a) no individual exposure data (e.g. on cumulative exposure, side of head mostly used, and use of cordless phones); including users of cordless phones in the reference category; (b) no control for use of mobile phones in the population after the establishment of the cohort; and (c) no operator-verified data on years of subscription was available. These limitations are likely to have led to an underestimate of any risk in this study. One would expect considerable misclassification of mobile phone use both among subscribers and the reference population since no new subscribers were included in the exposed cohort after 1995.

The publication of the latest update of the Danish study [61] was accompanied by an editorial by Ahlbom and Feychting from the Karolinska Institute in Sweden [64]. It began with the statement: "*Evidence is reassuring, but continued monitoring of health registers and prospective cohorts is still warranted*." They pointed out methodological advantages, such as elimination of non-response and selection bias, but did forget to mention that less than 50% of the initial cohort remained for analysis. However, they were more lenient on the methodological limitations that they had previously pointed out as serious. In a letter to the Editor in 2007 on an earlier publication of the same cohort [59] they pointed out that several methodological shortcomings undermined the authors' conclusion that "*any large association of risk of cancer and cellular telephone use can be excluded*" [65]. Although more long-term data was now available and adjustment for socioeconomic factors could be made, the update by Frei et al. [61] suffers from basically the same methodological limitations – mainly related to exposure assessment – as the first one did. Instead of addressing the limitations of the Danish cohort study in full, Ahlbom and Feychting [64] used their space to selectively report on results in the Hardell group studies choosing the time period 2000–2003 [23,24] although the whole investigation period was 1997–2003 [27,40]. They discussed incidence data on brain tumours in Sweden instead of Denmark, which would have been more appropriate regarding a Danish cohort study.

The authors of the Danish study have themselves pointed out the main causes of such considerable exposure misclassifications [61]: mobile phone subscription holders not using the phone were classified as 'exposed', non-subscribers using the mobile phone were classified as 'unexposed'; corporate subscribers of mobile phones (200,507 people), which are likely to have been heavy users, were classified as 'unexposed'; persons with a mobile phone subscription later than 1995 were classified as 'unexposed' and users of cordless phones not using a mobile phone were also classified as 'unexposed'.

Other limitations are the absence of analysis by laterality (the side of head where the phone is used in relation to the side of the tumour) and the complete absence of actual exposure data. These and other shortcomings in the cohort study have been discussed elsewhere in more detail [58,65].

It is clear from these limitations that the authors' conclusion that: "*In this update of a large nationwide cohort study of mobile phone use, there were no increased risks of tumours of the central nervous system, providing little evidence for a causal association*" is not soundly based [61].

3.11. Hazard ratio (HR) for survival of patients with glioma

A poorer survival among children with acute lymphoblastic leukaemia exposed to ELF-EMF has been reported in two studies [66,67]. These findings certainly strengthen a causal association between exposure to ELF-EMF and childhood leukaemia. Thus, a carcinogenic effect of RF-EMF emissions would be strengthened if exposure might correlate with survival of glioma patients. To further elucidate that possibility we analysed survival of all cases with malignant brain tumour ($n = 1251$) in our case-control studies [26–28]. Most cases were diagnosed with glioma ($n = 1132$ in this study) so in the following results for glioma are presented in short, for further details see Hardell and Carlberg [68].

Hazard ratio (HR) for survival was close to unity for all glioma cases for use of wireless phones, HR = 1.1, 95% CI = 0.9–1.2. However, latency >10 years increased HR to 1.2, 95% CI = 1.002–1.5. Increased ratio was found for both mobile phone use, HR = 1.3, 95% CI = 1.0005–1.6, and cordless phone use, HR = 1.3, 95% CI = 0.9–1.9. HR increased also with cumulative number of hours of use of mobile phone and cordless phone with statistically significant trend for tertiles ($p = 0.01$) of use of both phone types.

Regarding different types of astrocytoma wireless phone use gave a decreased HR = 0.5, 95% CI = 0.3–0.9 for low-grade astrocytoma, WHO grades I–II. Similar results were found for both mobile and cordless phones. Latency did not change these results. Also cumulative numbers of hours for use yielded decreased HR for both mobile and cordless phone use.

For anaplastic astrocytoma, WHO grade III, there was no clear pattern of an association for latency or cumulative number of hours for use. On the contrary, for glioblastoma multiforme, WHO grade IV, long-term use >10 years latency of mobile phone increased the ratio, HR = 1.3, 95% CI = 0.9–1.7, and cordless phone, HR = 1.8, 95% CI = 1.2–2.8.

This study showed elevated HR, indicating decreased survival of all glioma cases with long-term and high cumulative use of wireless phones. For astrocytoma WHO grade IV an increased HR was found indicating a survival disadvantage. On the other hand HR was decreased for low-grade astrocytoma, WHO grades I–II, indicating a survival benefit in that group of cases. This could be caused by RF-EMF exposure leading to tumour-associated symptoms and earlier detection and surgery with better prognosis in that patient group [69].

3.12. Brain tumour incidence

It has been suggested that overall incidence data on brain tumours for countries may be used to qualify or disqualify the association between mobile phones and brain tumours observed in the case-control studies [53,64,70,71]. As mentioned above, in support of the cohort findings that Frei et al. [61] presented for Denmark, Ahlbom and Feychting [64] refer to data on overall brain tumour incidence from the Swedish Cancer Registry rather than from the Danish Cancer Registry, which would have been more relevant.

In Denmark a statistically significant increase in incidence rate per year for brain and central nervous system tumours (combined) was seen during 2000–2009; in men +2.7%, 95% CI = +1.1 to 4.3% and in women +2.9%, 95% CI = +0.7 to 5.2% (http://www-dep.iarc.fr/NORDCAN/english/frame.asp). Updated results for brain and central nervous system tumours have been released in Denmark. The age-standardised incidence of brain and central nervous system tumours increased with 40% among men and 29% among women during 2001–2010 (http://www.sst.dk/publ/Publ2011/DAF/Cancer/Cancerregisteret2010.pdf). A more recent news release based on the Danish Cancer Register stated that during the last 10 years there has been an increasing number of cases with the most malignant glioma type, glioblastoma multiforme (astrocytoma WHO grade IV), especially among men (http://www.cancer.dk/Nyheder/nyhedsartikler/2012kv4/Kraftig+stigning+i+hjernesvulster.htm). So far these incidence data are not generally available.

Also in the CEFALO study including Denmark, Sweden, Norway and Switzerland [53] only data from the Swedish Cancer Registry were used on time trends for brain tumour incidence. As we have displayed elsewhere [54] annual change in incidence in the age group 5–19 years differs between the Nordic countries. Thus, for the time period 1990–2008 in Norway a yearly increase in incidence with +3.3%, 95% CI +0.8 to 5.9% in boys and +2.5%, 95% CI +0.2 to 4.9% in girls was seen, whereas in Sweden there was a decline in boys and slight increase in girls. Thus, it would have been more appropriate in CEFALO to discuss trends in all included countries.

The quality of the Swedish Cancer Registry for reporting central nervous system tumours, particularly high-grade glioma, has been seriously questioned [72,73]. In the Deltour et al. [70] article on cancer incidence in the Nordic countries Sweden accounted for about 40% of the population and cases. Thus, under-reporting of brain tumour cases to the Swedish Cancer Register would make the conclusions of the Deltour et al. study less valid.

Little et al. [71] studied the incidence rates of glioma during 1992–2008 in the United States and compared with ORs for glioma associated with mobile phone use in the 2010 Interphone publication [9] and our pooled results published in 2011 [28]. Since our results are discussed and questioned by Little et al., their study needs to be reviewed in more detail. Our response to the journal (BMJ) was never accepted for publication in paper version and cannot be found via PubMed, only on the web (http://www.bmj.com/content/344/bmj.e1147/rr/578564).

First, one important methodological issue that was not stated in the abstract or in Figs. 2–4 in the article by Little et al. [71], but can be found in the web appendix, is that observed rates were based on men aged 60–64 years from the Los Angeles SEER registry as the baseline category. These data were used to estimate rates in the entire dataset, men and women aged ≥18 years and all 12 SEER registries. Thereby numerous assumptions were made as pointed out by Kundi [74] and Davis et al. [75].

Using only men, as Little et al. [71] did, ignores the fact that women had less frequent use of mobile phones than men in our studies, Table 10. Overall 31% of women reported such use versus 57% of men. Furthermore, use varies with age group with a large difference according to age, as we have explored in our publications [28,41]. Thus, the age group 60–64 year old men is not valid to use for these calculations.

Little et al. [71] do not explain how they obtained different results on incidence trends based on the Hardell group results and Interphone on the risk for mobile phone use. They ignored that the Hardell group assessed also use of cordless desktop phones in contrast to Interphone. As pointed out by IARC and the Hardell group the appropriate exposure category for wireless phone RF-EMF is use of both mobile and cordless phones [1]. We have compared our results with Interphone regarding different age groups and exposure categories in these studies. Thereby the results are similar for both study groups [14]. We have now updated the results based on our 2011 publication, Table 11 [14]. We restricted cases and controls to the age group 30–59 years and disregarded use of cordless phones as in Interphone. Odds ratios are in fact somewhat lower in our study than in Interphone. It is thus remarkable that the projected incidence rates by Little et al. are so different based on our results compared with Interphone although ORs are similar. It should be added that Little et al. [71] present

Table 10
Gender and age distribution for use of mobile phones among glioma cases aged 20–80 years in the Hardell group studies [28]; $n = 1148$.

Age, diagnosis	Men		Women		Total	
	No use/≤1 year latency, mobile phones	Use >1 year latency, mobile phones	No use/≤1 year latency, mobile phones	Use >1 year latency, mobile phones	No use/≤1 year latency, mobile phones	Use >1 year latency, mobile phones
20–24	8	7 (47%)	3	8 (73%)	11	15 (58%)
25–29	10	15 (60%)	5	10 (67%)	15	25 (63%)
30–34	11	26 (70%)	19	8 (30%)	30	34 (53%)
35–39	9	23 (72%)	8	13 (62%)	17	36 (68%)
40–44	10	26 (72%)	16	11 (41%)	26	37 (59%)
45–49	14	37 (73%)	12	16 (57%)	26	53 (67%)
50–54	22	61 (73%)	26	27 (51%)	48	88 (65%)
55–59	35	65 (65%)	59	20 (25%)	94	85 (47%)
60–64	41	51 (55%)	53	15 (22%)	94	66 (41%)
65–69	55	46 (46%)	57	13 (19%)	112	59 (35%)
70–74	43	16 (27%)	41	5 (11%)	84	21 (20%)
75–80	27	8 (23%)	35	2 (5%)	62	10 (14%)
All	285	381 (57%)	334	148 (31%)	619	529 (46%)

wrong latency periods for the results in our studies both in the publication and in the web appendix.

There are several other points that may be added. The results by Little et al. [71] for oligodendroglioma >10 year latency in our study are wrong in the web appendix, should be OR = 2.2, 95% CI = 0.9–5.4 and not OR = 1.4, 95% CI = 0.9–2.3. Another example is that the results for anatomical localisations and tumour grade [in Table 5 in the article] by Little et al. are based on numerous assumptions from SEER data, Interphone and the Hardell group studies. The authors seem not to have paid attention to the fact that the fraction of mobile phone users differs for gender and age groups, see Table 10. Furthermore, in the final Interphone Study Group [9] publication only results for the whole glioma group were presented in contrast to our published results for both low-grade and high-grade astrocytoma [27], results that are ignored by Little et al. We have now analysed the data further using our 2011 publication, Table 12 [28]. Obviously the risk is higher for high-grade (mostly glioblastoma multiforme) than low-grade astrocytoma for latency time >10 years. This is of interest considering the statistically significant yearly increasing incidence of high-grade glioma in the SEER data for 1992–2008, +0.64%, 95% CI = +0.33 to 0.95% published by Little et al. [71] without any further comments. On the contrary, the incidence of low-grade glioma decreased with −3.02%, 95% CI = −3.49 to −2.54%. Increasing yearly trend for glioma in the temporal lobe, +0.73%, 95% CI = +0.23 to 1.23% was also found [71]. Certainly these findings should have been explored in more detail in the study.

In summary the conclusion by Little et al. that "*Raised risk of glioma with mobile phone use, as reported by one (Swedish) study. . .are not consistent with observed incidence trends in the US population data. . .*" goes far beyond scientific evidence and what would be possible to show with the faulty methods used in the study. We agree with Kundi [74] that there is much room for improvement of the BMJ review process, as we have exemplified [54] regarding another recent BMJ publication by Frei et al. [61], as also discussed above.

One should be careful about using data on the incidence of brain tumours, like in Aydin et al. [53] and Deltour et al. [70], to dismiss results in analytical epidemiology. There might be other factors that influence the incidence rate like changes in exposure to other risk factors for brain tumours that are not assessed in descriptive studies. Cancer incidence depends on initiation, promotion and progression of the disease [76]. The mechanism for RF-EMF carcinogenesis is unclear which adds to the view that descriptive data on brain tumour incidence are of limited value.

There are in fact other studies that show an increasing incidence of brain tumours. In Australia the incidence of

Table 11
Odds ratio (OR) and 95% confidence interval (CI) for glioma in the Interphone study [9] and Hardell et al. [14] for the age group 30–59 years. Use of cordless phones disregarded in the Hardell group studies as was done in Interphone. Numbers of exposed cases (Ca) and controls (Co) are given.

	Interphone Appendix 2			Hardell et al.		
	Ca/Co	OR	95% CI	Ca/Co	OR	95% CI
Unexposed[a]	93/159	(1.0)	–	241/660	(1.0)	–
Latency						
2–4 years	460/451	1.68	1.16–2.41	128/322	1.09	0.84–1.41
5–9 years	468/491	1.54	1.06–2.22	121/258	1.11	0.84–1.47
10+ years	190/150	2.18	1.43–3.31	84/103	1.75	1.23–2.50

[a] Unexposed Interphone Appendix 2: Latency 1–1.9 years; unexposed Hardell et al.: No use + latency ≤ 1 year.

Table 12
Odds ratio (OR) and 95% confidence interval (CI) for mobile phone use and astrocytoma, cf. Hardell et al. [28].

	>1–5 year latency		>5–10 year latency		>10 year latency		Total, >1 year latency	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Astrocytoma, high grade ($n = 820$)	1.2	0.9–1.5	1.5	1.1–1.9	3.0	2.1–4.2	1.5	1.2–1.8
Astrocytoma, low grade ($n = 132$)	1.4	0.8–2.2	1.3	0.7–2.4	1.7	0.7–4.0	1.4	0.9–2.2

primary brain tumours was studied in two areas, the state of New South Wales and Australian Capital Territory, with about 7 million inhabitants [77]. The study covered the time period 2000–2008 and all diagnoses had a histopathological verification. It included 13 pathology databases servicing 24 neurosurgical centres. Adults aged ≥65 years recorded the largest proportion of malignant brain tumours, 52%. The Annual Percentage Change (APC) for malignant tumours increased statistically significant +3.9%, 95% CI +2.4 to 5.4%. An increase was seen among both men and women. The APC for benign tumours increased with +1.7%, 95% CI −1.4 to +4.9%, thus not statistically significant.

From urban Shanghai an increasing incidence of brain and nervous system tumours for the time period 1983–2007 was reported with APC +1.2%, 95% CI +0.4 to 1.9% in males and APC +2.8%, 95% CI +2.1 to 3.4% in females [78]. No results were given for different tumour types, e.g. malignant and benign brain tumours, or anatomical site. The authors concluded that "*The study did not support an association between cellular telephone use and increased risk of brain and nervous tumours.*" However, that statement goes far beyond what is scientifically justified from this register based study and what was actually investigated.

Certainly it is more informative to analyse incidence trends by anatomical site and histology of the tumour. de Vocht et al. [79] reported in England for the time period 1998–2007 a statistically significant increasing incidence of brain tumours, the majority glioma, in the temporal lobe for men ($p < 0.01$) and women ($p < 0.01$), and frontal lobe for men ($p < 0.01$). The incidence increased also for women in the frontal lobe, although not statistically significant ($p = 0.07$). The incidence decreased in other parts of the brain.

Zada et al. [80] studied incidence trends of primary malignant brain tumours in the Los Angeles area during 1992–2006. APC was calculated for microscopically confirmed histological subtypes and anatomic sub sites. The overall incidence of primary malignant brain tumours decreased over the time period with the exception of glioblastoma multiforme (astrocytoma WHO grade IV). The annual age adjusted incidence rate of that tumour type increased statistically significant in the frontal lobe with APC +2.4% to +3.0% ($p \leq 0.001$) and temporal lobe APC +1.3% to +2.3% ($p \leq 0.027$) across all registries. In the California Cancer Registry the incidence of glioblastoma multiforme increased also in cerebellum, APC +11.9% ($p < 0.001$). In the parietal and occipital lobes or in overlapping lobes no statistically significant changes in incidence were seen. For lower grade astrocytoma decreases of annual age adjusted incidence rates were observed. The authors concluded that there was a real increase in the incidence of glioblastoma multiforme in frontal and temporal lobes and cerebellum. These results by Zada et al. [80] are of interest since the highest absorbed dose of RF-EMF emissions from mobile phones has been calculated to occur in these parts of the brain [6].

It should be noted that also Deltour et al. [70] reported increasing glioma incidence rates in Denmark, Finland, Norway, and Sweden for the time period 1979–2008. APC increased for men with +0.4%, 95% CI +0.1 to 0.6% and for women with +0.3%, 95% CI +0.1 to 0.5%. Unfortunately no data were given for subtypes of glioma and anatomical sites of the tumours, which would certainly have been informative. The authors did not consider these and other limitations when they conclude that "*Our data indicate that, so far, no risk associated with mobile phone use has manifested in adult glioma incidence trends...many increased or decreased risks reported in case-control studies are implausible, implying that biases and errors in the self-reported use of mobile phone have likely distorted the findings.*" It should be noted that regarding Sweden we reported increasing incidence of astrocytoma WHO grades I–IV during 1970–2007. In the age group >19 years the annual change was +2.16%, 95% CI +0.25 to 4.10% during 2000–2007 [41].

4. Discussion

The most comprehensive results on use of wireless phones and the association with brain tumours come from the Hardell group in Sweden and the international Interphone study. As pointed out by IARC [1] other studies as discussed above are too small with short latency times, usually in the range of at most 5 years. Both the Hardell group studies and Interphone give results for latency time of 10 years or more. Thus, a summary evaluation will mainly be based on results from these two study groups.

Both were case-control studies and the cases were recruited during similar time periods, 1997–2003 in the Hardell group and during 2000–2004 in Interphone, with somewhat different years in the varying study regions. There was no overlapping of cases in the Hardell group studies and the Swedish part of Interphone. Cases were ascertained from Regional Cancer Registries in the Hardell group studies and all diagnoses were based on histopathological verification. Thus, all cases had been operated or undergone biopsy of the tumour for diagnosis. In contrast, in Interphone cases were identified from neurological or neurosurgical facilities in the

study regions; in some centres also from cancer registries. The diagnoses of glioma, meningioma and acoustic neuroma were based on histopathology or diagnostic imaging. It should be pointed out that the diagnosis of both meningioma and acoustic neuroma has a rather high precision using CT and/or MRI. Regarding glioma it is certainly more difficult to establish a valid diagnosis without histopathology, especially when it comes to subgroups such as different grades of astrocytoma (WHO grades I–IV). In the publication by Lahkola et al. [81] most glioma diagnoses were based on histopathology, whereas this has not been published for Interphone in total. It is notable that Interphone [9] has not presented separate results for astrocytoma in total in contrast to the Hardell group. Especially results for high-grade glioma including the most common glioma type, glioblastoma multiforme (WHO grade IV), would be of value since the highest risk was found for that subtype by Hardell et al., Table 12 [27,28]. It is also of interest that we found higher risk for use of mobile and cordless phones for astrocytoma grades III–IV than for grades I–II [82]. Some results were published for glioblastoma multiforme from the 5 North European countries [81]. Certainly the total result for glioma and >10 years since first ipsilateral mobile phone use with OR = 1.39, 95% CI = 1.01–1.92 (p for trend 0.04) would have been of interest for glioblastoma multiforme separately in Lahkola et al. [81].

The Hardell group included cases aged 20–80 years whereas eligible cases in Interphone were aged 30–59 years at diagnosis. This difference is important since the highest incidence of astrocytoma WHO grade IV (glioblastoma multiforme) is found in the age group 45–75 years with mean age 61 years and 80% older than 50 years [83]. As can be seen in Table 10, the highest prevalence of use of mobile phones in the Hardell group studies was up to the age of 54 years, so limiting the age to 59 years as in Interphone diminishes the possibility to find an increased risk taking a reasonable tumour induction period. It seems as if the age distribution in Interphone was more decided by prevalence of mobile phone use in the population than age distribution for glioma cases. Excluding the age group 20–29 years, as in Interphone, makes also an evaluation of young users more difficult, see Table 9.

Meningioma is a slow growing benign tumour with a peak incidence in the sixth and seventh decade of life with a 3:2–2:1 female:male ratio [84]. As pointed out by Interphone [10] the incidence peak of acoustic neuroma is in the age group 50–65 years. Thus, again limiting upper age to 59 years for cases in Interphone excluded a large proportion of cases with meningioma or acoustic neuroma taking a reasonable latency period.

One control subject matched on age, gender and geographical area (region) to each case in the Hardell group studies was drawn from the national population register. The register covers the whole population and each person is assigned a unique id-number making it possible to trace current address for all inhabitants. In Interphone one control was selected for each case from a 'locally appropriate population-based sampling frame'. In Germany the centres used individual matching or frequency matching. The matching variables were age within 5 years, gender and region of residence; in Israel also ethnic origin. When stratified matching was used individual matching was made afterwards from the whole control sample with cases being assigned one control subject (two in Germany) interviewed as close as possible in time to the case [9]. Regarding the Interphone study on acoustic neuroma some centres sampled special controls to the cases, other draw controls from the pool of controls in the glioma and meningioma studies, or used a mixture of both methods.

The Nordic countries have population registers that were used in Denmark, Norway and Finland for recruitment of controls in Interphone. Also Germany used a population register [85]. However, UK used general practioners' lists [86] and in Japan random digit dialling was used [44,87]. Certainly the methods used in Interphone may introduce selection bias. Patient lists are usually selective to use for drawing of controls and do not represent the whole population which is the source of the cases. Also random digit dialling has the potential to introduce selection bias since persons that are registered to subscribe a phone are usually wealthier than non-subscribers. Furthermore, it seems not to be the most appropriate method for selection of controls in a study on mobile phone use, and certainly not regarding cordless phones, since phone subscribers are selected as controls. Furthermore, later selection of controls from a pool with individual matching may give the possibility for selection bias if this is not done in a blinded manner as to exposure status.

These methods contrast to the Hardell group where controls were drawn consequently to the cases and all controls that answered the questionnaire were included in the analyses. In Interphone proxy interviews were performed for 13% of glioma cases but only 1% of controls [9]. This is in contrast to the Hardell group study on deceased cases with malignant brain tumours [26]. Deceased controls were drawn from the Death Registry in Sweden. Relatives to both deceased cases and deceased controls were interviewed, thereby creating the same condition for assessment of exposure among cases and controls. Although using proxy interviews for both cases and controls is the more appropriate method exclusion of proxy interviews in Interphone had little impact on the overall result in the sensitivity analysis.

Use of wireless phones was carefully assessed by a self-administered questionnaire in the Hardell et al. studies. The information was supplemented over the phone by trained interviewers thereby using a structured protocol. This was done blinded as to case or control status. The ear that had mostly been used during calls with mobile phone and/or cordless phone was assessed by separate questions; >50% of the time for one side, or equally for both sides. This information was checked during the supplementary phone calls. Moreover every person that had used a mobile phone received after that a letter asking them again to specify the ear that had been used during phone calls and to what extent that side of the head was mostly used. There was a very good agreement of the results using these three methods to assess these data. Also

other exposures were assessed in the questionnaire. After the interviews all personal data like names and addresses were removed from the questionnaires so that only an id-number that did not disclose if it was a case or a control was shown. Thus, coding of the data for statistical analysis was performed without personal data on the individual.

We investigated in more detail the possibility of recall and observational bias in our second case-control study [21]. Reporting a previous cancer or if a relative helped to fill in the questionnaire did not change the results, i.e., were no confounding factors. Potential observational bias during phone interviews was analysed by comparing change of exposure in cases and controls after these interviews. No statistically significant differences were found, showing that our results could not be explained by observational bias, for further details see discussion in that publication [21].

On the contrary information on past mobile phone use was mostly collected during face-to-face interviews in Interphone obviously disclosing if it was a case or a control that was interviewed. These interviews were performed by a large number of interviewers at different participating centres. In the personal interviews a computer program that guided the interview with questions read by the interviewer from a laptop computer screen was used. The interviews in the Swedish part lasted for about 45 min. The answers were entered directly into the computer by the interviewer. Cards were shown to if possible identify the model of the mobile phone [88]. The purpose of the study was thereby obviously disclosed to the cases and controls. This was in contrast to the Hardell group mailed questionnaire that contained a large number of other questions without special attention to wireless phones.

We regard hospital based interviews of cases, as in the Interphone study, to be a major disadvantage and ethically questionable. At that time the patient has not fully recovered from e.g. surgery, may not have been fully informed about the diagnosis, treatment and prognosis and may even be under sedation by drugs. Using computer based face-to-face interviews may also be a stressful situation for the patient. In fact patients scored significantly lower than controls due to recalling of words (aphasia), problems with writing and drawing due to paralysis in the Danish part of Interphone [89]. Obviously observational bias could have been introduced by the interview methods in Interphone. Only Finland used a paper version of the questionnaire, but Finland has never published country specific results on the different tumour types, which would certainly have been of interest. For unclear reasons the results on glioma were only included as part of the results for the 5 North European countries [81] and as part of the whole Interphone study [9]. Furthermore, it has not been disclosed how the personal interviews were performed in sparsely populated areas, e.g. in the Northern Sweden. Did the interviewers travel long distances for interviews of controls in rural areas or were all controls living in the largest cities thereby creating selection bias?

It should be noted that the number of participating cases and controls from each centre in Interphone was quite low. It varied for glioma from 60 (Japan) to at most 421 (UK North), for meningioma from 52 (New Zealand) to 350 (Israel) and for acoustic neuroma from 18 (New Zealand) to 152 (UK South). Similarly the number of controls varied according to centre [9,10]. It is obvious that with so low number of interviewed subjects by many different interviewers the quality may have been hampered in Interphone by low training and experience of certain interviewers. Experienced interviewers were defined as those who conducted at least 20 interviews. In fact, in the sensitivity analysis the risk increased for glioma for cumulative mobile phone use $\geq$1640 h from OR = 1.40, 95% CI = 1.03–1.89 to OR = 1.50, 95% CI = 1.10–2.06 if 'experienced interviewers only' were considered. In the Hardell group studies few persons conducted all interviews of the 1251 participating cases with malignant brain tumour, 1254 cases with benign brain tumour, and 2438 controls (total 4942; note one case had both a malignant and a benign brain tumour). All interviewers were first educated; they used a defined protocol and gained considerable experience as interviewers. In fact, they were obliged to carry out the interviews extensively to fulfil the quality in data assessment according to the structured protocol. It is obvious that the few interviewers in the Hardell group study must have been much more experienced than the diversity of interviewers in Interphone. The higher risk restricting analysis to 'experienced interviewers' in Interphone indicates observational bias during assessment of exposure decreasing the risk. Furthermore, 20 interviews as the definition was in Interphone to be an experienced interviewer, is after all a very low number.

Several other sensitivity analyses were performed in Interphone without any major impact on the results. It is discussed in the Interphone study [9] that the increased risk for glioma in the highest decile of cumulative exposure was caused by a number of subjects reporting >5 h call time per day. This number may be real in e.g. certain occupations using the phone as a working tool. Furthermore, if call time was truncated to 5 h per day no statistically significant difference of the risk was found, OR = 1.38, 95% CI = 1.02–1.87 for glioma and OR = 3.03, 95% CI = 1.62–5.67 for acoustic neuroma (exposure up to 5 years before reference date). Certainly it is not justified to exclude these subjects from the analysis as was done in some of the calculations in Interphone [9,10].

It is always essential to have a high response rate in case-control studies to get as valid results as possible. In the Hardell group studies the response rate was 85% (n = 1251) for cases with malignant brain tumour, 88% (n = 1254) for cases with benign brain tumour, and 84% (n = 2438) for controls [29,40]. Lower response rates were obtained in the Interphone study, 64%, range by centre 36–92%, (n = 2765) for glioma cases, 78%, range 56–92%, (n = 2425) for meningioma cases, 82%, range 70–100% (n = 1121) for acoustic neuroma cases, and 53%, range 42–74%, (n = 7658) for controls [9,10]. Certainly these low response rates, less than half of the cases and controls in some centres, may have created the possibility of considerable selection bias and are examples of the multiple methodological problems in Interphone. As has been

discussed elsewhere not responding controls in Interphone tended to be less frequent users of mobile phone than participating controls leading to underestimation of the risk [32].

There are other differences between the Hardell group studies and Interphone study such as restricting age to 30–59 years in Interphone compared with 20–80 years in the Hardell-group studies and considering use of cordless phones as no exposure to RE-EMF in Interphone. Even if the prevalence of mobile phone use is highest in the age group 30–59 years, excluding older cases diminishes the possibility to find an increased risk, assuming a reasonable latency time. As discussed above the peak incidence of most brain tumours is at a higher age. In a case series from Canada all brain tumours showed a bimodal age distribution with one peak in the 0–4 age group and the other in the 60–69 age group [90]. As shown elsewhere [14] step-wise exclusion of the age group 20–29 years, 60–80 years and including cordless phone use among unexposed reduced OR in the Hardell-group studies to similar results as in Interphone [see Tables 1 and 2 in the publication]. Thus, Interphone seems to have underestimated the risk also for these reasons.

Survival of patients with glioma has only been presented by the Hardell group [68]. Decreased survival of glioma cases with long-term and high cumulative use of wireless phones was found. We found a survival disadvantage for astrocytoma WHO grade IV among cases using mobile phone or cordless phone indicating a worse prognosis in that patient group. On the contrary, a survival benefit for astrocytoma WHO grades I–II was observed. The fact that there was no clear trend with intensity or duration of wireless phone use for low-grade astrocytoma does not speak in favour of an effect of RF-EMF from such use. The exposure might, however, produce awareness bias in these cases. RF-EMF may give tumour promotion [91] inducing disease related personality disturbances and habit changes leading to earlier tumour diagnosis than among unexposed patients. This would result in earlier treatment with a better prognosis after surgery in this patient group [69]. These findings indicate a complex biological effect from RF-EMF exposure and strengthen a causal association between these tumour types, e.g. astrocytoma WHO grade IV (glioblastoma multiforme), and use of wireless phones.

By placing a strong emphasis on incidence data an association between use of wireless phones and brain tumours has been challenged [92]. The authors considered that, if the increased risks seen in case-control studies reflect a causal relationship, there would already be an increase in incidence of brain and central nervous system tumours, for which there seemed to be little evidence. This belief is unfounded for two reasons. The first relates to latent periods for glioma and acoustic neuroma development, typically 10–40 years [93,94]. The results on long-term use of wireless phones are scanty and at most latency period of 10+ years have been studied. Furthermore, we know little about the earliest events in the genesis of glioma in humans for obvious reasons. However, progression of glioma has been studied in large series of tumours of different malignancy grades. Patients with low-grade glioma have been followed with later progression to high-grade glioma [95]. Thus, since the natural history of most glioma from earliest events to clinical manifestation is unknown, but most likely several decades, the exposure duration in most studies is incompatible with a tumour initiating effect. An initiating effect is what would have the most direct effect on the incidence. The other reason concerns the possibility of an effect on tumour development (promotion) and its consequences on the increase in incidence that can possibly occur. If the exposure acts as a promoter, this would decrease latency time for already existing tumours, giving a temporary but not a continuous increase in incidence. In addition it has to be pointed out that any such effect on tumour development is limited by the magnitude of the shift of the age-incidence function and its slope for the respective tumour type [91]. It should be noted that studies on tumour type and anatomical localisation indicate by now an effect from RF-EMF on the incidence of brain tumours [71,77,79,80].

5. Conclusions

There is a consistent pattern of increased risk of glioma and acoustic neuroma associated with use of mobile phones and cordless phones. The epidemiological evidence comes mainly from two study centres, the Hardell group and the Interphone study group. In the same studies by the Hardell group and Interphone study group no consistent pattern of an increased risk was found for meningioma. These results strengthen the other findings, i.e., increased risk for glioma and acoustic neuroma, since a systematic bias in the studies would also have been inherit for meningioma. Furthermore, a causal association between use of mobile phone and glioma and acoustic neuroma comes from the meta-analyses as presented in this publication and also reviewed elsewhere [96]. Supportive evidence comes also from anatomical localisation of the tumour to the most exposed area of the brain, cumulative exposure and latency time that all add to the biological relevance of an increased risk. In addition risk calculation based on estimated absorbed dose gives strength to the findings as well as the impact on survival of glioma patients relating to their use of mobile and cordless phones.

Evidence is increasing that workers with heavy use of wireless phones who develop glioma or acoustic neuroma should be compensated. In fact, the first case with such compensation has now been established in court. The Italian Supreme Court affirmed a previous ruling that the Insurance Body for Work (INAIL) must grant worker's compensation to a businessman who had used wireless phones for 12 years and developed a neuroma in the brain (www.applelettrosmog.it; www.microwavenews.com). He had used both mobile and cordless phones for five to six hours per day preferably on the same side as the tumour developed. The neuroma was located in the trigeminal Gasser's ganglion in the brain. This fifth cranial nerve controls facial sensations and muscles. It is

the same type of tumour as the acoustic neuroma in the eighth cranial nerve located in the same area of the brain. The Italian case fulfils the criteria for a causal association; more than 10 years use of wireless phones, high cumulative exposure on the same side as the tumour appeared, and a tumour type that would be predicted based on previous research on use of wireless phones and brain tumour risk. No further appeal of the Supreme Court decision is possible.

In summary there is reasonable basis to conclude that RF-EMFs are bioactive and have a potential to cause health impacts. There is a consistent pattern of increased risk for glioma and acoustic neuroma associated with use of wireless phones (mobile phones and cordless phones) mainly based on results from case-control studies from the Hardell group and Interphone Final Study results. Epidemiological evidence gives that RF-EMF should be classified as a human carcinogen. The current safety limits and reference levels are not adequate to protect public health. New public health standards and limits are needed.

Authors' contributions

Lennart Hardell was responsible for drafting of the manuscript and Michael Carlberg made all statistical calculations. Michael Carlberg and Kjell Hansson Mild read and gave valuable comments on the manuscript. All authors have read and approved the final version. No conflicts of interest reported.

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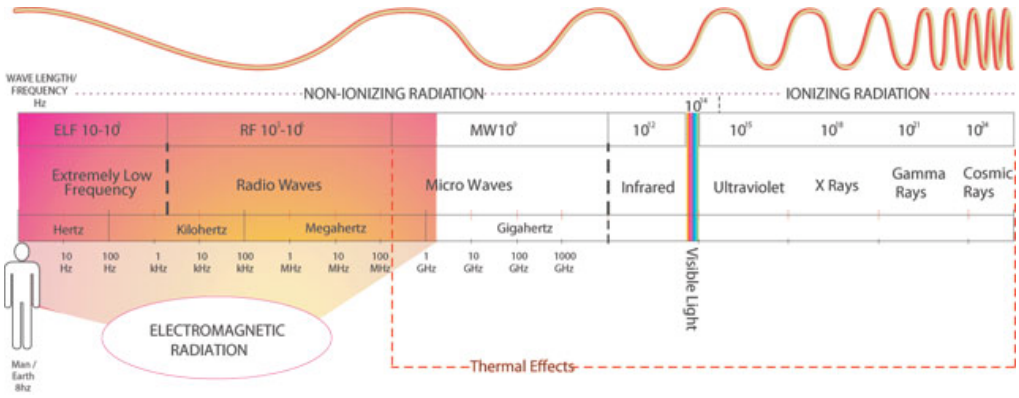
Harmful Radio Waves: The Invisible Health Threat Of Wireless SmartMeters

By Kate Bernier

During the Cold War, U.S. Embassy staff members in Russia developed cancer after being continuously exposed to a kind of radiation that is alarmingly similar to that emitted by the new Smart Grid wireless utility meters (SmartMeters). These staff members and their children all lived and worked in the same nine-story building in Moscow. The Cold war Soviets, in a covert effort to gather intelligence and sabotage U.S. spy equipment, for at least 15 years regularly irradiated the Embassy with low-level pulsed MWs (pulsed microwaves[2]) from across the street. The effects of these non-thermal microwaves include chromosomal, hematological, and reproductive changes, and the growths of numerous types of cancers including breast cancer.[1] In California, PG&E has been hastily and ambitiously installing millions of so-called 'Smart' Meters, and exposing entire communities to the same kind of harmful pulsed microwaves that the Soviets used as a weapon.

A comparison of the embassy situation to the SmartMeter phenomenon is not so far-fetched – both scenarios involve obtaining private information and significant health threats. PG&E's controversial $2.2 billion SmartMeter project to reach 10 million customers was implemented without meaningful public consultation, education or notification. These wireless meters communicate data from houses and businesses to PG&E using radio frequency signals. This is an **infringement of our privacy rights**, because information can be determined from a household's energy usage on a moment-to-moment basis. For example, SmartMeters can detect how many times you get up during the night, or when residents leave the house or come home. If nothing else, this information reveals to anyone with the correct equipment the number of people who live in a residence, and when they are home or absent. In the wrong hands, such information is a security risk. Further, these details could be sold to energy sector corporations, for whom such information would be very valuable. Lee Tien from the Electronic Frontier Foundation has raised concerns about other possible ways our privacy could be creatively violated, with realistic theories of how criminals and hackers could use this information to plan burglaries, or divorce lawyers could subpoena household information.

Even more significantly, the radio frequency pulses of the wireless meters can have a detrimental effect on our health. **These high-frequency pulses carry extremely low frequency [ELF] modulation signals. Prominent American brain researcher Ross Adey discovered that ELFs can, even at low intensities, alter brain function and human behavior.[3]** SmartMeters emit the same pulsed 450 Mhz frequency used in his experiments.



Cold war Soviets thoroughly researched and used a variety of pulsed MWs as weaponry. They knew, for example, that **ELFs can damage the thyroid. Thyroid problems have been shown to be caused by ELFs from a range of 900 Mhz[4] – roughly the same pulsed frequency emitted by SmartMeters**. The Soviets were also aware of the potential for ELFs to induce immune, central nervous system, and brain dysfunction.[5] Further, the U.S. National Academy of Sciences has more recently acknowledged the "sensitivity of neural systems to [electromagnetic] fields modulated at mammalian brain wave frequencies."[6] Evidence that these pulses are harmful has been established by many studies.

ELFs may have potentially detrimental effects on the human mind at various levels of consciousness. In 1982, the U.S. Navy concluded that ELFs can affect moods, including the inducement of apathy, depression, and violent behavior.[8] More recently, in his preliminary SmartMeter field measurement survey, Bay Area independent electronics technician/consultant Dan Mattson found that the range of ELFs occurring within each electrical SmartMeter varied from only a few per second up to approximately 30 per second.[7] This range overlaps and resonates with human brain-wave frequencies, including alpha waves. Alpha brain waves, with a frequency range of 8-12Hz, are associated with the subconscious state of mind. Beta waves, which correlate with conscious thought, also fall within the ELF range of Mattson's findings. **Mattson also determined that one of his clients in San Leandro, CA had a SmartMeter that pulsed approximately 100 times in 15 minutes. This is directly contrary to PG&E spokesman Paul Moreno's assurance that the SmartMeters emit low-level frequency pulses only once every four hours for less than one second.** Others in the Bay Area have also observed this discrepancy in measurements.

Pulse modulation is characterized as having very high peak power and low average power – instead of radiating continuously at low levels like a cell phone, pulses fluctuate on and off repeatedly in spiked bursts. Nobody seems to agree what the SmartMeter peak pulses are, and this is crucial in determining exactly how harmful the radiation exposure levels are. **According to prominent NIH researcher Allen Frey, peak pulse exposure with the appropriate ELF modulations is the critical factor in ELF-induced, inter-cranial sound and word perception in both normal and deaf human subjects.[9,10]** In the meantime, PG&E is using an old trick of misrepresenting the strength of the radiation with time-averaged power calculations that include the inactive intervals between pulses.[11] This is like saying that zapping your hand in a microwave oven for two minutes is okay because the radiation is not dangerous when averaged over the rest of the week.

PG&E often emphasizes that their SmartMeters meet the Federal Communications Commission (FCC) specifications, but these standards are both embarrassingly outdated, and simply misleading. FCC safety standards are based on the theory that if a source emits radio waves that do not actually cook human tissue, then that source may be deemed harmless. It is a thermal-based formula that dismisses any detrimental non-thermal effects of radio waves. Prominent authorities in medicine and public health – including UC Berkeley School of Public Health director Joel Moskowitz, and the Radiation Protection Division of the Environmental Protection Agency – have openly questioned the reliability of FCC's safety standards.

A recent study from Italy shows that the currents of a high-frequency device (similar in form and function to the SmartMeter) superimposed on low-frequency power lines penetrate human cells more deeply than the power frequencies acting alone.[12] Noteworthy also is the fact that many of these frequencies open up the blood/brain barrier to environmental toxins.[13] Contemporary Russian scientist Yuri Grigoriev in his article "Electromagnetic Fields and the Public: EMF Standards and Estimation of Risk" warns that **"existing standards cannot guarantee the safe, healthy development of the next generation of humanity."**[14]

These not-so-SmartMeters are being deployed worldwide at lightning speed, with no Environmental Impact Report (EIR). An EIR is necessary for adding new bike paths to a park, but not for installing radiation-emitting devices in our homes. Already, customers are reporting related adverse health impacts from the meters, including tinnitus and pressure on the ears (known as "Frey Effect" [9]). What opt-out choices could PG&E realistically provide these customers, as ubiquitous smart meter radiation bounces from house to house throughout both commercial and residential neighborhoods in its mesh network?

The simple fact is that these meters are untested, and have not been subject to even a very standard environmental impact report. There is enough evidence of potential risks that the widespread implementation of these meters at this stage is reckless and dangerous.

PLEASE TAKE ACTION NOW! Tell our representatives that we don't want these untested meters thrust upon us. Industry regulators like the CPUC must do their job, which is to ensure safe, reliable and affordable utility service. We need to retain or restore the analog meters at no additional cost to the customer!

Contact: Governor Brown & the **California Public Utilities Commission** (CPUC):

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For more information read: "**The Body Electric**," Robert Becker.
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Dirty Electricity and Electrical Hypersensitivity: Five Case Studies

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Abstract

Deteriorating power quality is becoming increasingly common in developed countries. Poor power quality, also known as dirty electricity, refers to a combination of harmonics and transients generated primarily by electronic devices and by non-linear loads. We have assumed, until recently, that this form of energy is not biologically active. However, when Graham/Stetzer™ filters were installed in homes and schools, symptoms associated with electrical hypersensitivity (such as chronic fatigue, depression, headaches, body aches and pains, ringing in the ears, dizziness, impaired sleep, memory loss, and confusion) were reduced. Five case studies are presented that include one healthy individual; one person with electrical hypersensitivity; another with diabetes; and a person with multiple sclerosis. Results for 18 teachers and their classes at a school in Toronto are also presented. These individuals experienced major to moderate improvements in their health and wellbeing after Graham/Stetzer filters improved power quality in their home or work environment. The results suggest that poor power quality may be contributing to electrical hypersensitivity and that as much as 50% of the population may be hypersensitive; children may be more sensitive than adults and dirty electricity in schools may be interfering with education and possibly contributing to disruptive behavior associated with attention deficit disorder (ADD); dirty electricity may elevate plasma glucose levels among diabetics, and exacerbate symptoms for those with multiple sclerosis and tinnitus. Graham/Stetzer filters and meters enable individuals to monitor and improve power quality in buildings and they provide scientists with a tool for studying the effects of dirty electricity. For the first time we can progress from simply documenting electrical hypersensitivity to alleviating some of the symptoms. These results are dramatic and warrant further investigation. If they are representative of what is happening worldwide, then dirty electricity is adversely affecting the lives of millions of people.

Key words: ADD, ADHD, electrical hypersensitivity, EHS, dirty electricity, diabetes, Graham/Stetzer filter, multiple sclerosis, MS, power quality, tinnitus, Stetzerizer

Introduction

We are living in an increasingly complex electrical environment and are inundated daily with electromagnetic frequencies ranging from less than 20 Hz (electric trains) to greater than 1 billion Hz (wireless telecommunication). Most of these frequencies are man-made and were not present until the invention and subsequent commercialization of electricity (early 1900s), radio (1920s), radar (1940s), television (1950s), computers (1970s), and cell phones (1980s). Whether, and at what intensities, these frequencies have biological effects has been a subject of scientific debate for decades.

The present paper is restricted to the electromagnetic spectrum associated with the distribution of electricity and the poor power quality that results from electronic devices that generate high frequencies and transients that ride on top of a normal 50/60 Hz sine wave. Graham/Stetzer filters are able to improve power quality by reducing microsurges [refer to website for definition, www.stetzerelectric.com] in the frequency range of 4 to 100 kHz on electrical wiring. This paper documents the response of individuals to the removal of dirty electricity in their home or work environment. Five case studies are presented. They include a healthy individual; a person who has symptoms of electrical hypersensitivity; a person with multiple sclerosis; one with diabetes; and the response of 18 teachers and their students to improved power quality in their school.

Dirty Electricity

Since the introduction of electricity and the rapid growth in our use of electronic devices the quality of electrical power flowing along conductors (wires) within the home and workplace has been deteriorating. The public became aware of poor power quality, also known as dirty electricity, when home computers became popular. These computers would periodically "malfunction" and these malfunctions were associated with power surges on the electrical wiring. Surge suppressors are now commonly used as a consequence of poor power quality to protect sensitive electronic equipment.

In most homes today the 50 or 60 Hz sine wave, when viewed with an oscilloscope, is often distorted by microsurges or high frequency harmonics and transients (Figure 1). Computers, television, dimmer switches, and energy efficient lighting and appliances within the home and arcing on distribution lines, caused by contact with tree branches, as well as non-linear loads on power lines contribute to dirty electricity. Even the 25 MHz burst of energy every 1.5 seconds from strobe lights (without an RF choke) on cell phone towers has been measured on the ground and on wires more than 5 km away.

We have learned to protect sensitive electronic equipment with surge suppressors and have assumed, until recently, that this form of energy is not biologically active. Evidence suggests otherwise.

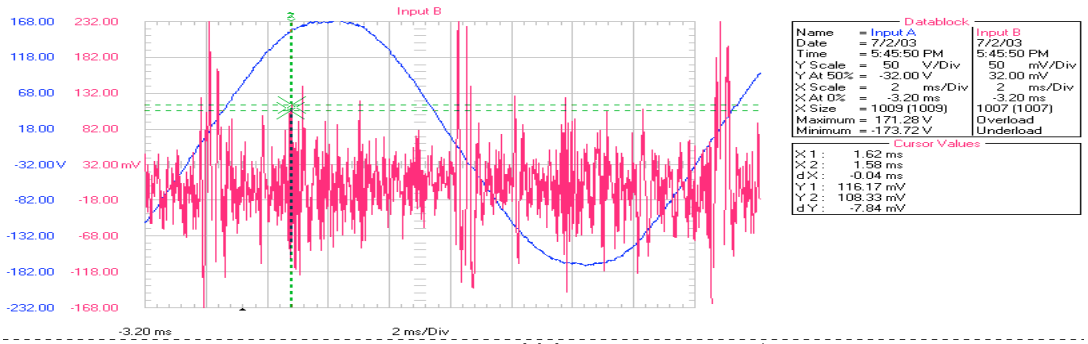
Capacitors smooth out high frequency noise on electrical wires. Graham/Stetzer filters[1] were designed to reduce microsurges on indoor wiring and they work most effectively within the frequency range of 4 to 100 kHz.

Various models have been designed to predict the flow of electromagnetic energy around and through living organisms. According to the Cornell Cow Model (Reines et al. 2000), at frequencies below 1 kHz 80% of the energy is dissipated on the skin and 20% is dissipated internally; and at frequencies above 2 kHz all the energy is dissipated internally. A similar human electrical model (Reilly 1992) predicts that 75% of the energy is dissipated internally at lower frequencies and all is dissipated internally at higher frequencies. The frequency transition points tend to vary based on the path of the current, the wetness of the skin etc. The G/S filters, therefore, remove frequencies that are most likely to be internalized. The Republic of Kazakhstan has Sanitary Norms that state that a person should not be exposed to more than 25 V/m under 2 kHz and no more than 2.5 V/m between 2-400 kHz. The same is

[1] G/S filters are capacitors that reduce the amplitude of harmonics and transients on indoor wiring.

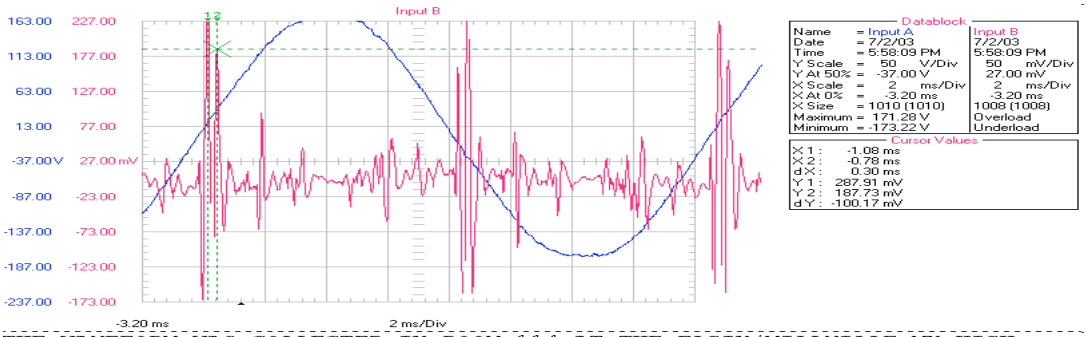
true for the magnetic component, which goes from 250 nT to 25 nT for the same frequencies (HSSP 2003)

(a) Before G/S filters were installed



THE WAVEFORM WAS COLLECTED IN ROOM 114 AT THE ELGIN/MILLVILLE MN HIGH SCHOOL. CHANNEL 1 WAS CONNECTED TO THE 120 VAC UTILITY SUPPLIED POWER RECEPTACLE. CHANNEL 2 WAS CONNECTED TO THE SAME POTENTIAL, EXCEPT THROUGH THE GRAHAM UBIQUITOUS FILTER. (REMOVES THE 60 HERTZ) THE AREA BETWEEN THE CURSORS REPRESENTS A FREQUENCY OF 25 KILO HERTZ. A TEACHER WHO PREVIOUSLY OCCUPIED THE ROOM DIED OF BRAIN TUMORS AND THE TEACHER IN THE ADJOINING ROOM DIED OF LUEKEMIA.

(b) With G/S Filters installed



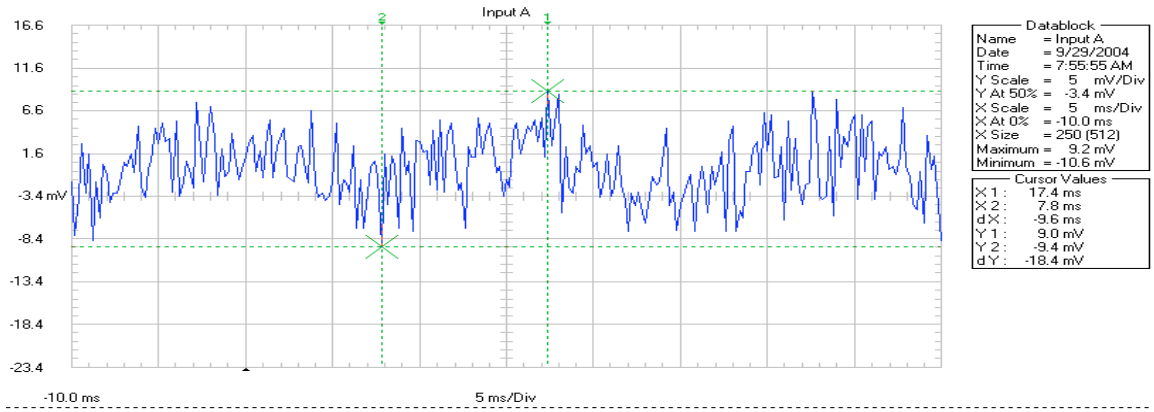
THE WAVEFORM WAS COLLECTED IN ROOM 114 AT THE ELGIN/MILLVILLE MN HIGH SCHOOL. CHANNEL 1 WAS CONNECTD TO THE UTILITY SUPPLIED 120 VAC POWER WALL RECEPTACLE. CHANNEL 2 WAS CONNECTED TO THE SAME POTENTIAL, EXCEPT THROUGH THE GRAHAM UBIQUITOUS FILTER. 2 GRAHAM/STETZER SOLUTIONS FILTERS WERE PLUGGED IN AT THE TIME. THE FREQUENCY REPRESENTED BY THE AREA BETWEEN THE CURSORS WAS REDUCED FROM 25 KILO HERTZ TO 3.3 KILO HERTZ AND THE READINGS ON THE MICRO SURGE II METER WAS REDUCED FROM 455 TO 70.

Figure 1. An oscilloscope waveform showing the 60-Hz (blue) sine wave (channel 1) and the high frequency (pink) microsurges (channel 2) on indoor wiring at a school in Minnesota. Top graph (a) is without Graham/Stetzer filters and bottom graph (b) is with Graham/Stetzer filters installed.

It should be noted that high frequency currents tend to become ground currents (Hughes 2004) and an object that is in contact with the ground becomes part of the circuit, as shown in Figure 2 for a man standing in his kitchen with EKG patches on his ankles. The 60-Hz sine wave is distorted with high frequency microsurges that travel up one leg and down the other.

In summary, high frequency microsurges (dirty electricity), generated by, among other things, electronic devices, travel along the electrical distribution grid (wires inside buildings and between buildings) and along the ground. Conducting objects, including living organisms, in contact with the ground become part of the circuit. Frequencies above 2 kHz are likely to penetrate living organisms, while those below 1 kHz dissipate externally

(heating the skin). Graham/Stetzer filters reduce the amplitude of microsurges on indoor wiring and thus reduce the frequencies most likely to be biologically active.



The waveform was recorded between 2 EKG patches placed on the ankles of XXXXXX XXXXXXXXX standing in front of his kitchen sink at his home near Bright Ontario. It shows a distorted 60 cycle sine wave containing high frequencies applied to each foot, allowing high frequency current to freely oscillate up one leg and down the other. XXXXXX has been diagnosed with prostrate cancer since moving to the house in less than a year. He was standing with feet shoulder width apart, wearing shoes, at the time of the readings. The amplitude increased as the feet were placed farther apart.

Figure 2. Oscilloscope waveform on the ankles of a man standing in his kitchen in Ontario.

Case Studies:

Case #1: 51-year old female, no health complaints; Ontario, Canada

A healthy 51-year old female installed the G/S filters in her home and in her office at work. She completed a wellness questionnaire daily for 1 week prior to installation of the filters and for 4 weeks after filters were installed (Sept 6 to Oct 10, 2004). The rectifier, in light dimmer switches, chops the sine wave and generates microsurges that travel along electrical wiring. For this reason, readings[2] of the dirty electricity were taken in her home with and without the dimmers on (Table 1). The dirty electricity in her home reached a peak at 470 GS units (see www.stetzerelectric.com for definition of GS units) with dimmer switches off and 1130 GS units with them on. Graham/Stetzer filters reduced values from an average of 300 to 40 GS units with dimmer switch off and from 440 to 70 GS units with dinner switch on. Values should be less than 50 and, for optimum effectiveness, less than 30 GS units (HSSP 2003). She also installed 4 filters in her office at work but was able to reduce the dirty electricity from 400 to only 100 GS units since microsurges were coming from neighboring offices. In situations like this, G/S filters need to be installed in neighboring offices as well. Ideally an entire building should be filtered to optimize power quality. During the period of the study she spent most of her time at home and approximately 6 hours at work each weekday.

Although this person considered herself healthy and ranked herself high on the wellness questionnaire, she did notice changes after the filters were installed. Her sleep improved immediately (this is a common response) and she began to have vivid dreams. If she woke up in the middle of the night she would return to sleep quickly. Although she did not

[2] Readings were taken with a Stetzerizer™ Microsurge Meter (Model GS-M300-A, www.stetzerizer.com).

consider herself anxious, she noticed that she was calmer and had more energy after the filters were installed. She had less head "pressure", stiffness, and muscle pain (Figure 3). She also noticed that she no longer had cold extremities at night (see Case Study #4).

Table 1. Power quality in the home or workplace of each of the case studies.

Case	Details	Dirty Electricity (GS units) Without Filters		With G/S Filters	
		Mean	Range	Mean	Range
#1: Healthy	Home: Dimmer Switches off	300	190-470	40	30-50
	Home: Dimmer Switches on	440	190-1130	70	30-290
	Office	400		100	
#2: EHS[1]	Home	~900	300-1900	~20	13-30
#3: MS[2]	Home	170		30	
#4: Diabetes	Home	800	160 - > 2000	13	10-15
#5: School[3]	School	23	13-101	13	8-24

[1] EHS: electrical hypersensitivity
[2] MS: multiple sclerosis
[3] values for school are in mV (rms) for frequencies up to 20 kHz. Measurements were taken with a Fluke 79 III meter connected to a Graham Ubiquitous Filter, which removes the 60-Hz sine wave.

She wanted to participate in this study because her recently deceased husband, who was suffering from mercury poisoning, felt "discomfort" in certain rooms of the house. When we measured the dirty electricity in her home, the high values corresponded to rooms in which he felt unwell. She wanted to know if her wellbeing was affected by the poor power quality in her home. These results suggest that it was and raise the question, "Is she electrically hypersensitive?"

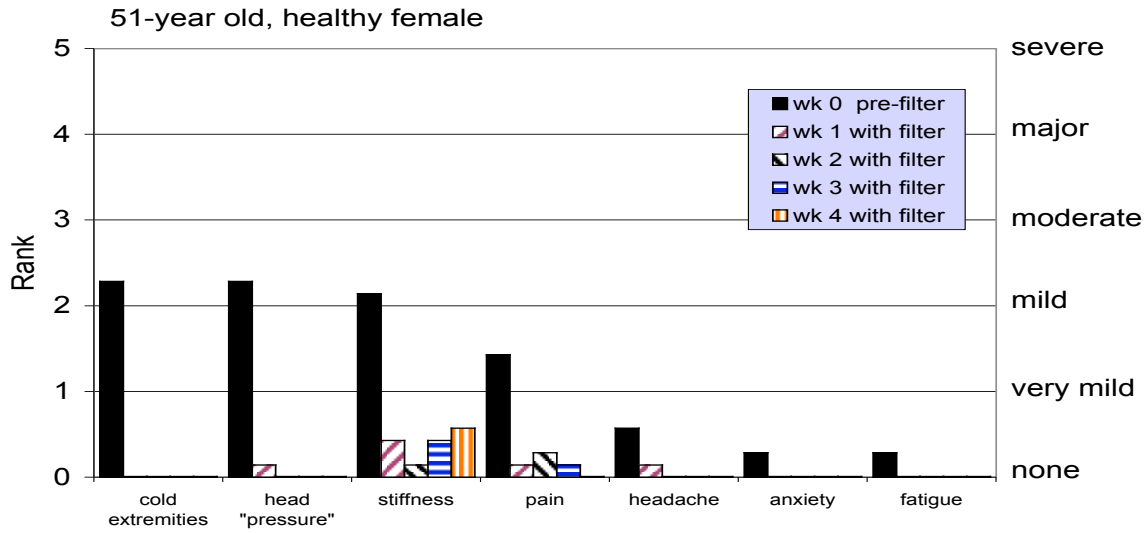


Figure 3. The response of a healthy 51-year old female to G/S filters, Sept/Oct 2004

Case #2: 42-year old male; EHS symptoms include disturbed sleep, headaches, painful teeth and gums, ringing in ears, fatigue and irritability; Barbados

A 42-year old male experienced ringing in his ears (tinnitus), painful teeth and gums, and headaches behind his eyes for which he took over-the-counter medication weekly. He slept poorly and was tired and irritable during the day. These symptoms are consistent with electrical hypersensitivity (Levallois 2002), although he did not use this term. His symptoms

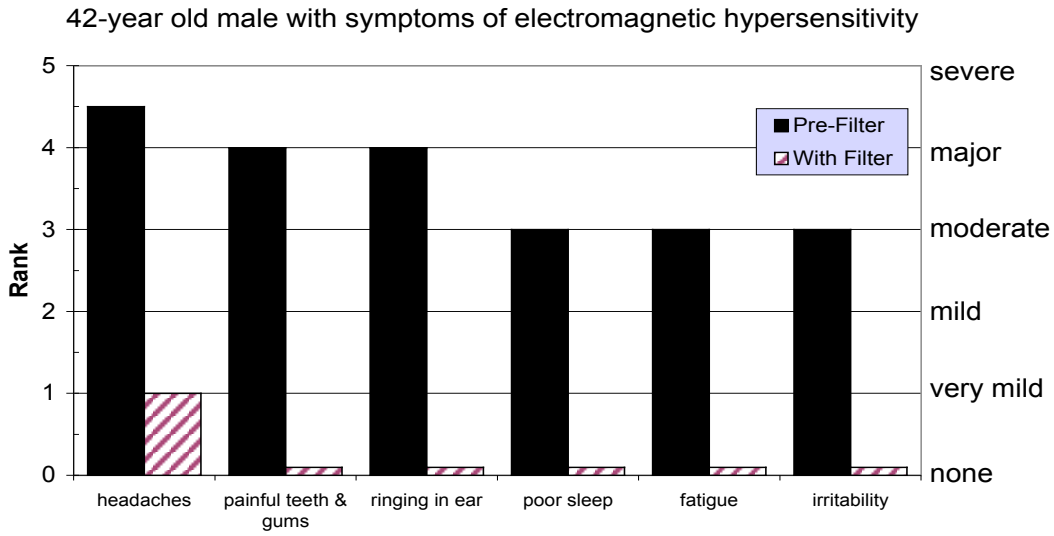


Figure 4. Response of a 42-year old male who was experiencing symptoms of electromagnetic hypersensitivity to G/S filters, May to September 2004.

began 4 years ago and in May 2004 he installed G/S filters in his home. Readings in his home dropped from an average of approximately 900 to 20 GS units (Table 1). His sleep improved immediately (similar to Case #1) and all his other symptoms have disappeared (Figure 4). Since the filters were installed (seven months ago) he can recall having only two headaches.

Tinnitus, one of his symptoms, is the medical term for the perception of sound in one or both ears or in the head when no external sound is present. It is often referred to as "ringing in the ears," although some people hear buzzing, hissing, roaring, clicking, chirping or whistling. Tinnitus can be intermittent or constant and its perceived volume can range from subtle to shattering according to the American Tinnitus Association (2004).

An estimated 1 out of every 5 people experiences some degree of tinnitus. Of the more than 50 million Americans who experience tinnitus, 12 million seek medical attention, and two million are so seriously debilitated that they cannot function on a "normal," day-to-day basis. There is no known cure for tinnitus and treatments range from biofeedback, to drugs, to cochlear implants. Family doctors may also refer patients, who have no obvious physical damage, to psychiatrists.

Several individuals with tinnitus who have tested the G/S filters have reported a significant reduction in the volume of the sound they hear. Some have noticed that when the buzzing is loud, the dirty electricity in their home is high. If some tinnitus sufferers are able to perceived dirty electricity as “noise” then the removal of the dirty electricity may help alleviate their symptoms. The mechanism for this hearing is not known.

The human auditory response to pulses of radio frequency energy, referred to as RF hearing, is well established for frequencies in the MHz range (2.4 –10,000 MHz) (Elder and Chou 2003). Evidence supports a heating effect, whereby audible sounds are produced by rapid thermal expansion of tissue resulting in a clicking, buzzing, or chirping sound. For this reason, the hearing phenomenon depends on the dimensions of the head and on the energy in a single pulse and not on average power density. In our study, exposure was to frequencies in the kHz range that are not associated with a heating phenomenon, so it is possible that some other mechanism is involved in producing the sounds heard.

Case #3: 43-year old female with multiple sclerosis; Ontario, Canada

Graham/Stetzer filters were installed in the home of a 43-year old woman, who has had MS for 8 years. She walked with a cane and did "wall-walking" in her home. "Wall-walking" refers to a person using the wall or furniture to help maintain balance. Readings in her home decreased from an average of 170 to 30 GS units after 13 filters were placed into receptacles in various rooms of her house (Table 1).

Figure 5 shows her response during a 6-week period with the G/S filters installed and a 1-week pre-filter period. Within 24 hours her sense of balance improved and she was able to walk a short distance carrying objects in both hands without assistance (no cane or wall-walking). Within 1 week joint stiffness, joint pain, and muscle weakness decreased significantly and she had less difficulty walking (Figure 5). Within 2 weeks she was able to walk without ankle support and was able to bend forward without losing her balance. She had less muscle weakness and was not as dizzy (Figure 5). Swelling in her hands and feet decreased and her extremities were not as cold (similar to Case #1). The quality of her sleep improved and her level of fatigue decreased (data not shown). This subject is very sensitive to changes in temperature and humidity. During weeks 3 to 6, this part of Ontario received record precipitation and all of her symptoms worsened but were not as severe as her pre-filter symptoms. This subject continues to improve, although her rate of improvement is not as rapid as it was during the first two weeks after the filters were installed.

Symptoms of multiple sclerosis vary between individuals depending on what part of the brain/nervous system is affected. Symptoms include cognitive dysfunction (including problems with memory, attention, and problem-solving); dizziness and vertigo; difficulty walking and/or balance or coordination problems; bladder and bowel dysfunction; depression; fatigue; numbness in extremities; pain; vision problems; hearing loss; speech and swallowing disorders (National Multiple Sclerosis Society, 2004).

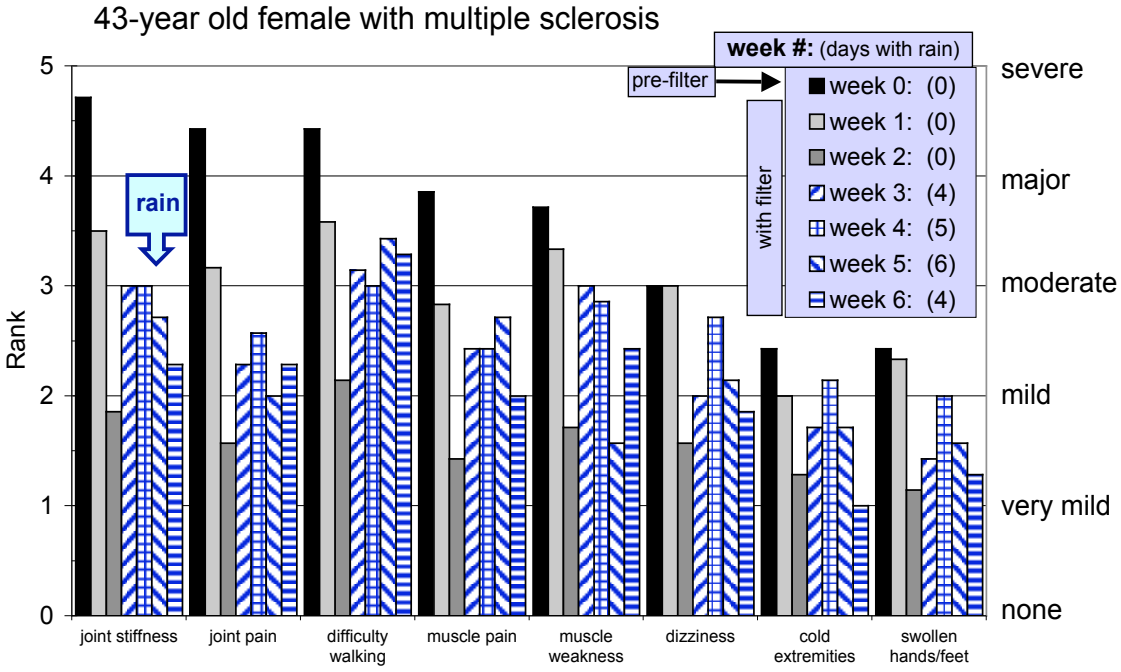


Figure 5. Response of a 43-year old female with multiple sclerosis to Graham Stetzer filters, June/July 2004.

Symptoms can change rapidly and unpredictably. Many people with MS are sensitive to hot or cold conditions and to wet/humid weather. An exacerbation (also known as an attack, a relapse, or a flare) is a sudden worsening of MS symptoms. Temporary improvements are also known to occur and for this reason, one case study showing an improvement may simply have coincided with a normal/temporary remission of this disease. So far, at least 5 people with MS have reported improvements following the installation of G/S filters. More studies are currently underway.

Case #4: 80-year old female with diabetes; Arizona, USA

Graham/Stetzer filters were installed in the home of an 80-year old female with diabetes on June 12, 2004. Her home had very high values for dirty electricity (800 GS units on average with values above 2000 in some rooms) and these dropped significantly to no greater than 15 GS units (Table 1). Because she was diabetic and taking insulin, she regularly monitored her blood sugar levels. Before the filters were installed this subject's fasting plasma glucose (FPG) levels taken at 7 am each morning before breakfast ranged from 152 to 209 with a average of 171 mg/dL (9.4 mmoles/L) (Figure 6). According to the America Diabetes Association a person with a fasting blood glucose level of 126 mg/dL or higher is considered to be diabetic. A fasting blood glucose level between 100 and 125 mg/dL signals pre-diabetes.

The day after filters were installed in her home, this subjects fasting plasma glucose was 87 mg/dL (well below the diabetic range) and she did not take her morning insulin (Figure 6). During the first week her FPG ranged from 87 to 168 and averaged 119 mg/dL (6.5 mmoles/L). Her average daily insulin intake (Humlin 70/30) decreased from 36 to 9 units within the first week. The filters had no effect on her plasma glucose measured at 5 pm. On days that this subject visited shopping malls and casinos, places that are likely to have poor power quality, her evening plasma glucose levels increased significantly (above 250 mg/dL or 14 mmoles/L) (see Havas and Stetzer 2004 for details and more examples).

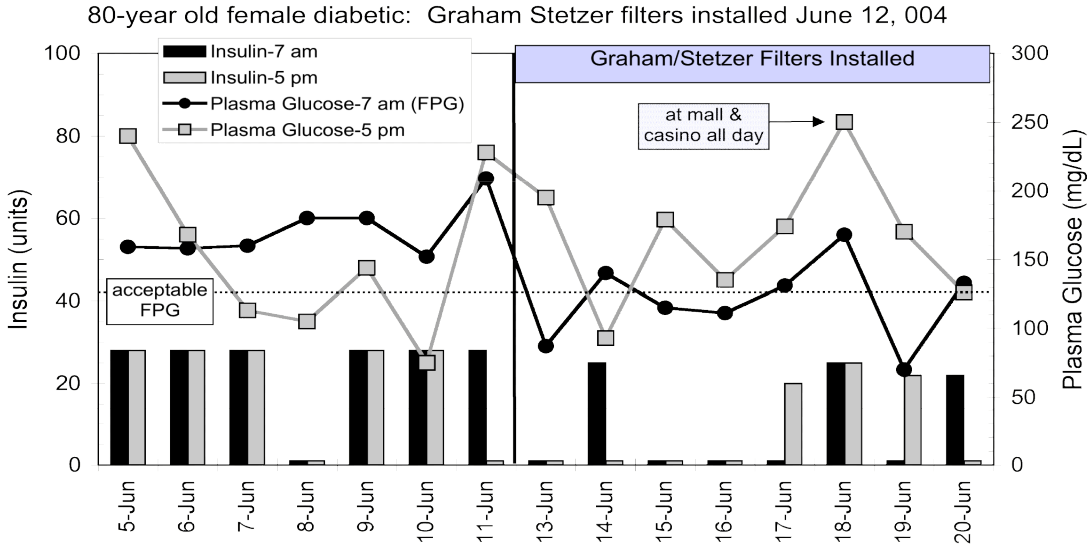


Figure 6. Response of an 80-year old female with diabetes to G/S fitlers installed in her home, June 2004.

In addition to Case #4, we have worked with individuals who have both type 1 and type 2 diabetes and those who are pre-diabetic and have found that blood sugar levels can change rapidly (within a matter of 20 minutes or so for some individuals) as they move from an environment that is electrically dirty to one that is electrically clean (and back again). The percentage of the diabetic population that responds to dirty electricity and to RFR needs to be determined.

Diabetes is on the increase. According to the World Health Organization (2004) in 1985 there were 30 million diabetics worldwide; by 1995 the number increased to 135 million and by 2000 to 177 million. The WHO estimates that by 2025 there will be 300 million diabetics globally. Four million deaths each year (9% of the global total) are attributed to diabetes. Lifestyle (lack of exercise) as well as genetics and environmental factors play a role.

Three types of diabetes have been diagnosed: *Type 1 diabetes* (also known as childhood onset diabetes) results from the body's failure to produce insulin. This is the common form for children and accounts for 5 to 10% of all diabetics. *Type 2 diabetes* (adult onset diabetes) results from insulin resistance (a condition in which the body fails to properly use insulin), combined with relative insulin deficiency and is usually diagnosed in adults. Type 2 diabetes accounts for 90 to 95% of diabetics. Gestational diabetes is a temporary condition that affects approximately 4% of pregnant woman and accounts for 135, 000 cases in the US each year. A forth classification is pre-diabetes, a condition that occurs when a person's blood glucose levels are higher than normal but not high enough for a diagnosis of type 2 diabetes. An estimated 41 million Americans are likely to be pre-diabetic, in addition to the 18 million (6% of the population) with diabetes of which only 13 million have been diagnosed with this disease (American Diabetic Association, 2004).

Based on our studies we would like to suggest that, in addition to *Type 1* and *Type 2* diabetes, there is a *Type 3* diabetes that may be attributed to poor power quality. This form of pollution may be contributing to the rapid growth of this disease and affecting the large number of people who have difficulty controlling their blood sugar with medication (brittle diabetics) and the increasing number who are classified as “pre-diabetic” according to the American Diabetes Association and.

Case #5: Willow Wood School, Toronto, Canada

A study conducted at Willow Wood School in Toronto (January/March 2003) demonstrated that teachers and students responded to improved power quality. This was a single blind study that lasted 6 weeks (3 weeks with filters and 3 weeks without) (see Havas et al. 2004 for details). The Stetzerizer™ microsurge meter was not yet available when this study was done so the power quality was measured with a Fluke 79 III meter connected to a Graham Ubiquitous Filter (to remove 60-Hz frequencies) and values are expressed as mV (rms) rather than GS units (Table 1). The fluke meter measures frequencies up to 20 kHz while the G/S filter removes frequencies up to 100 kHz, hence the Fluke meter underestimates what was actually removed.

Fifty filters were installed in Willow Wood School and the dirty electricity (for frequencies up to 20 kHz) was reduced by 43% from 23 mV (range 13-101 mV) to 13 mV (range 8-24 mV) (Table 1). A school of this size requires 150 filters or more to reduce the microsurges

produced by computers, photocopy machines, fluorescent lightly etc. Even though values were not as low as recommended, significant improvements were noted among teachers and in some classes.

While G/S filters were installed at Willow Wood School, teachers were less tired, less frustrated, less irritable (Figure 7). They had less pain and fewer headaches. They had a greater sense of satisfaction and accomplishment. If these improvements are a sign of electrical hypersensitivity, then 55% of the teachers at WW School may be electrically hypersensitive. This is a much larger percentage than the two percent for self-reported EHS as documented by Hillert et al. (2002). Our results are similar to those reported by Arnetz et al. (1997, as cited in Levallois 1999) for 133 employees of an insurance company who all worked in the same building. More than 50% of those who worked with computers reported that they had health symptoms induced by VDU-related work. The checklist of symptoms were typical of EHS and included musculoskeletal, respiratory, dermatological, gastrointestinal, neurological and memory problems.

If teaches in Willow Wood School were asked if they were electrically hypersensitive, very few would have answered in the affirmative. Indeed, after the study when we presented our results to the teachers, we learned that the concept of electrical hypersensitive was new to them.

Student behavior at Willow Wood School also improved while the filters were installed, especially in grades 1 to 6 as compared with middle school (grades 7-9) and high school (grades 10-12) (see Havas et al. 2004). Students were more active and were better able to focus on their lessons (Figure 8). There was less "inappropriate" classroom noise and class time was used more productively. Teaches spent less time dealing with disruptions or repeating instructions.

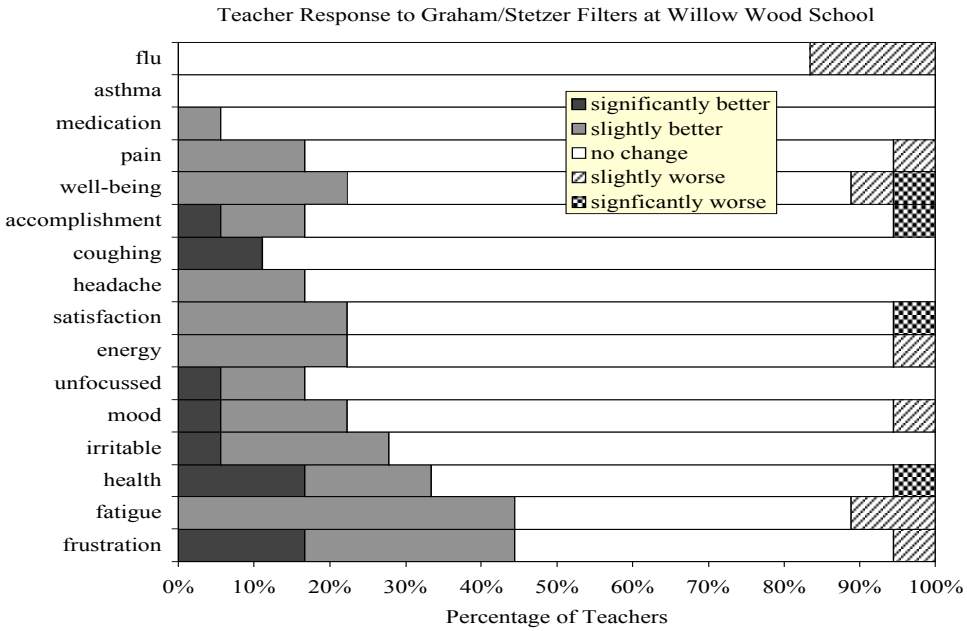


Figure 7. Teacher response to G/S Filters in Willow Wood School. Results are based on 18 teachers, 10 females and 8 males.

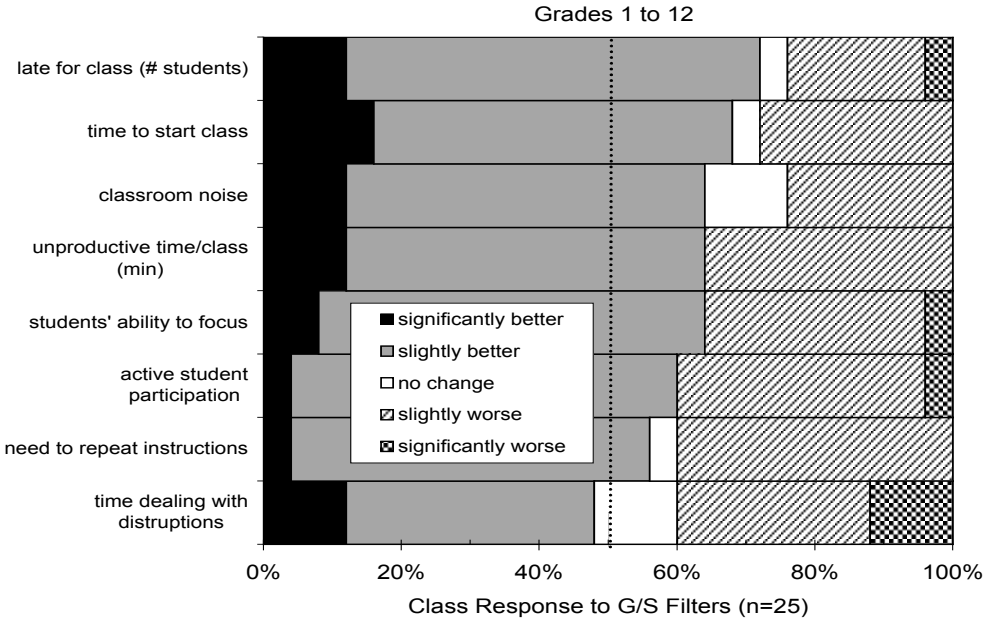


Figure 8. Student response to G/S Filters at Willow Wood School, January/March 2003. Results are based on 25 classes.

Our results suggest that dirty electricity may be interfering with teacher performance and student education. Other schools that have installed G/S filters have also reported improvements among their students and staff. At one school, Melrose-Mindoro in Wisconsin, the District Nurse (Char Sbraggia, R.N.) reported that after the G/S filters were installed teachers were less tired and students also seemed to have more energy. Several staff with allergies were taking less medication since they were experiencing fewer symptoms. But perhaps the most striking result was for students with asthma. Of the 37 students using inhalers, only three continue to use them and only for exercise-induced asthma before their physical education classes (www.electricalpollution.com). At Willow Wood School we had no reported cases of asthma among teachers and did not obtain health information about students.

More and more children are being diagnosed with and medicated for attention deficit disorder (ADD) and attention deficit hyperactivity disorder (ADHD). ADD is the most commonly diagnosed behavioral disorder of childhood. Estimates of its prevalence range from 2% to 18% of school-aged children depending on type of diagnosed (University of Maryland Medicine 2002). In the US, the diagnosis of ADHD in children increased from 950 thousand children in 1990 to 2.4 million by 1996. Attention Deficit Disorder is a neurobiological condition characterized by developmentally inappropriate level of attention, concentration, activity, distractibility, and impulsivity (University of Maryland Medicine 2002).

Some of the symptoms associated with these disabilities (such as inability to focus, disruptive classroom behavior, need for repeated instructions, inability to actively participate in lessons) are the symptoms that were reduced after the G/S filters were installed, which raises questions about the relationship between ADD and power quality. Children are exposed to more dirty electricity because they are now spending more time then ever in front of computers (at home and at school) and television sets and have, for the first time, ready access to cell phones (radio frequency radiation). Both computers and television sets

generate electromagnetic frequencies within the kHz and MHz range and these frequencies are not filtered at the set and thus travel along electrical wiring[3]. Studies testing the relationship between ADD/ADHD and dirty electricity (and radio frequency radiation) are urgently needed.

Conclusions

In this study we demonstrate that Graham/Stetzer filters can improve power quality by reducing the amplitude of harmonics and transients on electrical wiring in buildings; that dirty electricity flows along the ground and interacts with conducting objects (including people) in contact with the ground; and that when this form of energy is removed some symptoms that have been classified as electrical hypersensitivity can be alleviated. Furthermore we demonstrate that symptoms for diseases, not normally associated with electrical hypersensitivity such as multiple sclerosis and diabetes, can also be reduced when power quality is improved.

Instead of just documenting the symptoms of electrical hypersensitivity we now have a method by which these symptoms can be alleviated. Graham/Stetzer filters and microsurge meters enable individuals to monitor and improve power quality in buildings and they provide scientists with a tool for studying the effects of dirty electricity.

These results bring into question the definition of "electrical hypersensitivity". Is a person electrically hypersensitive if his/her health improves when dirty electricity is removed? We suggest that individuals are electrically hypersensitive if their symptoms change when some component of the electromagnetic environment is either increased (provocation studies) or decreased (hygiene studies). What components of the electromagnetic spectrum are bioactive and at what intensities remains to be tested. Our results strongly suggest that transients are biologically active within the frequency range of 4 to 100 kHz and at intensities currently found in homes and schools.

We present five dissimilar cases studies, but we have data for an additional six diabetics and are currently studying the response of more than 20 subjects with MS. To date we have had only one person with MS has not improved after installation of G/S filters.

The results from the cases studies are so dramatic that they warrant further investigation. They suggest that: (1) poor power quality may be contributing to electrical hypersensitivity; (2) a much larger population than originally assumed may be electrically hypersensitive (50% vs. 2%); (3) children may be more sensitive than adults; (4) dirty electricity in schools may be interfering with education and (5) possibly contributing to disruptive behavior associated with attention deficit disorder (ADD); (6) dirty electricity may elevate plasma glucose levels among some diabetics and it may exacerbate the symptoms for those suffering from (8) tinnitus and (9) multiple sclerosis. If these results are representative of what is happening in countries worldwide, then dirty electricity is adversely affecting the lives of millions of people.

[3] The microsurges generated by a TV or computer in one room have been measured with the Stetzerizer™ microsurge meter at the electrical receptacle that is on the same circuit in another room.

Acknowledgements

We would like to thank all the people who participated in the studies. We would also like to thank Art Hughes for providing technical information and Martin Graham for designing the Graham/Stetzer filter and the Stetzerizer™ microsurge meter.

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www.electricalpollution.com, provides other references dealing with power quality issues and provides information about the Graham/Stetzer filters and the Stetzerizer™ meter.

www.stetzerelectric.com provides definitions and more details of the meters and filters.

http://www.theunion.com/news/twi/david-adams-hazards-of-smart-meters-well-documented/

David Adams: Hazards of smart meters well documented

In The Union's previous reporting on the proposal to ban electrical utility "smart meters" in Nevada City, major parts of the relevant information are missing.

The quoted PG&E spokeswoman's attempt to pass the blame for the smart meters program off to the CPUC is disingenuous as best; both these parties were in long-term, probably illegal collusion to launch this program in California, as documented at http://www.healthfreedoms.org/smart-meter-scandal-in-california-emails-reveal-cpuc-may-have-known-and-concealed-health-risks-and-other-problems/.

One can't rely on PG&E for accurate scientific information or on the California Council on Science and Technology or even the American Cancer Society — and certainly not the Federal Communications Commission (FCC), which has refused to regulate use of this low-frequency/Wi-Fi/microwave kind of radiation at all. Their loose standards only apply to heat effects from high-frequency radiation.

A thoughtful and well-informed reportage needs to keep in mind that the manufacture and sale of the various devices that use and emit this kind of radiation is a more-than-a-trillion-dollar-a-year business, and that the corporations involved have enormous wealth and power, including an unhealthy revolving-door-staff influence on the federal government organizations, like the FCC, which are supposed to regulate the safety of their products for the public good rather than corporate profit. The proposed exposure limits in the 2012 Bioinitiative Report (designed to protect against the negative biological effects found in 67 key scientific studies) are one million times lower than current FCC limits.

It would be a progressive step if the Nevada City Council would agree to recognize the difficult truth of Wi-Fi radiation damage by banning the imposition of so-called smart meters in our homes and businesses.

The fact is that there are many, many thousands (one estimate is more than 20,000) of peer-reviewed, published scientific studies going back to the 1970s that mostly demonstrate a wide range of neurological and physiological damage from prolonged exposure to the kind of low-frequency radiation generated by smart meters (especially the non-industry-funded studies). These include not only various cancers, but single- and double-strand breaks in cellular DNA, irreversible mitochondrial damage to DNA, other chromosomal aberrations and mutations (e.g., Down syndrome), lowering of male sperm count and motility, greater risk of miscarriages and fetal abnormalities, breakdown of the blood-brain barrier allowing potentially toxic chemicals and proteins to enter the brain, altered brainwave and metabolic activity, racing heart rate (tachycardia),

damage to cellular membranes in the body (leading to cell deaths), and causing red blood cells to leak hemoglobin, which can lead to heart disease or kidney stones.

These slower-acting effects are in addition to the more typical symptoms of the "lesser" but more conscious symptoms that "electro-hypersensitive" (EHS) persons experience: fatigue, headaches/migraine, nose bleeds, difficulty concentrating, dizziness/nausea/vertigo, visual and auditory distortion, anxiety, depression, memory loss, attention deficit, skin rash, hyperactivity, night sweats, and insomnia. Children are more susceptible to all these effects than adults. If readers (and doubters) look at just one of the many websites about this problem, http://www.powerwatch.org.uk/, they will find much information as well as links to a few thousand of these scientific studies.

One final usually unmentioned aspect I could mention is the role of the U.S. military. Gong back to the 1970s there are more than 8,300 relevant scientific studies just by the military, which hopes to (and by some accounts already has) weaponize this spectrum of radiation. I could also mention a 2013 letter issued by the Board of the American Academy of Environmental Medicine that referred to an Australian scientific study of 92 case series that "clearly demonstrates adverse health effects in the human population from smart meter emissions."

It would be a progressive step if the Nevada City Council would agree to recognize the difficult truth of Wi-Fi radiation damage by banning the imposition of so-called smart meters in our homes and businesses.

David Adams, Ph.D. lives in Penn Valley.

March 6, 2011

Foes of smart meters resist and insist: Health effects are real

Citing symptoms caused by radio waves, 10 Mainers file a new petition that seeks an alternative to CMP's upgrade project.

By John Richardson jrichardson@mainetoday.com
Staff Writer

Julie Tupper's home is a wireless-free zone.

Gregg and Anat Levey, shown with Kaya, 6, and Aden, 4, say their smart meter led to insomnia and dizziness. The Leveys had CMP put the old analog meter back on their house in Falmouth. Meanwhile, company officials and regulators say there is no evidence of adverse effects from the meters' radio waves.

John Ewing/Staff Photographer

"I used to have wireless in the house (for Internet access), and I knew something strange was going on. I had it pulled out and the difference was night and day," she said.

The joint pain and other aches she had struggled with disappeared, she said. Soon, the cordless phone was gone, too, and the microwave retired. "I (got) all wireless out of my home because I knew it was causing problems for me."

Tupper, of South Portland, is one of an unknown number of Mainers who consider themselves especially sensitive to the invisible radio frequency waves sent out by wireless communication devices. Some, like Tupper, have turned their homes into safe havens where they can retreat, at least to some degree, from the ubiquitous radio waves floating around most offices, homes and residential neighborhoods.

Now, they say, they also are feeling the effects of new wireless electrical meters -- smart meters -- that Central Maine Power Co. is installing on homes in their neighborhoods. Some say symptoms such as heart palpitations and sleeplessness were bad enough to force them out of their homes until the meters could be temporarily removed.

Tupper and nine others filed a complaint with the Maine Public Utilities Commission in late February. It is the sixth petition seeking to suspend CMP's smart meter changeover or force the company to offer an alternative to customers who don't want the devices on their homes for a variety of reasons.

Maine, followed closely by California, is on track to become the first state to decide whether homeowners have a right to reject the new generation of electricity meters.

"There are utilities all across the country facing this or similar questions," said John Carroll, spokesman for CMP. "We are ahead of everybody."

The newest petition is the first one in Maine to focus exclusively on the health issue. It also raises the question of whether customers have a right to keep entire neighborhoods, or communities, free of smart meters and the wireless signals they send.

Health experts and government agencies say there is no scientific proof that the technology has anything to do with joint pains, headaches, dizziness, sleeplessness and other symptoms reported by the 10 Mainers who signed the petition, or by residents in other states who are reporting similar reactions. There also is no conclusive proof that the radio frequency waves are not causing health effects and the question deserves more study, they say.

For CMP, unproven health concerns are not enough to stall new technology that promises

to improve the efficiency of the grid and cut costs for the company and its ratepayers.
"There does not appear to be a link that is going to make these people sick," Carroll said. "The signals from these meters are very, very low-powered." And, he said, an average meter will only send signals a total of 4.4 seconds during a day.
Those who insist they can feel the health effects, however, say they don't want to be part of any smart meter experiment.
"You try to maintain your home as a place where you can get away from it," Tupper said. "People are saying, 'Oh, this isn't real.' This is real. People are getting sick. ... Someone like me is the canary in the coal mine."
Tupper said she's never been able to hold a cell phone to her head without a sharp headache, and can get heart palpitations or become dizzy when driving near cell towers. "It's like an allergy. You might not be allergic to mold, but somebody else is," she said.
CMP agreed to bypass Tupper's home, at least until the PUC complaints are resolved. But she can feel the signals from her neighbors' meters, she said. "I was sitting watching TV and I said to my husband, 'Oh, my God. They're here. I can feel it,' " she said. "It was kind of a jolting sensation."
While her husband doesn't feel the radio waves, she said, she can't go on one side of her property because it's too close to her neighbor's smart meter.
"It would be great if we could say for a 250-foot surrounding area, no smart meters." But, she sad, "what we want to do now is to focus on trying to create a safe haven for ourselves in our homes."
Gregg Levey, another petitioner, said CMP put a smart meter on the outside of his Falmouth home in December.
"About three or four days after this thing was put in I just started tossing and turning at night, like major insomnia, and I had never had insomnia before," he said.
Levey made the connection after he mentioned his sleeplessness to a friend who is a smart meter opponent. "She told me insomnia is the No. 1 symptom," he said.
The Leveys called CMP in early January and, within a day, the company put the old analog meter back on the house.
"Once it was taken out and I started to sleep more, it very much convinced me that this is what was doing it. It was pretty clear," Levey said. "It's my home and I should be able to make the choice."
Gregg Levey's wife, Anat, said she felt the effects, too.
"With me, it was every time I walked toward the house where the meter was, which happens to be (outside) our kitchen, I got really really dizzy," she said. "Ever since they removed it, I don't get that dizziness anymore."
Nancy Burns, a petitioner from Windham, said she's dealt with all kinds of allergies and environmental sensitivies her whole life.
"Microwaves I don't use anymore, with TVs I try to sit back a good distance," said Burns, who lives in Windham. "I knew the meter would probably be bad for me but I didn't object when they installed it because I didn't know I could object."
CMP installed a smart meter on her home in December, she said.
"At first I started being dizzy when getting up out of bed. I didn't think anything of it," she said. "It gradually got worse and worse."
She had back pain, headaches, confusion and panic attacks, she said. She got relief by sleeping in her car and then in a motel for a few nights before asking CMP to remove the

meter, she said.
"I can't live with it, I know that," she said. "It's hard to tell these things to people because they don't believe you."
Petitioners said their physicians have been supportive, although few in the medical community have publicly validated the health concerns.
One physician based in Scarborough, Stephen Kirsch, wrote a letter to the PUC last month saying further investigation of the health effects is needed.
"I have been treating one of my patients that I believe has suffered deleterious effects of smart meter installation in her community of South Portland," Kirsch wrote. He did not identify the patient and did not respond to an interview request last week.
"She has recovered after being hospitalized and returning to her daughter's home," he wrote. "She is fearful and unwilling to return to her home. Furthermore, my patient, her daughter and I are concerned that smart meters may be installed around and at her current safe haven in Scarborough."

Officially, there is no evidence that the waves coming from smart meters -- or other common wireless devices, for that matter -- are affecting the health of people around them, according to state and federal health and regulatory agencies.
The Maine Center for Disease Control and Prevention presented the PUC in November with a review of government research, in the United States and other countries.
"Our review of these agency assessments and studies do not indicate any consistent or convincing evidence to support a concern for health effects ...," the agency said.
It also found no evidence of a link to "symptoms that have been described as electromagnetic sensitivity."
A more detailed study by the California Council on Science and Technology in January came to the same conclusion, saying smart meters result in smaller levels of radio frequency exposure than cell phones and microwave ovens.
"To date, scientific studies have not identified or confirmed negative health effects," it said.
The reviews also say more research is needed to identify, or rule out, health effects at various levels of exposure.
So far, the PUC has sidestepped the health issue. In response to previous complaints, it deferred to the Federal Communications Commission, which sets safety standards for wireless transmissions and has deemed the meters to be well within safety limits.
"The commission does not have the institutional expertise regarding potential RF health impacts," the PUC wrote in a recent filing.
It's unclear whether the new petition will force the PUC to examine the issue.
CMP is sure to argue that the complaint be dismissed. It has already replied to earlier complaints with testimony from a scientific expert who argued there is no proof of any health effects from the meters or other similar sources of radio frequency waves.
Carroll, the CMP spokesman, said the argument by Tupper and others that they are being affected by their neighbors' smart meters raises other issues for the company and the smart meter project.
He said the level coming from neighboring homes is similar to the levels given off by the human body. And, he said, homeowners shouldn't have to get their neighbors' permission to have a smart meter.
"If you're living in a neighborhood, you're within the field of your neighbor's cell phone

or your neighbor's Wi-Fi router," Carroll said. "No one has ever exercised a property right that says, 'Your radio signal is trespassing on my property.' Under that scenario, you could go over after WBLM radio."

CMP has so far installed about 137,000 smart meters. About 3,000 households have opted out while the issue is pending before the PUC, Carroll said.

CMP and some lead complainants have met to discuss a settlement of the smart meter dispute. One possible resolution could give customers a choice to opt out -- if they agree to pay a higher fee for wireless-free meters.

Allowing customers to simply opt out would jeopardize the benefits of the entire project, as well as the $96 million in federal funds for the two-year smart meter project. "That could erode the effectiveness and efficiency of the system," Carroll said.

Remember when reading this article that the key word is: “Officially” no evidence. Studies out of the country have already been published, but the “Big Money and Government” doesn’t want it acknowledged or released, so that they can continue to force their agenda! (Millions of people who become sick after installation couldn’t be delusional could they?)

Health impact of electromagnetic radiation from telecommunication towers located in close proximity to residential areas

Petition: No. 255

Issue(s): Governance, human health/environmental health, science and technology, and other

Petitioner(s): Dennis Noble and Sharon L. Noble

Date Received: 25 June 2008

Status: Completed

Summary: The petitioners allege that electromagnetic radiation emitted from telecommunication towers is causing significant health issues to people living in close proximity to these transmitters. The petitioners raise questions about the objectivity of scientific studies supporting the government's position related to the potential health hazards of electromagnetic radiation and about the perceived independence of department staff assessing these studies. In addition, the petitioners request that Health Canada invoke the precautionary principle in order to safeguard Canadians.

Federal Departments Responsible for Reply: Health Canada, Industry Canada

Petition

Environmental Petition to the Auditor General
Submitted June 22, 2008

Petitioners:

[Original signed by Sharon L. Noble and Dennis Noble]

Sharon Noble

Dennis Noble

818 Bexhill Place
Victoria, British Columbia
(250) 478-7892

The Auditor General of Canada
Commissioner of the Environment and Sustainable Development
240 Sparks St.
Ottawa, ON
K1A 0G6

Attn. Petitions
Auditor General,

Health Canada's Safety Code 6 was established as a protection against thermal radiation and, therefore, is set at a dangerously high level for all who live close to transmission towers. It provides no protection whatsoever from the real danger to residents: non-thermal electromagnetic radiation. And Health Canada appears only too willing to ignore the health concerns of the residents in order to protect the interests of the telecommunication industry.

We live on the top of Triangle Mountain, in a cul-de-sac with 28 other homes, most of which were built in 1992-1994. At that time there was one small radio tower, which had been there for decades. In, addition there was an amateur radio antenna about 300 meters away on Walfred Road.

Suddenly, in 2000 this was removed and 2 new, tall towers were built and 3 FM transmitters with 2 Studio Link Transmitters (STLs) were installed, location address Fulton Road. These towers are as close as 30 meters from our homes. (Please see attached photos*)

Company	Frequency	Avg. power	Peak power
CIOC-FM ROGERS	98.5 Mhz	47,000 Watts	100,000 Watts
CHTT-FM ROGERS	103.1	9,400	20,000
CFEX-FM CTV	107.3	9,700	20,000
CTV STL	955.525		
ROGERS STL	957.6875		

From the very beginning, the residents experienced harmful interference with their electronic equipment. Despite numerous complaints that continue even to this day and with an emission level in the year 2001 that is more than 1100 times higher than is allowed under the new CPC-2-0-03 guidelines, Industry Canada is quoted as saying: “To date…the Broadcasters have successfully remedied the issues.” (letter of May 26, 2008 from Mr. Neil Allwood, A/Director, Industry Canada, Coastal District Office. To Mayor Jody Twa, Colwood).

But, as harmful as this interference is, and as irritating as Industry Canada’s failure to live up to its obligation is, they are nothing, nothing, in comparison to the real harm the transmitters are causing us.

In 2000, the residents on Bexhill Place expressed concern about the possible health implications and were repeatedly assured that Safety Code 6 provides protection. In 2001, with the help of the City of Colwood, the residents were able to get Industry Canada to perform a test of emission levels, which we later learned was not done with the proper equipment or following the correct protocol. (please refer to page 23 of petition) After a few hours of testing over 2 consecutive days in August, everyone was told the emissions were under Safety Code 6 and therefore there was nothing to worry about.

Before building our home, we asked various authorities about the FM towers and any potential health implications and received repeated assurances that Industry Canada has strict guidelines which ensure that there is no danger from RF emissions. We believed them.

Neighbours soon began to complain about health problems and at a gathering in 2005 many discussed sleeping problems including insomnia and nightsweats, skin rashes, and headaches. We decided to investigate to see if proximity to the transmitters might be the cause.

We've since learned that within 1 city block of the towers we have several people with various cancers, neurological problems, multiple miscarriages, and dermatological problems. This was discovered through casual conversations; no survey of the neighbourhood has been done.

We approached Dr. Richard Stanwick, Vancouver Island Health Officer and he told us any problems were Health Canada's responsibility and he could not get involved. In numerous discussions with people at the BC Cancer and Radiation Centre, specifically Dr. Randy Ross, we have received assurance that Safety Code 6 is safe and any health problems are due to other causes. In telephone calls and letters to people at Industry Canada both in Vancouver (Mr. Bruce Drake) and Victoria (Mr. Jim Laursen) I've received the same response -- so long as the emissions are within the limits set by Safety Code 6, there is nothing that can be done. Through emails, [name withheld] of Health Canada assured us that Safety Code 6 is consistent with the rest of the world's guidelines and EMR at the non-thermal level is not dangerous.

Over the last year, we've learned that the scope of the problem has changed, with Industry Canada's requirement that broadcasters use existing towers wherever possible. Now there is a cell transmitter (869.00 MHz) on the FM towers (no notice was given, so I have no information on the installation date). The tower on Walfred has been removed and new towers were installed, with no notice or consultation. There are now many transmitters of various sorts and we were told by Mr. Laursen that 2 additional cell transmitters will be installed shortly. As of today, there are 44 transmitters within 1 kilometer of our home. (Please see the list from Industry Canada's website.)

	NO. ON WALFRED	NO. ON FULTON
1999	1	1
2000	1	5
2008	29	6

According to one of many influential studies : "During the first 3-5 years of exposure, people suffer sleep disorders, melatonin reduction which leads to immune deficiencies. From 5-7 years, neurological problems begin to become noticeable with headaches, confusion, and memory loss. After 10 years, serious disorders such as cancer occur and health damage become irreversible." (I.S.F. Institute for Stress Research, Berlin, Biological effects of electromagnetic fields on humans in the frequency range of 1 to 3 Ghz).

Most of the people in our neighbourhood have been exposed to these FM towers for 8 years.

We all are on borrowed time and we ask for Health Canada to reduce the allowable exposure level by studying independent, non-industry funded research and heeding the recommendations of the preponderance of credible peer-reviewed international scientists.

We respectfully petition the Auditor General, on behalf of all Canadians:

to have Health Canada and Industry Canada explain their reliance on and association with the telecommunication industry, to the detriment of the health of the citizens by whom they are employed;

to have Health Canada explain why Canadians are not granted the same level of protection that citizens of many other countries are granted;

to instruct Health Canada to revisit its decision regarding Safety Code 6 and to implement a biologically (health)-based standard for non-thermal electromagnetic radiation, patterned after those recommended by the BioInitiative Report, August 2007;

to ensure that all FM and cell phone transmitters presently in use be adjusted to meet this new standard;

to remind Health Canada that its mandate is to enhance and protect the health of Canadians;

to instruct that Health Canada use only scientific studies that are credible, peer-reviewed, non-industry funded that have no industry connections;

to ensure that Health Canada personnel no longer be allowed to have connections with bodies that tend to cast doubt on the impartiality of their work;

to ensure that Industry Canada carryout its mandates as published on their webpage. But while doing so that it respect the concerns of those not in industry but with an interest in decisions that may impact upon them to be properly considered, informed and respected;

to ensure that all dealings with the public be fair, objective, and aboveboard.

We earnestly petition the responders for Health Canada and Industry Canada to provide honest answers that are not mere repetitions of replies that already have been given to us and to many others but which do not respond to the questions.

[Original signed by Sharon Noble and Dennis Noble]

Petitioners:
Sharon and Dennis Noble
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I. INDEPENDENCE OF ADVISORY BODIES

[Information withheld]

Health Canada and Industry Canada receives great sums of money from the telecommunication industry each through various licensing fees, siting fees, spectrum auctions, etc. For example, according to CanWest News Source, May 28, 2008, more than $560 million was committed by 24 of the 60 participants on the first day of the recent auction of spectrum licenses. It was reported in The Times

Colonist of June 18, 2008, page 5B, that “Canada’s auction of the airwaves for wireless services … has raised about $3.77 billion in revenue“ and that the auction is not yet over.

From this arises the perception of a conflict of interest in Health Canada’s and Industry Canada’s responsibility of protecting the citizens of Canada from the potential dangers of electromagnetic radiation emitted by telecommunication transmitters and devices. We undertook to see if perception conflicts with reality:

A. Health Canada Independence

1. In his letter to me of Dec. 17, 2007, [name and position withheld], Consumer and Clinical Radiation Protection Bureau (CCRPB) of Health Canada, stated that "Myself and my colleagues maintain a vigilant surveillance of the health effects literature related to this issue and conduct our own research to evaluate potential bioeffects (such as DNA damage). It is Health Canada's position, and one which I personally agree with, that exposure to radiofrequency fields below the limits outlined in Safety Code 6 do not pose a health risk."

In reply to my request for examples of what Health Canada considers credible studies showing that there are no adverse health effects from non-thermal RF radiation, on March 17, 2008, [name withheld] sent me the following list:

a) [Information withheld]
b) [Information withheld]
c) [Information withheld]
d) [Information withheld]
e) Ahlbom A, Green A, Kheifets L., Savitz D, Swerdlow A; ICNIRP. Epidemiology of health effects of radiofrequency exposure. Enviro Health Perspect. 112:1741-1754 (2004)

2. I decided to apply [name withheld] "vigilant surveillance" to the quality and integrity of some of [name withheld] sources:

a) [Information withheld]

[Information withheld]

[Information withheld]

According to the University of Ottawa Gazette, May 10, 2001, "The Canadian project has received a grant from the Canadian Wireless Telecommunications Association (CWTA), which is being administered through the university-industry partnership program of the Canadian Institutes for Health Research (CIHR). CIHR is expected to fund half, with the CWTA funding the remainder. "Industry has a responsibility to contribute to health research on their products, to address questions about potential health risks associated with wireless telecommunications," he says. "The university-industry partnership program that CIHR has set up is exactly designed for this purpose."

In addition, "Roger Poirier, the man who negotiated the million dollar deal, is a consultant on the big cellphone study for IARC," as reported by CBC News, Nov. 25, 2003.

[Information withheld]

[Information withheld]

b) [Name and information withheld], "has a lucrative consulting practice on EMFs and health. Over the years, [name withheld] has earned hundreds of thousands of dollars disputing the existence of adverse EMF health effects, even those accepted by most other members of the EMF community."

[Name and information withheld]. "Over the last 16 years, only one positive paper on microwave genotoxicity appeared in *Radiation Research*.... 80% of the negative papers (17 out of 21) published in *Radiation Research* were paid for by either industry or the U.S. Air Force."

Microwave News is "meticulously researched and thoroughly documented." **Time Magazine, July 30, 1990.**

“the most authoritative journal on ELF fields and health." **Fortune Magazine, Dec. 31, 1990.**

"the world's most authoritative source on EMF health risks." **Washington Journalism Review, Jan/Feb 1991.**

c) [Information withheld]

[Information withheld]

d) [Information withheld]

[Information withheld]

e) [Information withheld]

f) R. Mandeville—President and CSO of Biophage, Inc, a biopharmaceutical company. **Company Partners:** The Company’s partners include the REGA Institute of the University of Leuven in Belgium, Nymox Inc., the Defence Research Establishment Suffield (DRES) and Biopolymer Engineering of Eagan, MN.

Dr. Mandeville is on the Board of Directors of Montec Holdings, which is directly associated with telecommunication companies. (www.Montecholdings.com/boardofdirectors.htm).

QUESTION:

1) How can Health Canada rationalize using research that is influenced to such a degree by people who rely upon industry for funding?

2) Who in Health Canada is responsible for vetting researchers and the peer-reviewed research used to confirm that Safety Code 6 is safe?

3) Are Health Canada and Industry Canada employees required to sign conflict of interest statements that declare they have no affiliation with any organization that may bring into question the impartiality of their work?

4) Are scientists conducting research for Health Canada and Industry Canada required to sign conflict of interest statements that declare they have no affiliation with any organization, nor do they accept, directly or indirectly, funding from any source that could be perceived in anyway to cast doubt on the objectivity of their work?

5) Do Industry Canada and Health Canada adhere to the rule that the authors, whatever their affiliation, of all studies that Industry Canada or Health Canada depend on to support their position on EMR, must clearly be seen to be independent, and must be willing to declare that they have no financial interests in the outcome of their studies and that they receive no industry funding, whether directly or indirectly, in carrying out their studies?

B. Royal Society

1. According to Artnarong Thansandote, Chief, Electromagnetics Division, CCRPB, Health Canada, in a letter of June 2, 2006, to Pim Vanderveen, Industry Canada, copied to Robert Bradley, Director CCRPB, "...at the request of Health Canada, the Royal Society of Canada assembled an expert panel on radiofrequency (RF) fields to conduct an independent review of the guidelines for safe exposure limits set out in the Code."

Yet even the Expert Panel convened by the Royal Society of Canada to review new scientific studies and to make recommendations about the adequacy of SC6, has persons with close ties to the telecommunications industries. In support of this statement I provide the following:

1. [Information withheld]

2. R.W.Y. Habash has connections with the R. Samuel McLaughlin Centre, which is largely industry-funded. (See WHO 2005 Annual Report) (please refer to #2a)

3. B. Habbick also works for the R. Samuel McLaughlin Centre. (please refer to #2a)

4. [Information withheld]

5. [Information withheld]

6. R. Mandeville, President and CSO of Biophage, Inc a biopharmaceutical company. (refer to #2f for information)

QUESTION:

6) When at least half the members of the "expert panel" have direct or indirect associations with the telecommunication industry, why should the public believe that the recommendations of these people are not influenced by the industry?

7) How does Health Canada refute the perception that it is unduly supportive of telecommunication companies because of its dependence upon researchers who have ties to that industry?

C. WHO

1. a) [Information withheld]

b) [Information withheld]

c) [Informtion withheld]

d) [Information withheld]

QUESTION:

8) Since WHO accepts funding from the wireless industry, why should any credence be given to studies that WHO sponsors?

9) Since the researchers appear to be so closely associated with the industry that has a direct interest in the results of their research, why should we not assume that those results are biased in its favour?

II. SCIENTIFIC EVIDENCE

A. Credible Studies?

1. In his letter to me of Dec. 17, 2007, [name withheld] said, "I must point out that while there are some studies reporting evidence of adverse effects from radiofrequency field exposure, there are a much larger (sic) of other studies which do not find similar findings..."

In response to our request for more examples of credible, scientific, peer-reviewed studies that showed the absence of harm from non-thermal radiation, [name withheld] provided 20. Of these 20 studies, 18 were published in 3 journals funded by the telecommunication industry:

Radiation Research, funded by Industry and US Air Force (Microwave News, July 31, 2006.

Bioelectromagnetics Society Journal, funded by Motorola. [Name and position withheld] Motorola. (Microwave News, [information withheld]).

International Journal of Radiation Biology published by Informa Healthcare which, along with its partner, Informa Media and Telecom, are part of the Informa Group Plc.

In explanation of this reliance on industry-funded journals, Microwave News, July 31, 2006, pointed out, [information withheld]. "The assumption here is that industry science is superior to everyone else's. They make no effort to resolve inconsistent results."

Studies have confirmed that this could apply to industry-funded researchers and research projects regarding radiofrequency dangers.

A comparison of 85 Genotox Studies done from 1990-2006. 45 reported negative effects and 42 reported none. Of the 45 positive report, 3 were industry funded. Of the 42 negative all but 5 were industry funded, and one of these 5 was by [name withheld] of Health Canada who has ties to industry but would not commit whether he was industry funded or not. ***Microwave News, [information withheld]).***

[Information withheld]

Dr. Henry Lai**,** compared 326 Cell Phone Biological Studies in an internal 2006 study for the Univ. of Washington and found the following:

> Of the studies showing no biological effects, 72% were industry-funded.
> Of the studies showing biological effects, 33% were industry-funded.

Egger, Nat. Inst. Of Environ. Health Science (NIEHS), Vol. 115 #1 Jan 2007: “Health effects of radiofrequency radiation should take sponsorship into account.”

QUESTION:

10) How does Health Canada refute the perception that it discounts credible peer-reviewed scientific studies that are not industry-funded and favors studies that are industry-funded?

11) How does H.C. refute the perception that just as the multibillion dollar asbestos and tobacco industries were able to persuade government overseers to ignore credible evidence harmful to the bottom line of those industries, the multibillion dollar telecommunications industry is not persuading Health Canada to ignore credible evidence that is harmful to the bottom line of that industry?

B. Credible Studies

1. In [name withheld] letter to me of Dec. 17, 2007, [name withheld] said, "When evaluating the scientific evidence for a potential health risk, one must consider all data (not just a selected subset of the literature) to make scientifically sound health risk assessment."

Yet, it is maintained by both HC and the 'expert panel', the Royal Society of Canada, that there has been no new evidence to justify revision of SC 6 since its 1999 review.

Please find below just a few of quite credible studies from around the world that were reported since 1999, showing health effects from non-thermal radiation and, apparently, have been overlooked by the Royal Society of Canada and Health Canada.

REFLEX Report, (December 2004) *Risk Evaluation of Potential Environmental Hazards From Low Frequency Electromagnetic Field Exposure Using Sensitive in vitro Methods*, A project funded by the European Union under the programme "Quality of Life and Management of Living Resources".

"Twelve institutes in seven countries have found genotoxic effects and modified expressions on numerous genes and proteins after Radio frequency and extremely low frequency EMF exposure at low levels, below current international safety guidance, to living cells in-vitro. These results confirm the likelihood of long-term genetic damage in the blood and brains of users of mobile phones and other sources of electromagnetic fields. The idea behind the REFLEX study was to attempt replicate damage already reported to see if the effects were real and whether, or not, more money should be spent of research into the possible adverse health effects of EMF exposure. They concluded that in-vitro damage is real and that it is important to carry out much more research, especially monitoring the long-term health of people."

Eger H *et al*, (November 2004) *The Influence of Being Physically Near to a Cell Phone Transmission Mast on the Incidence of Cancer*, Umwelt Medizin Gesellschaft 17, 4 2004.

"Newly diagnosed cancers were significantly higher among those who had lived for 10 years within 400 metres of the mast, in operation since 1993, compared with those living further away, and the patients had fallen ill on average 8 years earlier. People living within 400 metres of the mast in Naila had three times the risk of developing cancer than those living further away. This seems to be an undeniable clustering of cancer cases."

Oberfeld G *et al*, (October 2004) *The Microwave Syndrome - Further Aspects of a Spanish Study*, Conference Proceedings.

"The adjusted (sex, age, distance) logistic regression model showed statistically significant positive exposure-response associations between the E-field and the following variables: fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorder, depressive tendency, feeling of discomfort, difficulty in concentration, loss of memory, visual disorder, dizziness and cardiovascular problems. The inclusion of the distance, which might be a proxy for the sometimes raised "concerns explanation", did not alter the model substantially."

Hallberg O, Johansson O, (July 2004) *Malignant melanoma of the skin - not a sunshine story!*, Med Sci Monit. 2004 Jul;10(7):CR336-40.

"A good correlation in time was found for the rollout of FM/TV broadcasting networks while the increased amount of "sun travel" by air (charter) did not start until 7 years after the melanoma trend break in 1955. Counties that did not roll out their FM-broadcasting network until several years after 1955 continued to have a stable melanoma mortality during the intervening years. The increased incidence and mortality of melanoma of skin cannot solely be explained by increased exposure to UV-radiation from the sun. We conclude that continuous disturbance of cell repair mechanisms by body-resonant electromagnetic fields seems to amplify the carcinogenic effects resulting from cell damage caused e.g. by UV-radiation.

Boscol et al. reported that RFR from radio transmission stations affected immunological system in women [Effects of electromagnetic fields produced by radiotelevision broadcasting stations on the immune system of women. Sci. Total Environ 273:1-10, 2001].

Salford et al. (2003) have shown that extremely low doses of GSM radiation can cause brain damage in rats. The authors reported nerve damage following a single two-hour exposure at a SAR of 2 mW/kg. They showed that RF energy can impair the BBB, but they added that the chemicals that leak through the BBB probably damage neurons in the cortex, the hippocampus and the basal ganglia of the brain. The cortex is close to the surface of the skull, while the basal ganglia are much deeper...

BioInitiative Report, August 2007. An international working group of scientists, researchers and public health policy professionals (The BioInitiative Working Group) has released its peer-reviewed report on electromagnetic fields (EMF) and health. By reviewing more than **2000** peer-reviewed studies, they document serious scientific concerns about current limits regulating how much EMF is allowable from power lines, cell phones, and many other sources of EMF exposure in daily life. The report concludes that the existing standards for public safety are inadequate to protect public health.

Clark, M.L. et al, "Biomonitoring of Estrogen and melatonin metabolites among women residing near radio and television radio broadcasting transmitters" concluded that RF and temporally stable 60 Hz exposures were associated with increased E1G excretion among post-menopausal women. J. Occup. Environ. Med. 2007;49: 1149-1156.

QUESTION:

12) How does Health Canada explain why each of these non-industry funded studies is not considered relevant or credible by the experts at HC and the Royal Society?

13) How much has the telecommunications industry spent for research annually over the last 5 years?

14) How much has Health Canada spent for independent, non-industry funded research annually during the last 5 years?

III. OUR PROTECTION?

A. Safety Code 6

1. Health Canada and Industry Canada continue to assure the public that Safety Code 6 is adequate to protect the general public. In [name withheld] letter to me of Dec. 17, 2007, [name withheld] said, "... we would not support Safety Code 6 unless we personally felt it was adequately protective."

The public has been told that we should be comforted by knowing that Canada's Safety Code 6 is one of the most stringent in the world and is consistent with most other western countries.

In reality, “an increasing number of countries have implemented stricter public exposure limits in response to concerns about and studies demonstrating health problems from RF exposure at levels lower than those allowed by SC 6. Many western European countries have done so following the precautionary principle attempting to keep RF exposure as low as possible.

In eastern European and Asian countries, lower standards are being established to protect the public from effects observed in their studies among people chronically exposed to RFs through their work, such as changes in the central nervous, endocrine and immune system functions.’ (Toronto Prudent Avoidance Policy on Siting Telecommunication Towers and Antennas, Nov. 20, 2007).

As reported by the Medical Officer of Health of the Toronto Board of Health in the Siting Policy, “there are already several jurisdictions that have adopted lower exposure limits for the public. Some, such as Bulgaria, China, the Czech Republic, Hungary, Italy, Poland, Russia, and Switzerland have established legally enforceable national levels. Several other local governments have made exposure limits more protective, primarily through cooperative arrangements with industry: Auckland, Brussels, Paris, Salzburg (Austria), and several municipalities in Australia.” In 1999, the Toronto Board of Health recommended exposure limits of .1W/meter squared (1W/m2).

Following are a number of countries and their national standards for 450MHz frequency.

Austria's "precautionary limit	0.001 W/m2
Russia's exposure limit	0.02 W/m2
ECOLOG recommendation 1998	0 023 W/m2
Poland's exposure limit	0.1 W/m2
Italy's exposure limit	0.16 W/m2
CSSR's exposure limit	0.24 W/m2
New Zealand's exposure limit	2.0 W/m2
Canada's exposure limit	**3.0 W/m2**

Following are the national standards in many countries for 1800MHz frequency.

Toronto Board of Health precautionary	0.10 W/m2
Italy regulatory, precautionary	0.10 W/m2
Switzerland, regulatory, precautionary	0.10 W/m2
China, regulatory	0.10 W/m2
Russia, regulatory	0.10 W/m2
Paris precautionary, cooperative	0.10 W/m2
Salzburg, precautionary, cooperative	0.001 W/m2
ICNIRP Guideline*	10.0 W/m2
Canada	**10.0 W/m2**

Canada has the same guideline as ICNIRP which says it is only intended to protect the public against short term gross heating effects and NOT against 'biological' effects such as cancer and genetic damage from long term low level microwave exposure from mobile phones, their masts and many other wireless devices. This statement is made at: **http://ww.icnirp.de/documents/emfgdl.pdf**

QUESTION:

15) Will Health Canada justify the current exposure standards of SC 6, which are at levels to protect the public only against short term gross heating effects, as per ICNIRP?

16) Will Health Canada and Industry Canada amend its public documents to reflect the fact that Canada's standard is not consistent with most other developed countries and to instruct its researchers to stop telling the public that Canada's standards are among the most stringent in the world?

17) Health Canada and Industry Canada do not follow the stricter safety codes of most of Europe but rather the much more lax safety codes of the U.S. To what degree is this because Health Canada and Industry Canada have been unduly influenced by the powerful North American telecommunication industry?

IV. POLICY APPROACHES

The **International Commission for Electromagnetic Safety** (ICEMS) is a non-profit organization that promotes research to protect public health from electromagnetic fields and develops the scientific basis and strategies for assessment, prevention, management and communication of risk, based on the precautionary principle.

In Dec. 2007 and June 2008 ICEMS and the 47 scientists who were signatories to the Benevento Resolution stated in the follow-up Venice Resolution:

"…we are compelled to confirm the existence of non-thermal effects of electromagnetic fields on living matter, which seem to occur at every level of investigation from molecular to epidemiological…" and urged the immediate adoption of precautionary measures to protect the public. (**www.icems.eu**).

A. The Precautionary Principle

1. The Precautionary Principle adopted in 1998 at the Wingspread Conference:

"We believe existing environmental regulations and other decisions, particularly those based on risk assessment, have failed to adequately protect human health and the environment, as well as the larger system of which humans are but a part.

We believe there is compelling evidence that damage to humans and the worldwide environment, is of such magnitude and seriousness that new principles for conducting human activities are necessary.

While we realize that human activities may involve hazards, people must proceed more carefully than has been the case in recent history. Corporations, government entities, organizations, communities, scientists and other individuals must adopt a precautionary approach to all human endeavors.

Therefore it is necessary to implement the Precautionary Principle: Where an activity raises threats of harm to the environment or human health, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.

In this context the proponent of an activity, rather than the public bears the burden of proof." (the emphasis is mine) (**www.sehn.org/wing.html**).

2. In several of [name withheld] letters to me, and in response to a question asking [name withheld] for studies that prove that living in the midst of FM and cell transmitters, as we do, is safe, [name withheld] responded in [name withheld] letter of April 3, 2008, "It is technically impossible to ever 'prove' that any activity, product, or item is absolutely safe…" In the same letter [name withheld] admits, "There are some studies claiming that biological effects may occur at RF energy levels below SC 6 limits."

3. According to an Environment Canada pamphlet:

"Canada applies the precautionary approach in situations when a decision must be made about a risk of serious or irreversible harm and where there is scientific uncertainty. These factors should not be used as a reason to postpone decisions. The precautionary approach/principle is a distinctive approach to managing threats of serious or irreversible harm where there is scientific uncertainty. The precautionary approach recognizes that the absence of full scientific certainty shall not be used as a reason to postpone decisions where there is a risk of serious or irreversible harm. Even though scientific information may be inconclusive, decisions have to be made to meet society's expectations that risks be addressed and living standards maintained." (**www.ec.gc.ca/econom/pamphlet_e.htm**).

B. Risk Assessment

1. Health Canada has publicly subscribed to the Risk Assessment/Management approach that balances harm against cost.

2. But Health Canada and Industry Canada are attempting to redefine the Wingspread precautionary principle, as per their FAQ on Radiofrequency Fields (**www.ic.gc.ca/epic/site/smt-gst/nsf/print-en/sf08792e.html#3**):

"(21) What is the precautionary principle and when should it be used?

The precautionary principle (PP) is a public policy approach for **risk management** of possible, but unproven, adverse effects….If you are concerned about RF exposure, you may apply PP by limiting the length of your calls on cell phones and using a "hands-free" device that keeps the cell phone away from your head and body."

5. Obviously Health Canada and Industry Canada do not understand the precautionary principle to mean the same thing as the Wingspread Conference intended**. It is not an approach to manage risk, but to avoid risks where there is a possible threat of serious or irreversible harm.**

Health Canada and Industry Canada also confuse precautionary principle with precautionary avoidance, eg. recommending limiting the length of cell phone calls is PA, not PP.

Perhaps Health Canada's and Industry Canada's redefining its risk management approach can best be explained by a report presented by Wirthlin, a public relations firm, and Nichols Dezenhall Communications Management, specialists in crisis management. In the report, entitled Industry's Response to the Precautionary Principal, industry is encouraged to "Conduct research and (**http://209.204.197.52/publicns/report/PPFINAL.PDF**), as Mr. Vecchia, chairman of ICNIRP advised: "Be realistic about the EMR issue and consider the economical impact of precautionary measures."

QUESTION:

18) Why do Health Canada and Industry Canada require that the risk be established before the precautionary principle is applied when the essential point of the Precautionary Principle is to provide protection in the absence of full scientific certainty?

19) Given the risk involved and the growing body of credible scientific evidence indicating serious harm from non-thermal levels of RF, will Health Canada follow the lead of other Federal Departments (eg. Environment Canada), and implement the original Wingspread Statement on the Precautionary Principle in place of the current risk assessment method of determining the exposure level for the general public?

20) Until and unless the precautionary principle is implemented as intended, would Health Canada and Industry Canada amend their public statements so as to eliminate the possibility of confusing the public about the fact that they are employing risk management, not the precautionary principle?

21) Have Industry Canada and Health Canada changed the label of their risk assessment approach (which emphasizes cost) to the "Precautionary Principle" (which emphasizes safety) in an attempt to co-opt the positive public opinion of the Precautionary Principle without having to change the focus of their approach?

22) Why does Health Canada hold, as stated by [name withheld], that the danger associated with RF must be proven before action is taken, rather than taking the stance, recommended by the Wingspread Conference and Environment Canada, of making the proponent of the product (eg. the telecommunication industry) prove that RF exposure is safe? If it is not possible to prove its safety, as [name withheld] states, then how does Health Canada justify imposing a potentially unsafe product on the Canadian public?

23) How does Health Canada recommend utilizing its avoidance approach by those living next to or under transmission towers 24 hours a day for years on end?

24) Why is it Health Canada's policy that, contrary to the industry standard whereby a new product must be shown to be safe before it is introduced to the public, in the case of cell phones and FM transmitters, they are first introduced to the public and then it becomes the public's obligation to prove them to be unsafe?

25) If Health Canada applied the Precautionary Principle as Environment Canada defines it, new technology would be withheld from public use until it is demonstrated to be safe.

Since to Health Canada the Precautionary Principle is really a synonym for industry's Risk Assessment, are there any tests that new technology must undergo before it is approved for public use?

V. HEALTH IMPLICATIONS

A. Electromagnetic Sensitivity

1. Recent studies in many countries have indicated that more and more people are suffering from electromagnetic sensitivity. The symptoms are varied and severity ranges from mild to debilitating. Sweden now recognizes this as a disability and more people are going on disability pensions each year.

Sweden, Austria, Germany, United States, Switzerland, England and Ireland participated in studies which indicate an increase in the number of people affected which corresponds to the increase in exposure, through more technological development and wider use of transmitters, such as cell phone towers.

As reported in the journal "Electromagnetic Biology and Medicine", 25:189-191, 2006: 190 **Hallberg and Oberfeld** Table 1 Estimated prevalence of electrosensitive people in different years and countries Measured % El year sensitive Country, reported year Ref. No.:

1985 0.06 Sweden 1991 (0.025–0.125%) National Encyclopedia Sw., 1991
1994 0.63 Sweden 1995 Anonymous est., 1994
1995 1.50 Austria 1995 Leitgeb N. et al., 1995, 2005
1996 1.50 Sweden 1998 SNBHW, Env. report, 1998
1997 2.00 Austria 1998 Leitgeb N. et al., 1998, 2005
1997 1.50 Sweden 1999 Hillert L. et al., 2002
1998 3.20 California 2002 Levallois P., 2002
1999 3.10 Sweden 2001 SValberg PANBHW, Env. report, 2001
2000 3.20 Sweden 2003 Sw Labour Union Sif, 2003
2001 6.00 Germany 2002 Schroeder E., 2002
2002 13.30 Austria 2003 (7.6–19%) Spiß B., 2003
2003 8.00 Germany 2003 Infas, 2003
2003 9.00 Sweden 2004 Elöverkänsligas Riksförbund, 2005
2003 5.00 Schweiz 2005 Bern, Medicine Social, 2005
2003 5.00 Ireland 2005 This is London, 2005
2004 11.00 England 2004 Fox E., 2004
2004 9.00 Germany 2005 Infas, 2004
2017 50.00 Extrapolated to 50%

3. EHS—which can be very debilitating - is thought to result from large changes in the immune system caused by continuing exposure to microwave radiation, leading to chronic inflammation and allergic responses. Estimates of EHS vary from 3% to 10% of the population in the UK and other European countries. (The London Resolution, Dec. 3, 2007).

Canada did not have the technology and number of cell phones as Europe for some time, but it is logical to assume that Canada's exposure is growing at the same rate, and the health complaints are, too.

QUESTION:

Without acknowledging that there is evidence of health effects in humans exposed to non-thermal RF, and with the awareness that Health Canada has publicly subscribed to the risk assessment/management approach that balances harm against cost:

26) What research has Health Canada done to determine the current and future costs to our health system from the effects of EMR?

27) What level of harm will prompt Health Canada to revise its Safety Code 6 guideline to a lower biologically based but, perhaps, more costly level? Please give examples.

B. Consequences of Long-term exposure to FM and cell transmitters

1. Dr. Louis Slevin, editor of the authoritative Microwave News, upon learning that we lived within 100 meters of 3 FM transmitters, warned us that "cell phone transmitters are very dangerous, but FM transmitters can kill you." (in a telephone conversation on June 18, 2008).

2. There are, and were in 2000, many studies **specific to FM transmitters**, concluding that prolonged exposure to radiation from these powerful antennae lead to various types of cancer including childhood leukemia. Examples are:

Chiang et al. found that people who lived and worked near radio antennae and radar installations showed deficits in psychological and short-term memory tests [Health effects of environmental electromagnetic fields. Journal of Bioelectricity 8:127-131, 1989].

Dolk H, **Shaddick G**, **Walls P**, **Grundy C**, **Thakrar B**, **Kleinschmidt I**, **Elliott P**. Department of Public Health and Policy, London School of Hygiene and Tropical Medicine, England. PMID: 8982016 [PubMed - indexed for MEDLINE] **Am J Epidemiol.** 1997 Jan 1;145(1):1-9.

Melanoma Incidence and Frequency Modulation (FM) Broadcasting Ref 3. Hallberg Ö, Johansson O. Melanoma incidence and frequency modulation (FM) broadcasting. Arch Environ Health (2002); 57: 32-40.

Magras & Xenos (**1997**) have reported irreversible sterility in mice after 5 generations of exposure to 0.168 to 1.053 microwatts per square centimeter in an "antenna park." Note that the current, applicable US exposure standard would be 579 microwatts per square centimeter, -- 500 times higher! -- and that this very low exposure level would relate more to a person living near a Cellular Tower, than a phone user. (**http://www.wave-guide.org/library/cellphones.html**).

Dr Vini Gautam Khurana is a Mayo Clinic-trained neurosurgeon with an advanced neurosurgery Fellowship in cerebral vascular and tumour microsurgery. He has established that long term exposure and its effects on the body, particularly its electrical organ, the brain, are compounded by numerous other simultaneous long-term exposures including continuous waves from radio and TV transmitter towers, cordless phone base stations, power lines, and wireless/WiFi computing devices. (**www.brain-surgery.net.au**).

3. According to Report, University of Washington, by Henry Lai, Sept. 2004.

“when considering the health effect of radiation from wireless transmitters, one has to consider the effect of long-term exposure. People who live, attend school, or work close to transmitters are constantly being exposed to the radiation for months or years. Even though the level is low, it would matter if the effects of radiofrequency radiation turn out to be cumulative (eg. add up over time). Small doses cumulate over a long period of time will eventually lead to harmful effects. Therefore, exposure of the general public to radiofrequency radiation from wireless transmitters should be limited to a minimal level.” (**www.Salzburg.gv.at/henrylailetterspt132004.PDF**).

QUESTION:

28) If Health Canada continuously monitors all relevant scientific information, as they profess, how can it justify having allowed the corporations to install these dangerous transmitters among my neighbours on Triangle Mountain?

C. Consequences of Proximity to FM and cell transmitters

1. Many studies demonstrate that living near (within 300 meters of a base station) is dangerous:

a) A German study found a threefold higher frequency of cancer among people living in the vicinity (400 m) of a GSM base station compared to people living further away from the antenna. The risk for mammary cancer was 3,4 times greater and the average age of contracting this disease was considerably lower, 50,8 years than in the control group (69,9 years). The frequency increased also the longer people had been exposed to the radiation. The study covered a ten year long period (1994-2004), starting the year after the installation of the base station. Before the installation of the base station, there was no difference in cancer incidence between people living in the vicinity of the (future) base station and the control area.

Excerpt:

"The result is a quite concrete epidemiological proof of a connexion between exposition to radiation from GSM Base stations and Cancer. This result is, considering the available documentation about the effect of high frequency electromagnetic radiation not only plausible but probable."

Source (in German): Horst Eger, Klaus Uwe Hagen, Birgitt Lucas, Peter Vogel, Helmut Voit, **Einfluss der räumlichen Nähe von Mobilfunksendeanlagen auf die Krebsinzidenz.**
Umwelt·Medizin·Gesellschaft | 17 | 4/2004.

b) New Austrian research confirms health effects of base station radiation. Despite exposure to radiation far below recommended levels (max. 4.1 mW/m2), effects on wellbeing and performance on cognitive tests was observed in a study of 365 subjects living within 20-600 metres from Mobile Phone Base stations.

Source: Hutter HP, Moshammer H, Wallner P, Kundi M. **Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations.** *Occup Environ Med*. 2006 May;63(5):307-13.

c) Studies “on symptoms experienced by people living in vicinity of base stations shows that, in view of radioprotection, ***minimal distance of people from cellular phone base stations should not be < 300 m***.” **Physicians and Scientists for Responsible Application of Science and Technology,** June 15, 2008.

d) Clark, M.L. et al, “Biomonitoring of Estrogen and melatonin metabolites among women residing near radio and television radio broadcasting transmitters” concluded that RF and temporally stable 60 Hz exposures were associated with increased E1G excretion among post-menopausal women. J. Occup. Environ. Med. 2007;49: 1149-1156.

QUESTION:

29) Given than many people living in proximity to these are suffering serious diseases which are consistent with those attributable to chronic exposure to radiation from FM transmitters, what will Health Canada do to enforce removal of these transmitters to non-residential areas?

30) Given that these FM transmitters are in close proximity to and directed toward schools, and given that children are more susceptible to radiation danger, how will Health Canada and Industry Canada respond to concern from parents about their children’s health?

C. Antenna Farms

1. “In releasing Professor Dobell's review, Minister Rock acknowledged the Mayor, City Council and citizens of Colwood as having helped inspire the National Antenna Consultation, announced in October 2002. The National Antenna Tower Policy Review will give all Canadians the opportunity to shape the Department's tower siting procedures to ensure they keep pace with an evolving technological and consumer environment to best meet citizens' concerns.” (Industry Canada’s Minister Releases Third Party Review of Triangle Mountain Antenna Towers Siting Process, Feb. 6, 2003.)

2. In its circular CPC-2-0-03 effective Jan. 1, 2008, Industry Canada in section 3 states:

"Before building a new antenna-supporting structure, Industry Canada requires that proponents first explore the following options:

1) consider sharing an existing antenna system, modifying or replacing a structure if necessary;
2) locate, analyze and attempt to use any feasible existing infrastructure such as rooftops, water towers, etc."

3. In layman's term, such arrangements are called 'antennae farms', where multiple transmitters are grouped on one towers. When I asked why this was being encouraged, I was told by Jim Laursen, a local IC official, that people didn't object to transmitters but they do object to towers.

Industry itself admits, as stated in the Canadian Association of Broadcasters' submission, Oct. 17, 2003, "electromagnetic field levels in excess of HC's limits may be produced on the site if additional facilities are added."

[Information withheld]

4. Narda, the leading manufacturer of equipment to measure all aspects of EMR, used by Industry Canada in its field surveys, states that today’s multi-emitter transmission sites present difficulties for

“accurate RF emissions measurements. Multiple emitters dramatically complicate the measurement process, and it is quite easy to make measurements that appear accurate but are, in fact, quite the opposite. The fact that data gathering must be conducted in the field at sites where there are other transmitting systems besides the one to be measured compounds measurement difficulties. The emitters may also

operate at different frequencies, invoking more than one level of acceptable exposure as defined by today's frequency-dependent standards.
The antennas for these systems are usually located within a stone's throw of each other. Without the ability to discriminate among signals, it is almost impossible to determine the radiation level of a specific emitter. In addition, diode detectors that have often been used for electric and magnetic field measurements in the broadcast industry have characteristics that make their accuracy questionable in these applications." ***(Narda East Product Brochure*)**.

(Please note: Even with improper equipment and giving no consideration for compounding effects of multiple transmitters, the measurements taken by Industry Canada in my neighbourhood in 2001 were as high as 115 microwatts per square centimeter, or up to 685 times higher than those used in the Magras & Xenos study (see page. 17). And since 2001, many more antennae have been added within 300 meters, with plans for more. Canada's Safety Code 6 allows 200 microwatts per square centimeter for the general public.)

5. In the Canadian Association of Broadcasters submission to Industry Canada as part of the Antenna Policy Review, Oct. 17, 2003, the broadcasters state one of the key licensing conditions imposed by IC is that all RF installations must meet the requirements of HC with respect to non-ionizing RF fields, as set out in SC 6. Engineering submissions supporting applications for new or modified facilities (eg. antenna farms) must include a technical analysis demonstrating that the facilities will not exceed the levels of SC 6. This is done by making "theoretical signal-level calculations."

In the same submission, the broadcasters state that "although the effective radiated power from FM/TV/DAB broadcasting installations can often be quite high, tall antenna towers are generally used. This automatically ensures that high-energy zones are located well above the ground.

In all of my research I have been unable to find even one long-term study of the effects of these antenna farms on nearby residents.

QUESTION:

It is uncontested that when wireless electronic equipment is added in an already existing EMR zone that the result is a compounding of emissions.

In light of the recent study **BY Dr. Khurana** regarding the impact of the compounding effects of multi-product use, without acknowledging that the evidence of documented health effects in animals or humans exposed to non-thermal levels of radiation is conclusive, and in the interest of protecting Health Canada from a future charge of failing in its fiduciary responsibility to protect the health of its citizens, and in mitigating somewhat the possibility of the telecommunications industry from being held liable for injuries caused by EMR:

31) Will Health Canada advocate/support the placing of warning signs within 200 meters of the transmitter sites with the wording?

WARNING! YOU ARE ENTERING AN AREA OF HIGH ELECTROMAGNETIC RADIATION EMISSIONS. USE OF WIRELESS EQUIPMENT, INCLUDING CELL PHONES, WITHIN A RADIUS OF 200 METERS OF THESE TRANSMITTERS IS TO BE AVOIDED.

32) Who is responsible for establishing the parameters for technical analyses associated with multiple transmitters?

33) Do these "theoretical calculations" take into consideration the fundamental properties of EM fields, namely reflection and compounding?

34) How does Ind. Can. ensure that the allowable limits for maximum values are never exceeded?

35) With the knowledge that "the effective radiated power from FM/TV/DAB broadcasting installations can often be quite high", why has Health Canada allowed, and continues to allow, installations of these transmitters near homes and schools which are at or near the same elevation of the transmitters? Please justify this practice.

36) Why is Industry Canada taking the approach of requiring the placement of multiple transmitters on towers? Is it, as I have been told by Mr. Jim Laursen of Industry Canada, because people see the towers and complain; they don't see the transmitters and don't complain?

37) Upon what scientific evidence does Health Canada base its decision to force proliferation of these antenna farms near residences and schools?

38) Under the new siting policy, CPC-2-0-03, no consultation is required for placement of new transmitters, only for new towers. Why was this presented to the public as an effort for more consultation between Ind. Can. and the public when it really was intended to allow the creation of antenna farms with no consultation with or input by the public?

D. OUR SITUATION

1. In the study entitled “Biomonitoring of Estrogen and melatonin metabolites among women residing near radio and television radio broadcasting transmitters” M.L. Clark, et al, concluded that RF and temporally stable 60 Hz exposures were associated with increased E1G excretion among post-menopausal women. J. Occup. Environ. Med. 2007;49: 1149-1156.

The study took place at Lookout Mountain, Colorado, where people live with multiple FM and TV antennae. Results of the long-term study showed that long-term exposure to RF results in increases in estrogen in post-menopausal women and reduction in melatonin production, both of which have been shown to be related to cancer.

It should be pointed out that the closest house to the transmitters was 900 meters away and the scientists conducting the study considered, for their purposes, a high exposure level to be anything greater than 4 microwatts per centimeter squared.

2. However, I and my neighbours who live on top of Triangle Mountain live at nearly the same elevation as the FM and cell transmitters, and some live as close as 30 meters from them. Even with inadequate testing methods, which I will detail in the following section, the exposure level in the Triangle Mountain study was as high as 114 microwatts per centimeter squared and today there are 10 times the number of transmitters here than there were in 2001. There are 44 transmitters of varying frequencies within 1 kilometer of my home, 55 within 2 kilometers.

And within approximately one kilometer there are two schools, an elementary school and a middle school, in direct line with the transmissions.

3. The Triangle Mountain study:

In August 2001, at the request of the City of Colwood and the residents of Triangle Mountain, two experts from Industry Canada spent 2 days at 10 different locations, measuring emission levels, in an effort to provide reassurance that health was not endangered by 3 FM transmitters and 2 Studio Link Transmitters (STLs) that were installed in 2000.

According to Safety Code 6,6.1: "the objective of a survey is to determine whether the device or installation complies with recommended standards of performance and personnel exposure…."

a) SC 6, 6.1f says that equipment shall match the source and the exposure levels in the near- and far-field.

According to the report written by [name withheld], the spectrum analyzer was used merely to find the FM emissions, not to measure them. Instead, an electronic survey meter and a Narda field probe were used. According to an independent expert with whom I consulted, this means that not all RF emissions were measured from the STLs or other nearby transmitters.

In addition, according to Narda specifications, the Narda field probe that was used is "very suitable for Occupational Exposure levels and **partially suitable for General Public Levels."**

Conclusion:

The correct equipment for the situation was not used.

b) SC 6, 6.2a says that records shall be kept for all RF survey measurements, including calibration date, and, SC 6, 6.1f says that survey instruments shall be fully calibrated at least every 3 years.

No calibration data was provided with the report and when, in Oct. 2007, [name withheld] of Industry Canada, who performed the tests, was asked for the data, [name withheld] said it had not been kept. But [name withheld] replied that some of equipment had last been calibrated on March 19, 1998, or 3 ½ years before the test.

Inconsistencies in the results were noted in the report and readings could not be duplicated, a clear indication that the equipment was not performing properly.

Conclusion:

Industry Canada's protocol regarding equipment and record keeping was not followed.

c) SC 6.2.2.1a requires that testing be done using a time averaging over a period of .1 hour (6 minutes).

Industry Canada reported that a 30 second averaging method was used.

Conclusion:

Industry Canada's protocol regarding time averaging was not followed.

d) Narda, the equipment manufacturer, states that the antenna should be at head level (1.5-1.75 meters) and should be placed on a non-conducting tripod connected to a basic unit via cable. This ensures that the field being measured is not influenced by the unit or the tester.

The Industry Canada report describes how the probe was moved slowly up and down as the surveyor held it and walked back and forth. “The probe was held high over his head, pointing the probe away from the body.” Variable readings were explained by the movement of nearby people.

Conclusion:

Neither manufacturer nor Industry Canada’s instructions for testing were followed.

e) SC 6.2.4.3 states that if measured strengths are as high as 20% of limits, induced and contact current measurements should be taken.

No such measurements were taken even though readings were reported to be as high as 54.5% .

Conclusion:

Industry Canada’s protocol was not followed.

Even using improper equipment and incorrect protocol, the highest reported reading was 20.3 V/m or 109 uW/cm2. (When the calculations were checked for accuracy, the highest reading actually was 20.7 W/m or 114 uW/cm2 outdoors and 75 uW/cm2 indoors.)

To put this into perspective, the precautionary maximum set by the BioInitiatve Report is .1 uW/cm2 outdoors and .01uW/cm2 indoors, 7500 times lower than the results from the measurements done in 2001 inside a home where people live, exposed, for 24 hours a day.

4. It should come as no surprise, then, that there are many people on my street suffering severe diseases: sleep disorders, memory reduction, loss of concentration, multiple miscarriages, skin rashes, multiple cataracts, prostate cancers, breast cancers -- all within one city block of the FM transmitters.

Whenever I have written to Health Canada or to Industry Canada informing them about our problems, I've been told the emissions are within Safety Code 6 levels for the general public. Therefore 1) there is nothing I can do; 2) there is no proof of a connection between the illnesses and electromagnetic radiation from the transmitters.

5. 21:08 06.08.2006 "microwave radiation can...functionally interfere with the natural processes involved in DNA replication and repair, by subtly altering molecular conformation (architecture), for example; this could well account, respectively, for the reports of chromosome aberrations / micronuclei formation and for the increased amount of DNA fragmentation observed under irradiation." Source: **How Exposure to GSM & TETRA Base-station Radiation can Adversely Affect Humans**. By Dr Gerard Hyland.

QUESTION:

39) Please define "general public" as the term is used in Safety Code 6.

40) If, as according to ICNIRP, levels allowed by Safety Code 6 apply to short-term acute exposure, why are there no biologically (health)-based standards which apply to chronic, long-term exposures for people who are living with the transmitters 24 hours a day, 365 days a year?

41) Would Industry Canada provide the power level of each of the 55 transmitters within 2 kilometers of my home?

42) Does Industry Canada have a limit to the number of transmitters that will be added within this radius?

43) Would Health Canada commit to having an independent epidemiological study done to determine the health status of people on Triangle Mountain?

44) Would Health Canada commit to an immediate and independent investigation into the dangers posed by antenna farms and, should these show harm, would it commit to establishing biologically (health)-based exposure standards?

45) Considering the improper procedures and equipment used in the 2001 testing for EMR on Triangle Mountain, why should the residents of Colwood have any confidence in Health Canada's and Industry Canada's assurances that they are safe since the actions of their employees left them in no position to offer an opinion?

46) Given the lack of concern for the public demonstrated by their employees at every level, why should the citizens of Canada have confidence in anything Health Canada or Industry Canada says or does?

Closing Statement

It is strikingly clear to us that Canada is in desperate need of a Corporate Manslaughter Act. The UK enacted one in 2007. It came into force in April, 2008. It made public and private corporations, as well as agents of these corporation, criminally responsible for actions that result in a person's death. The Act, and offence, also applies to Crown bodies.

With such an act in place here in Canada, there would be no need to have written this petition.

It is particularly offensive to us that the telecommunications industry appears to have such an influence over governmental departments that it can deleteriously impact the public weal. It has led to the bizarre situation in which the citizens of Canada are forced to act as guinea pigs testing potentially harmful telecommunications technology.

But this was to be expected when Canada allowed the telecommunications industry to introduce its products before any testing was done to prove them safe. Now it is up to the Public, by epidemiological studies showing their tumours, lesions, heart problems, sleep disorders, childhood leukemia, and cancers, to prove them unsafe.

Easy enough, you might think, if the evidence is that clear. Ah, but what matter clarity when it is industry, abetted by their Faustian enablers within Health Canada and Industry Canada, that has the final say. Not for nothing comes the proverb: "He who pays the piper, calls the tune."

And to prove the faith that industry has placed in them has not been misapplied, Health Canada and Industry Canada have now gone so far as to improvise on a theme made infamous in Orwell's classic, 1984. Every schoolboy remembers "War is Peace" and "Slavery is Freedom". But they'll never place: "Cost is Harm" "Risk Management is the Precautionary Principle" and "Precautionary Avoidance is Living Under Transmission Towers."

Ah, yes, indeed, it is a brave new world today. But will we be around to enjoy tomorrow?

*[attachments not posted]

[top of page]

Joint Response: Health Canada, Public Health Agency of Canada

5 November 2008

Ms. Sharon and Mr. Dennis Noble
818 Bexhill Place
Victoria, British Columbia V9C 3V5

Dear Ms. and Mr. Noble:

This is in response to your environmental petition no. 255 of June 22, 2008, addressed to Mr. Scott Vaughan, the Commissioner of the Environment and Sustainable Development (CESD).

In your petition you raised concerns about the effects of electromagnetic radiation.

I am pleased to provide you with the enclosed joint Health Canada and Public Health Agency of Canada response to your petition. I understand that the Minister of Industry will be responding separately to the questions that fall within the purview of his department.

I appreciate your interest in this important matter, and I hope that you will find this information useful.

Yours sincerely,

[Original signed by Leona Aglukkag, Minister of Health]

Leona Aglukkaq

Enclosure

c.c. Mr. Scott Vaughan, CESD
The Honourable Tony Clement, P.C., M.P.

Response to Environmental Petition No. 255
filed by Ms. Sharon Noble and Mr. Dennis Noble
under Section 22 of the *Auditor General Act*
Received July 9, 2008

Effects of Electromagnetic Radiation (EMR)

November 6, 2008

Minister of Health and the Minister for the Federal Economic Development Initiative for Northern Ontario

1. How can Health Canada rationalize using research that is influenced to such a degree by people who rely upon industry funding?

5. Do Industry Canada and Health Canada adhere to the rule that the authors, whatever their affiliation, of all studies that Industry Canada or Health Canada depend on to support their position on EMR, must clearly be seen to be independent, and must be willing to declare that they have no financial interests in the outcome of their studies and that they receive no industry funding, whether directly or indirectly, in carrying out their studies?

*7. How does Health Canada refute the **perception** that it is unduly supportive of telecommunication companies because of its dependence upon researchers that have ties to that industry?*

*9. Since the researchers appear to be so closely associated with industry that has a direct interest in the results of their research, why should we not **assume** that those results are biased in its favour?*

*10. How does Health Canada refute the **perception** that it discounts credible peer-reviewed scientific studies that are not industry funded and favours studies that are industry funded?*

*11. How does HC refute the **perception** that just as the multibillion dollar asbestos and tobacco industries were able to persuade government overseers to ignore credible evidence harmful to the bottom line of those industries, the multibillion dollar telecommunications industry is not persuading Health Canada to ignore credible evidence that is harmful to the bottom line of that industry?*

12. How does Health Canada explain why each of these non-industry funded studies is not considered relevant or credible by experts at HC or the Royal Society?

Answer to Questions 1, 5, 7, 9, 10, 11 & 12:

Health Canada's Safety Code 6 sets out safety requirements for the installation and use of radiofrequency (RF) and microwave devices that operate in the frequency range from 3 kHz to 300 GHz. It is based on internal scientific reviews of original relevant scientific studies that are published in internationally recognized peer-reviewed journals. For further information, please refer to **http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/99ehd-dhm237/index-eng.php.**

All credible peer-reviewed scientific studies are included in Health Canada's weight-of evidence approach. Each study is evaluated individually for its scientific quality, the important factors being proper scientific design and analysis. The fact that some studies are either directly or indirectly funded, in whole or in part, from the wireless industry or any other sources does not constitute a valid reason to dismiss these research findings outright. The only scientifically justifiable approach is to evaluate the science in each study based upon its merits and deficiencies and then roll up the analysis using a weight-of-evidence approach.

Health Canada conducts its own analysis of the scientific literature in a completely independent fashion. All research, review and surveillance activities in the area of bioelectromagnetics health risk assessment by Health Canada have been solely funded by the Government of Canada. Health Canada is not dependent on any external parties for its risk assessment of the safety of RF fields.

Health Canada cannot control such perceptions about the adequacy of the scientific process used to evaluate scientific studies. We endeavour to maintain an open and fair environment for scientific discourse and respond to any questions regarding the evaluation process.

2. Who in Health Canada is responsible for vetting researchers and the peer-reviewed research used to confirm that Safety Code 6 is safe?

Safety Code 6 was written by a team of scientists at Health Canada as stated in the document. The proposed guidelines were reviewed by a number of internal and external referees, including the Royal Society of Canada's (RSC) Expert Panel on Radiofrequency Fields. It is important to point out that the health effects literature reviewed by Health Canada staff is the same as that reviewed by all other national and international standards organizations. The safety limits outlined in Safety Code 6 are consistent with other international science-based exposure limits.

3. Are Health Canada and Industry Canada employees required to sign conflict of interest statements that declare they have no affiliation with any organization that may bring into question the impartiality of their work?

4. Are scientists conducting research for Health Canada and Industry Canada required to sign conflict of interest statements that declare they have ***no affiliation with any organization****, nor do they accept, directly or indirectly, funding from any source that could be perceived in any way to cast doubt on the objectivity of their work?*

Answer to Questions 3 & 4:

Health Canada staff adhere to the *Values and Ethics Code for the Public Service* and make declarations of conflict of interest as required. All work performed by Health Canada staff in this area has been entirely funded by the Government of Canada.

6. When at least half of the members of the "expert panel" have ***direct or indirect associations*** *with the telecommunication industry,* ***why should the public believe*** *that the recommendations of these people are not influenced by industry?*

The RSC is a highly reputable organization which is composed of esteemed scientists. Health Canada contracted with the RSC to independently select an expert panel to review Safety Code 6 and the scientific basis for its exposure limits for the protection of the public from RF fields. While Health Canada wrote the terms of reference for the tasks of the Expert Panel, the selection of Panel members was done entirely by the RSC and Health Canada had no part in the research, review and development of the conclusions and recommendations presented by the panel.

8. Since WHO accepts funding from the wireless industry, why should ***credence*** *be given to studies that WHO sponsors?*

The World Health Organization (WHO) is a highly reputable international science-based organization which is composed of a diverse set of esteemed scientists from around the world in a variety of disciplines.

The fundamental purpose of the WHO EMF project is to advise and assist national health authorities to develop protection measures for their populations from exposure to electromagnetic fields. This is especially valuable for smaller countries lacking the scientific infrastructure to undertake their own

reviews and develop guidelines. Countries are not obligated to accept the recommendations of the WHO and are free to formulate their own protective measures. This is the case in Canada, where Safety Code 6 was one of the first national exposure guidelines developed and continues to be supported by the scientific community.

The WHO EMF project receives funding from many national health authorities and private industry. However, the WHO EMF project does not fund research studies, but rather reviews the literature and identifies knowledge gaps which require further research.

14. How much has Health Canada spent for independent, non-industry funded research annually during the last 5 years?

Research in the field of bioelectromagnetics conducted by Health Canada scientists is solely funded by the Government of Canada. Since 2003, Health Canada has spent a total of approximately $500,000 plus approximately 15 person-years of staff time on EMF research, evaluation, survey and surveillance activities.

15. Will Health Canada justify the current exposure standards of SC6, which are at levels to protect the public only against short term gross heating effects, as per ICNIRP?

Health Canada's Safety Code 6 takes into account all possible biological and/or health effects of RF fields, including short-term heating effects, non-thermal effects and/or long-term effects. It should also be pointed out that the exposure standards of Safety Code 6 are applicable for continuous, uninterrupted exposure (24 hours per day, 7 days per week) and not only for short-term or intermittent exposure.

16. Will Health Canada and Industry Canada amend its public documents to reflect the fact that Canada's standard is not consistent with most other developed countries and to instruct its researchers to stop telling the public that Canada's standards are among the most stringent in the world?

17. Health Canada and Industry Canada do not follow the stricter safety codes of most of Europe but rather the much more lax safety codes of the U.S.. To what degree is this because Health Canada and Industry Canada have been unduly influenced by the powerful North American telecommunication industry?

Answer to Questions 16 & 17:

The basic restrictions outlined in Health Canada's Safety Code 6 guideline are similar to both the Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz (IEEE C95.1) and International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, adopted by most Western European nations and the United States. The Guidelines can be found at the following links: **http://www.icnirp.net/documents/emfgdl.pdf, and http://standards.ieee.org/reading/ieee/std_public/description/emc/C95.1-1991_desc.html.**

Health Canada's Safety Code 6, however, is more restrictive in terms of compliance. It requires Specific Absorption Rates (SAR) evaluations to be conducted using an averaging volume of 1 g of tissue, whereas a 10 g volume is used for both IEEE C95.1 and ICNIRP guidelines. This means greater accuracy with Safety Code 6.

As described above, Health Canada's recommendations regarding safety of exposure to RF fields have not been influenced by the telecommunications industry in any way.

18. Why do Health Canada and Industry Canada require that the risk be established before the precautionary principle is applied when the essential point of the Precautionary Principle is to provide protection in the absence of full scientific certainty?

19. Given the risk involved and the growing body of credible scientific evidence indicating serious harm from non-thermal levels of RF, will Health Canada follow the lead of other Federal Departments (eg. Environment Canada), and implement the original Wingspread Statement of the Precautionary Principle in place of the current risk assessment method of determining the exposure level for the general public?

20. Until and unless the precautionary principle is implemented as intended, would Health Canada and Industry Canada amend their public statements so as to eliminate the possibility of confusing the public about the fact that they are employing risk management, not the precautionary principle?

21. Have Industry Canada and Health Canada changed the label of their risk assessment approach (which emphasizes cost) to the "Precautionary Principle" (which emphasizes safety) in an attempt to co-opt the positive public opinion of the Precautionary Principle without having to change the focus of their approach?

25. If Health Canada applied the Precautionary Principle as Environment Canada defines it, new technology would be withheld from public use until it is demonstrated to be safe. Since to Health Canada the Precautionary Principle is really a synonym for industry's Risk Assessment, are there any tests that new technology must undergo before it is approved for public use?

Answer to Questions 18, 19, 20, 21, & 25:

Health Canada endorses the precautionary principle and its approach to decision making can be found online at **http://www.hc-sc.gc.ca/sr-sr/advice-avis/decision/index-eng.php.**

Health Canada's position and public statements are consistent with the Precautionary Principle. If the guidelines in Safety Code 6 are respected, then there is no convincing scientific evidence to expect any adverse human health effects.

22. Why does Health Canada hold, as stated by [name withheld], that the danger associated with RF must be proven before action is taken, rather than taking the stance, recommended by the Wingspread Conference and Environment Canada, of making the proponent of the product (eg. the telecommunication industry) prove that RF exposure is safe? If it is not possible to prove its safety, as [name withheld] states, then how does Health Canada justify imposing a potentially unsafe product on the Canadian public?

Health Canada staff do not advocate that the dangers associated with RF must be proven before action is taken. If the guidelines in Safety Code 6 are respected, Health Canada's position is that there is no convincing scientific evidence to expect any adverse human health effects. Health Canada does not impose, regulate, license or monitor the compliance of wireless technologies in Canada. These activities are responsibilities of the Department of Industry.

23. How does Health Canada recommend utilizing its avoidance approach by those living next to or under transmission towers 24 hours a day for years on end?

28. If Health Canada continuously monitors all relevant scientific information, as they profess, how can it justify having allowed the corporations to install these dangerous transmitters among my neighbours on Triangle Mountain?

29. Given that many people living in close proximity to these are suffering serious diseases which are consistent with those attributable to chronic exposure to radiation from FM transmitters, what will Health Canada do to enforce the removal of these transmitters to non-residential areas?

30. Given that these FM transmitters are in close proximity to and directed toward schools, and given that children are more susceptible to radiation danger, how will Health Canada and Industry Canada respond to concern from parents about their children's health?

31. Will Health Canada advocate/support the placing of warning signs within 200 meters of the transmitter sites with the wording?

WARNING! YOU ARE ENTERING AN AREA OF HIGH ELECTROMAGNETIC RADIATION EMISSIONS. USE OF WIRELESS EQUIPMENT, INCLUDING CELL PHONES, WITHIN A RADIUS OF 200 METERS OF THESE TRANSMITTERS IS TO BE AVOIDED.

35. With the knowledge that "the effective radiated power from FM/TV/DAB broadcasting installations can often be quite high", why has Health Canada allowed, and continues to allow, installations of these transmitters near homes and schools which are at or near the same elevation of the transmitters? Please justify this practice.

37. Upon what scientific evidence does Health Canada base its decision to force proliferation of these antenna farms near residences and schools?

Answer to Questions 23, 28, 29, 30, 31, 35, & 37:

Health Canada is not responsible for siting, licensing or compliance of wireless transmitters. Those activities are the responsibility of Industry Canada.

It is Health Canada's scientific position that there are no anticipated adverse health effects associated with short-term or long-term exposure of the general public to RF fields, provided that exposure levels are below the limits outlined in Safety Code 6.

It is Health Canada's opinion that there is no scientific justification for such a warning. However, it is the responsibility of Industry Canada to determine whether warning signs are warranted.

24. Why is it Health Canada's policy that, contrary to the industry standard whereby a new product must be shown to be safe before it is introduced to the public, in the case of cell phones and FM transmitters, they are first introduced to the public and then it becomes the public's obligation to prove them to be unsafe?

In the case of cellular technology, exposure guidelines existed (1979 in Canada) well before the introduction of the technology (about the late 1980's in Canada). A large body of scientific research also existed before the introduction of the technology, much of which looked at the possibility of non-thermal effects. Health Canada does not promote, regulate, license or monitor the compliance of wireless and broadcast technologies in Canada. These activities are the responsibilities of the Department of Industry. There is no convincing scientific evidence that exposure to RF fields at levels below the limits outlined in Safety Code 6 cause any adverse health effects.

26. What research has Health Canada done to determine the current and future costs to our health care system of EMR?

Health Canada has not assessed the possible costs to the health care system from exposure to electromagnetic radiations (EMR) since there is no convincing scientific evidence of adverse health effects as long as the exposure limits outlined in Safety code 6 are respected.

27. What level of harm will prompt Health Canada to revise its Safety Code 6 guideline to a lower biologically-based but, perhaps, more costly level? Please give examples.

Any credible, independently replicated and consistent adverse health effect that is demonstrated to arise from RF field exposures below the limits outlined in Safety Code 6 would prompt Health Canada to revise its exposure limits.

39. Please define "general public" as the term is used in Safety Code 6.

The term "general public" is defined in Safety Code 6 (Appendix VIII, Definitions, page 67) as follows: "All persons not employed as RF and microwave exposed workers or those not working in controlled environments (areas). They include pregnant women, the aged, children, the chronically ill and disabled". For more information, please refer to the following link: **http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/99ehd-dhm237/index-eng.php.**

40. If, as according to ICNIRP, levels allowed by Safety Code 6 apply to short-term acute exposure, why are there no biologically (health)-based standards which apply to chronic, long-term exposures for people who are living with the transmitters 24 hours a day, 365 days a year?

Health Canada's Safety Code 6 takes into account all possible biological and/or health effects of RF fields, including short-term heating effects, non-thermal effects and/or long-term effects.

43. Would Health Canada commit to an independent epidemiological study done to determine the health status of people on Triangle Mountain?

Conclusions from a WHO expert workshop, published in 2007, state that public exposures to permissible RF levels from mobile telephone and base stations are not likely to adversely affect human health. Based on current evidence of health effects, the Public Health Agency of Canada has no plans to carry out an independent epidemiological study in Triangle Mountain.

44. Would Health Canada commit to an immediate and independent investigation into the dangers posed by antenna farms and, should these show harm, would it commit to establishing biologically (health)-based exposure standards?

It is Health Canada's scientific position that no adverse health effects associated with exposure of the general public to RF fields are anticipated, provided that exposure levels are below the limits outlined in Safety Code 6. Nevertheless, should any credible, independently replicated and consistent adverse health effect be demonstrated at RF field exposures below the limits outlined in Safety Code 6, Health Canada would initiate a revision of its exposure limits. Ensuring that human exposures do not exceed the human exposure limits outlined in Health Canada's Safety Code 6 near antennas and/or antenna farms is the responsibility of Industry Canada.

45. Considering the improper procedures and equipment used in the 2001 testing for EMR on Triangle Mountain, why should the residents of Colwood have any confidence in Health Canada's and Industry Canada's assurances that they are safe since the actions of their employees left them in no position to offer an opinion?

Health Canada had no involvement in the testing of EMR on Triangle Mountain. Compliance of wireless transmitters is the responsibility of Industry Canada.

46. Given the lack of concern for the public demonstrated by their employees at every level, why should the citizens of Canada have confidence in anything Health Canada or Industry Canada says or does?

Health Canada is the federal department responsible for helping Canadians maintain and improve their health. This is a responsibility that all staff at Health Canada, including those involved in the health risk assessment of EMF, take seriously.

Health Canada conducts its own analysis of the scientific literature on EMF in a completely independent fashion. All research, review and surveillance activities in the area of bioelectromagnetics health risk assessment by Health Canada have been solely funded by the Government of Canada. Health Canada is not dependent on any external parties for its risk assessment of the safety of RF fields.

It is Health Canada's scientific position that no adverse health effects associated with exposure of the general public to RF fields are anticipated, provided that exposure levels are below the limits outlined in Safety Code 6.

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Minister's Response: Industry Canada

29 January 2009

Mrs. Sharon and Mr. Denis Noble
818 Bexhill Place
Victoria, British Columbia V9C 3V5

Dear Mr. and Mrs. Noble:

I am writing to provide you with Industry Canada's response to two Environmental Petitions, No. 255, received 25 June 2008, regarding the effects of non-thermal electromagnetic radiation at Triangle Mountain, Colwood, British Colombia, and Environmental Petition No. 255-B, received 21 July 2008, requesting that transmission towers be removed from there. These petitions were forwarded to the Minister of Health and the Minister of Industry by the Commissioner of the Environment and Sustainable Development. I am pleased to respond to your questions that fall within Industry Canada's area of responsibility.

Environmental Petition No. 255

Question 3: Are Health Canada and Industry Canada employees required to sign conflict of interest statements that declare they have no affiliation with any organization that may bring into question the impartiality of their work?

Question 4: Are scientists conducting research for Health Canada and Industry Canada required to sign conflict of interest statements that declare they have no affiliation with any organization, nor do they accept, directly or indirectly, funding from any source that could be perceived in any way to cast doubt on the objectivity of their work?

Question 5: Do Industry Canada and Health Canada adhere to the rule that the authors, whatever their affiliation, of all studies that Industry Canada or Health Canada depend on to support their position on

(EMR), must clearly be seen to be independent, and must be willing to declare that they have no financial interests in the outcome of their studies and that they receive no industry funding, whether directly or indirectly, in carrying out their studies?

Question 13: How much has the telecommunications industry spent for research annually over the last 5 years?

Regarding the quantity of money spent by the telecommunications industry on research, Industry Canada does not maintain records of this nature.

Question 16: Will Health Canada and Industry Canada amend its public documents to reflect the fact that Canada's standard is not consistent with most other developed countries and to instruct its researchers to stop telling the public that Canada's standards are among the most stringent in the world?

Question 17: Health Canada and Industry Canada do not follow the stricter safety codes of most of Europe but rather the much more lax safety codes of the US. To what degree is this due to Health Canada and Industry Canada having been unduly influenced by the powerful North American telecommunication industry?

Question 18: Why do Health Canada and Industry Canada require that the risk be established before the precautionary principle is applied when the essential point of the Precautionary Principle is to provide protection in the absence of full scientific certainty?

Question 20: Until and unless the precautionary principle is implemented as intended, would Health Canada and Industry Canada amend their public statements so as to eliminate the possibility of confusing the public about the fact that they are employing risk management, not the precautionary principle?

Question 21: Have Industry Canada and Health Canada changed the label of their risk assessment approach (which emphasizes cost) to the "Precautionary Principle" (which emphasizes safety) in an attempt to co-opt the positive public opinion of the Precautionary Principle without having to change the focus of their approach?

Question 30: Given that these FM transmitters are in close proximity to and directed toward schools, and given that children are more susceptible to radiation danger, how will Health Canada and Industry Canada respond to concerns from parents about their children's health?

Health Canada has established safety guidelines for exposure to radiofrequency fields in its Safety Code 6 publication entitled *Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz*. To Industry Canada's knowledge, Health Canada endorses the precautionary principle and its approach to decision making can be found on their website at http://www.hc-sc.gc.ca/sr-sr/advice-avis/decision/index-eng.php.

While the responsibility for developing Safety Code 6 rests with Health Canada, Industry Canada has adopted this guideline for the purpose of protecting the general public, which includes pregnant women, seniors, children, the chronically ill, and persons with disabilities.

Industry Canada requires that all proponents and operators ensure that their radiocommunication and broadcasting installations comply with Safety Code 6 at all times. Proponents and operators must also consider the combined effects of nearby installations within the local radio environment.

Industry Canada independently chose to adopt Safety Code 6 for the protection of the general public. This decision was not taken due to influence by the telecommunication industry.

To Industry Canada's knowledge, Health Canada's Safety Code 6 takes into account all possible biological and/or health effects of radiofrequency fields, including short-term heating, non-thermal and/or long-term effects. Furthermore, it has been determined that there is no convincing scientific evidence that exposure to radiofrequency fields at levels below the limits outlined in Safety Code 6 cause any adverse health effects.

Question 32: Who is responsible for establishing the parameters for technical analyses associated with multiples transmitters?

Question 34: How does Industry Canada ensure that the allowable limits for maximum values are never exceeded?

The technical aspects of radiocommunication, including the technical aspects of broadcasting, is under the responsibility of Industry Canada. It is the responsibility of proponents and operators of installations to ensure that all radiocommunication and broadcasting installations comply with Health Canada's Safety Code 6 at all times, including consideration of combined effects of nearby installations within the local radio environment.

Compliance with Safety Code 6 is an ongoing obligation. Antenna system operators may be required, as directed by Industry Canada at any time, to demonstrate compliance with Safety Code 6 by (i) providing detailed calculations, and/or (ii) conducting site surveys and, where necessary, by implementing corrective measures.

Question 33: Do these "theoretical calculations" take into consideration the fundamental properties of EM fields, namely reflection and compounding?

Industry Canada's internal tools that are used for assessing Safety Code 6 compliance take into account the fundamental properties of EM fields. Ground wave reflection of the electromagnetic waves, as well as the compounding of field strengths produced by all antenna systems, are taken into account when theoretical calculations are made to determine radio frequency (RF) exposure compliance. Numerous other electromagnetic properties of antennas, such as frequency, effective radiated power (ERP), antenna gain, antenna pattern, size of the antenna and antenna tilt, need to be accounted for during theoretical calculations, where appropriate and as required.

Question 36: Why is Industry Canada taking the approach of requiring the placement of multiple transmitters on towers?

Is it, as I have been told by Mr. Jim Laursen of Industry Canada, because people see the towers and complain; they don't see the transmitters and don't complain?

Question 38: Under the new siting policy, CPC-2-0-03, no consultation is required for placement of new transmitters, only for new towers. Why was this presented to the public as an effort for more consultation between Industry Canada and the public when it really was intended to allow the creation of antenna farms with no consultation with or input by the public?

Procedures for the installation of new towers are set out in Industry Canada's Client Procedures Circular (CPC) 2-0-03, entitled *Installing Radiocommunication and Broadcasting Antenna Systems*, Issue 4, which replaces the former CPC-2-0-03, entitled *Environmental Process, Radiofrequency Fields and Land-Use Consultation*, Issue 3, 24 June 1995. In preparing its update to the procedures, the department studied the recommendations of both the Telecommunications Policy Review and the National Antenna Tower Policy Review. These reviews indicate that there are compelling social and economic reasons to support antenna tower and site sharing.

Industry Canada has incorporated many of the key recommendations of these two independent public reviews into the updated procedures, notably those relating to sharing and the exclusion from consultation for certain types of installations, while recognizing the requirement to balance the need for local input with the orderly development of radiocommunication in Canada. Local consultation regarding the installation of a new tower gives the public an opportunity to provide their input.

Question 41: Would Industry Canada provide the power level of each of the 55 transmitters within 2 kilometres of my home?

Publicly available licence information, including power levels, is available on Industry Canada's Spectrum Direct website at https://sd.ic.gc.ca, which is updated regularly and therefore provides the most current information. One of the features of the website is a geographic search feature that permits search radii that can encompass all of Canada.

Question 42: Does Industry Canada have a limit to the number of transmitters that will be added within this radius?

No, Industry Canada does not have a preset limit on the number of transmitters for a given geographic area. However, there are a number of technical issues that may limit the number of transmitters in a given location. For example, Industry Canada applies Health Canada's Safety Code 6 for the protection of the general public related to radiofrequency exposure. The field strength limits described in Safety Code 6, are not to be exceeded at any location accessible to the public.

Question 45: Considering the improper procedures and equipment used in the 2001 testing for EMR on Triangle Mountain, why should the residents of Colwood have any confidence in Health Canada's and Industry Canada's assurances that they are safe since the actions of their employees left them in no position to offer an opinion?

The department can assure the residents of Colwood that the employees who took measurements have proper training to work in the radio frequency discipline, have knowledge of electromagnetic field theory and followed proper engineering methods and practices. In 2001, the power density levels at Triangle Mountain were tested and Industry Canada staff found the levels to be in compliance with Safety Code 6 at all locations examined. The department has full confidence in the testing procedures and measurement equipment that were used to verify public Safety Code 6 compliance on Triangle Mountain in 2001 and, again, in 2008.

Question 46: Given the lack of concern for the public demonstrated by their employees at every level, why should the citizens of Canada have confidence in anything Health Canada or Industry Canada says or does?

Industry Canada employs competent and professional staff. Our employees are often called upon to find solutions for complex situations and, in doing so, may need to weigh competing interests with consideration of Industry Canada's official mandate.

As can be expected in these types of complex situations, it may be necessary to make decisions that are not supported by the competing interests. Industry Canada employees would never knowingly place the health of the Canadian public at risk.

I appreciated this opportunity to respond to your petition, and trust this information is of assistance.

Yours sincerely,

[Original signed by Tony Clement, Minister of Industry]

Tony Clement

c.c. Mr. Scott Vaughan
Commissioner of the Environment and Sustainable Development

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Review Article

Health Implications of Electromagnetic Fields, Mechanisms of Action, and Research Needs

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Electromagnetic fields (EMF) have been implicated to influence a range of bodily functions. Given their ubiquitous nature, widespread applications, and capability to produce deleterious effects, conclusive investigations of the health risks are critical. Accordingly, this paper has been constructed to weigh the bioeffects, possible biointeraction mechanisms, and research areas in bioelectromagnetics seeking immediate attention. The several gaps in the existing knowledge do not permit one to reach a concrete conclusion but possibility for harmful effects cannot be underestimated in absence of consistent findings and causal mechanisms. Several studies with appropriate methodologies reflect the capacity of electromagnetic radiations to cause adverse health effects and there are several credible mechanisms that can account for the observed effects. Hence, need of the hour is to activate comprehensive well-coordinated blind scientific investigations, overcoming all limitations and demerits of previous investigations especially replication studies to concretize the earlier findings. Furthermore, appropriate exposure assessment is crucial for identification of dose-response relation if any, and the elucidation of biological interaction mechanism. For the time being, the public should follow the precautionary principle and limit their exposure as much as possible.

1. Introduction

The terrestrial electromagnetic environment has been and is being rapidly altered by humans as a result of technological advancements. This was well recognised very early in the seventies by Dr. Robert O. Becker (twice nominated for Nobel Prize) who said "I have no doubt in my mind that, at the present time, the greatest polluting element in the earth's environment is the proliferation of electromagnetic fields (EMFs)." On one hand, these electromagnetic waves (EMW) provide immeasurable benefits; on the other hand, they may also create potential hazards through uncontrolled and excessive radiation emissions. There are various types of electromagnetic radiations (EMRs) and depending upon their frequency and wavelength they are categorized into different types. Broadly the EMFs are categorized into two groups, namely, extremely low frequency (ELF) EMF (>3 Hz–3 kHz) and radiofrequency radiation (RFR) EMF (3 kHz–300 GHz). Scientific investigations concerning the interaction of EMF with living systems, especially its health effects, are increasing in number. There are arguments for both positive [1–3] and negative bioeffects [4–8]. However, the lack of sufficient knowledge on biological effects of the vast majority of frequencies even below the safety limit leads to several apprehensions [9–11]. The discussion is still ongoing especially regarding the contentious nonthermal effects. It is considered that the energy absorbed calculated in terms of specific absorption rate (SAR) [12] is too low to produce biological effects [13]. At the same time, several studies have demonstrated the influence of EMF by energies that are much lower than those capable of producing temperature changes in living tissues [10, 14]. The cell physiology either in vitro [14] or in vivo [15] can be affected by these temperature-insensitive reactions. Whether this could result in pathological alterations in higher life forms is a matter of debate [16]. Despite the documentation of temperature-insensitive biological effects, they have not been considered in the existing EMF safety standard; rather it is principally based on heating effect of EMF [17]. The current SAR values

Table 1: Showing the SAR values for general public and occupational groups laid by ICNIRP [18], International Commission on Nonionising Radiation Protection; SAR stands for specific absorption rate expressed in Watts per kilogram (W/kg).

Frequency range	General public			Occupational exposure		
	Whole body SAR	Localized SAR-head and trunk	Localized SAR-limbs	Whole body SAR	Localized SAR-head and trunk	Localized SAR-limbs
100 KHz–10 MHz	0.08	2	4	0.4	10	20
10 MHz–10 GHz	0.08	2	4	0.4	10	20

for general and occupational groups are presented in Table 1. As a result, current recommendations are established on the lowest exposure known to induce acute observable effects due to heating [7].

In the past, when much of the attention was centered on certain EMW called ionizing radiation, the others called nonionizing radiation (NIR) were generally assumed to be harmless. However, after World War II, this assumption has been reconsidered. The overwhelming scientific investigations concerning health effects of NIR have highlighted their potential to affect the well-being of biological organism. Several researchers have raised questions regarding adequacy of current safety limits [17] and asserted for their revival so that the new biologically based exposure limits will be capable of eliminating the possibility of bioeffects [19].

Some of the documented bioeffects include changes in melatonin levels [20–25], induction of heat shock protein (hsp) [26], effects on spatial memory [27, 28], alteration of intracellular calcium concentration [29], changes in blood-brain-barrier permeability (BBB) [30], enzyme activity [31], genotoxicity [32, 33], nonspecific disabilities, and subjective symptoms [34–37] to name a few. Also, radiation exposure from mobile phones (MPs) has been linked with tinnitus, brain tumours, and acoustic neuroma [38–41]. Additionally, studies at cellular/molecular level are important in illuminating the actual primary injury produced by EMFs [17, 27].

The field of bioelectromagnetics is surrounded with controversies because some studies are contradictory [11, 42] and not always corroborated by independent researchers [35]. The lack of any accepted causal mechanism further adds to the controversy. As a result, important details are simply not comprehended and generate confusion in the general public. As uses expand, the new situations are likely to further increase the environmental EMF levels. To cope with these situations and to promote life of biological organisms more comfortably and efficiently achieving a scientific understanding of the biointeractions of these fields and evaluation of health risks is highly desirable. This paper, therefore, has been constructed to weigh carefully the bioeffects, biointeraction mechanisms and lacunae in EMF research areas seeking immediate attention so that the public is not excessively exposed nor the technological advancements suffer a setback by unjust fears that may or may not exist. In this review, we shall restrict our discussion to the health relevant effects of ELF-EMF and RFR-EMF.

ELF and RFR-EMF related studies were identified by peer-reviewed literature and data searched in electronic database (PubMed) using a number of key words and their combinations (electromagnetic field, health effects, electric, magnetic, reproductive outcome, and biointeraction mechanisms as examples) in order to find English-language reports related to electromagnetic field health effects and their probable modes of action. A number of papers were retrieved by hand searching several journals and few were obtained through direct correspondence with the authors. Unlike other review papers, no strict inclusion criteria were set. However, a rational explanation of the experimental design, use of control/sham population, exposure conditions, blinding of the research, statistical assessment of the data, and role of artifacts could be reached for most, but not all investigations.

2. Health Effects of Electromagnetic Fields

2.1. Electromagnetic Hypersensitivity (EHS). EHS is a recent phenomenon of occurrence of subjective signs and symptoms in some sensitive individuals with EMF experience from varied electronic sources. Despite lower levels of exposures, symptoms of ill health have been observed among the subjects [34]. According to WHO [43], about 1–3% of the world's population are affected by this EHS syndrome. The exposure to EMFs especially at lower levels and for long duration was originally reported among the East European radar workers and linked with a number of subjective and objective (skin and mucosa-related) symptoms. Sufferers often label EHS as loner's disease because of the consequent social isolation [9]. Epidemiological investigations have been conducted on people complaining about unpleasant symptoms (Table 2). Complainants have related their symptoms most frequently to exposure to MP base stations (74%) followed by MPs (36%), cordless phones (29%), and power lines (27%) [36]. Objective skin symptoms of EHS have been related to increase in mast cell counts and their degranulation, thereby causing the release of inflammatory substances such as histamine responsible for allergic hypersensitivity, sensation of itch and pain, edema, local erythema, and many kinds of dermatoses [19]. With reference to effects of ELF-EMF, Barsam et al. [44] studied the effect of occupational exposure on sleep quality in high voltage substation workers. In their case-control study, they found poor sleep quality among 90.5% of cases and 85.3% of controls. Despite, the increased prevalence of poor sleep quality in exposed group, no statistically significant difference was reached. Similar occupational studies conducted in substation units of a petroleum complex also revealed higher percentage of poor sleep quality in addition to poor health condition in

Table 2: Subjective signs and symptoms of electromagnetic hypersensitivity (EHS) [34, 36].

(1) Sleep disorders	(2) Headaches	(3) Palpitations	(4) Hot flushes
(5) Sweating	(6) Tinnitus	(7) Fatigue	(8) Dizziness
(9) Concentration difficulties	(10) Limb pain	(11) Heart disease	(12) Nervousness
(13) Arthropathy	(14) Skin rash	(15) Oculopathy	(16) Depression
(17) Back pain	(18) Tremor	(19) Nausea	(20) Loss of energy
(21) Circulatory disturbance	(22) Loss of appetite	(23) Breathing difficulties	

exposed population when compared to control population [45]. However, the researchers in this group also could not reach any statistically significant correlation between the ELF-EMF exposure level and poor quality of sleep and health status. Another case-control study undertaken on the occupational group of electric utility workers highlighted the increased rate of suicide attempts in exposed group as compared to controls [46]. The authors also suggested that the occurrence of depression in the exposed workers might be the plausible reason. A study by Beale et al. [47] demonstrated the occurrence of psychological symptoms like suicide, depression, and unmanageable emotional condition amongst the residents exposed to chronic 50 Hz MF exposure as a result of their residence in the vicinity of high-voltage substations and power transmission lines. Case studies and anecdotal reports in this regard indicate that people's health problems like diabetes, multiple sclerosis, asthma, and so forth could have some association with biologically active dirty electricity which has been found to improve when levels are reduced [48]. Dirty electricity present in the surroundings has been shown to affect the well-being of teachers and pupils. Use of filters ameliorated the effects, thereby protecting sensitive individuals [49].

As regards RFR-EMF, Navarro et al. [37] carried out a health survey in the vicinity of a cellular phone base station, working in DCS-1800 MHz frequency range with exposition time greater than 6 hours/day, 7 days/week, in 95% of the subjects. Exposure assessment was done by measuring microwave power densities at residence of respondents. Statistical analysis revealed a significant correlation between the declared severity of symptoms and measured power density. The study also showed an increase in the declared severity in groups with higher exposures. Comparable studies have also been performed reporting significant relation of some symptoms to the measured exposures [34]. Epidemiological studies suggest that frequency and severity of symptoms tend to increase with duration of exposure and are reversible if exposure is discontinued temporarily or permanently with symptomatic and general supportive treatment and also severity weakens for those residing far away from exposure source. For instance, in one of the health surveys among self-declared EHS individuals, 90% of subjects reported occurrence of health symptoms when present in the exposure area and disappearance of the same after leaving the exposure area [36]. Studies have also highlighted the significant link between longer duration of daily MP use and health effects [31, 50, 51]. The MP use by children in this regard can be deleterious as their nervous system is under development and greater amount of energy is absorbed because of their thinner skull bones as compared to adults; additionally longer exposure duration increases their vulnerability to a greater extent [52]. However, to date, quality double-blind studies have not shown any correlation between subjective health complaints and RF exposure [43]. At the same time, epidemiological studies of EMF well-being are difficult to conduct because of imprecision in exposure assessment [53–56] and lack of objectivity in measuring health effects or complaints [35]. In addition, the symptoms are nonspecific and subjective, based on self-reporting, and hence difficult to prove clinically in absence of clear diagnostic criteria for the condition [57]. The subjective complaints of well-being also vary from individual to individual and are a function of several variables like age, sex, social status, anxiety, current health status and accompanying disease, and personality traits [35] as well as the fear generated due to awareness of adverse effects from EMF exposures [34]. Psychological stress may be one of the consequences of EHS in patients and incomplete understanding of pathophysiology of these complex symptoms in absence of any single biomarker so far recognized unique to EHS makes the diagnosis and medical treatment a complicate endeavour [9, 35]. It has also been suggested that subjective symptoms could be the consequence of already prevailing psychiatric condition or stress response resulting from EMF health concerns instead of the exposure itself [43]. In today's modern world, when we cannot part away from electronic gadgets, the EMF experiences are real and practically unavoidable, resulting in disturbances, which could be devastating for a few afflicted individuals. In dearth of any visible causal mechanism and pathophysiological biomarker, its etiology is quite incomprehensible. The pain of EHS patients aggravates further, when the majority of population do not experience any symptom with EMF exposures. The increasing number of reports on EHS however warns us to take this research promptly and locate the biomarkers that could give some clue in ameliorating the problems of such individuals. More investigations are hence needed to completely delineate the pathophysiology of EHS along with the generation of clear diagnostic criteria to identify the problem and develop strategies to limit the suffering of afflicted individuals. Besides, investigations dissecting the relation between EHS manifestation in elderly, children, and diseased persons (like neurodegenerative diseases, mentally and genetically unstable conditions) with EMF experiences are crucial. The lacunae in human studies, with regard to

exposure assessment, inclusion of suitable controls, and data collection, and so forth, need to be eliminated to reach fruitful insights. For the time being, individuals with EHS need to be supported by the family, society, and the government to lead a normal and respectable life.

2.2. Cytotoxic and Genotoxic Effects. DNA alteration is considered to instigate carcinogenesis [8, 58] and change in DNA or micronuclei (MN) generation is an accepted indication for genotoxicity [59]. Different cell types and organisms have been reported to react differently to differing exposure characteristics [26, 32, 60]. Concerning this, Ivancsits and coworkers [61] have identified three responders (fibroblast and melanocytes from human, granulosa cells from rat) and three nonresponder cell types (lymphocytes, monocytes, and skeletal muscle cells from human) when exposed to intermittent ELF-EMF using alkaline and neutral comet assays. Delimaris et al. [62] examined the effect of pulsed 50 Hz EF on human lymphocytes and showed significant DNA damage in exposed group in comparison to controls. However, Scarfí et al. [58] could not detect any statistically significant genotoxic difference in human fibroblasts exposed to intermittent 50 Hz EMFs. A number of studies have demonstrated the potential of ELF-EMF to cause DNA damage [33, 63–66].

As regards RFR-EMF, d'Ambrosio and coworkers [67] have documented significant micronuclei occurrence with phase modulated RFR as against no effect by continuous wave (CW). Phillips et al. [68] observed reduced and increased SSB, at least in some experiments at low and high SARs, respectively, with RF-EMF exposures as opposed to sham controls. Increased DNA damage was reported in human lens epithelial cells exposed to 1.8 GHz at 3 W/kg [69]. Similar findings were reached by Sun et al. [70] on the same cell types after two-hour exposure to 1.8 GHz at SARs of 3 and 4 W/kg. DNA damage at 4 W/kg was found to be irreversible. Studies on marine radar operators also registered significant increase in MN frequency and comet parameters of % of DNA in tail and tail moment after EMF exposures [1]. A detailed summary of various studies have been tabulated (Table 3). The occurrence of aneuploidy is well acknowledged to enhance the risk of tumour. In this context, linear and SAR dependent aneuploidy rise for chromosome 17 detected by fluorescence in situ hybridization post RFR exposure further substantiates their carcinogenic potential [67]. Significant DNA damage occurred after EMF exposure [71], which decreased with free radical scavenger treatment suggesting free radical involvement in inducing damage [3, 33]. Ferreira et al. [72] found a significant increase in erythrocyte MN frequency in newborn pups from irradiated pregnant rats suggesting the genotoxic potential of EMF exposure. Some investigations have shown the genotoxic potential of EMFs only when coupled with some mutagen or carcinogenic or physical agents indicating their synergistic effect [13, 64]. Cell-culture studies by Luukkonen and coworkers [73] conducted on human SH-SY5Y neuroblastoma cells to study the combined effect of CW-RF (872 MHz) and global system for mobile communication (GSM) with menadione suggested that 872 MHz CW-RF radiations at 5 W/kg might enhance chemically induced reactive oxygen species (ROS) production and thus cause secondary DNA damage. At the same time, enhancement of chemically induced DNA damage observed in this study was associated only with the CW-RF; no effects were seen with GSM signal. Amid these positive effects, Lagroye and coworkers [8] did not find any alkali-labile DNA damage, DNA-DNA cross-links, and DNA-protein cross-links in mouse fibroblast cells exposed to continuous 2450 MHz at 1.9 W/kg for two hours implying their inability to produce genotoxic effects directly by damaging the DNA. Proteomic study on endothelial cell-lines showed the manifestation and phosphorylation of various, chiefly unidentified proteins with RF-EMF exposure [14]. Amid these proteins is Hsp 27, a biomarker for cellular stress. Variation in the expression of cellular stress marker Hsp 90 postirradiation suggests the complex cell defense mechanism and cell response to EMF [26]. EMF interaction with biological system is a very complex process and is a function of several biological, physical, and environmental factors. The exquisite sensitivity of biological systems to EMF experiences leads to intriguing results and regardless of scientific evidences accumulated so far, it is difficult to conclude about EMF toxic effects as the contradictory findings tangle the results confounding the true findings. The differences in experimental protocols in terms of frequency applied, modulation, intensity, investigated endpoints, cell type used, sample size, and so forth have also added to the controversy [5, 10, 60]. Evaluation of present data also becomes difficult due to relatively small number of replication studies because of want for funding. However, possibility of genetic hazard cannot be eliminated in view of conflicting scientific outcomes and lack of accepted causal mechanisms, as the confusion has been generated by some commercial groups in their own interest. Therefore, the need of the hour is to critically analyse the differences and similarities in study variables with greater emphasis with regard to biological systems used, exposure characteristics, study protocol used, findings, data interpretation, and conclusions drawn along with recognising the source of funding, rather than giving weight to the number of studies either observing or not observing an effect. Addition of statistically sound scientific investigations dissecting EMF biointeraction with respect to field direction, orientation, polarization, duration and time of exposure, and so forth needs to be elucidated to gain fruitful insights into cellular behaviours and their responses. However, this province seems of least interest in bioelectromagnetics research. Further investigations investigating the link between EMF exposures and the blue print, that is, the DNA of children, aged, and sick (neurodegenerative, genetic, or mental disease), are needed and will further substantiate the earlier findings. Given the inconspicuous nature of EMF health effects, even slight deviations in experimental protocols can head towards intriguing outcomes. Therefore, sound experimental designs with appropriate methodologies are critical in order to reach firm grounds. In light of the researches done so far, we conclude that the bulk of literature on EMF and cytogenetic endpoints reflect both positive as well as negative effects. Hence, for now, precautions should be taken to limit the exposures as much as possible.

2.3. EMF and Cancer. Epidemiological investigations have focused attention towards association between ELF-EMF exposures and incidence of tumours [6, 40, 41, 77]. Investigations concerning military personnel also indicate the development of tumours [17]. Amongst all cancer endpoints weighed in epidemiological investigations, childhood leukemia in connection to postnatal exposure exceeding 0.4 μT gets the maximum support for an association [54]. Recently, a formal assessment for suggestion of carcinogenesis from exposure to static and ELF fields by the International Agency for Research on Cancer [78] concluded that ELF-MFs are possibly carcinogenic to humans and grouped them in 2B category.

With regard to RFR-EMF, Hardell et al. [38] in their study suggested that occurrence of vestibular schwannoma has increased in the decades after introduction of cell phones in Sweden, the country with the highest use of mobile technology [17]. Hardell et al. [38] conducted a cross-sectional study in order to find the association between cell phone usage and vestibular schwannoma. Self-administered questionnaire was used for exposure and symptom assessment. Cases were identified from the Swedish cancer registries with age, sex, and geographical area matched control. Histopathological and anatomical tumour localization was done by CT and MRI scans. The authors reported risks for vestibular schwannoma among cell phone users. Significant rise in risk was reached for analogue phone users. Elevated risks were also calculated for cordless and digital phones but these results could not reach statistical significance. The researchers also reported cases of unilateral tinnitus in some persons using cell phone on ipsilateral side; however, a causal relation could not be established on the basis of case report. With regard to association between vestibular schwannoma and cordless and cellular phones, another interesting finding was observed. The highest rising incidence was obtained for men and the age group of 50–59 years. MP use has also been associated with ipsilateral cerebral brain tumours [77, 79], astrocytoma and acoustic neuroma [40, 41], and contralateral temporal tumours [79]. Muscat et al. [79] evaluated the risk of brain tumour in relation to handheld cellular phone use. They included the malignant brain tumour patients as cases (469) and hospital patients as controls (422) after matching for gender, age, race, hospital, and month of admission. Structured interview was employed to gain information related to MP use. The mean duration of MP usage for cases and controls was found to be 2.8 years and 2.7 years, respectively. Out of the 41 measurable tumours, 26 appeared on the ipsilateral side while 15 appeared on the contralateral side. The authors did not find any association between short-term handheld cellular phone use and cerebral brain tumour risk. Another study by the same group [80] based on hospital derived acoustic neuroma patients as cases (90) and patients with nonmalignant diseases as controls (86) reported an average cell phone use of 4.1 and 2.2 years, respectively. Odds ratio was found to increase from 0.5 for 1-2 years cell phone use to 1.7 for 3–6 years group; however, the relative risk did not differ significantly with regard to the frequency, duration, and lifetime hours of use. The study by Muscat group was surrounded with limitations like lack of data on long-term users especially with regard to under-estimation of risks for slow growing tumours. Hepworth et al. [81] found no association between increased glioma risk and MP use along with absence of any relation with time since first use, years of use, total hours of use, or number of phone calls. The positive association observed between glioma risk and ipsilateral MP use in conjunction with the negative association as regards contralateral MP use was attributed to recall bias as the glioma patients tend to overreport the use on the same side of the tumour while under mentioning the same on the opposed side. This large case-control study was carried out with cases identified from hospital records and cancer registries whereas controls were selected randomly from the general practitioner's list after matching and personal contact. The details regarding the tumour site and laterality and tumour grade were judged from the pathology reports and scans. Computer assisted personal interviews were used to extract the details pertaining to MP use, number of calls made and received, start and stop year, side of use, model and make of MP used, network operator, use of handsfree, usage in rural/urban area, and so forth. On the basis of two case-control studies on brain tumours with regard to MP and cordless phone use, the Hardell group found an elevated risk for ipsilateral exposure with >10 years latency period and subjects started using MP and cordless phone below 20 years of age as regards both astrocytoma and acoustic neuroma [41]. Questionnaire method was employed to evaluate the exposures and cases were identified from the cancer registries. The tumour was assessed with regard to the anatomical region in the brain and was associated with the head side used during phone calls with ipsilateral use defined as greater than 50% and contralateral as less than 50% of the calling time. A review was undertaken with an aim to assess the brain tumour risk in relation to long-term use of mobile phones greater than 10 years and ipsilateral exposure [40]. The reviewers based their findings on the basis of 18 studies (2 cohort and 16 case-control) and found an increased risk for acoustic neuroma and glioma. In addition, the chance of tumour was found to be the highest for ipsilateral exposure in all the studies as reflected by the increased odds ratio. Another review by Levis et al. [82] concluded that the risk for head tumours doubles with long-term MP use. They also observed that methodological flaws with regard to nonblinding of experiments produce negative results and underestimate the risk for tumour development, whereas those studies, which are free from errors, biases, and financial interests, therefore, employing blind protocols, yield positive results indicating a cause-effect link between log-term use of MPs and statistically significant rise in head tumour risk. With increasing number of dynamic MP users worldwide, scientists consider this as the "largest biophysical human experimentation" ever conducted in the past history [17]. An interesting finding was reached in which incidence of brain tumour was found to be higher in populations of cell phone users in rural areas as compared to urban [39]. Also, average exposures have been observed to be slightly higher in rural areas compared to urban areas from MP base stations [34]. In this regard, the connection between exposures and geographic area, ethnicity, nutritional status,

Table 3: Studies on the cytotoxic and genotoxic effects of electromagnetic fields.

EMF characteristics	Study group	Method	Study outcome	Reference
7 mT 50 Hz MF for 3 h, ferrous chloride ($FeCl_2$, 10 μg/mL), melatonin (0.5 or 1.0 mM)	Rat peripheral blood lymphocytes	Alkaline comet assay	Significant DNA damage only after simultaneous exposure to $FeCl_2$ and MF, melatonin ameliorates the effect.	[64]
1.748 GHz, either CW or phase only modulated wave GMSK* for 15 min. Maximum SAR = 5 W/kg	Human peripheral blood lymphocytes cultures	Cytokinesis block MN Assay and proliferation index	Statistically significant rise in MN frequency following exposure to phase modulated wave.	[67]
60 Hz MF at 0.01 mT for 24 h and 48 h	Male Sprague Dawley rats	Microgel electrophoresis assay	Significantly increased single and double DNA strand breaks, prolonged 48-hour exposure resulted in a larger increase.	[33]
847.74 MHz CDMA†, 835.62 MHz FDMA‡, 813.56 MHz iDEN¶ 836.55 TDMA§, 24 h	Molt-4 T lymphoblastoid cells	Single cell gel electrophoresis and annexin V affinity assay	No DNA damage or apoptosis at any frequency, modulation or exposure time.	[7]
MW frequency ranging from 800 to 2000 MHz.	MP users and age, sex matched controls	Comet assay & MN assay	Significantly elevated comet tail lengths and MN frequency in MP users	[74]
980, 950 MHz, 200 KHz modulation, 5 w and 500 ppm toluene applied for two weeks.	Male bulb/c mice	MN assay on lymphocytes	MW radiation in combination with toluene produced significant cytogenetic effects but not alone	[13]
UHF‖-EMF (600 mWpeak; 834 MHz; 26.8–40 V/m; vertical polarization) Irradiation from 5.30 pm to 2.00 am for 8.30 h/day, since day of sperm detection until offspring birth.	Adult pregnant Wistar rats only for irradiation and their offspring for study	MN assay, activity of antioxidant enzymes, quantified total sulfhydryl content, protein carbonyl, thiobarbituric acid reactive species, and total nonenzymatic antioxidant defense	Significant rise in MN frequency, no difference in oxidative stress parameters in offspring blood and liver	[72]
RF-EMF, SAR = 1.3 W/kg	Small area of fore arm's skin in 10 female volunteers	Collection of punch biopsies from exposed and nonexposed areas of skin. Protein extraction by 2-DE and protein expression changes analyzed using PDQuest software.	Radiation exposures from MPs have also been suggested to affect protein expression in human skin samples	[75]
MP radiation	85 MP users and 24 nonusers	MN assay on buccal mucosa epithelial cells	Significant rise in MN frequency and positive correlation with duration of use	[76]
915 MHz, 1 h/day for 2 weeks at 2.4 W/m^2, whole body average SAR-0.6 W/kg	Wistar rats	Detection of DNA alteration in peripheral leukocytes by standard and Fpg# modified comet assay	Oxidative stress could be the likely cause of increased DNA damage in exposed group	[71]
2.45 GHz, 2 h/day for 35 days to 0.34 mW/cm^2 power density, whole body SAR = 0.11 W/Kg.	Male wistar rats, control and exposed group	Double strand DNA damage by microgel electrophoresis, antioxidant enzymes, and histone kinase estimation in brain cells	Significant elevation in comet head, tail length, and tail movement, decrease in GPx[1], SOD[2], and histone kinase, and increase in catalase	[31]

Table 3: Continued.

EMF characteristics	Study group	Method	Study outcome	Reference
Pulsed MW from 3 GHz, 5.5 GHz and 9.4 GHz Marine RADAR	Marine RADAR operators	Comet assay, MN assay, GSH[3], and MDA[4] estimation	Significant changes found in comet and MN assay parameters indicating cytogenetic disruptions with dropped GSH levels and increased MDA levels in exposed groups	[1]

*GMSK: Gaussian minimum shift keying, †CDMA: code division multiple access, ‡FDMA: frequency division multiple access, ¶iDEN: integrated digital enhanced network, §TDMA: time division multiple access, ||UHF: ultrahigh frequency, #Fpg: formamidopyrimidine DNA-glycosylase, [1]GPx: glutathione peroxidise, [2]SOD: superoxide dismutase, [3]GSH: glutathione, and [4]MDA: malondialdehyde.

economic status, and so forth may provide some remarkable insights and further enhance our understanding. However, association between brain cancer incidence and MP use remains unclear due to inconsistent findings. Short-term and long-term cellular telephone use also did not reflect any connection with cancer risk [6]. As far as cancer risk in animals is concerned, lymphoma risk was found to be significantly higher in experimental groups of mice exposed to pulsed RFR 900 MHz coming from cellular phone than in controls [83].

Study by Cho and Chung [59] suggested the role of low density ELF-EMF as an enhancer in initiation process of Benzopyrene rather than as an initiator of mutagenic effects in human lymphocytes. Most reviews, however, do not support EMF exposures to be carcinogenic. Lack of supportive animal data for carcinogenic potential of EMF also makes the understanding of epidemiological outcomes a difficult enterprise along with faults in human experiments especially with respect to exposure assessment. Majority of the reviews have indicated lack of evidence for cancer initiation by magnetic field (MF) alone; however, accumulating evidence suggests that they could act as cocarcinogens if given in combination with known genotoxic or nongenotoxic carcinogens showing their synergistic effect. Additionally, the DNA damaging potential of EMFs by free radical generation and also by increasing their lifespan coupled with alterations in DNA repair mechanisms is of concern. However, considering the information in hand on carcinogenesis, cocarcinogenesis with tangling results in the absence of established mechanisms, strict limitations to exposures are suggested till the time any firm conclusion is reached.

2.4. Effects on Endocrine System. Among the several hormones secreted by the body, melatonin gained the focus of most of the EMF investigations. Melatonin, essentially a tryptophan derivative produced chiefly from the pineal gland has been documented to be affected by EMF in animals [25, 84, 85] as well as in humans [21, 22, 24]. In addition, the enzyme machinery involved in melatonin biosynthesis has also been reported to be affected by EMF action [86, 87]. Recently, Bellieni et al. [88] investigated the effect of ELF-EMFs from incubators on melatonin production in newborns who had been kept in the incubators for at least 48 hours. In their study, they found a transitory rise in melatonin secretion almost immediately after the babies were taken out from the incubators, highlighting the EMF potential to influence newborn melatonin production. Significant melatonin depression was registered in an occupational cluster of electronic equipment repairers exposed to ELF-EMFs due to their work in comparison to controls [89]. Epidemiological studies performed on Swiss railway workers exposed to 16.7 Hz MFs exhibited statistically significant reductions in mean evening 6-OHMS (6-hydroxymelatonin sulphate) concentrations after first and fifth days of exposure [24]. The result of yet another occupational study conducted among male electric utility workers exposed to 60 Hz yielded a decrease in postwork shift 6-OHMS/creatinine excretion with temporally stable MF exposures [21]. However, the reduction was found on second and third days of exposure whereas no change was observed on the very first day as opposed to that by Pfluger and Minder [24] indicating the role of exposure duration and that exposure effect may be delayed by several days. Anyway, the experiment of Wood et al. [22] suggested that exposure of humans to 50 Hz circularly polarized 20 μT MF result in a delay in the onset of rise of plasma melatonin concentrations. As regards animal studies, Kumlin et al. [20] found an interesting augmenting effect on the circadian rhythm of melatonin synthesis in female mice strain (CD_2F_1) exposed to 50 Hz MF having no or very low natural melatonin rhythm in contrast to previous researches using rodents showing chiefly diminishing effects. The findings do not corroborate the registered melatonin diminution in MF-exposed animals but do imply MF effects on pineal gland. Another experiment showed striking reduction in night-time melatonin concentrations as a result of exposure to rapid on/off mode MFs during the day for several days [25]. The authors pointed that rapidly changing exposure conditions create difficulties in acclimatization as opposed to stable exposure characteristics. The inadequacy in exposure characterization and the conduct of investigation at different times, for different exposure durations and at different locations, render the comparison among studies complicated [87]. Melatonin is highly accepted for its antioxidant and tumour inhibiting properties; hence, if oxidative stress (OS) is accompanied by suppression of melatonin levels, it may produce deleterious effects [87]. Given the importance of melatonin for organisms, further

studies with better EMF characterization and standardization are crucial. Hormone serotonin, a tryptophan derivative produced chiefly from the pineal gland, has also been documented to be affected by EMF [85, 90]. However, there are very few studies investigating serotonin and EMF connection. Serum cortisol and ACTH concentrations were found to rise significantly in male guinea pigs exposed to 50 Hz EMF reflecting the capacity to cause stress regardless of being a low frequency [91]. Noticeable depression in melatonin and corticosterone levels were reached in a study investigating the effect of continuous EMF emission from video display units in exposed embryos and young chickens [92]. In addition, significant rise in fetal loss was also registered indicating the adverse effects of these EMF emissions. Occupational studies focused on the effect of EMFs released from magnetostrictive cavitrons used by dentists showed serum cortisol diminution [93]. In the midst of all these studies reporting either an increase or decrease in cortisol concentration, another group of researchers reported no significant change [94] reflecting the inconsistency in this field. With regard to adrenaline and noradrenaline level, significant suppression was registered in electric utility workers exposed occupationally to 50/60 Hz EMFs [95].

As regards RFR, 900 MHz with 217 Hz pulse frequency from digital wireless communication was reported to have no significant effect on salivary melatonin in healthy male students [96]. Cortisol which is a steroid hormone and one of the key stress biomarkers released from adrenal glands has been shown to be affected by RFR-EMF experience [96–99]. It is assumed that RFR-EMF may act as a stressor evident from the increased cortisol concentration documented in previous investigations with animals [100, 101] and humans [102–104]. However, the reports of cortisol increase are contradicted by the results of cortisol diminution [97, 98] and investigations reflecting no effect on adrenal cortisol secretion [96, 105] highlighting the disagreement in this field of investigation. Given the relevance of cortisol, any imbalance can lead to health impairments in due course [103]. More studies therefore in this connection are required to assess the course of action of the biological system in response to EMF stress. ACTH levels were reported to decrease [98] as well as not being affected [97] by RFR exposure. Significantly, higher levels of the stress biomarkers adrenaline and noradrenaline have been reported in physiotherapists [103]. Buchner and Eger [106] also assessed the catecholamines in subjects exposed to cell phone base station. They examined the acute as well as chronic effects of EMF exposure and found a significant increase in adrenaline and noradrenaline levels after EMF exposure, following a drop, but the normal levels were not restored even at the end of the study (about one and a half year). They also observed significant diminution in dopamine levels. Given the role of these catecholamines in controlling B.P., heart rate (HR), and other biological functions, the shift from baseline values due to stress has immense significance for health and well-being and, hence, their continual alteration may prove harmful in due course. Decreases in testosterone concentration with EMF exposure have been stated by some research groups [98, 105, 107] with no effect as well in some reports [97]. FSH levels have also been found to reduce with EMF exposure at MP frequency [105]. So far as, effect on female reproductive hormones is concerned, there is limited number of studies. The few investigations on RFR from MPs and base stations have shown to mutate prolactin but not progesterone levels indicating the consequent effects on menstruation and pregnancy [98]. Significant rise in serum progesterone concentration has also been reported in pregnant rats after microwave exposure [108]. In addition, parallel studies investigating prolactin levels have documented normal levels even after exposure to radio-cellular phones [97, 109]. As far as thyroid hormones are concerned, decrease in T3 [98, 100] and T4 [98, 110] and increase in T4 [100] in parallel to no effect or retention of normal T3 levels [110] have all been documented with EMF contact. These findings when taken together reflect the variation in EMF research and puzzle the understanding about EMF biointeraction and therefore urge for more studies. In light of the above evidences, it seems that EMF acts as a stressor and has the potential to affect the various endocrine secretions posing a significant health threat.

2.5. Effects on Cardiovascular System. An experiment on human head exposure to 37 Hz EMF at a flux density of 80 μT suggested that EMF could alter nociception and may be associated with cardiovascular abnormalities [111]. Håkansson et al. [112] indicated a low level rise in AMI risk in the highest exposure group and observed by means of the synergy index of 2.7 in monozygotic twins that the genetically predisposed subjects have an increased EMF influence for AMI, possibly induced by reduced heart rate variability (HRV). A cohort study on electric utility workers pointed towards an association between occupational 50 Hz ELF-EMF exposure and arrhythmia related heart disorders [113]. On the contrary, a cohort study of railway workers exposed to 16.7 Hz intermittent MF indicated no association with fatality from arrhythmia related heart diseases or acute myocardial infarction (AMI) [4]. Because of the electric character, the circulatory and the nervous system particularly the autonomic nervous system is vulnerable to EMF effects [114]. More explicit damage of neurovegetative regulation, especially a decreased parasympathetic function, may result with high-intensity EMFs leading to cardiovascular malfunctioning [115]. ELF-EMFs have been also implicated to affect the HRV in newborns [116] and interfere with electronic medical equipment like implanted pace makers, but only when kept close to chest [117]. The detailed summary of various investigations concerning cardiovascular system effects have been listed (Table 4). Ali et al. [118] has attributed the alterations in rat heart functions as a result of decreased RBC membrane elasticity, permeability, and changes in molecular structure of haemoglobin exposed to 50 Hz, 0.2 mT MFs. Yet another study on rats linked the observed histopathological alterations like unclear cytoplasm, polymorphic nucleus, disrupted fibrous tissue, necrosis, and bleeding in heart epithelial tissue with 50 Hz EMF exposure [119].

As regards RFR-EMF, Bortkiewicz et al. [115] found more impairment in 24-hour and resting ECG in AM (amplitude modulation) broadcast station workers when compared to radio-link station workers who are supposed to have less

Table 4: Studies concerning the effects of electromagnetic fields on the cardiovascular system.

EMF characteristic	Study group	Method	Study outcome	Reference
Medium frequency EMF	MF broadcast and radio link station workers	General medical examination, cardiological, and family history survey, 24-hr ECG*, LVP†, HRV, and ABP‡ measurement	EMF exposure is linked to abnormalities in the neurovegetative regulation of cardiac function	[120]
EMF exposure from MP			Interference with medical equipment like implanted pacemakers	[117]
MF exposure	Electric utility workers	Cohort study Cause of death from death certificates	Association between elevated MF exposure in electric utility jobs and mortality from arrhythmia related causes	[113]
50 Hz, 0.2 mT MF for 15 and 30 days	Male albino rats	ECG, osmotic fragility, shape of RBCs¶ membrane and Hb§ structure tests, dielectric relaxation of Hb molecules measured	Alterations in ECG, RBCs membrane elasticity and permeability and changes in molecular structure of Hb.	[118]
BC|| 6–25 MHz and TV stations: 66–900 MHz	BC, TV, and radio relay station operators	Arterial pressure, lipid profile, BMI, waist/hip ratio, smoking habits, and family history for cardiovascular disease	RF EMR exposure contributed to a higher risk of becoming hypertensive and dyslipidemic	[121]
Intermittent 16.7 Hz MF, 7.5 hrs/day and 240 working days/year was assumed	Railway workers	Cohort study Cause of death from death certificates, average ELF-MF exposure determined by measurements and modelling	No association between long-term exposure to MF and death from arrhythmia related heart diseases or AMI	[4]
EMF from incubators	Newborn babies	15-minute HRV measurement in supine position at least 1 hour after feeding	Alterations in HRV	[116]

*ECG: electrocardiography, †LVP: late ventricular potential, ‡ABP: ambulatory blood pressure, §Hb: hemoglobin, ¶RBC: red blood cell, and ||BC: broadcast.

exposure. A significantly higher frequency of irregularity identified as conduction, rhythm, or repolarization disturbances in resting and 24-hour ECG (electrocardiography) was noticed among subjects exposed to medium frequency when compared to control [120]. Stress is considered to increase B.P. (blood pressure) and exposure to EMFs has been implicated to cause stress [103, 111]. Vangelova and colleagues [121] found significantly higher systolic and diastolic B.P., total cholesterol, and low-density lipoprotein cholesterol levels in radio operators exposed to RFR and confirmed stronger association between RFR-EMF exposure and the likelihood of becoming hypertensive and dyslipidemic. The researchers, however, noted that the results could be influenced by the extended shifts and monotonous work as well. The study also revealed that majority of the hypertensives who were under medication reached their normal B.P. only when stayed away from the station. Earlier findings have also reported increased hypertension with RFR exposures [115]. Significantly higher levels of stress biomarkers like adrenaline, noradrenaline, and cortisol have been documented in medical staffs with RFR-EMF exposures, which could also influence B.P., heart rate (HR), and so forth, [103]. Recent findings have highlighted the possibility of small short-term and medium-term effects on HR and cerebral blood flow to intermittent universal mobile telecommunication system (UMTS) exposures [122]. Andrzejak and coworkers [123] reported an increased parasympathetic tone and decreased sympathetic tone during MP use measured by HRV analysis and indicated the potential of MPs in affecting the autonomic balance in healthy individuals. However, the confounding effect of talking during measurement of the parameters cannot be neglected. Similar results of sympathetic domination and parasympathetic suppression were reached by Kodavanji et al. [124] pointing towards the link between long-term MP use and adverse effects on HRV, thereby affecting the autonomic balance in healthy individuals. However, since the study was undertaken on a small population without randomization, the results need further confirmation. To add, a recent investigation with the intent to find the effect of RFR-EMF from MP on the electrocardiographic parameters in ischemic heart disease patients taking into account the gender aspect reached some interesting results. They observed prolongation

of QT interval in male subjects with or without ischemic heart disease in addition to interference with voltage property of ECG records in myocardial ischemia patients excluding the female counterparts from these effects [125]. In the midst of studies reporting positive findings, parallel studies reporting absence of effects [126–128] create confusion and hampers our understanding. Further long-term studies with better exposure characterization and health assessment are essential to depict the true picture in light of the prevailing controversy with the employment of the latest techniques. In this connection, EMF effect on newborns and patients with electronic implants or on life supporting systems needs immediate attention.

2.6. Effects on Nervous System. The inability of neuronal cells to divide and repair once damaged makes the organism susceptible to develop several neurodegenerative diseases. The occurrence of Parkinson's disease, and so forth, has been linked to cumulative DNA damage in brain tissues [60]. The increased prevalence of Alzheimer's disease reported among workers of textile factories exposed to ELF-MFs [129] could be one such instance. Ahlbom and coworkers [54] in their review also indicated towards a possible relation between amyotrophic lateral sclerosis (ALS) and occupational ELF-EMF exposure. However, effect of confounders cannot be ruled out. Cognitive performances like attention, perception, and memory have been reported to diminish instantly by 50 Hz, 1 mT ELF-EMF exposure in human subjects [130]. In concert, authors have found significant alterations in learning and information acquisition in passive avoidance learning task in both male and female mice exposed to 8 mT, 50 Hz ELF-EMF [131]. Authors have also found association between occupational ELF-EMF exposures and problems like dementia and depression [132, 133]. Results from animal studies in mice have also established the induction of depression at ELF-EMF exposures due to increased nitric oxide levels in cortex, hippocampus, and hypothalamus [134]. Studies have indicated that short-term ELF-EMF exposure may cause small alterations in neurotransmitter metabolism and in circulating amino acids [90] as well as influencing monoamine metabolism when exposure is in the same direction as the mouse position [42]. In connection, Rajeswari et al. [135] highlighted the importance of orientation of the field exposure with respect to the subject in human experiments. They found the subjects to be restless and aggressive when exposed to pulsations in north orientation, and cholinesterase levels in serum were significantly increased. In east, west, and south orientations, the subjects appeared to be calm and serum cholinesterase levels were normal, which suggested the increase of cholinesterase due to MF stress. Prato and colleagues [136] have reported significant inhibitory effects of a variety of ELF-MFs on endogenous opioid and exogenous opiate induced analgesia in snail Cepacea. Zecca et al. [137] found that higher field strength exposure may raise norepinephrine levels in pineal gland of rats accompanied with key changes in brain involving opioid system in frontal cortex, parietal cortex, and hippocampus. Pertaining to this, the documented calcium ion efflux from brain tissue at RFR exposure can be an important neurochemical effect as their significance in routine nervous system operation is well known, for example, neurotransmitter release for cellular interaction [138].

With reference to RFR-EMF, authors have reported that RFR-EMFs interact with cognitive functions like shortening of reaction times, particularly during tasks that require attention or manipulation of information in the working memory [27, 143]. In yet another study, shorter latency in passive avoidance task was registered in MP RF-EMF exposed rats reflecting significant impairments in memory retention and retrieval [144]. The authors suggested that the RFR-EMF exposure induced damage might lead to alterations in neuronal functioning of both hippocampus and amygdala resulting in changed behaviour during task performance. A cross-sectional study meant to detect neurobehavioural deficits among residents living close to base stations found the prevalence of neuropsychiatric complaints such as memory changes, headache, sleep disturbance, depressive symptoms, dizziness, and tremors to be significantly higher among exposed inhabitants than controls [145]. The study outcomes were based on a questionnaire survey, clinical examination, neurobehavioural test battery (NBTB), and environmental measures with age, sex, education level, smoking habit, occupation, and MP use matching. The NBTB indicated that the exposed inhabitants exhibited a significantly lower performance than controls in one of the tests of attention and short-term auditory memory. The inhabitants opposite the station showed a major reduction in performance in problem-solving test than those under the station. However, in the tests of visuomotor speed and one test of attention the exposed individuals performed significantly well as compared to controls. A cross-sectional community based study conducted among hand-held cellular telephone users in Singapore found headache to be the most prevalent central nervous system symptom as compared to nonusers and the prevalence increased significantly with increased duration of usage per day [146]. The findings were further substantiated by reduced prevalence by more than 20% among those who used handsfree equipment as opposed to those who never used them. The reduced exposure as a result of using handsfree equipment could be possible because the antenna is kept farther away from the head. Studies have proved the sensitivity of brain cells towards RFR-EMF exposures [139, 140]. Significant increases in brain glucose metabolism in regions closest to MP antenna have been observed with acute exposures [147]. GSM-MP radiations have been demonstrated to induce seizures in rats made seizure prone by subconvulsive picrotoxin doses and to alter the cerebral activity reflected by significantly higher c-Fos levels in some brain regions, which raises question for persons with epileptic disorders [15]. MP-EMFs have been suggested to affect the normal neurophysiology through alterations in cortical excitability as a result of demodulation or direct interference with membrane ionic changes, which results in depolarisation and excitation of nerve cells [53]. However, no histopathological changes have been observed with long-term MP exposures [148]. Increased BBB permeability has also been documented not only immediately but also after seven days of exposure to MPs [30]. So far, the

Table 5: Studies concerning the health effects of electromagnetic fields on the nervous system.

EMF characteristics	Study group	Method	Study outcome	Reference
1 mT 50 Hz EMF plus 45 dB SPL (expand) noise for 1 hr duration	66 subjects	Double-blind study	Decreased cognitive performance in attention, perception, and memory	[130]
Four different groups with different durations, days, orientation, and levels of EMF exposure (60 Hz, 1, 3.3, 10 Gauss)	Male C57BL mice	Concentrations of DOPAC*, HVA†, and 5-HIAA‡ in brain tissue were determined with HPLC-ECD	Monoamine levels are affected only by EMF when the exposure is in the same direction as the mouse position.	[42]
700 MHz continuous RF-EMF, 25.2–71.0 V/m, 5–15 min	Slices of rat hippocampus	Evoked field potential	Increases in the level of neuronal excitability	[139]
900 MHz CW MP emissions	15 subjects, two sessions for 45 min	Recording of motor evoked potential using paired-pulse paradigm, tympanic temperature	Influence on motor cortex excitability	[140]
ELF-MFs	Mice Balb/c	Y-maze	Impairment in spatial recognition memory depending on field strength and length of exposure	[141]
GSM 900 MHz from MP, 2 h/days for 4 days at SAR = 0.41 to 0.98 W/kg	16-week-old female rat	Morris water maze	Reduced ability to consolidate and retrieve the learned spatial information	[27]
900 MHz EMF (1 h/day for 28 days) SAR-0.016 whole body and 2 W/kg (locally in the head)	Sham exposed group, 16 rats, and four exposure groups, each with eight rats	Number of pyramidal cells in CA¶ region in hippocampus following postnatal exposure, histopathological evaluations on sections of CA region	Significant reduction in pyramidal cell number in the CA of the EMF group	[142]
GSM 915 MHz for 2 h in TEM§ cells at SARs of 0, 0.12, 1.2, 12 and 120 mW/kg	Forty-eight inbred male and female Fischer 344 rats	Histopathological assessment of albumin extravasation over the BBB, neuronal albumin uptake, and neuronal damage	Interruption of BBB permeability as evidenced by enhanced albumin extravasation in exposed rats after seven-day recovery period	[30]

*DOPAC: dihydroxyphenylacetic acid, †HVA: homovanillic acid, ‡5-HIAA: 5-hydroxyindoleacetic acid, ¶CA: cornu ammonis, and §TEM: transverse electromagnetic cell.

most reliable findings have been reached regarding the brain electrical activity [10]. Impairment in spatial learning and memory functions has been demonstrated in animal studies [27, 143]. Details of investigations with exposure characteristics have been tabulated (Table 5). Lai et al. [28] pointed towards 2450 MHz MW induced short-term memory deficits in rats by the stimulation of endogenous opioids in brain resulting in depressed cholinergic activity responsible for memory functions. The results of Xu et al. [149] pointed towards the connection between extended low intensity GSM 1800 MHz (2.4 W/kg) exposure and synaptic activity evident by decreased excitatory synaptic activity and excitatory synapse number in cultured rat hippocampal neurons. A study investigated the effect of GSM modulated 900 MHz RF-EMF at 1 W/kg on neuron development in two different cell systems by the assessment of morphological parameters and mRNA expression for β-thymosin and stress-related proteins [150]. The authors found a diminution in neurite generation from the soma without any effect on branching and neurite length in both the cellular systems, which was also found to be associated with β-thymosin mRNA overexpression. Yuasa et al. [151] conducted an investigation in order to study the acute effects of pulsed high frequency MP-EMF emissions used for 30 min on somatosensory evoked potentials (SEPs) in healthy individuals. They demonstrated negative effects on SEPs as well as their recovery function indicating the absence of immediate effects on the sensory cortex. EMRs from MP base stations may expose residents to risk of developing neuropsychiatric difficulties and alterations in performance of neurobehavioural functions either by inhibition or facilitation [145]. The comparative analysis of studies relating cognitive and nervous system performance with EMF experience gets complicated due to different assessment tools employed and exposure situations and despite the bulk of scientific evidence, the results turn into conflicting and unconvincing outcomes. At present, the precise mechanism of EMF ill effects on neurons lacks sound understanding; however, some investigations have indicated the role of lipid

peroxidation and free radical generation [2, 152]. To add, the nervous system is chiefly helpless to ROS insults because of its high metabolic rate, inadequate oxidant protection, and reduced cellular turnover [152].

2.7. Effects on Reproductive Functions. Rising male infertility cases in recent times have led to scientific investigations, which indicate the involvement of EMRs as one of the possible environmental factors [153]. Understanding of EMF effect on reproductive functioning is also clouded by contradictory findings [154] despite several decades of research. MPs rather than being a status symbol nowadays have become a part and parcel of everyone's life since the past decade and a half [155]. As it is often carried in pockets in very close proximity to body and the reproductive system, effect of the same on male infertility is an important issue, which seeks immediate attention. Various studies have been undertaken to investigate the potential of ELF field characteristics in inducing damage to the reproductive system [156–160]. In this regard, intermittent 50 Hz low frequency horizontal EF exposure has been reported to cause significant histopathological alterations like focal tubular atrophy, necrosis, and seminiferous epithelial erosion in rat testis [156]. The serum testosterone levels, however, did not differ significantly between exposed and control groups. Toxic effects of 60 Hz, 1 mT ELF-EMF were also reported in male rat offspring exposed from gestation day 13 to postnatal day 21 [159]. The study found a reduction in the count, diameter, area, and volume of seminiferous tubules and height of seminiferous epithelium along with leydig cell count indicative of the harmful effects on testis development. On the contrary, 60 Hz, 500 μT exposure for 21 hours/day from gestation day 6 to postnatal day 21 in pregnant rats did not elicit any significant difference between the exposed and the controls with regard to spermatogenesis and fertility in male offspring [160]. With reference to investigations in mice, 60 Hz EMF was found to raise significantly the germ cell death and defects in seminiferous tubules without any effect on the body or testes weights. At the same time, the same frequency of EMF at 0.5 mT was shown to induce DNA breakage though cell survival was not significantly impaired [157]. Another study at 60 Hz, 14 μT, and 200 μT reported the induction of apoptosis in mice testicular germ cells [158].

As regards RF-EMF exposure, animal studies undertaken so far document higher levels of sperm head abnormalities, positively correlated to RF-EMF exposures suggesting a dose-response effect [165]. Aitken et al. [166] reported alterations in genome of epididymal spermatozoa in mice exposed to 900 MHz RF-EMW, 12 h/day for 7 days. Parallel studies in rats have documented lower spermatocyte counts along with leydig cell hyperplasia and elevated testosterone levels at 2.45 GHz frequency [154]. Significant decline in protein kinase C and total sperm count together with increased apoptosis was reported in male rats exposed to RF-EMF (2 hours/days, 35 days, 0.9 W/kg) from MPs [167]. The investigators indicated the possible role of ROS behind these findings. Previous study on rats found major impairments in OS equilibrium in reproductive tissues along with modified semen parameters reflecting the fundamental connection between RF-EMR exposures and mutations in semen quality [168]. In contradiction, no difference in testicular function was found at GSM-RF exposure from cellular phone in rats [169]. An in vitro study assessing the effect of 900 MHz MP radiation at a SAR of 2.0 W/kg on human sperm's fertilizing potential found no harmful effects on acrosome reaction [170]. However, the researchers did reach significant findings with regard to sperm morphometry and a measurable decline in sperm binding to hemizona was found thus indicating a significant effect of RF-EMF on male fertilizing potential. Interesting findings were reached in a study evaluating the effects of RFR released from GSM multiband MP (900/1900 MHz at a SAR of 1.4 W/kg) in Drosophila melanogaster exposed during the 10-day developmental period from egg laying through pupation [171]. The authors reported elevation in offspring count, stress protein hsp70 concentration, and binding activity of serum response element (SRE) in conjunction with phosphorylation of nuclear transcription factor, ELK-1 indicative of cellular stress, which could further lead to critical alterations in the organism. Observational studies conducted in connection to RFR-EMF exposure reported diminution in semen quality by reduced sperm count, motility, viability, and normal morphology which were also found to be a function of duration of MP use [163]. Wdowiak et al. [172] also demonstrated an increase in the proportion of sperm cells with abnormal morphology and a decrease in the proportion of rapid progressive sperms with the frequency of exposure from GSM-MPs. Davoudi et al. [161] also reported a decrease in rapid progressive motile sperm due to GSM-MPs. The details of investigations have been summarised in Table 6. Extended MP uses have been reported to elicit harmful effects on sperm motility in previous researches as well [162, 173]. Studies show a possible relationship between occupational exposure to radiofrequency equipment including radar and reduced fertility and sperm quality [164, 174]. Epidemiological investigations have indicated a link between male infertility and MP use, but the mechanism of action is unclear. The role of hyperthermia in causing infertility is apparent but the nonthermal effects are debatable [154]. However, it has been speculated that the effect could be specific to EMR effect, a thermal effect, or due to the combination of both [168]. So far, motility or sperm movement is the only factor observed to be affected significantly [155]. Reproductive functions like meiosis, fertilization, and so forth are particularly vulnerable to toxic insults [154]. De Iuliis et al. [153] have highlighted the occurrence of ROS and DNA fragmentation after RF-EMR exposure putting a question mark on the safety of MP use especially in the context of fertility and children's health. Until now, the malfunctioning porous cell membrane and disrupted calcium homeostasis along with OS can be accounted for the damaging effects on testicular cells [12]. Conclusive outcomes have not yet been reached despite extensive researches. So far, long-term studies concerning EMF effects on male reproductive functions are lacking to substantiate the findings and give any clue regarding the biointeraction mechanisms. As far as effect on female reproductive system is concerned, there is limited number of studies. RFR from MPs and base stations have been shown to mutate prolactin but not progesterone levels indicating

Table 6: Studies concerning the health effects of electromagnetic fields on the reproductive system.

EMF characteristics	Study group	Method	Study outcome	Reference
GSM-MP, 6 h/day for 5 days	MP users	Semen analysis	Decrease in rapid progressive motility of sperm	[161]
MP	MP users	Semen analysis	Duration of use and transmission time correlated positively and negatively with proportion of slow progressive and rapid progressive motile sperm, respectively.	[162]
MP	MP users with suitable controls	Sperm parameters like volume, liquefaction time, pH, viscosity, sperm count, motility, viability, and morphology	Statistically significant decrease in semen quality which was also a function of duration of MP use.	[163]
MP, 1 h	Human semen samples	Semen analysis	Significant decline in semen mobility, viability and ROS-TAC* score, rise in ROS level.	[164]
1.8 GHz RF EMR, SAR (0.4 W/kg to 27.5 W/kg)	Purified human spermatozoa	Vitality, motility, sperm density, DHE† assay, MSR‡ assay, 8-OH-dG¶, TUNEL assay, and flow cytometry	Significant decrease in motility and vitality and increase in ROS, 8-OH-dG and DNA fragmentation with increasing SAR.	[153]
RF radiations from GSM base station, 6-month exposure	Male mice, *Mus musculus*	Sperm head abnormality assay	High level of sperm head injury in exposed mice which correlated positively with radiation levels	[165]

* TAC: total antioxidant count, † DHE: dihydroethidium, ‡ MSR: MitoSOX Red, and ¶ 8-OH-dG: 8-hydroxy-2′-deoxyguanosine.

the consequent effects on menstruation and pregnancy [98]. Miscarriage risks have been shown to be higher in pregnant physiotherapists due to their occupation [175]. Han et al. [176] found significant rise in risk of embryo growth cessation in the first pregnancy trimester of pregnant women especially with the medical history of embryo growth termination with regard to increased exposures from television and MPs. Animal investigations also support the toxic effects of RFR. In this connection, Gul et al. [177] registered a fall in follicles count in rat ovaries submitted to intrauterine RF exposures whereas Xu et al. [178] demonstrated toxic alterations in the reproductive organs. Further studies in females are wanted with special relevance for pregnant women, who are also carrying the future generation. Children form yet another group of prime importance since their reproductive systems are immature and exposures are prolonged; hence, they can be the worst sufferers.

2.8. Auditory and Ocular Effects. A recent study [179] concluded that higher ELF-EMF exposure at 50 Hz, 10.182 kV/m coupled to 4.45 pT MF may give rise to adverse auditory effects especially to the organ of Corti and outer hair cells as a result of decreased distortion product auto acoustic emission amplitudes in higher frequency region localized in basal turn of cochlea in rabbits which have also resemblance with human's frequency spectra. As regards RFR-EMF, MP use has been associated with tinnitus and acoustic neuroma [38, 41]. Ear is the first biological structure to be hit by EMFs from MP. In addition, relatively greater vulnerability of cochlear outer hair cells to injuries from a diversity of exogenous and endogenous agents makes the system a victim of radiation emissions [179, 180]. These days, about 50% of world's population possesses a MP [30] and even greater than that are experiencing EMF emissions through "passive mobile phoning" [181]. Hearing problems reported in few observational studies [50] have also been investigated to occur in animals [179] with parallel contradictions [180, 182]. Studies with ten minutes acute MP radiation exposures have resulted in no immediate effect on hearing threshold level of pure tone audiometry, transient evoked otoacoustic emissions [183], auditory brain stem response [184], and any depreciation in hearing in young human volunteers. However, regular long-term MP use has been linked to increased relative risk of acoustic schwannoma [39]. Despite the interests in EMF effects due to MP, there is lack of solid evidence regarding the ill effects on auditory system and, hence, we are far from any conclusion and not able to develop safe and sound communication devices necessary for safeguarding one of the senses [11].

Heat-related skin injury and lens defects reported in eyes of man are the only undisputed harmful effects of MW exposure [56]. Carpenter [185] in late seventies reported that microwaves have the capability to induce cataracts and affect the eyes by reducing the ascorbic acid content of the lens coupled with the inhibition of DNA synthesis and mitosis in lens epithelium thereby slowing down the recovery

process. In addition, the lens becomes more vulnerable to EMF threats because of decreased water content and absence of vasculature [12, 56, 186]. Spector [187] suggested the role of OS in cataract development due to extensive oxidation of lens protein and lipid at older age. Nevertheless, the database is yet deficient to decide regarding ocular defects including cataracts in human subjects exposed for extended durations.

2.9. Effects on Sleep Parameters. Sleep insufficiency was observed to be more common in the occupational group of electronic equipment repairers exposed to ELF-EMF though not statistically significant when compared to controls [89]. Earlier studies have also documented diminished sleep and sleep efficiency with 60 Hz MF experience [188]. So far, studies evaluating sleep quality in the context of ELF-EMF exposure in humans have not reached any statistical significance [44, 45, 89].

In connection to RFR-EMF, Abelin et al. [189] reported the prevalence of difficulties of falling asleep and, in particular, maintaining sleep, which increased with increasing RF-EMF exposure in the vicinity of short-wave broadcast transmitter. In addition, sleep quality was found to improve after interruption of the exposure. A similar study found an association of EMF exposure with sleep quality and melatonin excretion but only in poor sleepers suggesting the sensitivity of a group of people [190]. The authors highlighted that the absence of blinding in their investigation could lead to such results. Another study by Wiholm et al. [191] indicated the negative influence on sleep component during laboratory exposure to 884 MHz wireless signals. Besides, volunteers with no self-reported symptoms related to MP use appear to have more headaches during actual RF exposure as compared to sham exposure. Several studies evaluating RF exposure effects on sleep parameters and sleep EEG are surrounded with contradictory outcomes owing to methodological limitations like small sample sizes and lack of replications of the previous findings. According to a clinical review [192], sleep disturbances do not seem to be a predominant complaint under exposure to high frequency EMF and with the present level of knowledge no final conclusion can be drawn concerning any potential health hazard. Hutter et al. [34] also reported no significant effect on sleep quality and pointed that it could be dominated by the fear of negative health effects of EMF radiations as well as age. Sleep is an important component of the biological species to overcome the daily wear and tear. Studies relating EMF exposures to sleep do suggest some biological effects; however, these do not provide evidence for any adverse health consequences. Further research with well-designed protocols is required with lessons from past experiments so that valuable information is updated in bioelectromagnetics field.

3. Mechanisms of Action

3.1. Thermal and Nonthermal Interactions. Due to lack of sufficient energy required to break the molecular bonds in cells by EMFs, the elicited effects are assumed to be indirect and secondary to other induced biochemical modifications [60, 76]. Ruediger [32] suggested the indirect role of microthermal processes, OS and altered DNA repair mechanisms behind the observed effects. However, studies have also pointed towards the involvement of resonance-like sensing mechanisms working only at specific combinations of frequency and amplitude suggestive of a direct EMF effect [136]. It is proposed that low frequency time varying electric fields (EFs) interact with the body by the induction of electric currents, formation of electric dipoles, and reorientation of existing dipoles whereas interaction of time-varying MFs leads to induced EFs and circulating electric currents. Higher current densities and EFs have been shown to be induced when the direction of external EF is parallel to the longer vertical axis of body (from head to feet) and the MFs are from front to back, respectively, due to better coupling with human body compared to other configurations [193]. Additionally, EMF effects are dependent on a number of physical (frequency, modulation, polarization, wave characteristics, near or far field configuration, duration and orientation of EF and MF exposure, dielectric properties, conductivity and water content of tissues, and environmental factors like humidity, temperature, etc.) and biological variables (species, shape and size of the body, weight, geometry of the body, and nutritional and health status).

The possible effect of EMF irradiation is either thermal or nonthermal depending on frequency and strength. The elicited effects are assumed to be noticeable when not shrouded by thermal noise also termed as Brownian motion which is a virtue of all objects/materials above absolute zero temperature. The thermal effects are induced as a consequence of heat gained by water contained in body tissues. Hence, body tissues or organs like lens of eye and testes with less vasculature or deficient in water content are the most vulnerable to even small rise in temperature. Usually, body parts with the smallest cross-section like hand, feet, fingers, and toes gain the maximum values of current densities and EFs [193].

3.2. Oxidative Stress. OS resulting from imbalance of reactive oxygen species (ROS) and antioxidants, leading to disruption of cell functions, has been proposed as one of the probable modes of EMF action [2, 5, 60, 71, 196]. EMFs have also been implicated to lengthen life of free radicals particularly by Fenton reaction [33], affect enzyme activity [31], and change protein levels indicative of induction of cellular stress response pathways [14]. Fenton reaction is a process in which hydroxy free radicals are generated from hydrogen peroxide produced during mitochondrial oxidative respiration in presence of transition metals like iron [60, 64]. EMF interaction with free radicals and transitional metals has also been linked to the observed genotoxic effects [33, 64]. In this regard, cells, which are metabolically active, or have higher cellular concentrations of free iron and superparamagnetic iron particles (magnetites) in body tissues like brain cells, are more vulnerable to EMFs [60]. Several studies have demonstrated OS inducing ability of EMF including MP-RFR in different animal models [31, 152, 196–198] or in cell cultures [64, 73] paralleled with negative findings as well [5, 7]. Studies

Table 7: Studies showing the oxidative stress inducing ability of electromagnetic fields.

EMF characteristics	Study group	Method	Study outcome	Reference
2450 MHz pulsed (2 msec pulses, 500 pps), 2 mW/cm^2, Avg. SAR = 1.2 W/kg, 2 h, melatonin and PBN* treatment before and after exposure	Male Sprague Dawley rats	Microgel electrophoresis assay in brain cells	Involvement of free radicals in inducing DNA damage in brain cells, and protective effects of melatonin andPBN as free radical scavenger	[3]
0.1 mT, 60 Hz, 5 h and 30 min after LPS† administration, mice were administered with NO‡ spin trap MGD-Fe¶	Male BALB/C mice	EPR§ measurement in liver	EMF increased LPS induced NO production but not alone	[194]
900 MHz, 30 min/day, 5 days/wk for 2 weeks, mel. (10 mg/kg daily orally)	Male Sprague Dawley rats in three groups	NO measurement in nasal and paranasal mucosa by Griess reaction	Increase in NO level in sinus and nasal mucosa, beneficial effect of melatonin in preventing these changes	[195]
900 MHz MW, melatonin (100 μg/kg sc before daily exposure)	Sprague Dawley rats in three groups	Lipid peroxidation in cortex brain and hippocampus tissue	Rise in MDA|| levels, melatonin caused decline in hippocampal MDA levels with no decrease in cortex	[2]
900 MHz RF, CW & GSM MP waves for 10 or 30 min, SAR = 0.3 & 1 W/kg, MX# = 500 μM	Murine L929 fibrosarcoma cells	Measurement of ROS	No ROS generation either alone or in association with MX	[5]
MP, 20, 40, 60 days, SAR = 0.043–0.135 W/kg), melatonin = 2 mg/kg body weight i.p.	Wistar rats in four groups	Biochemical estimation of MDA, carbonyl groups, XO[1] and CAT[2] activity in brain tissue	Significant rise in MDA, carbonyl groups, XO activity, and reduced CAT activity after 40 and 60 days exposure; melatonin ameliorates OS	[152]

* PBN: N-tert-butyl-a-phenylnitrone, † LPS: lipopolysaccharide, ‡ NO: nitric oxide, ¶ MGD-Fe: ferrous N-methyl-D-glucamine dithiocarbamate, § EPR: electron paramagnetic resonance, || MDA: malondialdehyde, # MX: 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone, [1] XO: xanthine oxidase, and [2] CAT: catalase.

demonstrating EMF's ability to cause OS are summarised in Table 7. Given the credence of free radicals in signal transduction and EMF in boosting the free radical lifetime, there are chances of EMF influencing signalling [194].

3.3. Melatonin Diminution. Several human and animal studies conducted thus far have suggested decrease in melatonin after EMF exposure [21, 23, 24, 87]. Like all other EMF effects, melatonin diminution is also surrounded with conflicting results [87]; however, the effects have been suggested to be somewhat constant, at least in rodents [199]. Some studies have also supported the protective effect of melatonin against oxidative damage induced by EMFs [2, 3, 64, 152, 195] pointing towards the OS mechanism involved in generating negative health outcomes and melatonin's beneficial properties. The hypothesised mechanism of EMF action on melatonin concentration is through the imitation of light rays to the retina [22]. To add, Yaga et al. [86] found significant suppression of N-acetyltransferase (NAT) activity, a rate-limiting enzyme in melatonin synthesis due to MF exposure. The melatonin forming enzyme hydroxyindole O-methyl transferase has also been documented to be affected [87]. Melatonin's shielding actions counter to EMF ill effects are supposed to shoot from its direct free radical foraging and indirect antioxidant property of inhibiting free radical production at the power house of the cell and, hence, diminution of pineal melatonin secretion could be proposed as a possible mechanism of EMF interaction with living organisms.

3.4. Calcium Flux. Calcium ion efflux/influx has also been proposed as the biological mechanism [200] and is dependent on ambient temperature, geomagnetic field intensity, direction, and signal strength [201–203]. Calcium ions are crucial for cAMP pathway as well as serotonin/melatonin conversion and their efflux from pinealocytes is supposed to cause melatonin suppression. Besides, calcium dependent signal transduction systems also have been implicated in the mediation of immune cell effects by low frequency EMF [29]. However, authors have indicated the occurrence of calcium efflux/influx at some specific exposure combinations but not at other relatively closer exposure characteristics mainly due to the "window" effect or nonlinear nature of modulation frequency and intensity effect.

3.5. Molecular Mechanisms. Similar to physiological stress response at the organ system level, there are also cellular stress responses at the cell level to impart protection to the cell from external and internal stressors. The cellular stress response is characterized by an elevation in stress protein concentration [204] in response to a stress causing damage to biomolecules like DNA and proteins [205]. EMFs at ELF, RF, and amplitude

modulated RF have been demonstrated to stimulate the same stress response [204, 206, 207]. Unlike the past assumption of absence of DNA-EMF interaction plausibility, recent investigations indicate the potential of EMF both ELF and RF to stimulate DNA and induce protein expression [14, 171, 208, 209]. Various studies have highlighted the genotoxic ability of EMF at both ELF and RF range as evidenced from DNA strand break reports post-EMF experience [33, 63–65, 68]. Recent investigations have further revealed the presence of an EMF reactive sequence in DNA [210] which acts particularly in response to EMF stimulus. These EMF reactive DNA sequences code for the production of the chief stress protein hsp70, in response to the binding of transcription factor, heat shock factor 1 (HSE-1) to heat shock element (HSE) in the promoter region [210–213]. Friedman et al. [209] delineated the molecular mechanism behind the stimulation of the ERKs in response to RFR exposure at MP frequencies. The RF-EMF through its interaction with NADH oxidase in the plasma membrane causes the formation of ROS, which further activate the MMPs (matrix metalloproteinases). Because of activation, the MMPs break into Hb-EGF [heparin-binding EGF (epidermal growth factor)] and stimulate the EGF receptor, which sequentially triggers the ERK cascade. The ERK cascade is one of the four mitogen-activated protein kinase (MAPK) signaling cascades that controls transcription and associated cellular processes like replication, cell-cycle progression, apoptosis, differentiation, metabolism, and so forth, in reaction to extracellular stimuli. The MP radiation induced overexpressed protein transcription factors have been found to regulate the cellular processes such as apoptosis [214] and replication and cell cycle progression [14, 215]. The reported findings with regard to cellular stress response post-EMF experience give critical insights into connection to harmful health-relevant potential of ELFs and RFRs in addition to their role as cellular biomarkers.

In light of several credible biointeraction processes, the OS mechanism appears to gain the maximum support. The hypothesised EMF biointeraction path may involve ROS generation, leading to diminished antioxidant capacity, affecting the antioxidant/prooxidant equilibrium and causing OS, thereby instigating adverse health effects. This sequence may be paralleled by calcium efflux, which alters serotonin conversion into melatonin thus triggering melatonin diminution, which further substantiates OS. At the same time, ROS may lead to the activation of signal transduction pathway trigging the ERK cascade. The cellular stress response mediated by hsp70 overexpression can also be considered but this effect is limited to certain group of cells while other cell types are being nonresponsive [216]. The exact mode of biointeraction mechanism still needs to be elucidated.

4. Research Needs

The limited quality of research works in bioelectromagnetics and methodological problems is an important concern [57, 155]. Until now, epidemiological investigations have failed to get the SAR value which is the most direct dosimetric measure of an individual's exposure at the tissue or organ level under study [217]. Moreover, lack of an appropriate exposure assessment method [55] and reliable equipment for calculation of energy absorbed in the body and the intricate relation with species, frequency, power, EMF source, and modulation dosimetry has inhibited the utilization of laboratory results to human conditions [53] and the conduct of epidemiological studies [56]. Hutter et al. [34] suggested the usage of personal "exposimeter" or long-term exposure monitoring as the best way for exposure assessment. So far, errors in exposure assessment due to lack of long-term exposure monitoring by EMF dosimeters, exposure has been assessed by crude methods in most studies, such as wiring codes, occupation or residence in relation to proximity to a source, spot measurements, time-weighted average and self-reports, and hence results in underestimation of actual risk and clouds the true relationship. Absence of suitable control population for comparison as all of us are exposed to EMFs every day coming from varied sources with different degrees further complicates the understanding of literature on human EMF exposure [52, 55].

Furthermore, clear understanding is hampered by the multipart interactions of different EMF exposure factors [12, 53] and shape, size, mass, orientation, and electrical characteristics of body and individual characteristics like age, gender, activity level, incapacitation, or illness [218]. Environmental parameters like ambient temperature, wind velocity, humidity, and body insulation also affect the communication between body and the EMF vector. Anatomical differences among humans and animal models as regards size, shape, reproductive tract variations, and so forth further complicate the understanding of observed results [12].

As far as studies investigating exposure of humans to MP radiations are concerned, they have followed the standard method of EMF exposure assessment by retrospective interviews or obtaining information or self-reports of subjects on total duration of use or number of calls, number of years of use, side of use ipsilateral, or contralateral along with exposure duration estimates and billing records from service providers [52, 79]. However, these parameters have been questioned for recall bias [52]. Animal experimentation especially using primates or species closely related to humans would eliminate the chances of recall bias regarding MP use and give meaningful directions. Besides, the duration based exposure assessment is built on the postulation of equivalent power emissions per minute from all phones which may not be correct with expanding use of GSM based phones with variable power outputs ending in miscalculation of true exposure in spite of recall accuracy [217]. Besides, geographic area, physical environment, user location rural or urban, distance between user and base station antenna, handsfree use, individual characteristics of phone handset, and its use as well as technical features of provider network all have some effect on EMF emissions and consequent exposure to the individuals [12, 34, 52, 219].

A research carried out by Erdreich et al. [217] to increase the accuracy of exposure estimation in epidemiological studies of GSM-MPs found that the average power output rate in GSM phones varies with several characteristics of phone use, the largest being the site of investigation, followed by user movement and location (indoor or outdoor), use of handsfree

device, and urbanicity. The understanding is complicated further by factors like distance to the phone, holding position, position of antenna, pinna size, elasticity of ear, thickness of skull bone, type of tissue, tissue type distribution, and so forth, governing the actual amount of power absorbed [220]. In addition, lack of long-term studies also restricts our understanding. Apart from this, role of media finds significance in focusing the attention on the potential adverse health effects caused by MP radiations. This may give rise to fear or awareness forcing MP users to report more symptoms than nonusers even if the prevalence of symptoms were equal [146].

Animal and cell culture studies are surrounded with conflicting results as a consequence of the heterogeneous exposure conditions (type of EMF- RF, MW, CW, Pulsed, and so forth, SAR value, exposure duration) [5, 7] and differing assay protocols [53]. At the same time, vested interests of sponsors also influence the study outcome with quality studies having mixed funding and, hence, sponsorship should be taken into consideration while interpreting the findings [221]. We strongly advocate that with mere swelling number of studies no fruitful conclusions can be reached. If we do not address the limitations of past investigations, we may not be able to truly contribute to the domain of bioelectromagnetics. Therefore, need of the hour is to do innovative research with sound designs and appropriate methodologies rising above the demerits of past researches.

5. Conclusion

Given the ubiquitous nature of EMFs, their widespread applications, and their capability to produce deleterious effects, conclusive investigations of the health risks are critical. With the published literature on EMF, it is still not sufficient enough to reach a concrete conclusion. But the possibility of negative consequences cannot be excluded. Several studies with appropriate methodologies reflect the capacity of EMFs to cause adverse health effects. However, the absence of any established biointeraction mechanism does not diminish the reliability of these studies as there are several credible mechanisms like OS that can account for the observed effects.

Therefore, need of the hour is to restrict the swelling numbers of scientific investigations and in place activate comprehensive well-coordinated blind scientific investigations especially long-term studies overcoming all limitations and demerits of previous findings with suitable replication studies and follow-up. There is a need for standardized research methodology along with the inclusion of appropriate exposure assessment technique which is crucial for identification of dose response relation if any and the elucidation of mechanism for biological interaction. If we do not work upon the demerits of previous findings, we may remain far from any concrete conclusion. At the same time, it is critical to analyse the EMF investigations giving more weight to the similarities and dissimilarities rather than giving more importance to the endpoints reached.

For the time being, since it is difficult to protect oneself from EMFs, the only practical way to check exposures is to distance oneself from the source. Together, the precautionary approach and ALARA (as low as reasonably achievable) principle can also be applied to save us from substantial exposures and the possible ill effects if any. The objective is to minimize EMF exposures to the greatest degree possible without significant economic cost and disturbance.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Electrical induction of ventricular fibrillation in the human heart. A study of excitability levels with alternating current of different frequencies.

Kugelberg J.

Abstract

An experimental study was made on induction thresholds for ventricular fibrillation with alternating currents at frequencies ranging between 6 and 1 600 c/s. The tests were performed on experimental dogs and on patients in association with open-heart surgery. The most vulnerable range was found to be between 12 and 60 c/s. A close similarity was demonstrated between canine and human hearts. The induction of ventricular fibrillation during open-heart surgery is discussed. Ventricular fibrillation, caused by electricity, is either accidental or deliberately induced for medical purposes. The myocardial threshold of excitability towards alternating currents is dependent on two parameters, current and frequency. The vulnerability of the heart towards current has been thoroughly investigated by several authors (Walter, 1969; Dalziel & Lee, 1969; Nickel & Spang, 1965; Kugelberg, 1975). A frequency of 50-60 c/s was utilized in all these determinations, as this is the one of choice in networks for distribution of electric power all over the world. Thus, accidental ventricular fibrillation is most likely to occur with currents of this frequency, and inductions for medical purposes, i.e. during open-heart operations, are achieved in the easiest way with simple transformers delivering the same frequency.

http://www.foxnews.com/world/2017/10/12/sound-recordings-from-havana-possibly-linked-to-u-s-embassy-attacks.html

First recording emerges of high-pitched 'sonic weapon' linked to attacks on US Embassy workers in Cuba

Go here to listen to the sound: https://www.youtube.com/watch?time_continue=3&v=Nw5MLAu-kKs

FILE - In this Aug. 14, 2015, file photo, a U.S. flag flies at the U.S. embassy in Havana, Cuba. The Associated Press has obtained a recording of what some U.S. Embassy workers heard in Havana, part of the series of unnerving incidents later deemed to be deliberate attacks. (AP Photo/Desmond Boylan, File)

The first public recording of high-pitched, cricket-like sounds out of Havana could be linked to the attacks on U.S. Embassy workers, according to a new report.

The recording, first released by the Associated Press on Thursday, is reportedly one of several from Havana that first led investigators to believe a sonic weapon was involved.

Of Americans affected in Cuba, not all of them reportedly heard the sounds. But some who did said, while not identical, that the recording was relatively consistent with what they heard.

“That’s the sound,” one witness said.

US EXPELS CUBAN DIPLOMATS FROM EMBASSY IN WASHINGTON

The recording, which has not yet provided much insight about what is harming diplomats, has been sent to the U.S. Navy for further examination. The Navy has advanced capabilities for analyzing acoustic signals.

It is unclear whether the sounds are directly responsible for the attacks, which have been shown to cause hearing, cognitive, visual, balance, sleep, and other problems.

At least 22 U.S. Embassy workers were injured in the attacks that began last year in Havana.

As a result, the U.S. has pulled 60 percent of its government employees out of the country. It also expelled 15 Cuban diplomats from the embassy in Washington D.C.

Secretary of State Rex Tillerson said the move was made because Cuba had failed to protect American diplomats on its soil.

"Until the government of Cuba can ensure the safety of our diplomats in Cuba, our embassy will be reduced to emergency personnel to minimize the number of diplomats at risk of exposure to harm," Tillerson said.


Video

John Kelly says Cuba could stop diplomat attacks

US TOURISTS BACK FROM CUBA CLAIM SYMPTOMS SIMILAR TO MYSTERIOUS ATTACKS

The Cuban government has denied all knowledge or involvement in the attacks, calling the U.S. move “hasty” and “irresponsible.”

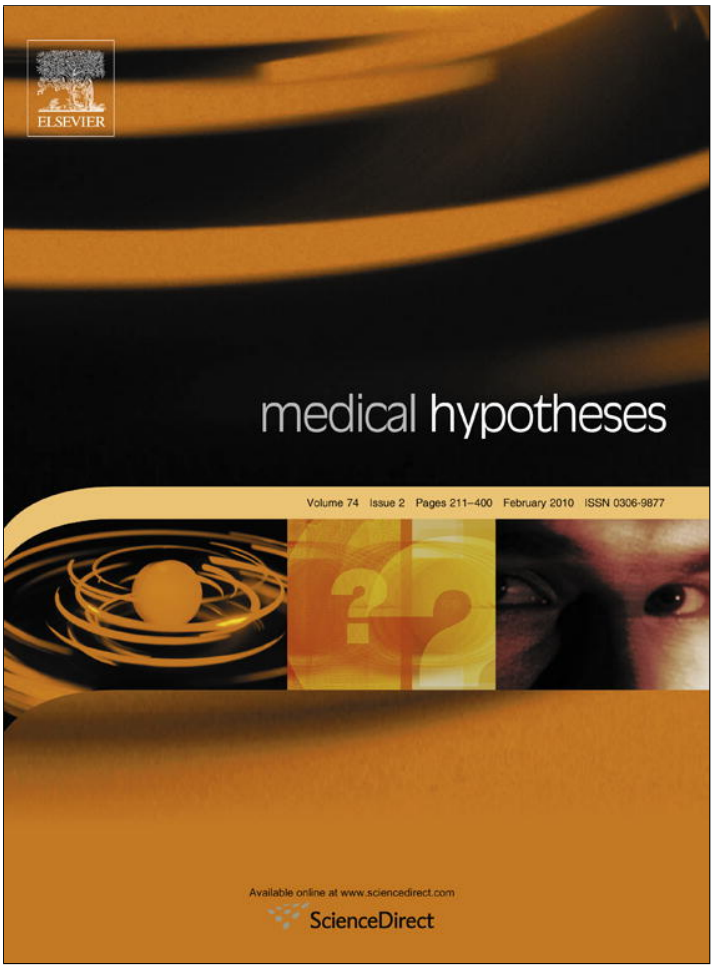
The State Department also issued a warning to American tourists, urging them to stay away from Cuba, saying that the U.S. cannot guarantee that individuals staying at Havana hotels would not also be harmed.

Some U.S. tourists have since complained of symptoms similar to those experienced by government workers.

The recording was shared with workers at the U.S. Embassy in order to teach them what to listen for.

Because of the limited information available, the U.S. government has only been able to advise workers that if they think they’re being attacked, they should move to another area because the attack is unlikely to be able to follow them.

The Associated Press contributed to this report.



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Historical evidence that electrification caused the 20th century epidemic of "diseases of civilization" ☆

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SUMMARY

The slow spread of residential electrification in the US in the first half of the 20th century from urban to rural areas resulted by 1940 in two large populations; urban populations, with nearly complete electrification and rural populations exposed to varying levels of electrification depending on the progress of electrification in their state. It took until 1956 for US farms to reach urban and rural non-farm electrification levels. Both populations were covered by the US vital registration system. US vital statistics tabulations and census records for 1920–1960, and historical US vital statistics documents were examined. Residential electrification data was available in the US census of population for 1930, 1940 and 1950. Crude urban and rural death rates were calculated, and death rates by state were correlated with electrification rates by state for urban and rural areas for 1940 white resident deaths. Urban death rates were much higher than rural rates for cardiovascular diseases, malignant diseases, diabetes and suicide in 1940. Rural death rates were significantly correlated with level of residential electric service by state for most causes examined. I hypothesize that the 20th century epidemic of the so called diseases of civilization including cardiovascular disease, cancer and diabetes and suicide was caused by electrification not by lifestyle. A large proportion of these diseases may therefore be preventable.

Background

In 2001, Ossiander and I [1] presented evidence that the childhood leukemia mortality peak at ages 2–4 which emerged in the US in the 1930s was correlated with the spread of residential electrification in the first half of the 20th century in the US. While doing the childhood leukemia study, I noticed a strong positive correlation between level of residential electrification and the death rate by state due to some adult cancers in 1930 and 1940 vital statistics. At the time, a plausible electrical exposure agent and a method for its delivery within residences was lacking. However, in 2008 I coauthored a study of a cancer cluster in school teachers at a California middle school [2] which indicated that high frequency voltage transients (also known as dirty electricity), were a potent universal carcinogen with cancer risks over 10.0 and significant dose–response for a number of cancers. They have frequencies between 2 and 100 kHz. These findings are supported by a large cancer incidence study in 200,000 California school employees which showed that the same cancers and others were in excess in California teachers statewide [3]. Power frequency magnetic fields (60 Hz) measured at the school were low and not related to cancer incidence, while classroom levels of high frequency voltage transients measured at the electrical outlets in the classrooms accurately predicted a teacher's cancer risk. These fields are potentially present in all wires carrying electricity and are an important component of ground currents returning to substations especially in rural areas. This helped explain the fact that professional and office workers, like the school teachers, have high cancer incidence rates. It also explained why indoor workers had higher malignant melanoma rates, why melanoma occurred on part of the body which never are exposed to sunlight, and why melanoma rates are increasing while the amount of sunshine reaching earth is stable or decreasing due to air pollution. A number of very different types of cancer had elevated risk in the La Quinta school study, in the California school employees study, and in other teacher studies. The only other carcinogenic agent which acts like this is ionizing radiation.

Among the many devices which generate the dirty electricity are compact fluorescent light bulbs, halogen lamps, wireless routers, dimmer switches, and other devices using switching power supplies. Any device which interrupts current flow generates dirty electricity. Arcing, sparking and bad electrical connections can also generate the high frequency voltage transients. Except for the dimmer switches, most of these devices did not exist in the first half of the 20th century. However, early electric generating equipment

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and electric motors used commutators, carbon brushes, and split rings, which would inject high frequency voltage transients into the 60 Hz electricity being generated and distributed.

With a newly recognized electrical exposure agent and a means for its delivery, I decided to examine whether residential electrification in the US in the first half of the last century was related to any other causes of death. Most cancers showed increasing mortality in this period, and many are still increasing in incidence in the developed world.

Thomas Edison began electrifying New York City in 1880, but by 1920, only 34.7% of all US dwelling units and 1.6% of farms had electric service (Table 1). By 1940, 78% of all dwelling units and 32% of farms had electric service [4]. This means that in 1940 about three quarters of the US population lived in electrified residences and one quarter did not. By 1940, the US vital registration system was essentially complete, in that all the 48 contiguous United States were included. Most large US cities were electrified by the turn of the century, and by 1940, over 90% of all the residences in the northeastern states and California were electrified. In 1940 almost all urban residents in the US were exposed to electromagnetic fields (EMFs) in their residences and at work, while rural residents were exposed to varying levels of EMFs, depending on the progress of rural electrification in their states. In 1940, only 28% of residences in Mississippi were electrified, and five other southern states had less than 50% of residences electrified (Table 2). Eleven states, mostly in the northeast had residential electrification rates above 90%. In the highly electrified northeastern states and in California, urban and rural residents could have similar levels of EMF exposure, while in states with low levels of residential electrification, there were potentially great differences in EMF exposure between urban and rural residents. It took the first half of the 20th century for these differences to disappear. I examined US mortality records by urban and rural residence by percent of residences with electric service by state.

Hypothesis

The diseases of civilization or lifestyle diseases include cardiovascular disease, cancer and diabetes and are thought to be caused by changes in diet, exercise habits, and lifestyle which occur as countries industrialize. I think the critical variable which causes the radical changes in mortality accompanying industrialization is electrification. Beginning in 1979, with the work of Wertheimer and Leeper [5], there has been increasing evidence that some facet of electromagnetic field exposure is associated epidemiologically with an increased incidence of leukemia, certain other cancers and non-cancers like Alzheimer's disease, amyotrophic lateral sclerosis, and suicide. With the exception of a small part of the electromagnetic spectrum from infra red through visible light, ultraviolet light and cosmic rays, the rest of the spectrum is man-made and foreign to human evolutionary experience. I suggest that from the time that Thomas Edison started his direct current electrical distribution system in the 1880s in New York City until now, when most of the world is electrified, the electricity carried high frequency voltage transients which caused and continue to cause what are considered to be the normal diseases of civilization. Even today, many of these diseases are absent or have very low incidence in places without electricity.

Table 1
Growth of residential electric service US 1920–1956 percent of dwelling units with electric service.

Year	All		Urban and rural non-farm
	Dwellings	Farm	
1920	34.7	1.6	47.4
1925	53.2	3.9	69.4
1930	68.2	10.4	84.8
1935	68.0	12.6	83.9
1940	78.7	32.6	90.8
1945	85.0	48.0	93.0
1950	94.0	77.7	96.6
1956	98.8	95.9	99.2

Table 2
Percent of residences with electric lighting 1930 and 1940 by state.

Code	State	1930	1940
AL	Alabama	33.9	43.3
AZ	Arizona	68.8	70.5
AR	Arkansas	25.3	32.8
CA	California	93.9	96
CO	Colorado	69.6	77.6
CT	Connecticut	95.3	96.5
DE	Delaware	78.4	81.8
FL	Florida	60.9	66.5
GA	Georgia	35.5	46.6
ID	Idaho	64.5	79.1
IL	Illinois	86.1	89.9
IN	Indiana	74.8	84
IA	Iowa	65.6	76.7
KS	Kansas	62	71.5
KY	Kentucky	44.2	54.2
LA	Louisiana	42.2	48.9
ME	Maine	76.1	80.4
MD	Maryland	81.8	85.9
MA	Massachusetts	97.1	97.6
MI	Michigan	84.8	92.1
MN	Minnesota	65.9	75.8
MS	Mississippi	19.4	28.3
MO	Missouri	65.5	70.6
MT	Montana	58.2	70.7
NE	Nebraska	61	70.5
NV	Nevada	76.2	80.8
NH	New Hampshire	84.9	87
NJ	New Jersey	95.8	96.6
NM	New Mexico	39.8	49.2
NY	New York	94.5	96.4
NC	North Carolina	40.8	54.4
ND	North Dakota	41.6	53.8
OH	Ohio	85.2	90.6
OK	Oklahoma	45.3	55.1
OR	Oregon	79.5	85.8
PA	Pennsylvania	89.5	92.3
RI	Rhode Island	97.3	97.7
SC	South Carolina	34.3	46.2
SD	South Dakota	44.4	56.6
TN	Tennessee	42	50.9
TX	Texas	*	59
UT	Utah	88.4	93.9
T	Vermont	71.9	80.2
VA	Virginia	50.5	60.6
WA	Washington	86.3	90.9
WV	West Virginia	63.4	69.1
WI	Wisconsin	74.5	83.9
WY	Wyoming	60	70.9

*No data.

Evaluation of the hypothesis

To evaluate the hypothesis, I examined mortality in US populations with and without residential electrification. Vital statistics tabulations of deaths [6], US census records for 1920–1970 [7], and historical US documents [8,9] were examined in hard copy or downloaded from the internet. The same state residential electrification data used in the childhood leukemia study [1] was used in this study. Crude death rates were calculated by dividing number of deaths by population at risk, and death rates by state were then correlated with electrification rates by state using downloaded software [10]. Time trends of death rates for selected causes

of death by state were examined. Most rates were calculated by state for urban and rural residence for whites only in 1940 deaths, since complete racial data was available by urban/rural residence by state for only 13 of 48 states. Data was available for 48 states in the 1940 mortality tabulations. District of Columbia was excluded because it was primarily an urban population. Excel graphing software [11] and "Create a Graph" [12] software was used.

I had hoped to further test this hypothesis by studying mortality in individual US farms with and without electrification, when the 1930 US census 70 year quarantine expired in 2000. Unfortunately, the 1930 US farm census schedules had been destroyed.

Findings

Rural residential electrification did not reach urban levels until 1956 (Table 1). Table 2 shows the level of residential electrification for each state for 1930 and 1940. In 1930 and 1940 only 9.5% and 13%, respectively, of all generated electricity was used in residences. Most electricity was used in commercial and industrial applications.

Figs. 1–4 were copied and scanned from "Vital statistics rates in the United States 1940–1960", by Robert Grove Ph.D. and Alice M. Henzel. This volume was published in 1968. Fig. 1 shows a gradual decline in the all causes death rate from 1900 to 1960 except for a spike caused by the 1918 influenza pandemic. Death rates due to tuberculosis, typhoid fever, diphtheria, dysentery, influenza and pneumonia and measles all fell sharply in this period, and account for most of the decline in the all causes death rate. Figs. 2–4 show that in the same time period when the all causes death rate was declining, all malignant neoplasms (Fig. 2), cardiovascular diseases (Fig. 3), and diabetes (Fig. 4) all had gradually increasing death rates. In 1900, heart disease and cancer were 4th and 8th in a list of 10 leading causes of death. By 1940 heart disease had risen to first and cancer to second place, and have maintained that position ever since. Table 3 shows that for all major causes of death examined, except motor vehicle accidents, there was a sizable urban excess in 1940 deaths. The authors of the extensive 69 page introduction to the 1930 mortality statistics volume noted that the cancer rates for cities were 58.2% higher than those for rural areas. They speculated that some of this excess might have been due to rural residents dying in urban hospitals. In 1940, deaths by place of residence and occurrence are presented in separate volumes. In 1940 only 2.1% of all deaths occurred to residents of one state dying in another state. Most non-resident deaths were residents of other areas of the same state. Table 4 presents correlation coefficients for the relationship between death rates by urban rural areas of each state and the percent of residences in each state with

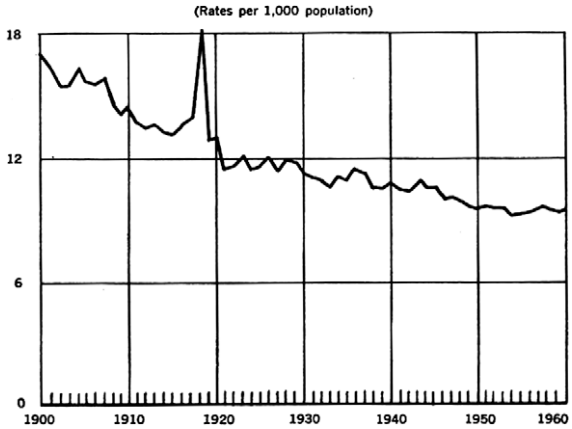

Fig. 1. Death rates: death registration states, 1900–32, and United States, 1933–60.

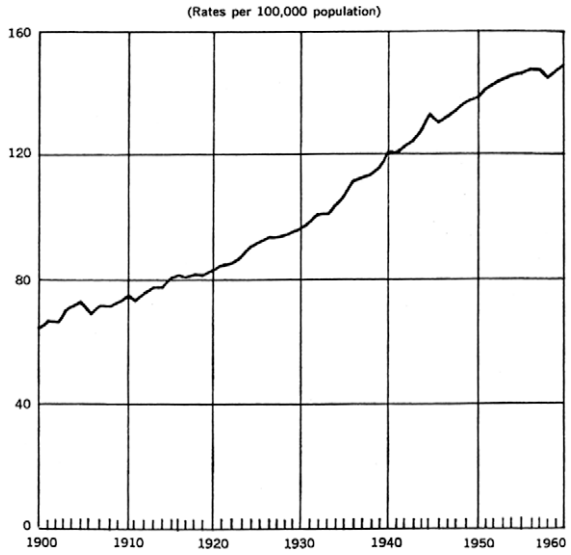

Fig. 2. Death rates for malignant neoplasms: death registration states, 1900–32, and United States, 1933–60.

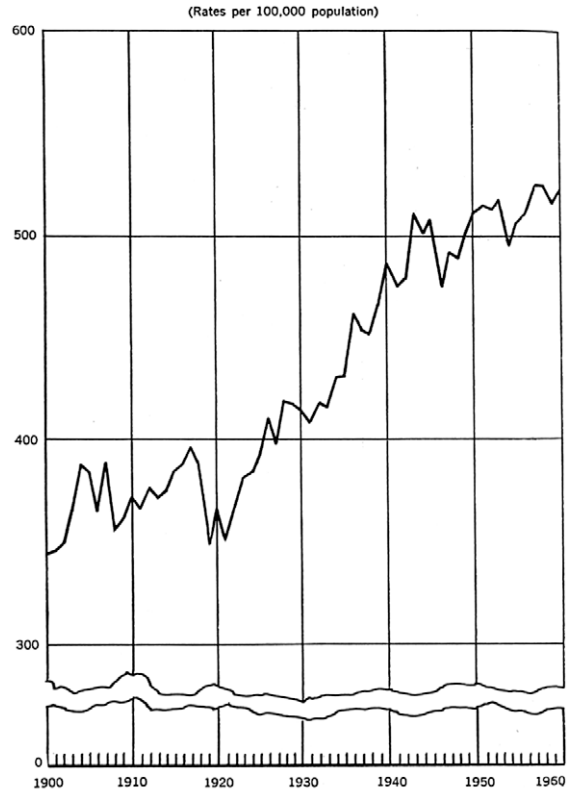

Fig. 3. Death rates for major cardiovascular renal diseases: death registration states, 1900–32, and United States, 1933–60.

electric service. In 1940 urban and rural residence information was not available for individual cancers as it was in 1930, but death rates for each cancer were available by state. They were used to calculate correlations between electric service by state and respiratory cancer, breast cancer and leukemia mortality.

All causes of death

There was no correlation between residential electrification and total death rate for urban areas, but there was a significant

correlation for rural areas ($r = 0.659$, $p = <0.0001$). Fig. 5 shows the 1940 resident white death rates for urban and rural areas of states having greater than 96% of residences electrified and states having less than 50% of residences electrified. In the highly electrified states, urban and rural death rates were similar, but in low electrification states, the urban death rates were systematically higher than the rural death rates. The urban death rates were similar in both high and low electrification states.

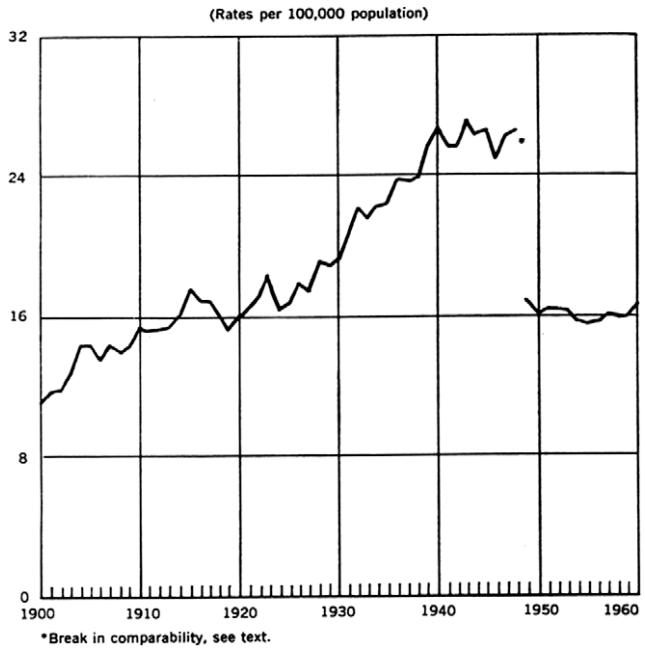

Fig. 4. Death rates for diabetes mellitus: death registration states, 1900–32, and United States, 1933–60.

All malignant neoplasms

In 1940, the urban total cancer rate was 49.2% higher than the rural rate. Both urban and rural cancer deaths rates were significantly correlated with residential electrification. Fig. 6 shows the 1940 resident white total cancer rates for urban and rural areas of states having greater than 96% of residences electrified and states having less than 50% of residences electrified. Four of the five high electrification states had similar urban and rural total cancer rates, while all the low electrification states had urban rates about twice as high as rural rates. Both urban and rural total cancer rates were lower in low electrification states than in high electrification states. Fig. 7 shows the time trend of the total cancer rate between 1920 and 1960 for Massachusetts (1940 electrification rate = 97.6%) and Louisiana (1940 electrification rate = 48.9%). The Massachusetts cancer rate was about twice that of Louisiana between 1920 and 1945. The Massachusetts rate leveled off in 1945, but the Louisiana rate increased steadily between 1920 and 1960. A declining urban–rural gradient for cancer is still evident in 1980–1990 US cancer incidence data [13]. Swedish investigators [14] have reported increasing cancer mortality and incidence time trend breaks in the latter half of the 20th century.

Table 3
1940 US white resident crude death rates per 100,000 by urban/rural residence.

Cause of death	ICD No.[a]	Urban rate	Rural rate	(%) Urban excess
All	1-200	1124.1	929.5	20.9
All cancers	47-55	145.8	97.7	49.2
Coronary disease	94	92.4	69.1	33.7
Other diseases of heart	90b,91,92a,d,e 93a,b,d,e 95a,c	217.0	162.8	33.3
Diabetes	61	33.2	20.0	66.0
Suicide	163-164	17.1	13.2	29.5
Motor vehicle accidents	170	26.6	26.3	1.1

[a] 1938 Revision International classification of disease.

Table 4
Correlation coefficients (r) 1940 crude US death rates by state by electrification for white resident deaths.

Cause	ICD No.[A]	Residence	r	r^2	p One tailed	Slope	Y intercept
All causes	1-200	Urban	0.083	0.007	0.285	0.007	11.114
		Rural	0.659	0.434	<0.0001	0.070	4.185
All cancers	45-55	Urban	0.667	0.445	<0.0001	0.883	75.970
		Rural	0.758	0.575	<0.0001	1.502	−10.040
Respiratory cancer[B]	47	State	0.611	0.374	<0.0001	0.071	1.020
Breast cancer female	50	State	0.794	0.630	<0.0001	0.170	−1.506
Diabetes	61	Urban	0.666	0.444	<0.0001	0.278	8.168
		Rural	0.693	0.480	<0.0001	0.366	−6.184
Leukemia[B]	72a	State	0.375	0.140	0.0042	0.021	1.980
Coronary artery	94	Urban	0.400	0.160	0.0024	0.494	61.570
Disease		Rural	0.781	0.610	<0.0001	1.252	25.319
Other diseases of the heart	90b, 91	Urban	0.449	0.202	0.0006	1.236	100.35
	92a,d,e 93a,b,d,e 95a,c	Rural	0.799	0.639	0.0001	2.887	−48.989
Suicide	163-4	Urban	0.077	0.006	0.2993	0.028	16.235
		Rural	0.729	0.532	<0.0001	0.181	0.299
Motor vehicle	170	Urban	−0.254	0.064	0.0408	−0.171	44.572
Accidents		Rural	0.451	0.203	0.0006	0.195	12.230

[A] International classification of diseases 1938 revision.
[B] Age adjusted death rate both sexes.

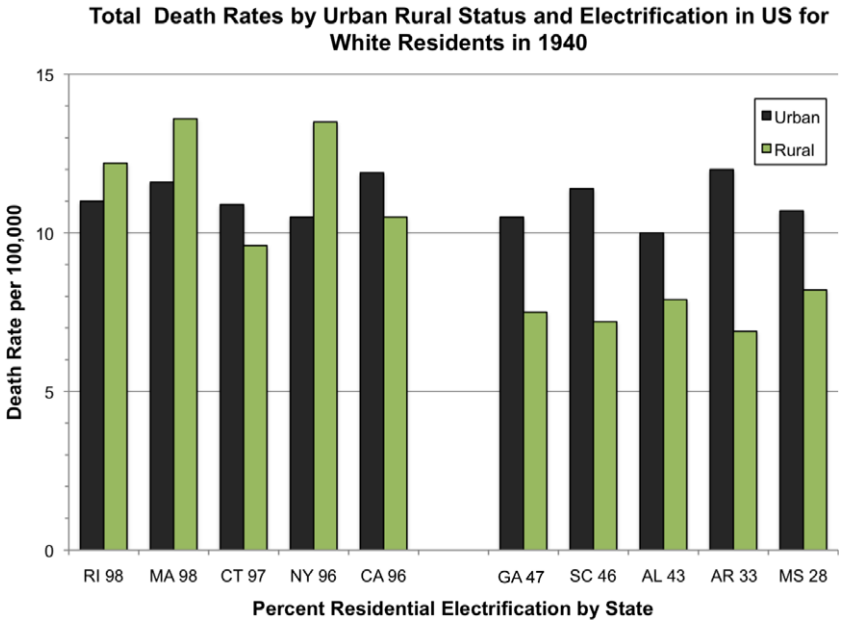

Fig. 5. All causes death rates by urban rural status and electrification in the US for white residents in 1940.

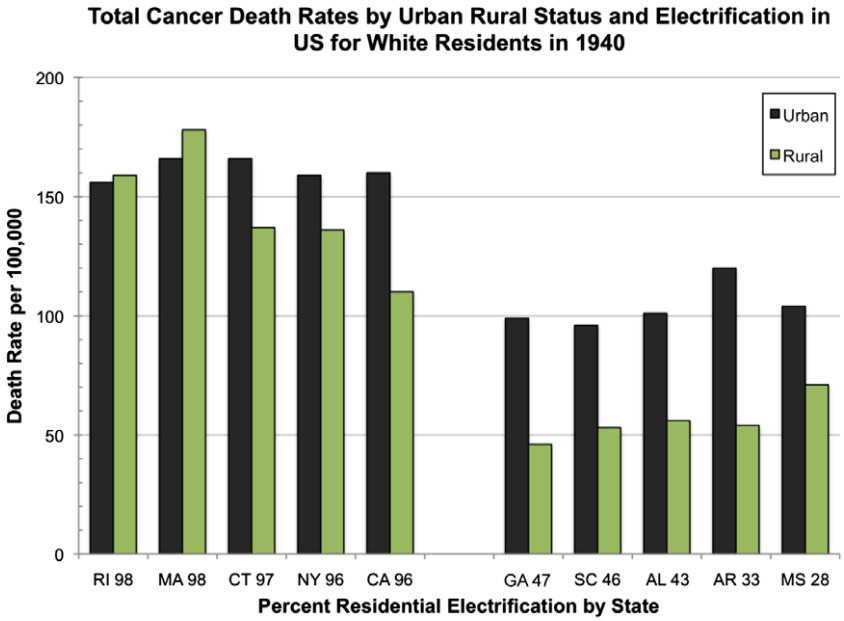

Fig. 6. Total cancer death rates by urban rural status and electrification in the US for white residents in 1940.

Respiratory cancer

No urban rural information was available for respiratory cancer, but the correlation between residential electrification and state death rates was $r = 0.611$; $p = <0.0001$. This cancer is etiologically strongly related to cigarette smoking, so the correlation with electrification is surprising. A large electrical utility worker cohort study found a high respiratory cancer incidence related to high frequency EMF transient exposure independent of cigarette smoking with a significant dose–response relationship [15].

Breast cancer

Although urban/rural information was not available for breast cancer, the 1940 state breast cancer death rates have a correlation of $r = 0.794$; $p = <0.0001$ with residential electrification. Fig. 8 shows the typical time trend of breast cancer death rates for a state with a high level of electrification (96%) and one with a low level of electrification (<50) in 1940. The California breast cancer death rate increased from 1920 to 1940, and then gradually decreased until 1960. The Tennessee breast cancer death rate is less than half of the California rate in 1920 and continues a steady increase until 1960.

Diabetes

This cause has a 66% urban excess. In spite of this, the correlation coefficients for urban and rural areas are similar at $r = 0.66$; $p = <0.0001$. There is some animal and human evidence that EMFs can effect insulin production and blood glucose levels [16]. Fig. 9

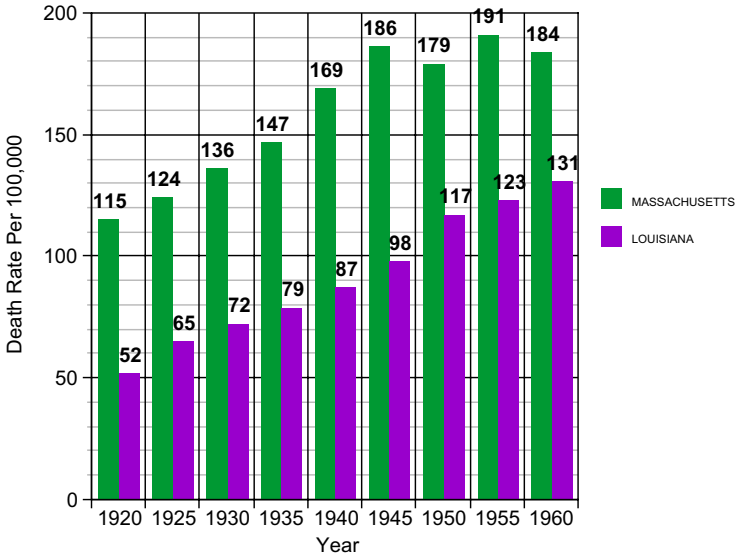

Fig. 7. US white resident total cancer death rates for Massachusetts (97.6% elect.) and Louisiana (48.9% elect.) by year.

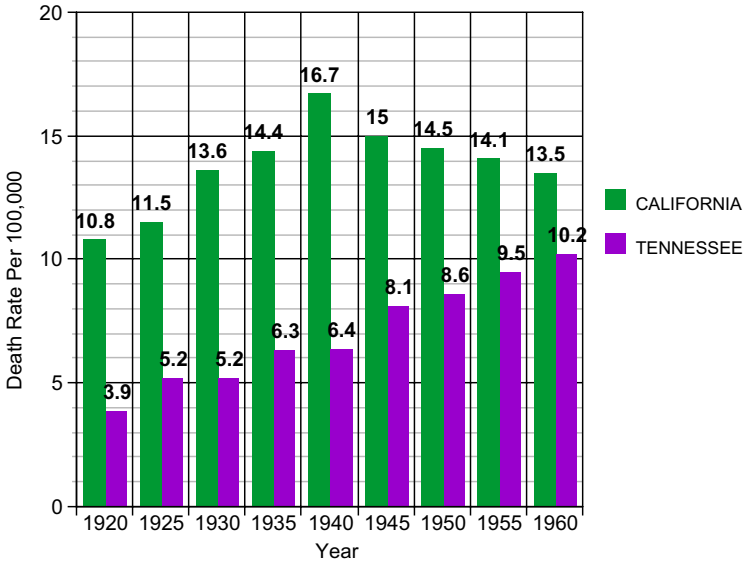

Fig. 8. US white resident breast cancer death rates for California (96% elect.) and Tennessee (50% elect.) by year.

shows that in states with low levels of electrification in 1940, the urban diabetes death rates are consistently higher than the rural rates, but are always lower than the urban and rural rates in the high electrification states.

Leukemia

Since the childhood leukemia age peak is strongly associated with residential electrification, it was interesting that the all leukemia death rate correlation was $r = 0.375$; $p = 0.0042$. Most of these deaths are in adults and are of different types of leukemia. A study of amateur radio operators showed a selective excess only of acute myelogenous leukemia [17].

Coronary artery disease and other heart disease

These two cause groups had the same percentage urban excess (33%), and very similar patterns of urban and rural correlation coefficients with residential electrification. The urban correlations were about $r = 0.4$ and rural deaths had correlations of 0.78 and 0.79, respectively. Fig. 10 shows the 1940 resident white coronary artery disease death rates for urban and rural areas of states having greater than 96% of residences electrified and states having less than 50% of residences electrified. Four of the five high electrification states had similar urban and rural total cancer rates, while all the low electrification states had urban rates about twice as high as rural rates. Urban and rural coronary artery death rates were lower in low electrification states than in high electrification states.

Suicide

The urban suicide death rate is about 30% higher than the rural rate. The urban suicide rate is not correlated with residential electrification ($r = 0.077$; $p = 0.299$), but the rural death rate is correlated with 1940 state residential electrification levels ($r = 0.729$; $p = <0.0001$). Fig. 11 shows the 1940 resident white suicide for

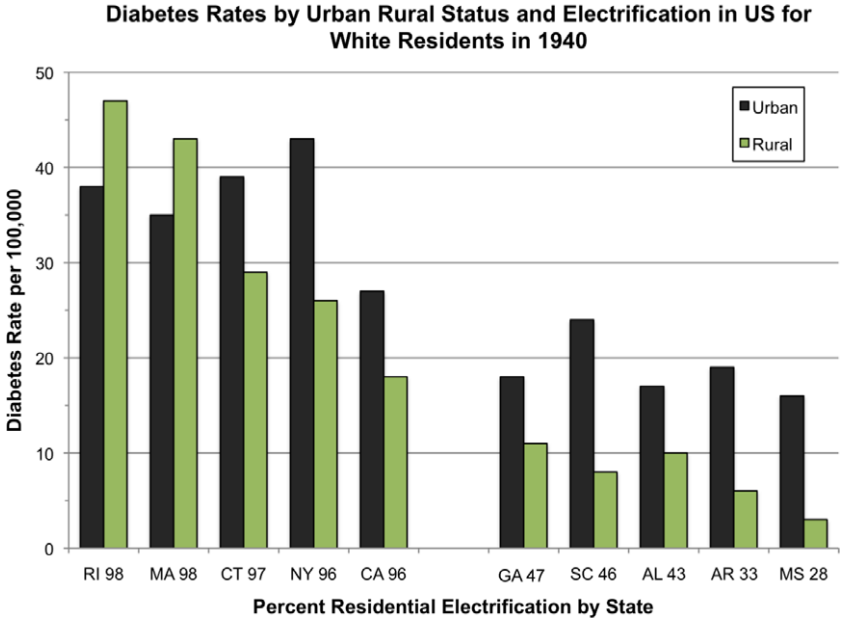

Fig. 9. Total diabetes rates by urban rural status and electrification in the US for white residents in 1940.

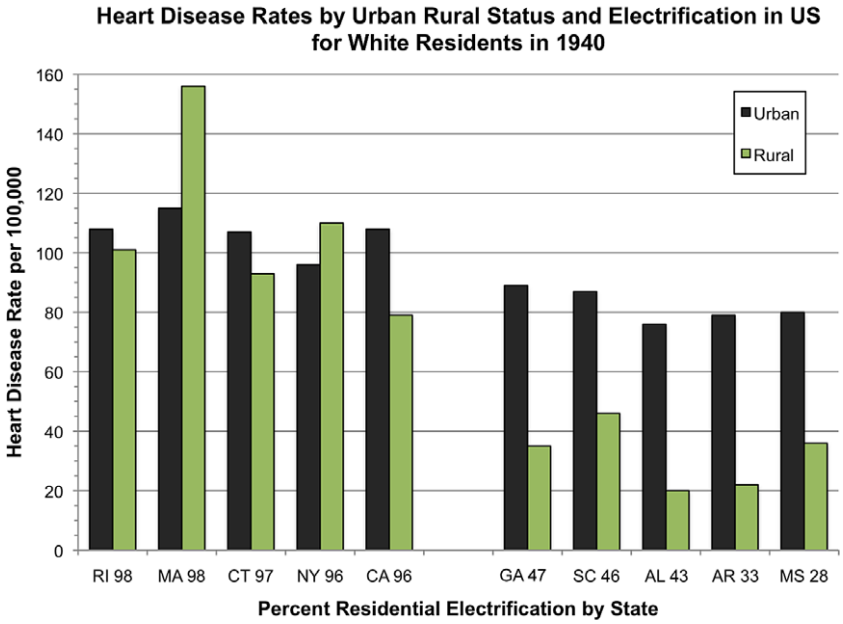

Fig. 10. Total heart disease rates by urban rural status and electrification in the US for white residents in 1940.

urban and rural areas of states having greater than 96% of residences electrified and states having less than 50% of residences electrified. In four of five high electrification states, rural suicide rates are higher than the urban rates. In all of the low electrification states, the urban rate is higher. The rural rates in the high electrification states are higher than the rural rates in the low electrification states. Fig. 12 shows X Y scatter plots for urban and rural suicide by electrification for 48 states. Suicide has been associated with both residential [18] and occupational [19] EMF exposure. Suicide is probably the visible peak of the clinical depression iceberg.

Motor vehicle accidents

Although the mortality rates are similar in urban and rural areas, the correlations with residential electrification levels are different. There is a slight negative correlation ($r = -0.254$) in urban areas and a positive correlation ($r = 0.451$) in rural areas. Since motor vehicle fatality is related to access to a vehicle and to speed. It may be that in the larger cities it was difficult to go fast enough for a fatal accident, and in rural areas especially on farms, a farmer who could afford electrification could also afford a car.

Discussion

When Edison and Tesla opened the Pandora's box of electrification in the 1880s, the US vital registration system was primitive at best, and infectious disease death rates were falling rapidly. City residents had higher mortality rates and shorter life expectancy than rural residents [8]. Rural white males in 1900 had an expectation of life at birth of over 10 years longer than urban residents.

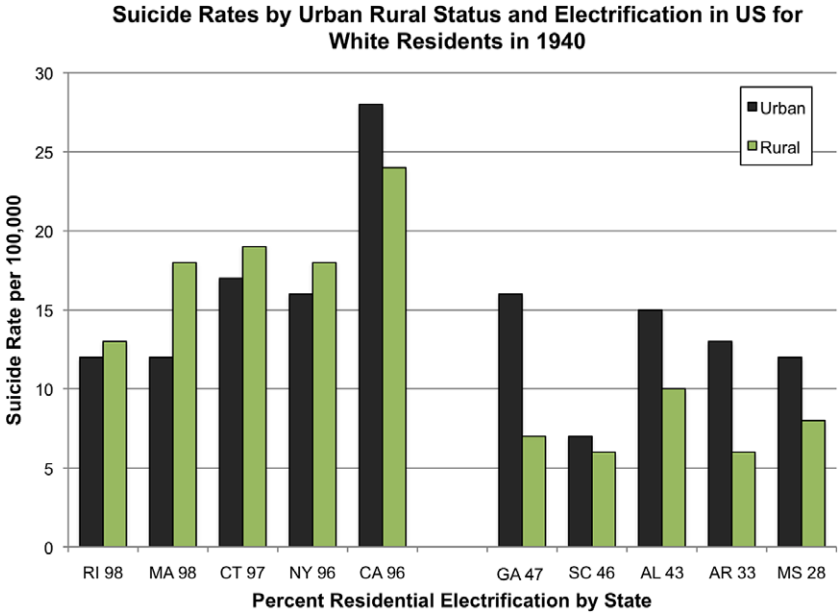

Fig. 11. Total suicide death rates by urban rural status and electrification in the US for white residents in 1940.

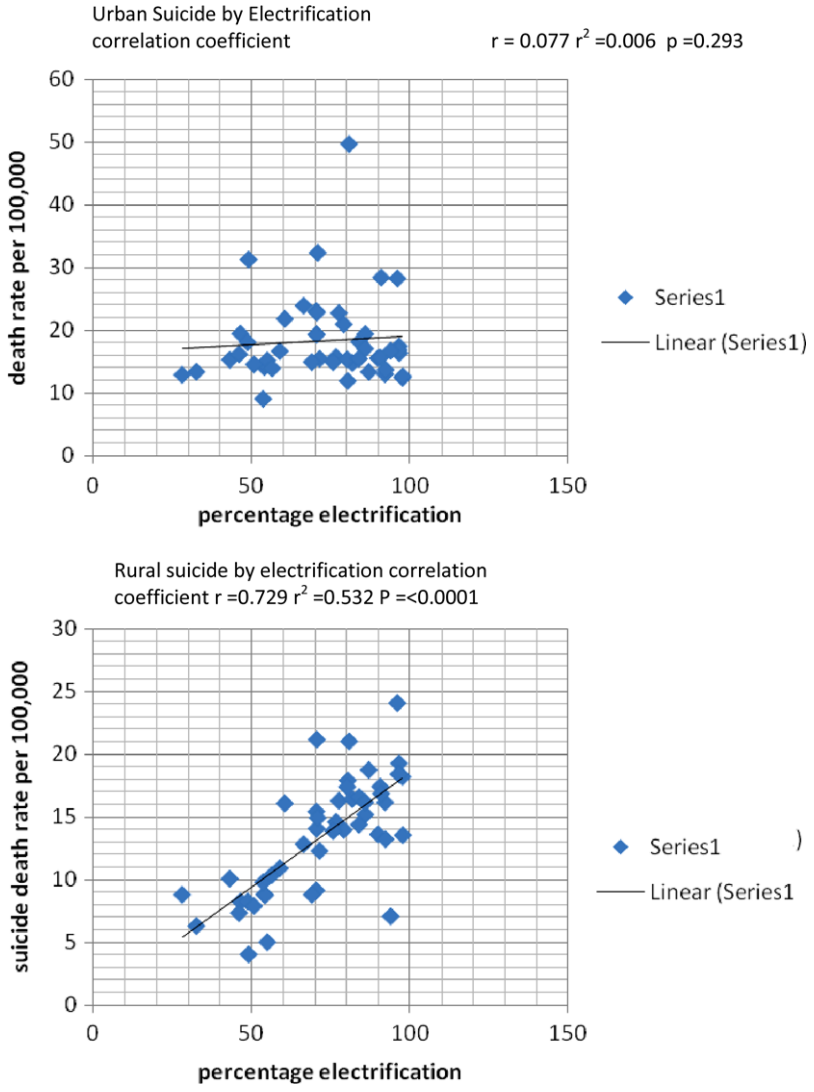

Fig. 12. 1940 US white resident urban rural suicide death rates by state and electrification.

Although the authors of the 1930 US vital statistics report noted a 58.2% cancer mortality excess in urban areas, it raised no red flags. The census bureau residential electrification data was obviously not linked to the mortality data. Epidemiologists in that era were still concerned with the communicable diseases.

Court Brown and Doll reported [20] the appearance of the childhood leukemia age peak in 1961, forty years after the US vital statistics mortality data on which it was based was available. I reported a cluster of childhood leukemia [21] a decade after it occurred, only because I looked for it. Real time or periodic analysis of national or regional vital statistics data is still only rarely done in the US.

The real surprise in this data set is that cardiovascular disease, diabetes and suicide, as well as cancer seem to be strongly related to level of residential electrification. A community-based epidemiologic study of urban rural differences in coronary heart disease and its risk factors was carried out in the mid 1980s in New Delhi, India and in a rural area 50 km away [22]. The prevalence of coronary heart disease was three times higher in the urban residents, despite the fact that the rural residents smoked more and had higher total caloric and saturated fat intakes. Most cardiovascular disease risk factors were two to three times more common in the urban residents. Rural electrification projects are still being carried out in parts of the rural area which was studied.

It seems unbelievable that mortality differences of this magnitude could go unexplained for over 70 years after they were first reported and 40 years after they were noticed. I think that in the early part of the 20th century nobody was looking for answers. By the time EMF epidemiology got started in 1979 the entire population was exposed to EMFs. Cohort studies were therefore using EMF-exposed population statistics to compute expected values, and case-control studies were comparing more exposed cases to less exposed controls. The mortality from lung cancer in two pack a day smokers is over 20 times that of non-smokers but only three times that of one pack a day smokers. After 1956, the EMF equivalent of a non-smoker ceased to exist in the US. An exception to this is the Amish who live without electricity. Like rural US residents in the 1940s, Amish males in the 1970s had very low cancer and cardiovascular disease mortality rates [23].

If this hypothesis and findings outlined here are even partially true, the explosive recent increase in radiofrequency radiation, and high frequency voltage transients sources, especially in urban areas from cell phones and towers, terrestrial antennas, wi-fi and wi-max systems, broadband internet over power lines, and personal electronic equipment, suggests that like the 20th century EMF epidemic, we may already have a 21st century epidemic of morbidity and mortality underway caused by electromagnetic fields. The good news is that many of these diseases may be preventable by environmental manipulation, if society chooses to.

Conflicts of interest statement

None declared.

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Accordingly, the requirements of Executive Order 12898 do not apply to this rule.

Executive Order 12988, Civil Justice Reform

This rule meets applicable standards in sections 3(a) and 3(b)(2) of Executive Order 12988, ''Civil Justice Reform'' (61 FR 4729, Feb. 7, 1996), to minimize litigation, eliminate ambiguity, and reduce burden.

Executive Order 13175, Consultation and Coordination With Indian Tribal Governments

This rule does not have Tribal implications under Executive Order 13175, ''Consultation and Coordination with Indian Tribal Governments'' (65 FR 67249, Nov. 9, 2000), because it does not have a substantial direct effect on one or more Indian Tribes, on the relationship between the Federal Government and Indian Tribes, or on the distribution of power and responsibilities between the Federal Government and Indian Tribes.

National Environmental Policy Act

This rule makes administrative technical changes to FEMA's regulations to reflect changes in agency organization and authorities. It is not a major agency action, nor will it affect the quality of the environment. This final rule will not require the preparation of either an environmental assessment or an environmental impact statement as defined by the National Environmental Policy Act of 1969, Public Law 91–190, 83 Stat. 852 (January 1, 1970)(42 U.S.C. 4321 *et seq.*), as amended.

Congressional Review of Agency Rulemaking

FEMA has sent this final rule to the Congress and to the Government Accountability Office under the Congressional Review of Agency Rulemaking Act (Act), Public Law 104–121, 110 Stat. 873 (March 29, 1996)(5 U.S.C. 804). The rule in not a ''major rule'' within the meaning of that Act and will not result in an annual effect on the economy of $100,000,000 or more. Moreover, it will not result in a major increase in costs or prices for consumers, individual industries, Federal, State, or local government agencies, or geographic regions. FEMA does not expect that it will have ''significant adverse effects'' on competition, employment, investment, productivity, innovation, or on the ability of United States-based enterprises to compete with foreign-based enterprises.

List of Subjects in 44 CFR Part 62

Claims, Flood insurance, Reporting and recordkeeping requirements.

■ For the reasons stated in the preamble, FEMA amends 44 CFR chapter I as follows:

PART 62—SALE OF INSURANCE AND ADJUSTMENT OF CLAIMS

■ 1. The authority citation for part 62 continues to read as follows:

Authority: 42 U.S.C. 4001 *et seq.;* Reorganization Plan No. 3 of 1978, 43 FR 41943, 3 CFR, 1978 Comp., p. 329; E.O. 12127 of Mar. 31, 1979, 44 FR 19367, 3 CFR, 1979 Comp., p. 376.

■ 2. In § 62.20 revise the second sentence of paragraph (e)(1) to read as follows:

§ 62.20 Claims appeals.

* * * * *

(e) * * *

(1) * * * The appeal should be sent to: DHS/FEMA, Mitigation Directorate, Federal Insurance Administrator, 1800 South Bell Street, Arlington, VA 20598–MS3010;

* * * * *

Dated: October 26, 2009.

W. Craig Fugate,

Administrator, Federal Emergency Management Agency.

[FR Doc. E9–26191 Filed 10–29–09; 8:45 am]

BILLING CODE 9110–11–P

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Office of the Secretary

45 CFR Part 160

RIN 0991–AB55

HIPAA Administrative Simplification: Enforcement

AGENCY: Office of the Secretary, HHS.

ACTION: Interim final rule; request for comments

SUMMARY: The Secretary of the Department of Health and Human Services (HHS) adopts this interim final rule to conform the enforcement regulations promulgated under the Health Insurance Portability and Accountability Act of 1996 (HIPAA) to the effective statutory revisions made pursuant to the Health Information Technology for Economic and Clinical Health Act (the HITECH Act), which was enacted as part of the American Recovery and Reinvestment Act of 2009 (ARRA). More specifically, this interim final rule amends HIPAA's enforcement regulations, as they relate to the imposition of civil money penalties, to incorporate the HITECH Act's categories of violations, tiered ranges of civil money penalty amounts, and revised limitations on the Secretary's authority to impose civil money penalties for established violations of HIPAA's Administrative Simplification rules (HIPAA rules). This interim final rule does not make amendments with respect to those enforcement provisions of the HITECH Act that are not yet effective under the applicable statutory provisions. Such amendments will be subject to forthcoming rulemaking(s).

DATES: *Effective Date:* This interim final rule is effective November 30, 2009. *Comment Date:* Comments on this interim final rule will be considered if received at the appropriate address, as provided below, no later than December 29, 2009.

ADDRESSES: Please submit comments to any one of the addresses specified below:

- *Federal eRulemaking Portal:* You may submit electronic comments at *http://www.regulations.gov.*
- *Regular, Express, or Overnight Mail:* You may mail written comments to the following address only: U.S. Department of Health and Human Services, Office for Civil Rights, Attention: HIPAA Enforcement Rule IFR (RIN 0991–AB55), Hubert H. Humphrey Building, Room 509F, 200 Independence Avenue, SW., Washington, DC 20201.
- *Hand Delivery or Courier:* If you prefer, you may deliver (by hand or courier) your written comments to the following address only: Office for Civil Rights, Attention: HIPAA Enforcement Rule IFR (RIN 0991–AB55), Hubert H. Humphrey Building, Room 509F, 200 Independence Avenue, SW., Washington, DC 20201.

FOR FURTHER INFORMATION CONTACT: Andra Wicks, 202–205–2292.

SUPPLEMENTARY INFORMATION:

I. Public Participation

A. Instructions for Submission of Public Comments

Please follow these instructions when submitting public comments. Please use only one of these methods.

- *Federal eRulemaking Portal:* Follow the instructions for submitting electronic comments at *http://www.regulations.gov.* Attachments will be accepted in Microsoft Word, WordPerfect, or Excel format, though Microsoft Word format is preferred.
- *Regular, Express, or Overnight Mail:* Submit one original and two copies of mailed, written comments. Please allow

sufficient time for timely receipt of mailed comments, as delivery may be subject to delay due to security procedures.

• *Hand Delivery or Courier:* Submit one original and two copies if delivering written comments by hand or by courier. Because access to the interior of the Hubert H. Humphrey Building is not readily available to persons without federal government identification, commenters are encouraged to leave their comments in the mail drop slots located in the main lobby of the building.

B. Inspection of Public Comments

All comments received before the close of the comment period will be available for public inspection, including any personally identifiable or confidential business information contained within each comment. We will post all comments received before the close of the comment period at *http://www.regulations.gov*.

II. Background

This interim final rule amends the sections within 45 CFR part 160 that relate to the authority of the Secretary of the HHS (the Secretary) to impose civil money penalties on entities that violate the HIPAA rules adopted under subtitle F of title II of HIPAA. The interim final rule amends subpart D of part 160 to conform its language to the revisions that became effective on February 18, 2009, under section 1176 of the Social Security Act (the Act), 42 U.S.C. 1320d–5, which was revised pursuant to section 13410(d) of the HITECH Act, Public Law 111–5, 123 Stat. 115, and correspondingly amends the ''Statutory basis and purpose'' section in subpart A. HHS issues these amendments as an interim final rule with request for comments to immediately provide regulated entities with additional notice as to how the Secretary's civil money penalty authority has been strengthened by the HITECH Act and to explain HHS' implementation of such authority with respect to violations occurring on or after February 18, 2009. HHS also pursues this expedited rulemaking to avoid any public misunderstanding or undue delay with respect to implementing Congress' intent to strengthen enforcement of the HIPAA rules.

We set out below the statutory and regulatory background for this interim final rule and follow with a description of our approach to this rulemaking. We then discuss each section of the interim final rule, request comments from the public, and conclude with our analyses of impact and other issues considered under applicable law.

A. Statutory Background

HIPAA Prior to the HITECH ACT

Subtitle F of title II of HIPAA, entitled ''Administrative Simplification,'' was enacted in 1996, for the purpose of improving the Medicare program under title XVIII of the Act, the Medicaid program under title XIX of the Act, and the efficiency and effectiveness of the health care system by encouraging the development of a health information system through the establishment of standards and requirements for the electronic transmission of certain health information. 42 U.S.C. 1320d note. To this end, subtitle F directs the Secretary to adopt national standards (HIPAA standards) for certain information-related activities and to protect the privacy and security of such information.

Under section 1172(a) of the Act, 42 U.S.C. 1320d–1(a), the HIPAA provisions apply to the following persons:

(1) A health plan.

(2) A health care clearinghouse.

(3) A health care provider who transmits any health information in electronic form in connection with a transaction referred to in section 1173(a)(1).

Under sections 1176 and 1177 of the Act, 42 U.S.C. 1320d–5 and 6, these persons or organizations, collectively referred to as ''covered entities,'' may be subject to civil money penalties and criminal penalties for violations of the HIPAA rules. HHS enforces the civil money penalties under section 1176 of the Act, and the U.S. Department of Justice enforces the criminal penalties under section 1177 of the Act.

Prior to the HITECH Act, section 1176(a) of the Act, 42 U.S.C. 1320d–5(a), authorized the Secretary to impose a civil money penalty, as follows:

> (1) IN GENERAL. Except as provided in subsection (b), the Secretary shall impose on any person who violates a provision of this part [42 U.S.C. 1320d *et seq.*] a penalty of not more than $100 for each such violation, except that the total amount imposed on the person for all violations of an identical requirement or prohibition during a calendar year may not exceed $25,000.
>
> (2) PROCEDURES. The provisions of section 1128A [42 U.S.C. 1320a–7a] (other than subsections (a) and (b) and the second sentence of subsection (f)) shall apply to the imposition of a civil money penalty under this subsection in the same manner as such provisions apply to the imposition of a penalty under such section 1128A.

Prior to the HITECH Act, section 1176(b) of the Act, 42 U.S.C. 1320d–5(b), set out limitations on the Secretary's above referenced authority to impose civil money penalties. Such limitations included prohibitions on imposing civil money penalties for: (1) An act that ''constitutes an offense punishable under section 1177'' of the Act (the criminal penalty provisions), (2) violations ''if it is established to the satisfaction of the Secretary that the person liable for the penalty did not know, and by exercising reasonable diligence would not have known, that such person violated the provision,'' and (3) violations if the failure to comply was due ''to reasonable cause and not to willful neglect'' and was corrected during a 30-day time period or pursuant to an extension determined to be appropriate by the Secretary based on the nature and circumstances of the covered entity's failure to comply.

Section 13410(d) of the HITECH Act

The HITECH Act was incorporated into ARRA to promote the adoption and meaningful use of health information technology. Subtitle D of the HITECH Act, sections 13400–13424, addresses the privacy and security concerns associated with the electronic transmission of health information. It does so, in part, through several provisions that strengthen the civil and criminal enforcement of the HIPAA rules. Many of these enforcement provisions became effective as of February 18, 2009 and are the impetus of this rulemaking. Other enforcement provisions have yet to become effective under the HITECH Act and are therefore subject to future rulemaking.

Section 13410(d) of the HITECH Act became effective February 18, 2009, revising section 1176 of the Act, 42 U.S.C. 1320d–5, to strengthen enforcement of the HIPAA rules in several ways. As modified, section 1176(a) establishes categories of violations that reflect increasing levels of culpability, requires that a penalty determination be based on the nature and extent of the violation and the nature and extent of the harm resulting from the violation, and establishes tiers of increasing penalty amounts that establish, by reference, the range of the Secretary's authority to impose civil money penalties. The revised text of section 1176(a) that became effective February 18, 2009, pursuant to section 13410(d) of the HITECH Act is as follows:

> GENERAL PENALTY.
>
> (1) IN GENERAL. Except as provided in subsection (b), the Secretary shall impose on any person who violates a provision of this part—

(A) in the case of a violation of such provision in which it is established that the person did not know (and by exercising reasonable diligence would not have known) that such person violated such provision, a penalty for each such violation of an amount that is at least the amount described in paragraph (3)(A) but not to exceed the amount described in paragraph (3)(D);

(B) in the case of a violation of such provision in which it is established that the violation was due to reasonable cause and not to willful neglect, a penalty for each such violation of an amount that is at least the amount described in paragraph (3)(B) but not to exceed the amount described in paragraph (3)(D); and

(C) in the case of a violation of such provision in which it is established that the violation was due to willful neglect—

(i) if the violation is corrected as described in subsection (b)(3)(A),[1] a penalty in an amount that is at least the amount described in paragraph (3)(C) but not to exceed the amount described in paragraph (3)(D); and

(ii) if the violation is not corrected as described in such subsection, a penalty in an amount that is at least the amount described in paragraph (3)(D).

In determining the amount of a penalty under this section for a violation, the Secretary shall base such determination on the nature and extent of the violation and the nature and extent of the harm resulting from such violation.

(2) PROCEDURES. The provisions of section 1128A (other than subsections (a) and (b) and the second sentence of subsection (f)) shall apply to the imposition of a civil money penalty under this subsection in the same manner as such provisions apply to the imposition of a penalty under such section 1128A.

(3) Tiers of penalties described.—For purposes of paragraph (1), with respect to a violation by a person of a provision of this part—

(A) the amount described in this subparagraph is $100 for each such violation, except that the total amount imposed on the person for all such violations of an identical requirement or prohibition during a calendar year may not exceed $25,000;

(B) the amount described in this subparagraph is $1,000 for each such violation, except that the total amount imposed on the person for all such violations of an identical requirement or prohibition during a calendar year may not exceed $100,000;

(C) the amount described in this subparagraph is $10,000 for each such violation, except that the total amount imposed on the person for all such violations of an identical requirement or prohibition during a calendar year may not exceed $250,000; and

(D) the amount described in this subparagraph is $50,000 for each such violation, except that the total amount imposed on the person for all such violations of an identical requirement or prohibition during a calendar year may not exceed $1,500,000.

Section 13410(d) of the HITECH Act also revised section 1176(b) of the Act by: (1) Striking the affirmative defense for violations in which the covered entity did not know, or by reasonable diligence would not have known, of the violation (such violations are now punishable under the first tier of penalties); and (2) revising the subsection that provides an affirmative defense for a 30-day time period of correction to only require that the covered entity demonstrate the violation was not due to willful neglect (the statute previously also required a showing that the violation was due to reasonable cause). The revised statutory text of section 1176(b) that became effective February 18, 2009,[2] pursuant to section 13410(d) of the HITECH Act is as follows:

LIMITATIONS.

(1) OFFENSES OTHERWISE PUNISHABLE. No penalty may be imposed under subsection (a) and no damages obtained under subsection (d) with respect to an act if the act constitutes an offense punishable under section 1177.

(2) FAILURES DUE TO REASONABLE CAUSE.

(A) IN GENERAL. Except as provided in subparagraph (B) or subsection (a)(1)(C), no penalty may be imposed under subsection (a) and no damages obtained under subsection (d) if the failure to comply is corrected during the 30-day period beginning on the first date the person liable for the penalty knew, or by exercising reasonable diligence would have known, that the failure to comply occurred.

(B) EXTENSION OF PERIOD.—

(i) NO PENALTY.—With respect to the imposition of a penalty by the Secretary under subsection (a), the period referred to in subparagraph (A) may be extended as determined appropriate by the Secretary based on the nature and extent of the failure to comply.

(ii) ASSISTANCE.—If the Secretary determines that a person failed to comply because the person was unable to comply, the Secretary may provide technical assistance to the person during the period described in subparagraph (A). Such assistance shall be provided in any manner determined appropriate by the Secretary.

(3) REDUCTION.—In the case of a failure to comply which is due to reasonable cause and not to willful neglect, any penalty under subsection (a) and any damages under subsection (d) that is not entirely waived under paragraph (3)[3] may be waived to the extent that the payment of such penalty would be excessive relative to the compliance failure involved.

B. Regulatory Background

Section 1173 of the Act, 42 U.S.C. 1320d–2, and section 264 of HIPAA, require the Secretary to adopt a number of national standards to facilitate the exchange of certain health information and to protect the privacy and security of such information. The Secretary has adopted a number of national standards to that end, which include the following: Standards for Electronic Transactions and Code Sets (Transactions and Code Sets Rules); Standards for Privacy of Individually Identifiable Health Information (HIPAA Privacy Rule); Standard Unique Employer Identifier (EIN Rule); Security Standards (HIPAA Security Rule); and Standard Unique Health Identifier for Health Care Providers (NPI Rule). *See* 70 FR 20224, 20225–26 (April 18, 2005) for a more detailed description of the history of these HIPAA rules. Covered entities are required to comply with these HIPAA standards.

In addition, the Secretary promulgated rules that relate to compliance with, and enforcement of, the HIPAA rules, which are codified at 45 CFR part 160, subparts C, D, and E and collectively referred to as the Enforcement Rule. The Secretary first issued an interim final rule promulgating the procedural requirements for imposition of civil money penalties on violations of the privacy standards on April 17, 2003, Civil Money Penalties: Procedures for Investigations, Imposition of Penalties (68 FR 18896). The Secretary subsequently proposed a rule on April 18, 2005, HIPAA Administrative Simplification: Enforcement; Proposed Rule (70 FR 20224), proposing the amendment of 45 CFR part 160, subparts A (General Provisions), C (Compliance and Enforcement), and E (Procedures for Hearing), proposing a new subpart D (Imposition of Civil Money Penalties) that addressed the substantive issues related to the imposition of civil money penalties, and proposing that the above provisions be applied to all of the HIPAA rules, rather

[1] We note that, as amended, section 1176 no longer includes a subsection (b)(3)(A). We interpret this text as referencing the 30-day period in section 1176(b)(2)(A), which was designated as section 1176(b)(3)(A) prior to the HITECH Act's amendment. We request public comment on this interpretation, to the extent there is disagreement.

[2] Note that section 13410(a) of the HITECH Act further amends section 1176(b) of the Act with respect to penalties imposed on or after February 18, 2011. These changes are not reflected in the statutory text, as they have yet to become effective.

[3] We note that this reference to paragraph (3) creates a circular reference which appears to be an error. Section 13410(d) of the HITECH Act redesignated the prior paragraph (3) to paragraph (2), but did not include a conforming revision to this reference. Accordingly, we interpret this reference as being to paragraph (2) (i.e., the affirmative defense for violations that are not due to willful neglect and are timely corrected) and request public comment to the extent there is disagreement.

than only the privacy standards. The Secretary then adopted a final rule, HIPAA Administrative Simplification: Enforcement; Final Rule (71 FR 8390, February 16, 2006). The preambles of these rulemakings provide additional information that may be helpful to readers seeking a general understanding of HIPAA's compliance and enforcement scheme. Where, if at all, language in these prior preambles is contrary to language in this preamble or regulation text, the language herein applies.

Subpart D of the Enforcement Rule pertains to the imposition of civil money penalties under section 1176 of the Act and includes a number of provisions that apply to violations occurring before section 13410(d) of the HITECH Act's effective date of February 18, 2009, but that conflict with the statutory language as it has been revised with respect to violations occurring on or after February 18, 2009. Thus, the primary objectives of this interim final rule are to conform the Enforcement Rule provisions found in subpart D to the amended language in section 1176 of the Act, to provide covered entities with additional notice of the Secretary's revised statutory authority with respect to the imposition of civil money penalties, and to avoid any public misunderstanding or undue delay with respect to Congress' intent to strengthen enforcement of the HIPAA rules.

III. Approach to the Interim Final Rule

As stated previously, this interim final rule amends several provisions of the Enforcement Rule, subpart D, to conform its language regarding HHS' imposition of civil money penalties to section 1176 of the Act, which section 13410(d) of the HITECH Act revised as of February 18, 2009. Subtitle D of the HITECH Act, which specifically pertains to privacy, contains several other provisions crafted to strengthen enforcement, some but not all of which pertain to HHS' implementation of the Enforcement Rule. We recognize that additional amendments will become necessary as such provisions become effective, but we do not adopt amendments in this interim final rule pursuant to those other provisions of subtitle D which have not yet become statutorily effective and have not, as a result, yet operated to revise HHS' enforcement authority under section 1176 of the Act.

HHS has concluded that it has good cause, under 5 U.S.C. 553(b)(B), to waive the notice-and-comment requirements of the Administrative Procedure Act (APA) and to proceed with this interim final rule. We first note that section 13410(d) of the HITECH Act's amendment of section 1176 of the Act, 42, U.S.C. 1320d–5, became effective the day after the date of enactment and that many covered entities may be unaware they are currently subject to significantly greater penalties for violations of the HIPAA rules. In addition, section 13410(d) of the HITECH Act's amendments have caused a number of provisions of the Enforcement Rule to conflict with the amended statute, and the resulting inconsistency has led to public confusion, both as to the penalty amounts for violations of the HIPAA rules and as to what defenses remain in effect. Delaying the promulgation of these conforming amendments would also forestall HHS' timely implementation of the strengthened enforcement approach mandated by statute and would maintain the status quo with respect to the heightened privacy and security concerns associated with the electronic transmission of health information among health care entities.

Based on the above reasons, we believe that delaying amendment to the Enforcement Rule, through the exercise of notice-and-comment rulemaking prior to publication of a final rule, would be impracticable, unnecessary, or contrary to public policy. Accordingly, HHS has good cause under the APA, 5 U.S.C. 553(b)(B), to waive notice-and-comment rulemaking and to proceed directly with the issuance of a final rule. At the same time, HHS is interested in the public's input and requests public comments regarding the substance of these amendments.

While HIPAA generally requires certain consultations with industry as a predicate to the issuance of the HIPAA standards, this interim final rule does not adopt standards, as the term is defined and interpreted under subtitle F of title II of HIPAA. Therefore, the requirement for such industry consultations in section 1172(c) of the Act, 42 U.S.C. 1320d–1(c), does not apply. For the same reason, the timeframes for compliance with the HIPAA rules, as set forth in section 1175 of the Act, 42 U.S.C. 1320d–4, do not apply.

IV. Provisions in the Interim Final Rule

This interim final rule amends 45 CFR part 160, subpart D, which establishes rules relating to the imposition of civil money penalties, to conform several provisions to section 13410(d) of the HITECH Act's amendments to section 1176 of the Act, 42 U.S.C. 1320d–6, which became effective February 18, 2009. This interim final rule's amendments distinguish between violations occurring before February 18, 2009, and violations occurring on or after that date, with respect to the potential amount of the civil money penalty and the affirmative defenses available to covered entities. We discuss this interim final rule's amendments to the Enforcement Rule on a provision-by-provision basis below:

A. Subpart A—General Provisions

1. Section 160.101—Statutory Basis and Purpose

Section 160.101 is amended to add the statutory citation for section 13410(d) of the HITECH Act to the list of the statutes that the requirements of the subchapter are designed to implement.

B. Subpart D—Imposition of Civil Money Penalties

1. Section 160.401—Definitions

Section 160.401 is added and defines the terms of *reasonable cause, reasonable diligence* and *willful neglect,* using the same definitions currently found at § 160.410. As discussed below, we are removing these terms from § 160.410 as a conforming amendment. This reorganization of the definitions signals the application of these terms to the entirety of subpart D. We do not discuss the terms further, as we are amending their placement in the rule but not their substance. Readers who would like a better understanding of these terms are encouraged to consult prior preamble explanations at 70 FR 20224, 20237–9 (April 18, 2005) and 71 FR 8390, 8409–11 (February 16, 2006).

2. Section 160.404—Amount of Civil Money Penalties

Subsection 160.404(b) is amended to revise the range of potential civil money penalty amounts a covered entity will be subject to based on the HITECH Act's amendments of section 1176 of the Act, 42 U.S.C. 1320–5, which are currently in effect. As amended, § 160.404(b)(1) retains the range of penalty amounts enumerated prior to the statutory revision for those violations occurring before February 18, 2009. The current content of § 160.404(b)(2) is re-designated as § 160.404(b)(3). A new § 160.404(b)(2) is added which identifies the range of penalty amounts for violations occurring on or after February 18, 2009.

Section 160.404 currently implements a penalty scheme, as required by section 1176(a)(1) prior to the HITECH Act's revisions, which explicitly established the maximum penalty amount for each violation as ''not more than $100'' and

the maximum penalty amount ''for all violations of an identical requirement or prohibition during a calendar year'' as ''not to exceed $25,000.'' Subsection 160.404(b)(1) retains this penalty scheme for violations occurring before February 18, 2009, though its language is slightly modified to accommodate the parallel provisions for those violations that occur on or after February 18, 2009.

As modified, section 1176(a)(1) generally establishes a minimum penalty amount ''for each such violation'' by stating the penalty amount is to be ''at least'' the amount described in a specifically referenced tier and establishes a maximum penalty amount per violation by stating that each such violation is ''not to exceed the amount described in [section 1176(a)(3)(D)].'' [4] Each referenced penalty tier additionally provides a total penalty amount for all such violations of an identical requirement or prohibition during a calendar year. The HITECH Act's revised penalty scheme is similar to its predecessor with respect to its identification of a range of available civil money penalty amounts, a maximum penalty amount for violations of identical provisions during a calendar year, and generally with respect to the discretion it allows HHS in determining the appropriate penalty amount within the range prescribed.

The revised penalty scheme differs significantly from its predecessor by its establishment of several categories of violations that reflect increasing levels of culpability. The revised penalty scheme also differs significantly from its predecessor in its establishment of the range of available penalty amounts for each category of violation by reference to tiers of penalty amounts. Each tier specifies a minimum penalty amount that accompanies the increasing culpability associated with each category of violation and, for three of the four violation categories, defaults to ''the amount described in paragraph 3(D)'' as the outside limit.

For example, in the case of a violation where it is established that a covered entity did not know of the violation and would not have known through the exercise of reasonable diligence, section 13410(d) of the HITECH Act provides that the minimum penalty amount for each such violation is ''at least'' the amount described in paragraph (3)(A) [section 1176(a)(3)(A)] (i.e., $100) but is ''not to exceed'' the amount described in paragraph (3)(D) [section 1176(a)(3)(D)] (i.e., $50,000). Paragraphs 1176(a)(3)(A) and (D) each additionally provide that the total penalty amount for multiple violations of an identical requirement or prohibition during a calendar year is $25,000 and $1.5 million respectively.

HHS considered the conflicting statutory language that references two tiers of penalties ''for each violation,'' which each provide a penalty amount ''for all such violations'' of an identical requirement or prohibition in a calendar year. With the exception of violations due to willful neglect that are not timely corrected, this interim final rule adopts a range of penalty amounts between the minimum given in one tier and the maximum given in the second tier for each violation and adopts the amount of $1.5 million as the limit for all violations of an identical provision of the HIPAA rules. For violations due to willful neglect that are not timely corrected, this interim final rule adopts the penalty amount of $50,000 as the minimum for each violation and $1.5 million for all such violations of an identical requirement or prohibition. These regulatory amendments are consistent with the most logical reading of section 1176(a)(1) and (3). The amendments are also consistent with Congress' intent to strengthen enforcement, in part, by increasing the minimum penalty amounts available according to categories of violation, and with the clear discretion Congress has provided to impose a penalty amount up to the amount described in ''paragraph (3)(D).''

More specifically, HHS amends § 160.404(b)(2) to reflect each category of violation that will serve as the basis for a civil money penalty on or after February 18, 2009, as well as the respective range of penalty amounts available. The range of penalty amounts available for the first three categories of violations (i.e., where it is established the covered entity did not reasonably know of the violation, the violation was due to a reasonable cause, or the violation was due to willful neglect but timely corrected) is defined consistent with the controlling language of section 1176(a)(1)(A)–(C)(i), whereby the minimum penalty amount for each violation is set pursuant to the specific tier referenced by each category of violation, and the maximum penalty amount for each violation is capped at $50,000, the amount identified ''for such each violation'' in section 1176(a)(3)(D). For these categories of violations, the maximum penalty amount available for all such violations of an identical provision in a calendar year is consistently capped at $1.5 million, the other amount referenced in section 1176(a)(1) as that ''not to exceed'' and identified in section 1176(a)(3)(D) ''for all such violations of an identical requirement or prohibition during a calendar year.''

The penalty amounts available for the fourth level of culpability (i.e., where it is established the violation is due to willful neglect but not timely corrected) are also consistent with the controlling language of section 1176(a)(1)(C)(ii). Unlike the other levels of culpability at section 1176(a)(1)(A), (B) and (C)(i), section 1176(a)(1)(C)(ii) only provides in its reference to section 1176(a)(3)(D) a minimum penalty amount of $50,000 ''for each violation'' and a penalty cap of $1.5 million for multiple violations of an identical requirement or prohibition in a calendar year.

We highlight the penalty amounts in Table 1, below, to ensure that covered entities are fully aware of their potential liability:

TABLE 1—CATEGORIES OF VIOLATIONS AND RESPECTIVE PENALTY AMOUNTS AVAILABLE

Violation category—Section 1176(a)(1)	Each violation	All such violations of an identical provision in a calendar year
(A) Did Not Know	$100–$50,000	$1,500,000
(B) Reasonable Cause	1,000–50,000	1,500,000
(C)(i) Willful Neglect—Corrected	10,000–50,000	1,500,000
(C)(ii) Willful Neglect—Not Corrected	50,000	1,500,000

[4] Section 1176(a)(1) notably provides no maximum penalty amount, however, with respect to ''each such violation'' described in subparagraph (C)(ii) (for violations established as due to willful neglect and not timely corrected), although a cap is set by section 1176(a)(3)(D). This caveat is discussed further below.

We note that HHS will not impose the maximum penalty amount in all cases. Rather, HHS will determine penalty amounts as required by the statute at section 1176(a)(1) and the regulations at § 160.408. That is, penalty determinations will be based on the nature and extent of the violation, the nature and extent of the resulting harm, as well as the other factors set forth at § 160.408 (such as the covered entity's history of prior compliance or financial condition).

For counting violations that occur on or after February 18, 2009, HHS will continue to utilize the methodology discussed in prior preambles of the Enforcement Rule. See 70 FR 20224, 20233–35 (April 18, 2005) and 71 FR 8390, 8404–07 (February 16, 2006). For violations that began prior to February 18, 2009, and continue after that date, we will treat violations occurring before February 18, 2009, as subject to the penalties in effect prior to February 18, 2009 and violations occurring on or after February 18, 2009, as subject to the penalties in effect on or after February 18, 2009.

3. Section 160.410—Affirmative Defenses

As previously discussed, the terms *reasonable cause, reasonable diligence* and *willful neglect,* have been moved from § 160.410 to § 160.401 in order to apply more generally to all of subpart D. Accordingly, we have removed the current paragraph (a) from § 160.410 and redesignated paragraph (b) as paragraph (a).

We also amended § 160.410 to conform its provisions to the statutory language in section 1176(a)(3), as revised by section 13410(d) of the HITECH Act. Section 160.410(b) currently provides three affirmative defenses to the Secretary's authority to impose a civil money penalty, including the following:

(1) The violation is an act punishable under 42 U.S.C. 1320d–6;

(2) The covered entity establishes, to the satisfaction of the Secretary, that it did not have knowledge of the violation, determined in accordance with the federal common law of agency, and by exercising reasonable diligence, would not have known that the violation occurred; or

(3) The violation is—

(i) Due to reasonable cause and not willful neglect; and

(ii) Corrected during either:

(A) The 30-day period beginning on the date the covered entity liable for the penalty knew, or by exercising reasonable diligence would have known, that the violation occurred; or

(B) Such additional period as the Secretary determines to be appropriate based on the nature and extent of the failure to comply

Section 13410(d) of the HITECH Act revises section 1176(b) of the Act to: (a) Strike the limitation on imposing a penalty when a covered entity establishes, to the Secretary's satisfaction, that it ''did not know, and by exercising reasonable diligence would not have known'' of the violation; and (b) extend the affirmative defense for violations that are timely corrected, which was previously limited to violations due to ''reasonable cause and not to willful neglect,'' to all violations not due to willful neglect.

The amendments conform § 160.410 to distinguish the limitations placed on the Secretary's authority to impose civil money penalties before and after the HITECH Act by: (a) Revising the current provisions, which have been redesignated as paragraph (a), to apply only ''[f]or violations occurring prior to February 18, 2009''; and (b) adding a new paragraph (b) that applies ''[f]or violations occurring on or after February 18, 2009.'' The amendments also conform § 160.410 to the amended section 1176(b) by removing a covered entity's lack of knowledge as an affirmative defense for violations occurring on or after February 18, 2009. As a result, a covered entity that did not know and reasonably should not have known of such violations, will not have this affirmative defense available, unless it also corrects the violation during the 30-day time period beginning on the first date of such knowledge or during the period determined appropriate by the Secretary based on the nature and extent of the failure to comply. The amendments likewise revise the affirmative defenses available for violations occurring on or after February 18, 2009 to conform to the amended statute by removing any specific reference to ''reasonable cause'' while retaining more generalized language applicable to all violations ''not due to willful neglect.'' Notwithstanding these revisions, the Secretary may continue to use discretion in providing technical assistance, obtaining corrective action, and resolving possible noncompliance by informal means where the possible noncompliance is due to reasonable cause or in the event a person did not reasonably know that the violation occurred.

We note that the amendments made to § 160.410 do not alter the beginning of the 30-day cure period. Section 1176(b)(2)(A) of the Act continues to provide that the 30-day cure period begins ''on the first date the person liable for the penalty knew, or by exercising reasonable diligence would have known, that the failure to comply occurred.'' As prior preambles to the Enforcement Rule explain, the statute, ''on its face suggests that the knowledge involved must be knowledge that a 'violation' has occurred, not just knowledge of the facts constituting the violation. * * * [HHS], thus, interpret[s] this knowledge requirement to mean that the covered entity must have knowledge that a violation has occurred, not just knowledge of the facts underlying the violation.'' However, the ''reasonable diligence'' requirement makes the affirmative defense unavailable, in the event a covered entity's ''lack of knowledge'' resulted from its failure to inform itself about its compliance obligations or to investigate received complaints or other information indicating likely noncompliance. See 70 FR 20224, 20237–8 (April 18, 2005) and 71 FR 8390, 8410 (February 16, 2006). Thus, HHS expects its determination of the beginning of the cure period will be based on evidence gathered during its investigation of when a covered entity had actual or constructive knowledge of a violation.

We also note that the amendments made to § 160.410 do not alter affirmative defenses with respect to violations due to willful neglect. Section 1176(b)(2)(A) still operates to exclude violations due to willful neglect from those that, if timely corrected, would be exempt from the imposition of a civil money penalty. Violations due to willful neglect are therefore not eligible for extension, nor will their timely correction be an affirmative defense. Timely correction will, however, determine which tier of penalty amounts will be applicable to violations due to willful neglect.

Thus, for example, referring to ''Table 1. Categories of Violations and Respective Penalty Amounts Available,'' which appears in the discussion about § 160.404, a covered entity's timely correction would bar the Secretary's imposition of the penalty amounts identified in columns two and three, if the covered entity did not reasonably know of the violation or if the violation was due to reasonable cause. In contrast, a covered entity's timely correction of a violation due to willful neglect would not be an affirmative defense that bars the Secretary's imposition of a penalty amount identified in columns two and three of the table.

To determine the appropriate penalty tier for a violation due to willful neglect, HHS will calculate the 30-day cure period in the same manner as that described above for the affirmative defense of timely correction of a violation not due to willful neglect. Our determination of when a covered entity

first had actual or constructive knowledge of a violation due to willful neglect for the purpose of calculating whether it was timely corrected will be based on evidence gathered during our investigation and will thus necessarily be made on a case-by-case basis. The minimum penalty amount under the HITECH Act for a violation due to willful neglect that is corrected during the 30-day cure period is significantly less than the minimum penalty amount for a violation due to willful neglect that is not timely corrected. In recognition of the HITECH Act's enhanced penalties and its application of a 30-day cure period to a determination of the appropriate penalty tier for a violation due to willful neglect, we request public comment on whether there are alternative approaches to calculating the beginning of the 30-day cure period for this purpose.

This interim final rule does not amend § 160.410 with respect to the affirmative defense pertaining to criminal violations, punishable under 42 U.S.C. 1320d–6, since the relevant statutory revision will not become effective until February 18, 2011. The interim final rule also does not amend § 160.410 with respect to the enforcement authority of state attorneys general to bring civil actions under the HIPAA rules in certain circumstances, as set forth in § 13410(e) of the HITECH Act, since such authority operates pursuant to the statute and does not require HHS rulemaking.

4. Section 160.412—Waiver

Section 160.412 is amended to reflect the revisions to § 160.410. Regardless of whether violations occur before, on, or after February 18, 2009, the Secretary may continue to provide a waiver for violations due to reasonable cause and not willful neglect that are not timely corrected (pursuant to the correction period in revised § 160.410(a)(3)(ii) or (b)(2)(ii), as applicable).

5. Section 160.420—Notice of Proposed Determination

Section 160.420(a)(4) is amended to add the requirement that, in addition to the proposed penalty amount, HHS identify the applicable violation category in § 160.404 upon which the proposed penalty amount is based. While such additional language is not required by statute, HHS makes this amendment to provide covered entities with additional notice and information to benefit their understanding of the violation findings in the Notice of Proposed Determination.

V. Request for Comments

HHS seeks public comments on any aspect of this interim final rule. In particular, we invite public comments with respect to the following: (1) The calculation of when the 30-day cure period begins for the purpose of determining the appropriate penalty tier for a violation due to willful neglect as discussed above in the penultimate paragraph of Section IV.B.3; (2) whether moving the definitions of ''reasonable cause,'' ''reasonable diligence,'' and ''willful neglect'' to the new § 160.401 leads to any unintended consequences; and (3) the HHS interpretations of Congressional intent referenced in footnotes 1 and 3.

VI. Impact Statement and Other Required Analyses

A. Paperwork Reduction Act

We reviewed this interim final rule to determine whether it invokes issues that would relate to the Paperwork Reduction Act (PRA). While the PRA applies to agencies and collections of information conducted or sponsored by those agencies, 5 CFR 1320.4(a) exempts collections of information that occur ''during the conduct of * * * an administrative action, investigation, or audit involving an agency against specific individuals or entities,'' except for investigations or audits ''undertaken with reference to a category of individuals entities or entities such as a class of licensees or an entire industry.'' The rules adopted below come squarely within this exemption, as they deal entirely with administrative investigations and actions against specific individuals or entities. Therefore, we have determined that the PRA does not apply to this interim final rule and need not be reviewed by the Office of Management and Budget under the authority of the PRA.

B. Executive Order 12866

We also reviewed the impacts of this interim final rule as required by Executive Order 12866 (58 FR 51735, October 4, 1993), which directs agencies to assess all costs and benefits of available regulatory alternatives and, if regulation is necessary, to select regulatory approaches that maximize net benefits (including potential economic, environmental, public health and safety effects, distributive impacts, and equity). Executive Order 12866 requires that a regulatory impact analysis (RIA) be prepared for ''significant regulatory actions,'' which it defines at section 3(f), to include rules that may:

(1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or state, local, or tribal government or communities;

(2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;

(3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or

(4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

Executive Order 12866 requires a full economic impact analysis only for ''economically significant'' rules under section 3(f)(1). The amendments contained within this interim final rule only conform the regulatory language of subpart D to that of the Act's revised statutory basis, in a way that differentiates the categories of violations for which a civil money penalty may be imposed, sets forth ranges of increasing penalty amounts with respect to each category of violation, and narrows the grounds for the affirmative defenses available.

HHS has concluded, for reasons similar, and in addition to, those discussed in the preambles to the proposed and final Enforcement Rules at 70 FR 20224, 20248–49 (April 18, 2005) and 71 FR 8390, 8424 (February 16, 2006), that the impact of this interim final rule is not such that it would reach the ''economically significant'' threshold under section 3(f)(1) of the Executive Order. As was the case at the time of earlier promulgations, the costs covered entities may incur with respect to their compliance with the Enforcement Rule, itself, should be low in most cases. That is, covered entities that comply with the HIPAA rules voluntarily, as is expected, should not incur any additional, significant costs with respect to the imposition of a civil money penalty. HHS' experience enforcing the HIPAA rules also suggests that violations should not collectively amount to an annual effect on the economy of $100 million or more, even in light of the higher penalty amounts prescribed by statute.

Further, HHS does not expect the imposition of civil money penalties pursuant to these amendments to ''adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or state, local, or tribal government or communities.'' To the contrary, HHS maintains that the benefits brought by

the HIPAA provisions and their strengthened enforcement under this interim final rule will far outweigh the potential costs. We believe the added penalties will encourage covered entities to take steps necessary to comply and thus not be liable for violations. In addition, we believe the conforming amendments made with respect to the affirmative defenses available will encourage covered entities to quickly and voluntarily correct acts or omissions that might otherwise be established as violations of the HIPAA rules. Greater vigilance in protecting privacy may also encourage public trust in the industry's use of health information technology. For these reasons, among others, a detailed cost-benefit assessment of the interim final rule is not required.

C. Other Analyses

We also examined the impacts of the interim final rule as required by the Regulatory Flexibility Act (RFA), section 1102(b) of the Act, the Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4), the Small Business Regulatory Enforcement and Fairness Act, 5 U.S.C. 801 *et seq.,* and Executive Order 13132.

The RFA requires agencies to determine whether a rule will have a significant economic impact on a substantial number of small entities. For purposes of the RFA, small entities include small businesses, nonprofit organizations, and government jurisdictions. The standard size of a ''small'' health care entity ranges from $7 million to $34.5 million in revenues in any one year. HHS assumes that the majority of covered entities to which this interim final rule is applicable are likely to be deemed small businesses based on the size standards of the Small Business Administration. As is discussed above, HHS expects that a covered entity's voluntary compliance and timely correction will not result in any significant economic impact, and that only a small percentage of violations occurring on or after February 18, 2009, will necessitate investigation and the imposition of a civil money penalty due to willful neglect. As discussed in prior enforcement rulemakings, (70 FR 20224, 20249 (April 18, 2005) and 71 FR 8390, 8424 (February 16, 2006)), the absence of evidence that small entities have a higher rate of noncompliance than larger entities provides additional support for the Secretary's certification that this rule will not have a significant economic impact on a substantial number of small entities.

Section 1102(b) of the Act requires agencies to prepare a regulatory impact analysis if a rule may have a significant impact on the operations of a substantial number of small rural hospitals. This analysis must conform to the provisions of section 603 (proposed documents)/ 604 (final documents) of the RFA. A small rural hospital, for purposes of section 1102(b) of the Act, is defined as a hospital that is located outside of a Metropolitan Statistical Area and has fewer than 100 beds. For reasons described above, this interim final rule is not expected to have a significant impact on small rural hospitals any more than it is expected to negatively impact any ''small'' health care entity.

Section 202 of the Unfunded Mandates Reform Act of 1995, 2 U.S.C. 1531 *et seq.,* requires that agencies assess anticipated costs and benefits before issuing a rule that may result in an aggregate expenditure of $100 million in any one year, by State, local, or tribal governments, or by the private sector. The Small Business Regulatory Enforcement Act of 1996 (SBREFA), 5 U.S.C. 801 *et seq.,* also requires that rules that will have an impact on the economy of $100 million or more per annum be submitted for Congressional review. For the reasons discussed above, this interim final rule would not impose a burden large enough to require a statement under section 202 of the Unfunded Mandates Reform Act of 1995 or Congressional review under the SBREFA.

Executive Order 13132 establishes certain requirements that an agency must meet when it promulgates a rule that imposes substantial direct requirement costs on State and local governments, preempts State law, or otherwise has Federalism implications. As previously discussed, this interim final rule is not likely to have substantial economic effects. Any preemption of State law that could occur would be a function of the HIPAA statute and the underlying HIPAA rules and not these amendments to the Enforcement Rule, which principally establish the means by which the statutory civil money penalty provisions will be implemented. This interim final rule does not have ''substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government,'' nor does it have ''Federalism implications.'' It is therefore not subject to Executive Order 13132.

List of Subjects in 45 CFR Part 160

Administrative practice and procedure, Computer technology, Electronic transactions, Employer benefit plan, Health, Health care, Health facilities, Health insurance, Health records, Hospitals, Investigations, Medicaid, Medical research, Medicare, Penalties, Privacy, Reporting and recordkeeping requirements, Security.

■ For the reasons set forth in the preamble, the Department of Health and Human Services amends 45 CFR subtitle A, subchapter C, part 160, as set forth below.

PART 160—GENERAL ADMINISTRATIVE REQUIREMENTS

■ 1. The authority citation for part 160 is revised to read as follows:

Authority: 42 U.S.C. 1302(a), 42 U.S.C. 1320d–1320d–8, sec. 264 of Public Law 104–191, 110 Stat. 2033–2034 (42 U.S.C. 1320d–2 (note)), 5 U.S.C. 552; and secs.13400 and 13402, Public Law 111–5, 123 Stat. 258–263.

* * * * *

■ 2. Revise § 160.101 to read as follows:

§ 160.101 Statutory basis and purpose.

The requirements of this subchapter implement sections 1171 through 1179 of the Social Security Act (the Act), as added by section 262 of Public Law 104–191, section 264 of Public Law 104–191, section 13402 of Public Law 111–5, and section 13410(d) of Public Law 111–5.

■ 3. Add § 160.401 to subpart D to read as follows:

§ 160.401 Definitions.

As used in this subpart, the following terms have the following meanings:

Reasonable cause means circumstances that would make it unreasonable for the covered entity, despite the exercise of ordinary business care and prudence, to comply with the administrative simplification provision violated.

Reasonable diligence means the business care and prudence expected from a person seeking to satisfy a legal requirement under similar circumstances.

Willful neglect means conscious, intentional failure or reckless indifference to the obligation to comply with the administrative simplification provision violated.

■ 4. Revise paragraph (b) of § 160.404 to read as follows:

§ 160.404 Amount of a civil monetary penalty.

* * * * *

(b) The amount of a civil money penalty that may be imposed is subject to the following limitations:

(1) For violations occurring prior to February 18, 2009, the Secretary may not impose a civil money penalty—

(i) In the amount of more than $100 for each violation; or

(ii) In excess of $25,000 for identical violations during a calendar year (January 1 through the following December 31);

(2) For violations occurring on or after February 18, 2009, the Secretary may not impose a civil money penalty—

(i) For a violation in which it is established that the covered entity did not know and, by exercising reasonable diligence, would not have known that the covered entity violated such provision,

(A) In the amount of less than $100 or more than $50,000 for each violation; or

(B) In excess of $1,500,000 for identical violations during a calendar year (January 1 through the following December 31);

(ii) For a violation in which it is established that the violation was due to reasonable cause and not to willful neglect,

(A) In the amount of less than $1,000 or more than $50,000 for each violation; or

(B) In excess of $1,500,000 for identical violations during a calendar year (January 1 through the following December 31);

(iii) For a violation in which it is established that the violation was due to willful neglect and was corrected during the 30-day period beginning on the first date the covered entity liable for the penalty knew, or, by exercising reasonable diligence, would have known that the violation occurred,

(A) In the amount of less than $10,000 or more than $50,000 for each violation; or

(B) In excess of $1,500,000 for identical violations during a calendar year (January 1 through the following December 31);

(iv) For a violation in which it is established that the violation was due to willful neglect and was not corrected during the 30-day period beginning on the first date the covered entity liable for the penalty knew, or, by exercising reasonable diligence, would have known that the violation occurred,

(A) In the amount of less than $50,000 for each violation; or

(B) In excess of $1,500,000 for identical violations during a calendar year (January 1 through the following December 31).

(3) If a requirement or prohibition in one administrative simplification provision is repeated in a more general form in another administrative simplification provision in the same subpart, a civil money penalty may be imposed for a violation of only one of these administrative simplification provisions.

■ 5. Revise § 160.410 to read as follows:

§ 160.410 Affirmative defenses.

(a) For violations occurring prior to February 18, 2009, the Secretary may not impose a civil money penalty on a covered entity for a violation if the covered entity establishes that an affirmative defense exists with respect to the violations, including the following:

(1) The violation is an act punishable under 42 U.S.C. 1320d–6;

(2) The covered entity establishes, to the satisfaction of the Secretary, that it did not have knowledge of the violation, determined in accordance with the federal common law of agency, and, by exercising reasonable diligence, would not have known that the violation occurred; or

(3) The violation is—

(i) Due to reasonable cause and not willful neglect; and

(ii) Corrected during either:

(A) The 30-day period beginning on the first date the covered entity liable for the penalty knew, or by exercising reasonable diligence would have known, that the violation occurred; or

(B) Such additional period as the Secretary determines to be appropriate based on the nature and extent of the failure to comply.

(b) For violations occurring on or after February 18, 2009, the Secretary may not impose a civil money penalty on a covered entity for a violation if the covered entity establishes that an affirmative defense exists with respect to the violations, including the following:

(1) The violation is an act punishable under 42 U.S.C. 1320d–6; or

(2) The covered entity establishes to the satisfaction of the Secretary that the violation is—

(i) Not due to willful neglect; and

(ii) Corrected during either:

(A) The 30-day period beginning on the first date the covered entity liable for the penalty knew, or, by exercising reasonable diligence, would have known that the violation occurred; or

(B) Such additional period as the Secretary determines to be appropriate based on the nature and extent of the failure to comply.

■ 6. Revise § 160.412 to read as follows:

§ 160.412 Waiver.

For violations due to reasonable cause and not willful neglect that are not corrected within the period described in § 160.410(a)(3)(ii) or (b)(2)(ii), as applicable, the Secretary may waive the civil money penalty, in whole or in part, to the extent that the payment of the penalty would be excessive relative to the violation.

■ 7. Revise § 160.420(a)(4) to read as follows:

§ 160.420 Notice of Proposed Determination.

(a) * * *

(4) The amount of the proposed penalty and a reference to the subparagraph of § 160.404 upon which it is based.

* * * * *

Dated: August 11, 2009.

Kathleen Sebelius,

Secretary.

[FR Doc. E9–26203 Filed 10–29–09; 8:45 am]

BILLING CODE 4150–03–P

FEDERAL COMMUNICATIONS COMMISSION

47 CFR Part 73

[MB Docket Nos. 07–294; 06–121; 02–277; 04–228; MM Docket Nos. 01–235; 01–317; 00–244; FCC 09–92]

Promoting Diversification of Ownership in the Broadcasting Services

AGENCY: Federal Communications Commission.

ACTION: Final rule.

SUMMARY: This document reconsiders the requirement that licensees report certain nonattributable interests on FCC Form 323, Ownership Report for Commercial Broadcast Stations. Therefore, entities will not have to report these interests biennially on Form 323. The Commission reaffirms all other changes it made to the FCC Form 323 in the 323 Order.

DATES: The rule in this document contains information collection requirements that have been approved by the Office of Management and Budget (OMB). The rule will become effective upon publication of a document in the **Federal Register** announcing the OMB approval.

FOR FURTHER INFORMATION CONTACT: Mania Baghdadi, (202) 418–2330, Amy Brett, (202) 418–2300.

SUPPLEMENTARY INFORMATION: This is a summary of the Commission's Memorandum Opinion and Order in MB Docket Nos. 07–294; 06–121; 02–277; 04–228; MM Docket Nos. 01–235; 01–317; 00–244, FCC 09–92, adopted

http://www.matrixintegration.com/healthcare-lifespring-wireless/

Is your hospital losing patients because of your wireless technology?

by Joe Mendoza | Apr 15, 2016 | Healthcare, Networking Solutions, Video

LifeSpring Health Systems partnered with Matrix Integration and designed a cutting-edge technology system to provide premium service for their patients.

Wireless devices and mobility are critical to the internal operations of a hospital, both for patient satisfaction and for HIPAA regulations around bring-your-own-device. Watch to see the solutions Matrix Integration provided:

Matrix Integration specializes in technology solutions for the healthcare industry. To discover how you can improve your hospital's wireless system to provide a premium patient experience, click here.

(See Video https://www.youtube.com/watch?v=9D3XHEwNhGA)

https://www.defendershield.com/emf-exposure-depression-anxiety-mental-health-issues

How EMF Exposure May Cause Depression, Anxiety & Other Mental Health Issues

Posted on December 19, 2017 by Daniel T. DeBaun

Medically & Scientifically reviewed by Dr. Russell John Kort & Joanette Biebesheimer, Biologist

Last Updated on October 19, 2020

From time to time, even the *healthiest* and *happiest* of us have periods when we feel **anxious** or **depressed**.

Stress, the most common trigger of these emotions, has always been an inherent part of the human experience, and this holds true today.

In fact, statistics suggest that stressors are more abundant than ever; nearly **1 in 5 adults** in the United States suffer from a **mental health condition.**

It's easy to assume that mental dysfunction, at least in certain forms, is just a byproduct of the demands that come with living in modern society.

But what about times when we can't consciously pinpoint the cause of these mind states? What about periods of anxiety or sadness that last *longer* than a few hours or days? Instead of a low mood that passes with life's changing circumstances, the feeling can last *indefinitely*, an untraceable heaviness that permeates all other aspects of our lives.

This sort of depression (or anxiety) isn't uncommon. Worse, it can be difficult to treat without medical intervention, as **many factors** could be causing or contributing to it: poor nutrition, poor sleeping habits, chemical imbalances in the brain, chronic stress, and physical inactivity all can lead to less-than-optimal brain health.

But there's another possible culprit that you may not have considered: **your daily exposure to EMF (electromagnetic field) radiation emitted by WiFi and our mobile electronic devices** such as laptops, tablets, and smartphones.

Link Between EMF Radiation Exposure and Mental Health Issues

Though not reported on by the mainstream media, there are now numerous studies confirming a link between high amounts of *EMF radiation exposure* and *negative psychiatric symptoms* in both humans and animals.

For example, this **Iranian study** followed **103 electricians**, dividing them into 5 different groups based on potential for exposure to extremely low frequency electromagnetic fields. It was found that the group with the ***highest exposure*** also had the ***highest probability*** of experiencing feelings of *depression*, *psychosis*, *obsessive-compulsive behavior*, *hostility*, and *anxiousness*.

Similarly, this **1997 study** of **540 adults living near high-voltage transmission lines** found that *higher doses of EMFs* were correlated with symptoms of *psychological distress*, regardless of each participant's beliefs about the health effects of exposure.

And this **cohort study** of roughly **139,000 workers in the electric industry** also found a higher incidence of *depressive symptoms* in the workers who consistently received *higher EMF exposure*. They also discovered that younger workers with recent exposure, in particular, were at increased ***risk of committing suicide***.

These studies demonstrate an important fact: **you don't have to be a compulsive smartphone addict or a heavy computer user to suffer from the neurological effects of EMF exposure.** The subjects in all three studies spent significant time in environments with higher amounts of electromagnetic fields. In today's world, where the majority of urban and suburban environments are saturated with EMFs, it is likely that many of us are *unknowingly affected* in the same way these study subjects were.

The case for EMFs posing a threat to the mental health of humans and animals has only become *stronger with time*.

A review of studies conducted by **Martin L. Pall** and published in 2015 stated that *"Two U.S. government reports from the 1970s to 1980s provide evidence for many neuropsychiatric effects of non-thermal microwave EMFs, based on occupational exposure studies. 18 more recent epidemiological studies provide substantial evidence that microwave EMFs from cell/mobile phone base stations, excessive cell/mobile phone usage and from wireless smart meters can each produce similar patterns of neuropsychiatric effects, with several of these studies showing clear dose–response relationships."*

How Can Electromagnetic Fields Cause Mental Dysfunction in Humans?

Pall's paper, called *"Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression,"* also sheds some light on the mechanisms by which EMFs can cause these unhealthy effects.

One way that EMFs are observed to influence human biochemistry is that they activate **voltage gated calcium channels (VGCCs).** These channels regulate the amount of calcium taken in by multiple types of cells throughout our bodies. A disruption in the delicate intracellular balance of calcium to other ions can in turn wreak havoc on key physiological processes.

"VGCC activation has been shown to have a universal or near universal role in the **release of neurotransmitters** in the brain and also in the **release of hormones** by neuroendocrine cells…Both the high VGCC density and their function in neurotransmitter and neuroendocrine release throughout the nervous system suggests that the ***nervous system is likely to be highly sensitive to low intensity EMFs.***"

You're probably familiar with some of the most well-known neurotransmitters: *serotonin*, *dopamine*, and *norepinephrine*. A proper balance of these chemicals is vital to a healthy and stable mood, good sleep, motivation, ability to focus, and calming of anxiety.

If these chemical signals are released in the wrong amounts, mind-states like depression or anxiety can become the new normal for us, regardless of how stable our lives are. This is especially true for children and the iGen generation, who are constantly connected to technology in a very vulnerable and developmental period in their lives. Read more about the increase in mental illnesses in kids and teens in our blog post about mental health and technology addiction.

Another neurotransmitter, melatonin, is responsible for regulating our sleep-wake rhythms. It has been established that ***EMF exposure suppresses the secretion of melatonin*** by the brain's pineal gland. As referenced by the cohort study, research from multiple sources shows a relationship between low amounts of melatonin and greater incidence of depression.

EMFs have also been shown to cause unhelpful changes to the central and peripheral nervous system in rodents. In this case, two major tissues that are adversely affected are the *hypothalamus* and the *pituitary gland*, which have the important role of synthesizing and releasing various hormones that are needed for r*egulating growth, body temperature, hunger/thirst, parental instincts, metabolism,* and *attachment behaviors*.

That isn't even an exhaustive list.

What's more, research says that while EMF-related neurological damage is (for the most part) reversible, **it may become permanent with chronic, prolonged exposure.**

Reducing the Risk

It may seem extraordinary that news of the harmful potential of EMFs hasn't become common knowledge, but it doesn't make the threats posed any less real.

If you experience periods of depression, anxiety, or other mental distress, this is something worth following up on, especially if you work and/or live in an environment with high levels of emission.

It's helpful to know the sources–cell phone towers, high-voltage power lines, smart meters, and of course our mobile electronic devices all contribute to the transmission of EMFs, and that list will only grow with time.

Though it is difficult (if not impossible) to completely avoid all sources, **reducing your usage** always helps. Others have found relief from EMF-related symptoms by relocating to a less urban space, using ethernet cables versus a WiFi connection, and using EMF-shielding with their devices.

Borrowing a grim but accurate statement made by one of the researchers in the review cited above,

"The primary questions now involve specific exposure parameters, not the reality of complaints or attempts to attribute such complaints to psychosomatic causes, malingering or beliefs in paranormal phenomena."

http://blog.heartland.org/2016/02/demand-lawmakers-enact-a-permanent-smart-meter-opt-out-for-illinoisans/

Demand Lawmakers Enact a Permanent Smart Meter Opt Out for Illinoisans

written by Nancy Thorner February 8, 2016

Nancy Thorner

Nancy Thorner is a musician and patriot who writes regularly for Illinois Review, and occasionally for The Heartland Institute's Freedom Pub blog.

Although the installation of Smart Meters by ComEd has already been completed in some areas of Illinois – despite protests from concerned citizens – a recent news account alerted Lake County residents that they have been targeted next for Smart Meter installation.

An article published in the *Daily Herald* on January 29, 2016, stated how Libertyville, IL, is in the next round of communities in Lake County to have standard analog meters replaced by "smart" devices. Quoted in the article was David Doherty, director of the Smart Meter transformation for ComEd, who explained how "Smart Meters collect energy usage information that can be read remotely, allowing the company to determine and react to power outages more quickly. The meters also will send a signal when a customer loses power."

According to company literature that is distributed by ComEd to community leaders in advance of Smart Meter installation: "Smart Meters will provide consumers benefits from the new technology, allowing consumers to access their power usage online so habits can be altered, as needed, to better manage their energy consumption. Smart Meters will likewise provide access to optional pricing programs, such as switching use to times when it costs less to produce."

Spin vs Truth

The above benefits most likely sound entirely logical to Illinoisans, especially when coupled with this canned statement frequently made by Smart Meter installers when questioned by home owners about the need for a Smart Meter: *Smart Meters will eliminate the need for meter readers.*

But Beware, Illinoisans! What you are receiving from ComEd is spin instead of facts. It was in July of last year when I took the CUBFacts Smart Meter information (Citizen Utility Board) propaganda sheet with its ComEd supplied facts to the woodshed for its inaccurate information. In my article, "Beware of Propaganda to Quell Inconvenient Truths About Smart Meters", the CUBFacts Smart Meter Information sheet was evaluated for misleading statements and edited accordingly. What is in **bold** was taken directly from CUBFacts, followed each time by my explanation of what really is true!

It is important to your family's health security and privacy to say NO to a Smart Meter installation when you are accordingly notified. Take the op-out delay that is being offered. Realize that the opt-out choice is not a permanent one and that Smart Meter installation is just being delayed until 2018 with no opportunity to oppose installation after that. Other states offer a permanent opt-out to their utility customers. ComEd customers in Illinois do not have that option.

ComEd Lobbyist Contrived No-opt out Law

As to the history of the law that makes Wireless Smart Meters **mandatory** in Illinois: ComEd lobbyists wrote the law; it was passed by the General Assembly against vehement and persistent opposition from the Attorney General, AARP, and informed citizens aware of the risks. ComEd spent 16 million dollars convincing the General Assembly to over-ride Governor Quinn's Veto. When elected, Governor Rauner then signed another bill favoring ComEd over the rights of citizens to have a choice.

It is tragic for consumers that Chicago's powerful and politically-connected ComEd was able to convince the General Assembly to pass a law that could potentially threaten homes, harm lives, adversely impact nature, invade privacy, and, in a broader scope, undermine the state's security by making the electric grid more vulnerable to cyber-attack.

Doesn't every ComEd customer deserve the right to have a choice to opt-out permanently in the face of the real and present dangers that having a Smart Meter on the side of their house or business could engender? It is unjust and un-American to ***force*** Wireless Smart Meters on every home without alerting residents to the many risks and offering them a choice.

Reasons to Reject Smart Meters

1. Health and Environment – Smart Meters are installed in a Mesh Network which relays data from one house to another and eventually on to a collector unit, which is an additional wireless network that sends the data back to the utility. ComEd says that Radio Frequency (RF) emissions only take place 4 times a day every 6 hours.

That may be true for one household's data measurements. However, Smart Meters also send and receive network management messages every few seconds around the clock. In a California Court the utility admitted that a Smart Meter emits from 10 to 190,000 bursts a day. Each burst is sending RF/microwave radiation into the home and throughout the neighborhood. The power level of each burst is about 1,000 milliwatts, making Smart Meters one of the most powerful RF radiators in a community.

What this means to ComEd Customers?: that a Class 2B Carcinogen (the category for wireless RF emissions, by the International Agency for Research on Cancer 'IARC" of the World Health Organization) is being

mandated on ALL homes in the ComEd service territory. Even worse, there is NO PERMANENT OPT-OUT OPTION AVAILABLE.

People who have already had their Smart Meter installed are complaining of headaches, ringing in the ears, rashes, nausea, insomnia, chest pressure, heart palpitations, nose bleeds, and weakness, etc. There is a potential threat to those with medical implants and weakened immune systems. The well-being of pets is also of concern. Studies that have been done on wildlife, trees, plants, and bees show that they will also suffer from the RF/microwave emissions blanketing the state.

Breaking news on January, 29, 2016: the Pennsylvania Utility Commission is allowing a hearing to go forward of a nurse who says Smart Meter made her sick. What makes this so interesting is that PECO is an Exelon Company, like ComEd.

2. Privacy Invasion — Without your consent, the computer inside the Smart Meter collects private energy behavior patterns that will be available to government agencies and could be at some point be for sale to marketers. A hacker or thief could use this data to know whether or not the home is occupied and if high-end electronics are in the home.

3. Hacking and Cyber-Security – Vulnerabilities in wireless data transmission can pose national security risks to the electric grid. A former CIA Director calls the Smart Grid "really, really STUPID". ComEd will be installing 4,000,000 access points to the Internet; every private home and business in their service territory.

4. Higher Bills – Smart Meters monitor usage 24/7 as a means of instituting Time-of-Use pricing. Due to escalating charges for peak time usage, bills can double, or worse. Time-of-Use pricing boosts ComEd profits while penalizing those who need lower electric rates the most—stay-at-home moms, the elderly, the unemployed, and those with disabilities. Anyone who is unable to change their behavior, such as washing dishes and doing laundry at off-peak hours, will not benefit from having a Smart Meter.

5. Appliances: RF Radiation and Privacy Invasion – New appliances come with mandated wireless RF transmitters that emit RF signals to the wireless Smart Meter around-the-clock. Manufacturers can also keep track of information about their appliances for future marketing through the wireless transmissions. Because the Smart Appliance Services are provided through wireless networks and the Internet, communications could be intercepted by others.

6. Lack of Control – The utility owns and maintains 100% control over computer hardware and software upgrades inside Smart Meters. With Demand Response, a utility company can selectively turn on/off appliances or an entire household.

7. Loss of Property and Safety – There has been hundreds of reports of electrical fires caused by arching and sparking within the Smart Meter. Homes with older wiring may be more susceptible to the risk of fire.

Corix, the company ComEd is using for installation gives their employees, who have no prior electrical experience, two weeks of classroom instruction and one week of field work. In California, more than a 100 GE Smart Meters (manufacturer ComEd selected) have exploded right on homes due to a power surge. And, Smart Meters have been known to "fry" electronics.

Should you still have doubts about the dangers posed by Smart Meters, this website deserves careful study. Under the name of SkyVision Solutions, this site (www.smartgridawareness.org) is dedicated to raising public awareness about the costs and risks associated with smart grid systems as well as the potential hazards related to Radio Frequency Radiation emissions from Smart Meters.

Here is the link to my https://youtu.be/aoodNMI3nzc appearance on a local Comcast TV cable show talking about the dangers posed by Smart Meters, with a warning about cell phones. Both wireless devices produce electromagnetic radiation. There is mounting evidence that that RF-EMF radiation is carcinogenic. The fact that exposure to our population is increasing at an exponential rate, the potential consequences are catastrophic.

Action Required

1) Call the ComEd Smart Meter installation line (866) 368-8326 and request a DELAY if a Smart Meter has not already been installed. If one has been installed, call and have it be replaced with a non-transmitting meter.

2) Contact Governor Bruce Rauner and your elected Illinois General Assembly legislators. Insist the Utility Modernization law be amended and the ICC ruling requiring mandatory compliance be changed. Demand a PERMANENT TRUE OPT-OUT, NOT JUST A DELAY!

ALL WIRELESS DEVICES, INCLUDING CELL PHONES, ARE VOLUNTARY AND CAN BE TURNED OFF WHEN NOT IN USE. SMART METERS ARE MANDATORY AND ARE ON 24/7, FOREVER.

IMMUNIZATION AGENDA 2030

A global strategy to leave no one behind

IA2030

CONTENTS

AT A GLANCE

Vision

A world where everyone, everywhere, at every age...

... fully benefits from vaccines...

... for good health and well-being

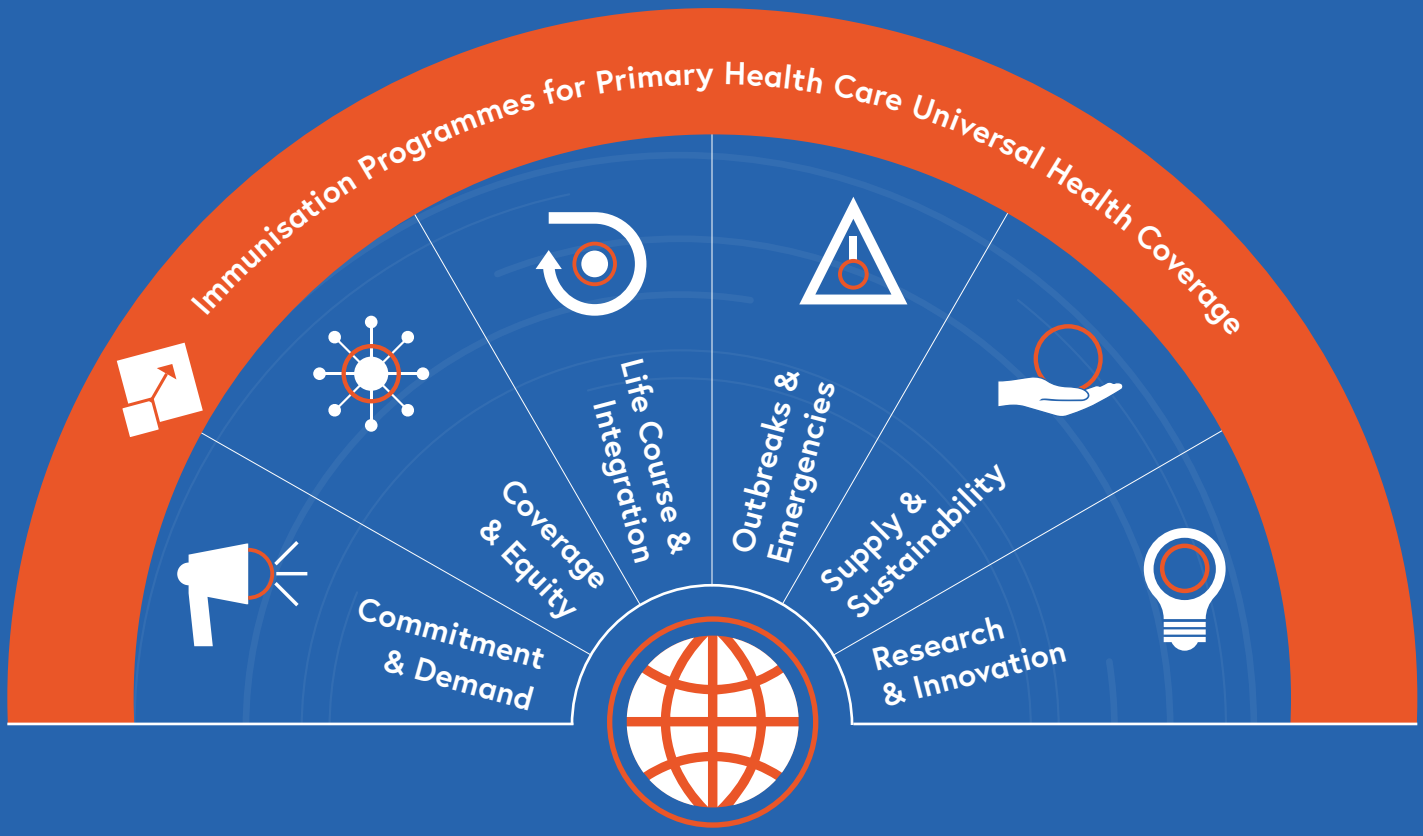
Impact goals

Reduce mortality and morbidity from vaccine-preventable diseases for everyone throughout the life course.

Leave non one behind, by increasing equitable access and use of new and existing vaccines.

Ensure good health and well-being for everyone by strengthening immunisation within primary health care and contributing to universal health coverage and sustainable development.

Strategic priorities



Core principles

People Centred

Country Owned

Partnership Based

Data Guided

INTRODUCTION

Immunization is a success story for global health and development, saving millions of lives every year. Between 2010 and 2018, 23 million deaths were averted with measles vaccine alone *(1)*. The number of infants vaccinated annually – more than 116 million, or 86% of all infants born – has reached the highest level ever reported. More than 20 life-threatening diseases can now be prevented by immunization *(2)*. Since 2010, 116 countries have introduced vaccines that they did not use previously *(3)*, including those against major killers like pneumococcal pneumonia, diarrhoea, cervical cancer, typhoid, cholera and meningitis.

Furthermore, there has been much innovation in vaccine development. There are now vaccines to protect against malaria, dengue and Ebola virus disease, and promising vaccines against respiratory syncytial virus, tuberculosis and all influenza virus strains are in the pipeline. New research on broadly neutralizing antibodies and therapeutic vaccines is opening fresh horizons. Increasingly, vaccines are protecting health beyond infancy – in adolescence and adulthood, during pregnancy and for older people.

Innovative ways are being found to distribute and administer vaccines and to improve immunization services. Digital tools, new, needle-free techniques for vaccine administration and more robust vaccine storage and supply chains promise to transform immunization programmes[1] over the next decade. Timely access to reliable data will provide new opportunities for national programmes to monitor and continuously improve their performance, reach and efficiency.

Vaccines are critical to the prevention and control of many communicable diseases and therefore underpin global health security. Moreover, they are widely seen as critical for addressing emerging infectious diseases, for example by containing or limiting outbreaks of infectious diseases or combatting the spread of antimicrobial resistance. Regional outbreaks (e.g. of Ebola virus disease), the COVID-19 pandemic and the threat of future pandemics (such as with a novel flu strain) have and will continue to strain even the most resilient health systems. A clear risk is a reduction in essential services and particularly vaccination and prevention of other communicable diseases. Countries should

1. Throughout this document, the term "immunization programme" is used to reflect shifts in both language and thinking. First, as immunization programmes are only one component of health systems, the term aligns the global vision and strategy with the broader health and development agenda. Secondly, the term is more comprehensive than the more commonly used "routine immunization," which does not capture the full spectrum of an immunization programme's activities, such as "catch-up" vaccinations, periodic intensification of vaccination activities or efforts to address missed opportunities for vaccination.

identify essential services that to be prioritized and maintained during emerging infectious disease threats and move as soon as feasible to provide missed vaccinations. In the longer term, intensive, collaborative investments in research and development and equitable supplies of new vaccines are likely to be part of the solution to averting recurrences.

Nevertheless, important challenges remain. The benefits of immunization are unevenly shared: coverage varies widely among and within countries. Some populations – often the poorest, the most marginalized and the most vulnerable, in fragile, conflict-torn settings – have poor access to immunization services. Each year, 20 million infants do not receive a full course of even basic vaccines, and many more miss out on newer vaccines. Of these, over 13 million receive no vaccines through immunization programmes – the "zero dose" children.

In some countries, progress has stalled or even reversed, and the risk that complacency will undermine past achievements is real. Outbreaks of measles and vaccine-derived polioviruses are stark reminders that strong immunization programmes and effective disease surveillance are necessary to sustain high levels of coverage and to eliminate and eradicate diseases. Because measles is highly infectious, its presence serves as a tracer (the "canary in the coal mine") of inadequate coverage and gaps in the health system. Detection of measles cases through surveillance reveals communities and age groups that are un- or under-immunized and immunization programmes and overall primary health care systems that are inadequate, indicating where particular attention and interventions are needed. High coverage with measles vaccine is an indicator of a strong immunization programme, which may signal a solid foundation for primary health care services. The second dose of measles vaccine is an opportunity to enhance focus on strengthening immunization programmes to reach children beyond the first year of life and to broaden immunization services throughout the life-course.

If all people are to access immunization services, vaccines must be delivered to areas that are isolated geographically, culturally, socially or otherwise and to marginalized populations such as displaced people and migrants and those affected by conflict, political instability and natural disasters. The causes of low vaccine use must be understood and addressed in order to increase people's demand for immunization services. Adequate, predictable supplies of appropriate, affordable vaccines of assured quality must be available at points of service delivery, and stock-outs must be avoided. Tailored strategies are necessary for understanding and overcoming barriers to vaccination, particularly gender-related barriers of caregivers and health workers to accessing immunization services. New approaches are required to reach older age groups and to deliver people-centred immunization services, integrated with primary health care.

The **Immunization Agenda 2030** (IA2030) sets an ambitious, overarching global vision and strategy for vaccines and immunization for the decade 2021–2030. It draws on lessons learnt, acknowledges continuing and new challenges posed by infectious diseases and capitalizes on new opportunities to meet those challenges. IA2030 positions immunization as a key contributor to people's fundamental right to the enjoyment of the highest attainable physical and mental health and also as an investment in the future, creating a healthier, safer, more prosperous world for all. IA2030 aims to ensure that we maintain the hard-won gains and also that we achieve more – leaving no one behind, in any situation or at any stage of life.

IA2030 is intended to inspire and align the activities of community, national, regional and global stakeholders – national governments, regional bodies, global agencies, development partners, health care professionals, academic and research institutions, vaccine developers and manufacturers, the private sector and civil society. Its impact will be maximized by more effective and efficient use of resources, innovation to improve performance and measures to attain financial and programmatic sustainability. Success will depend on building and strengthening partnerships within and outside the health sector as part of a coordinated effort to improve access to high-quality, affordable primary health care, achieve universal health coverage and accelerate progress towards the 2030 Sustainable Development Goals (SDGs).

IA2030 provides a long-term strategic framework to guide a dynamic operational phase, responding to changes in country needs and the global context over the next decade. This document is therefore just the beginning. The IA2030 global vision and strategy will be complemented by annexes providing detailed technical information on the strategic framework, together with new and existing strategies and immunization plans, including those for disease-specific programmes to control, eliminate or eradicate disease. IA2030 will become operational through regional and national strategies, a mechanism to ensure ownership and accountability and a monitoring and evaluation framework to guide country implementation.

Through collective endeavour by all stakeholders, we will achieve the vision for the decade: *A world where everyone, everywhere, at every age, fully benefits from vaccines for good health and well-being.*

THE CASE FOR IMMUNIZATION

1

Immunization reaches more people than any other health or social service and is a vital component of primary health care. It benefits individuals, communities, countries and the world. It is an investment in the future, in three ways.

1.1 Saving lives and protecting the health of populations *(4–6)*

Immunization has reduced the number of deaths from infectious diseases dramatically. Vaccines also prevent disability, which can impair children's growth and cognitive development, so that they not only survive but also flourish.

Vaccines benefit not only infants and children but also older people. They can prevent infection-related cancers and protect the health of the elderly and the vulnerable, allowing people to live longer, healthier lives. In addition, fewer infections mean less risk of transmitting disease to relatives and other members of the community.

In many countries, out-of-pocket payments for health care have a catastrophic impact on household finances, potentially plunging households into poverty. Preventing infection by vaccination can reduce families' expenditure on health care, contributing to financial protection, which is a core component of universal health coverage.

Between 2010 and 2017, the mortality rate of children under 5 years of age decreased by **24%**, due in large part to immunization *(4)*.

In countries that have introduced the vaccine against human papillomavirus (HPV), after 5–8 years, cancer causing HPV prevalence was reduced by **83%** among girls aged 13–19, and the prevalence of precancerous lesions decreased by **51%** among girls aged 15–19 *(5)*.

Vaccines will help keep an estimated **24 million** people from falling into poverty by 2030 *(6)*.

1.2 Improving countries' productivity and resilience *(7,8)*

Immunization is the foundation of a healthy, productive population. Preventing infections reduces the burden on health systems, and a healthier population is a more productive one. Children protected against infectious diseases have better educational attainment and contribute more to national development and prosperity.

Halting disease outbreaks is disruptive and costly. Outbreaks can overwhelm and profoundly disrupt public health programmes, clinical services and health systems. They may also have adverse effects on travel, trade and overall development. For seasonal diseases like influenza, the costs of treatment and lost productivity are borne repeatedly. Immunized communities are resistant to infectious disease outbreaks, and strong health systems and immunization programmes allow rapid detection and response to limit their impact.

Immunization against measles in 94 low- and middle-income countries returned an estimated **US$ 76.5** for every US$ 1 invested in vaccination *(7)*.

The full economic impact of the 2014–2016 outbreak of Ebola virus disease in West Africa has been estimated at **US$ 53.2 billion** *(8)*.

1.3 Enabling a safer, healthier, more prosperous world *(9–11)*

Vaccines are a critical component of the battle against emerging and re-emerging infections. Pathogens are not bound by national borders, and local and international movement of people can rapidly spread infections. Increasing urbanization results in large, dense populations, raising the likelihood of infectious disease transmission and outbreaks. In addition, climate change exposes new populations to vector-borne diseases and may alter the patterns and intensity of seasonal diseases. Detecting, preventing and responding to infectious disease threats are therefore key to **global health security**.

In all parts of the world, infectious diseases are increasingly developing resistance to antibiotics and other antimicrobials. Preventing infection through immunization not only protects people against drug-resistant infections but also reduces their spread and the need for and use of antibiotics, thereby contributing to the battle against **antimicrobial resistance**.

Immunization and disease surveillance are core capacities required by the **International Health Regulations (2005)**, as they contribute to resilient, sustainable health systems that can respond to infectious disease outbreaks, public health risks and emergencies *(11)*. Furthermore, the safe management and disposal of vaccine waste ought to be part of all vaccination activities, contributing directly to patient safety and quality of care, while reducing environmental and climate risks.

Immunization plays a critical role in **achieving the SDGs**, specifically SDG3, "Ensure healthy lives and promote well-being for all at all ages", and also contributes directly or indirectly to 13 other SDGs (Fig. 1).

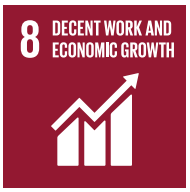
Climate change between 2030 and 2050 is expected to cause **60 000** additional deaths from malaria per year *(9)*. This trend may be changed by use of a malaria vaccine being pilot-tested in three African countries.

It is estimated that widespread use of thee pneumococcal conjugate vaccine (PCV) could reduce the number of days on antibiotics for pneumonia in children under 5 years by 47%, equivalent to **11.4 million days** on antibiotics per year *(10)*.

A 10% increase in the core capacities required by the International Health Regulations (2005) (e.g. surveillance, risk communication) is associated with a **19% decrease** in the incidence of cross-border infectious threats *(11)*.

Figure 1. Contributions and relevance of immunization to 14 of the 17 SDGs

Immunization plays a key role in **eliminating poverty**, by reducing treatment costs and increasing longer-term productivity by averting losses due to disability and death.



Immunization promotes a **healthy and productive workforce**, which contributes to the economy.

Immunization and **nutrition** go hand in hand. Malnourished individuals, especially children, are more likely to die from infectious diseases such as diarrhoea, measles and pneumonia.

Vaccine manufacture contributes to national industrial **infrastructure** in low- and middle-income countries.

Vaccination is one of the most cost–effective ways of saving lives and promoting good **health and well-being**.

Immunization prevents diseases that affect **the most marginalized groups**, especially those in poor urban or remote rural settings and in areas of conflict.

Immunization increases **educational attainment**, as it improves long-term cognitive development. Children who are immunized tend to attain more years of schooling and score higher in cognitive tests than those who are unvaccinated.

Immunization protects urban public health and interrupts disease transmission, ensuring **sustainable cities and communities**.

Removal of gender-related barriers to vaccination contributes to **gender** equality, as it supports women's full participation and equal opportunities for accessing health services.

Immunization is critical to building people's resilience to and mitigating the risk of disease outbreaks linked to **climate change**, such as yellow fever, malaria, meningitis and cholera.

When vaccination is complementary to **clean water, sanitation and hygiene**, it prevents diarrhoeal diseases, which are the leading cause of child mortality in low-income countries.

Effective, safe, people-centred health systems are the backbone of social institutions, and vaccination is often the regular point of contact of the population with the system.

Immunization logistics increasingly involve use of cleaner, more sustainable techniques based on solar and other **renewable sources of energy**.

Immunization programmes broaden **partnerships** and multisectoral approaches, ensuring that civil society, communities and the private sector work together towards common goals.

Source: reference 12

A STRATEGY FOR THE FUTURE

2

IA2030 envisions ***"A world where everyone, everywhere, at every age, fully benefits from vaccines for good health and well-being."***

To achieve this ambitious vision, lessons have been drawn from the past to identify factors that contribute to success.

2.1 Lessons from the Global Vaccine Action Plan

The Global Vaccine Action Plan (GVAP) was the global immunization strategy of the "Decade of vaccines" (2011–2020). Developed through extensive global consultations, GVAP brought together existing goals to eradicate and eliminate diseases and set new global goals that accounted for the full spectrum of functions of immunization programmes. The review of experience with GVAP in 2019 *(3)* revealed important lessons for the decade to 2030.

GVAP brought together many global, regional and national stakeholders in a **shared vision and strategy** for the future of immunization. The health and immunization community agreed to aspirational goals to catalyse action, and, although many GVAP goals have not been met, much progress has been made.

GVAP enhanced the visibility of immunization and helped build high-level **political will**. It provided a common framework for establishing priorities, aligning activities and assessing progress, and it created a platform on which further work can be built. GVAP was a comprehensive strategy, and most of its goals and objectives remain relevant.

GVAP was to be implemented through **national immunization programmes, with the support of partners**; however, GVAP was only partially successful in influencing national actions, and partner activities were not always fully coordinated globally or nationally. To enhance country ownership, which is critical to the success of the IA2030, tailored strategies will be necessary to respond to the significant differences among countries in size, resources and the conditions in which people live, with consideration of subnational differences. IA2030 will strengthen existing partnerships and build new relations, especially at the country level, such as with a wider range of civil society organizations and the private sector, under the leadership of national programmes.

During GVAP implementation, **regional vaccine action plans** were used to translate global strategies into regional plans. Regional vaccine action plans will be revised to align with IA2030, as a critical step in operationalization.

GVAP struggled to influence national and global responses to situations that arose during the decade, such as conflict, climate change, migration and urbanization,

as well as the spread of misinformation about vaccines. In IA2030, more flexibility may be required to account for national and subnational circumstances to in order to respond effectively to **emerging challenges**.

GVAP established the first global **monitoring and evaluation framework** for immunization, defining roles and responsibilities for stakeholders. The framework provided a wealth of information on progress and raised awareness of the importance of high-quality data. It was unable to ensure, however, that use of the data improved the performance or accountability of national programmes, especially at subnational level.

IA2030 will build on these lessons to further clarify roles and responsibilities, so that the agenda can be implemented nationally, regionally and globally, and improving the use of data to prompt action and ensure accountability.

2.2 Lessons from disease-specific initiatives

GVAP drew together existing goals to eradicate polio and to eliminate measles, rubella and maternal and neonatal tetanus. These disease-specific initiatives were inspired by the landmark achievement of smallpox eradication. They have the advantage of focusing on a single, clear objective and agreement on common approaches and timelines. After the World Health Assembly had endorsed GVAP, it approved additional disease-specific targets (Table 1).

Table 1. Goals and targets of disease-specific initiatives

Disease-specific goal or initiative	Targets
Polio eradication (GVAP, Polio Endgame Strategy 2019–2023)[a]	Interrupt transmission of all wild poliovirus by 2020.
	Stop circulating vaccine-derived poliovirus outbreaks within 120 days of detection.
	Certify eradication by 2023.
Neonatal tetanus elimination (GVAP)	Eliminate neonatal tetanus in the remaining 40 countries by 2015.
Measles and rubella elimination (GVAP, Global Measles and Rubella Strategic Plan 2012–2020)	Eliminate measles in at least five WHO regions by 2020.
	Eliminate rubella in at least five WHO regions by 2020.
Cholera control (Ending Cholera – A Global Roadmap to 2030)	Reduce cholera deaths by 90% by 2030.

Disease-specific goal or initiative	Targets
Elimination of viral hepatitis as a major public health threat (Global Health Sector Strategy on Viral Hepatitis 2016–2021)	Reduce new cases of chronic viral hepatitis B infections by 95% by 2030 (equivalent to 0.1% prevalence for HBsAg among children).
	Reduce viral hepatitis B deaths by 65% by 2030.
Control of vector-borne diseases (including Japanese encephalitis) (Global Vector Control Response 2017–2030)	Reduce mortality due to vector-borne diseases by at least 75% by 2030.
	Reduce case incidence due to vector-borne diseases by at least 60% by 2030.
	Prevent epidemics of vector-borne diseases in all countries by 2030.
Elimination of yellow fever epidemics (Eliminate Yellow Fever Epidemics)	Reduce yellow fever outbreaks to zero by 2026.
Elimination of meningitis epidemics and reduction of cases and deaths (Global Roadmap to Defeat Meningitis)	Eliminate meningitis epidemics by 2030.[b]
	Reduce the numbers of cases and deaths from vaccine-preventable bacterial meningitis by 2030.[c]
	Reduce disability and improve quality of life after meningitis due to any cause by 2030.
Reduction of seasonal influenza burden (Global Influenza Strategy 2019–2030)	No disease-specific targets.
Zero deaths from dog-mediated rabies by 2030 (Zero by 30: The Global Strategic Plan)	Reduce the number of deaths from dog-mediated rabies to zero by 2030.

a Target dates depend on the epidemiological situation.

b As of 13 September 2019.

c Targets will be set at regional level.

Although disease-specific goals are enduring global commitments that will continue to be an important element of IA2030, revisions may be made during development of the IA2030 monitoring and evaluation framework, especially to goals for which the target dates have passed.

Polio. Enormous progress has been made towards eradication of polio. Wild poliovirus is now circulating in only two countries, where conflict, lack of access, cross-border population movement, insufficient polio vaccine coverage in immunization programmes, difficulty in sustaining community engagement and

weak health infrastructure are major obstacles to reaching the polio eradication goal. The continuing challenges in interrupting the transmission of wild poliovirus and circulating vaccine-derived poliovirus outbreaks in countries that had been declared polio-free demonstrate the importance of strong immunization programmes as part of primary health care in reaching and sustaining global eradication. In addition, as the world moves closer to global polio eradication, the decrease in resources provided through the Global Polio Eradication Initiative (GPEI) is an additional challenge. In many countries, GPEI helped build an infrastructure, supporting immunization functions beyond polio. Effective planning without such infrastructure and resources is therefore vital to ensure that functions essential for shared disease-prevention goals – vaccine-preventable disease surveillance, strong immunization services and outbreak responses – are sustainably integrated into national immunization programmes.

Measles. Before measles vaccines were introduced in the 1960s, measles was a leading cause of child morbidity and mortality worldwide, responsible for more than 2 million deaths annually. Between 2000 and 2018, stronger health systems and increased measles vaccination coverage resulted in a 73% global decrease in mortality. Regional elimination has not, however, been achieved or sustained, and an alarming resurgence in measles cases and deaths has been seen around the world in recent years, in some cases with cross-border importations and even small pockets of immunity gaps leading to large outbreaks. As measles is so contagious, very high vaccine coverage (95%) with two timely doses of measles-containing vaccine is required to prevent its spread. Coverage with the first dose of measles vaccine has plateaued globally at around 85% over the past decade, and, although coverage with the second dose has increased to 69%, the percentage is not sufficiently high, and supplementary means of delivering vaccine are necessary through planned campaigns, periodic intensification of routine immunization and other strategies. Providing every child with two timely doses of measles-containing vaccine and effective elimination-standard measles surveillance are, therefore, critical indicators of a strong immunization programme, as an integral component of primary health care. Measles cases indicate gaps in population immunity, signalling inadequate access or uptake. A strong, resilient immunization programme is essential to respond to this challenge and a powerful, measurable means of achieving health equity.

Maternal and neonatal tetanus. Three fourths of priority countries have eliminated maternal and neonatal tetanus; more work is necessary to eliminate the disease in the remaining 25%. Elimination of maternal and neonatal tetanus will reduce neonatal mortality, which has decreased more slowly than for children under 5 years of age. Although current strategies address inequity, they target only pregnant women and women of reproductive age, leaving older boys and adult and elderly men unprotected from tetanus. Strategies that include booster doses for vaccination of whole populations in a life-course approach will help overcome gender disparities. As maternal and neonatal tetanus is also strongly

associated with poverty, its incidence can be used as a marker of the quality of the health services delivered to marginalized and underserved populations and of their uptake by these populations.

Strengthened systems for integrated disease control. Control of key infectious diseases equitably, efficiently and sustainably requires both robust immunization programmes and targeted, disease-specific strategies. Strong disease surveillance and immunization programmes are integral components of primary health care and are essential for raising immunity, reducing the risk of disease and preventing morbidity and mortality. Supplementary immunization activities may still be necessary, however, to boost immunity quickly in targeted populations. The mixture and balance of these two approaches depends on disease epidemiology, the context and the ability of health systems to deliver vaccines to those who need them most.

Lessons learnt from the past decade demonstrate that it is difficult to eradicate or eliminate a disease in the absence of an efficient, resilient immunization programme. IA2030, therefore, emphasizes building a strong national immunization infrastructure integrated into primary health care services, as a way to achieve and sustain elimination and eradication goals. To achieve universal health coverage through primary health care, all aspects of health systems will need to be strengthened, including immunization and other preventive services, disease surveillance, regular collection and use of reliable data, emergency outbreak preparedness and response, a strong workforce, good governance and social accountability, appropriate budget allocations, financial management and efficient patient care for existing and emerging diseases.

2.3 The changing context and challenges

IA2030 has been shaped by both lessons from the past decade and the changing global environment.

Sustaining trust. Uptake of vaccination depends on many factors, from the convenience and quality of facilities and services to the spread of misinformation about the safety and effectiveness of vaccines. These considerations must be understood and addressed to enhance and sustain trust in vaccines and immunization services in communities, to increase health literacy with a focus on vaccination at all levels, and to build resilience against misinformation. The harm being caused by anti-vaccine messaging, especially on social media, should be addressed by understanding the context and reasons for lack of trust and by building and keeping trust, especially in the face of fear and distrust in traditional establishments. Strategic investments to increase trust and confidence in vaccines, in particular through strong community engagement, would increase community support for vaccines and ensure that vaccination is viewed as a social norm.

Inequity. The benefits of immunization are not spread equally, either among or within countries. In 2018, 70% of unvaccinated children lived in **middle-income countries** *(13)*. Reaching all people will require higher national vaccination coverage, but also less **subnational inequity.** Success will require interventions that take into account poverty, education, socioeconomic and cultural factors and gender-related barriers to access.

Population movements. Continuing **urbanization** will pose major challenges, as it results in large, dense populations at high risk of infectious disease. Migration and **cross-border population movements** can result in large communities of unprotected individuals at risk of infection. Migrants and mobile populations are often difficult to reach or track. As they often move across borders, it is not even clear who is responsible for vaccinating them, and they may be marginalized and overlooked.

Ensuring immunization for all ages. Expanding the benefits of vaccination to all age groups offers tremendous opportunities, but it will require major shifts in immunization programmes. As more vaccines become available for older age groups, new methods will be necessary to deliver integrated, people-centred health services. Programmes will also have to respond to significant global **demographic shifts**. Regions such as Africa are undergoing rapid population growth and a resulting "youth bulge", while others are experiencing significant population ageing. These shifts will have a major impact on the design of immunization services.

Climate change and natural disasters. The world's changing climate will have significant implications for the prevalence of infectious diseases. New populations will be exposed to vector-borne diseases such as malaria and dengue, and more flooding will increase the spread of waterborne diseases such as cholera. Climate change is also disrupting seasonal disease patterns, shifting the timing, duration and pattern of their transmission. It may also alter the endemicity of infectious diseases. Climate-informed surveillance and response systems will be an essential part of national preparedness for infectious disease outbreaks. The environmental impact of vaccine waste, from excess packaging to the release of harmful pollutants during burning, will have to be addressed more comprehensively and minimized.

Conflict and political instability. Civil conflict can rapidly lead to loss of health service infrastructure and shortages of trained health workers, often for extended periods, thereby disrupting delivery of immunization services. The affected populations are also frequently at higher risk of infectious diseases because of the breakdown of national infrastructure and mass displacement into temporary settlements.

Outbreaks. The world continues to experience outbreaks of measles, yellow fever, diphtheria and other vaccine-preventable diseases and also emerging infections, such as Ebola virus disease. Disease surveillance and immunization are critical for preventing, detecting and controlling infectious disease outbreaks. **Disease surveillance** provides insight into the effectiveness of immunization programmes, indicates how they can be optimized and provides early warning of potential outbreaks. Comprehensive preparedness and response strategies, including research during outbreaks, will limit their impact on health and national finances.

Optimizing and maintaining supplies. Achieving the IA2030 vision will require a **reliable global supply of appropriate, affordable, innovative vaccines and other immunization products of assured quality**. Every year, many countries experience disruptions in their supplies of vaccines, often because of a mismatch between global production levels and needs. Healthy market dynamics must be achieved and maintained for vaccines and immunization products in the long term, both globally and regionally. Reliable forecasts of national vaccine requirements and priorities will continue to ensure healthy market dynamics and improve and maintain supplies. The **price of vaccines** is a key barrier to access and can delay the introduction of new vaccines into low- and middle-income countries. There are also regulatory, financing and procurement barriers to sustainable vaccine supplies. For instance, the markedly different procurement processes in countries might have to be adjusted to respond to changes in the vaccine market and in quality-assurance requirements.

2.4 What is new on the IA2030 agenda?

These lessons from the past and the changing context make IA2030 different from its predecessor, GVAP, in several respects.

- **Cooperative design from the bottom up.** IA2030 was developed collaboratively with countries, to ensure that the vision, strategic priorities and goals[2] are aligned with country needs.

- **Tailored to the national context.** The IA2030 strategic framework is flexible, allowing countries to adapt the global framework to their local context and partners to provide differentiated, targeted, customized support.

- **Adaptable to changing needs.** The IA2030 strategic framework can be adapted to changing needs and new challenges that may emerge during the decade.

2. In the context of this document, a "goal" is an ambitious commitment to address a single challenge; an "indicator" is a measure of a goal; and a "target" is a specific (sometimes time-bound) outcome of achievement of an indicator.

- **Targeted ways to reduce inequity.** IA2030 ensures that the benefits of immunization are shared equitably among and within countries. It gives priority to the populations that are not currently being reached, particularly the most marginalized communities, those living in fragile and conflict-affected settings and mobile populations, especially those moving across borders.

- **Gender-responsive strategies.** IA2030 focuses not only on equitable coverage of boys and girls, but aims at understanding and addressing all the direct and indirect barriers to access to immunization services, including those related to the gender of caregivers and health workers, and increasing women's full and equal participation in decision-making at all levels.

- **Stronger focus on systems strengthening.** IA2030 positions sustainable immunization programmes embedded within primary health care as the basis for achieving high vaccination coverage and universal health coverage. Notably, IA2030 builds on the goals of existing disease-specific initiatives, while at the same time stressing health system strengthening to help achieve the goals of disease control, elimination and eradication.

- **Measles as a tracer.** Measles coverage is an important indicator for attaining SDG3 indicator 3b 1.[3] In IA2030, measles vaccination coverage and incidence recorded by surveillance are tracers of the strength of immunization programmes, indicating communities and age groups that are un- or under-immunized and where more emphasis is required.

- **Life-course approach.** The growing number of new vaccines administered after childhood is opening frontiers for national immunization programmes and will require new methods for delivery. Furthermore, booster doses should be introduced for lifelong protection against diphtheria, pertussis and tetanus. IA2030 has a stronger focus on extending the benefits of vaccination throughout the life-course.

- **Strengthening partnerships beyond health.** The future of immunization will increasingly be based on integration and collaboration with stakeholders within and beyond health. IA2030 proposes closer collaboration with existing and new partners. Such enhanced collaboration will have mutual advantages, extending the benefits of immunization while helping others to achieve their goals.

3. Proportion of the target population with access to measles-containing-vaccine second-dose (MCV2) (%).

- **Accelerating innovation.** A more nimble, robust research agenda offers new opportunities to meet future challenges. IA2030 focuses on not only the development of new vaccines but also accelerating innovation to improve programme performance, surveillance and quality and to increase access to data, drawing on lessons from other sectors.

- **Better use of resources for self-sustainability.** IA2030 emphasizes maximization of the impact to be achieved with existing resources. Efficient, effective, resilient national immunization programmes delivered within primary health care, backed by strong political commitment and popular support, hold the key to progress and long-term sustainability. Partners play a vital role in supporting countries on the path to self-sustainability.

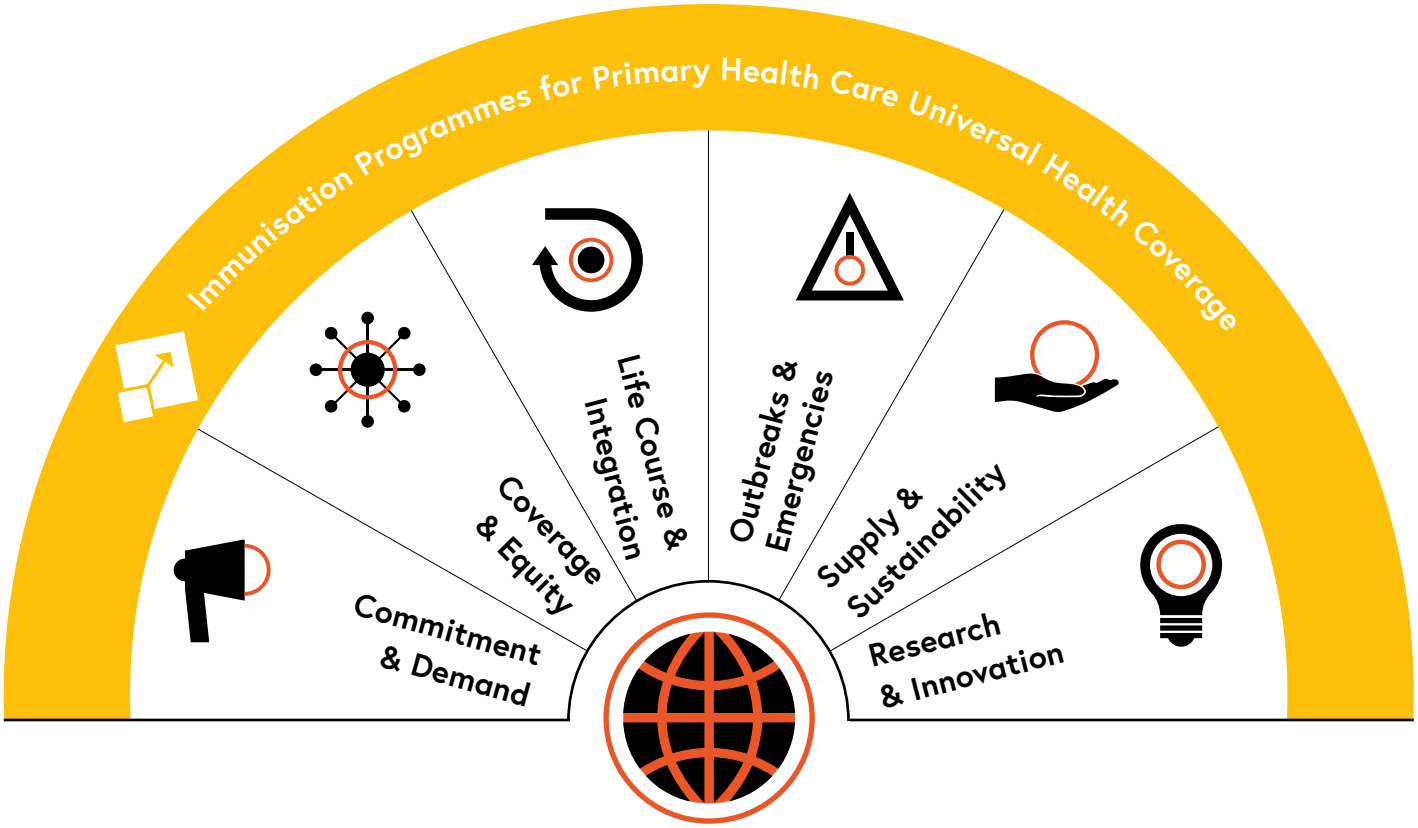
These shifts in emphasis do not lessen the importance of GVAP priorities that are still relevant, which are incorporated into the IA2030 framework for action.

A FRAMEWORK FOR ACTION

3

IA2030 is based on a conceptual framework of **seven strategic priorities** (Fig. 2). Each strategic priority has defined **goals and objectives** and **key areas of focus**. Action is necessary to achieve these interrelated strategic priorities to realize the overall vision and goals and to ensure that immunization fully contributes to stronger primary health care and attainment of universal health coverage.

Figure 2. The seven strategic priorities of IA2030



People Centred

Country Owned

Partnership Based

Data Guided

The **first, overarching strategic priority** is to ensure that immunization programmes are an integral part of primary health care to achieve universal health coverage. The second is commitment and community demand. These two strategic priorities are the **basis of an immunization programme** and are essential to deliver people-centred, demand-driven health services to individuals and communities.

The next three strategic priorities, coverage and equity, life-course and integration and outbreaks and emergencies, ensure the **delivery of immunization services**, in the face of population growth, continuing urbanization, rising migration, cross-border movement and displacement of populations, conflict, political instability, natural disasters and climate change.

The remaining two strategic priorities are **enablers of success**. Continued investment is necessary to combat infections for which there is no vaccine. Similarly, innovation will improve the performance of immunization programmes by ensuring the delivery of services to underserved populations. Ensuring a reliable global supply of affordable vaccines and the sustainability of national programmes worldwide are also essential for success.

These seven strategic priorities are anchored by **four core principles** that will shape the nature of actions undertaken to achieve each strategic goal and objective (Fig. 3). These principles are the threads that weave together the strategic priorities and provide guidance on translating the high-level strategy into practical actions. They convey the values and guiding principles for mutually beneficial partnerships and alignment of the activities of all partners within and outside of the immunization community.

Figure 3. The four core principles of IA2030

People-centred

Responding to populations needs.

The design, management and delivery of immunization services should be shaped by and responsive to the needs of individuals and communities, including addressing barriers to access to immunization services due to age, location, social and cultural norms and gender-related factors.

Country-owned

Driving progress from the bottom up.

Countries should establish targets that represent the local context and should be held accountable for achieving them.

Partnership-based

Aligning efforts to maximize impact.

Immunization partners should align and coordinate their actions to increase efficiency, build on complementarity and involve sectors beyond immunization for mutual benefit.

Data-guided

Promoting evidence-based decision-making.

High-quality, "fit-for-purpose" data will be used to track progress, improve programme performance and form the basis of decision-making at all levels.

STRATEGIC PRIORITY 1.

Immunization programmes for primary health care and universal health coverage	
Goal	Effective, efficient and resilient immunization services are accessible to all people as an essential part of primary health care, and thereby contribute to universal health coverage.
Objectives	• Reinforce and sustain strong leadership, management and coordination of immunization programmes at all levels. • Ensure the availability of an adequate, effective, sustainable health workforce. • Build and strengthen comprehensive vaccine-preventable disease surveillance as a component of the national public health surveillance system, supported by strong, reliable laboratory networks. • Secure high-quality supply chains for vaccines and related commodities and effective vaccine management, within the primary health care supply system. • Strengthen immunization information within a robust health information system, and promote use of high-quality, "fit-for-purpose" data for action at all levels. • Establish and maintain a well-functioning vaccine safety system involving all stakeholders.
Key areas of focus	**Immunization in primary health care:** Ensure that sustainable immunization programmes are an integral part of the national primary health care strategies and operations, and of national strategies for universal health coverage. **Leadership, governance and management:** Create an environment for effective coordination, financial management and performance monitoring at every level of the immunization programme. **Health workforce:** Ensure the availability and appropriate distribution of health workers who are motivated, skilled, knowledgeable and appropriately resourced to plan, manage, implement and monitor the performance of immunization programmes at all levels and locations, as part of primary health care. **Supply chain and logistics:** Strengthen supply chains to ensure that high-quality vaccines are always available in the right quantity and form at the right time, in the right place and stored and distributed under the right conditions. Promote integration with other supply chains for more effective delivery of primary health care. Invest in systems and infrastructure to safely manage, treat and dispose of vaccine waste to help reduce their environmental footprint.

Immunization programmes for primary health care and universal health coverage	
Key areas of focus	**Vaccine-preventable disease surveillance:** Increase the efficiency, responsiveness and comprehensiveness of disease surveillance (including epidemiology and laboratory capacity) in order to: encourage the introduction of vaccines; optimize immunization programmes; measure the impact of vaccines; monitor disease control, elimination and eradication; and detect, investigate and respond to outbreaks. These activities should be based on existing surveillance infrastructure, such as that for polio and measles. **Health information systems:** Ensure that health information systems allow health workers and decision-makers to generate and use high-quality, "fit-for-purpose" data to implement and manage immunization programmes effectively at all levels and that the data are also integrated into national health information systems. **Monitoring vaccine safety:** Ensure that national immunization programmes can detect and respond to any concern about vaccine safety by continuous monitoring and coordination among relevant stakeholders. **Disease control initiatives:** Ensure that strengthening of national health systems and initiatives for disease control, elimination and eradication are coordinated for mutual reinforcement.
Application of the core principles	**People-centred.** Immunization programmes will be designed and tailored to the needs and social and cultural preferences of people and communities.
	Country-owned. National strategies and plans to build and sustain robust immunization programmes will strengthen health systems and primary health care in order to attain universal health coverage.
	Partnership-based. Public and private partnerships will be formed, including with partners beyond the health sector, with the private sector and with civil society organizations, for coordinated strengthening of immunization programmes.
	Data-guided. Data, evidence and best practice will guide strengthening of immunization programmes and improve their design and performance for universal health coverage.

STRATEGIC PRIORITY 2.

Commitment & demand[4]	
Goal	Immunization is valued and actively sought by all people, and health authorities commit to ensuring that immunization is available as a key contributor to enjoyment of the highest attainable standard of health as a fundamental right.
Objectives	• Build and sustain strong political and financial commitment for immunization at all levels. • Ensure that all people and communities value, actively support and seek out immunization services.
Key areas of focus	**Commitment:** Ensure that key groups, champions and stakeholders advocate for greater commitment to and ownership of immunization programmes and for sustained national and subnational financing. Encourage leaders to prioritize immunization in strategic and operational planning and in policy, fiscal and legislative instruments. Strengthen evidence-based decision-making, with technical input from bodies such as a national immunization technical advisory groups (NITAGs). **Subnational support:** Build support for immunization and capacity for national and subnational leadership, management and coordination, especially in large countries and in those with decentralized health systems. Establish mechanisms for stakeholder coordination and participation in planning, implementation and monitoring. **Accountability:** Establish accountability frameworks for all stakeholders, with platforms for engagement and dialogue. Ensure that communities and civil society organizations are equipped to hold national and subnational authorities accountable for equitable delivery and for the quality of immunization services. Ensure access to data and information, and develop frameworks for joint monitoring. **Public trust and confidence:** Establish an ongoing understanding of all the behavioural and social drivers to vaccination (including social processes, gender-related barriers, practical factors and social media) to engage communities and encourage greater use of immunization services.

4. In the context of this strategic priority, "demand" refers to the actions of individuals and communities to seek, support or advocate for vaccines and vaccination services. Demand is dynamic and varies by context, vaccine, vaccination services, time and place. It can be fostered by governments, immunization programme managers, public and private sector providers, local leaders and civil society organizations that listen and act on the comments of individuals and communities .

Commitment & demand[4]	
Key areas of focus	**Public knowledge and understanding:** Include the topic of immunization in education curricula, formulate public education tools (including to meet the needs of vulnerable and marginalized groups), provide educational opportunities for the health workforce, and prepare information resources for advocacy groups. **Acceptance and value of vaccination:** Use local data to understand and devise tailored solutions to address the underlying causes of low vaccination rates. Use the evidence to respond to practical barriers, such as access to good-quality services, and to support positive attitudes and social influences. Proactively implement plans to prevent and respond to adverse events, rumours and hesitancy and strengthen resilience to these influences. **Addressing reluctance to vaccinate:** Understand and respond to public concern, and develop robust, innovative strategies to mitigate vaccine misinformation and reduce its propagation and negative impact.
Application of the core principles	**People-centred.** Community engagement will be at the heart of building people's trust and of their acceptance and use of vaccines. The emphasis is on dialogue, service quality, effective and respectful provider communication in primary care and accountability.
	Country-owned. Political leaders, civil society and immunization champions will ensure that countries are committed to ensure the enjoyment of the highest attainable standard of health and to protection of communities against vaccine-preventable diseases.
	Partnership-based. New partnerships will be built among multiple actors to increase knowledge and raise awareness of the value of immunization, to build community trust and to overcome barriers to equity, including gender-related barriers.
	Data-guided. Evidence on behavioural and social factors will be obtained locally and nationally to develop appropriate interventions. Communication technology will be used to increase commitment to and demand for immunization.

STRATEGIC PRIORITY 3.

Coverage & equity	
Goal	Everyone is protected by full immunization, regardless of location, age, socioeconomic status or gender-related barriers.
Objectives	• Extend immunization services to regularly reach "zero dose" and under-immunized children and communities. • Advance and sustain high and equitable immunization coverage nationally and in all districts.
Key areas of focus	**Disadvantaged populations:** Identify and address low coverage throughout the life-course of the poorest and most disadvantaged individuals and communities. **Barriers to vaccination:** Identify barriers to uptake of vaccination services due to age, location, social and cultural and gender-related factors, and use evidence-based approaches to overcome these barriers to achieving high, equitable coverage. **Gender-responsive strategies:** Understand the role of gender in accessing vaccination services, and use gender-responsive strategies to overcome the barriers faced by recipients, caregivers, service providers and health workers. **Measles as a tracer:** Use measles cases and outbreaks as a tracer to identify weaknesses in immunization programmes, and to guide programmatic planning in identifying and addressing these weaknesses. **Learning from disease-specific initiatives:** Use the experience of disease eradication and elimination initiatives in reaching the most marginalized populations, and integrate successful strategies for delivery and accountability into immunization programmes, with the full integration of disease control perspectives into primary health care. **Context-specific interventions:** Develop, evaluate and scale up innovative, locally tailored, evidence-based, people-centred approaches to reach poorly served populations. **Implementation research:** Strengthen local capacity to conduct implementation research to identify factors that affect the equity of immunization coverage, interventions that enhance coverage and equity and promote use of the results to implement locally tailored, context-specific interventions and innovations to address inequities.

Coverage & equity	
Application of the core principles	**People-centred.** Gaps in coverage and equity will be addressed, especially among marginalized and disadvantaged groups such as mobile and displaced populations, by actively engaging representatives of local communities and local health providers in designing interventions for these groups.
	Country-owned. To overcome barriers, national immunization programmes will use strategies based on proven, innovative approaches and local research on effective ways to deliver services to underserved groups.
	Partnership-based. Partnerships will be built with local communities and representatives of marginalized groups to understand the obstacles to access to vaccination (including gender barriers faced by recipients, caregivers and health workers) and to address inequities.
	Data-guided. Immunization data systems will be expanded subnationally to map and track "zero dose" and under-immunized populations and specific marginalized groups to ensure that they are covered by the immunization programme.

STRATEGIC PRIORITY 4.

Life-course & integration	
Goal	All people benefit from recommended immunizations throughout the life-course, effectively integrated with other essential health services.
Objectives	• Strengthen immunization policies and service delivery throughout the life-course, including for appropriate catch-up vaccinations and booster doses. • Establish integrated delivery points of contact between immunization and other public health interventions for different target age groups.
Key areas of focus	**Mobilizing support:** Raise awareness of the benefits of vaccination beyond early childhood, through adolescence and in priority adult groups such as pregnant women, health workers and older adults. **Evidence-based delivery practices:** Identify and evaluate new delivery strategies for increasing coverage of recommended vaccines throughout the life-course. **Missed opportunities:** Implement proven approaches to reduce the number of missed opportunities by integrating immunization into other primary health care planning, health registers and other record-keeping systems, and streamline use of all encounters with the health system to verify and provide missed vaccines and other essential health interventions. **Cross-sector collaboration:** Form collaborations to integrate age-appropriate and catch-up vaccination into public and private health services, emphasizing the reciprocal benefits of receiving vaccines with other health interventions. Establish collaboration beyond the health care sector to ensure integration of immunization into context-specific programmes such as for education, nutrition, water and sanitation, care of older people and women's empowerment. **Policy environment:** Promote changes in legislation or in the policy of immunization and other programmes to extend the national focus beyond early childhood immunization. Form new collaborations and private-sector partnerships to mobilize financing for vaccination of older age groups. **Tracking vaccination status:** Institute policies for monitoring vaccination coverage at different ages and facilitating administration of vaccines throughout the life-course. **Vaccine development:** Generate evidence on the disease burden among older age groups, the potential of vaccines to decrease it and the programmatic implications for introducing the vaccines.

Life-course & integration	
Application of the core principles	**People-centred.** Vaccination throughout the life-course is integrated into other health care services for different age groups, according to the needs of individuals.
	Country-owned. National immunization technical advisory groups will guide country programmes in extending vaccination beyond infancy throughout the life-course to reflect specific national and subnational contexts.
	Partnership-based. Partnerships with other health programmes and with non-health actors (including in education, water, sanitation and hygiene and nutrition) are built into comprehensive life-course approaches for disease control and elimination, including for pneumococcus pneumonia, diarrhoea and cervical cancer.
	Data-guided. Implementation and social and behavioural research will be conducted to generate evidence for effective delivery of integrated, coordinated packages of vaccination services and to identify new contact points for vaccination throughout the life course. Research will identify the vaccines required for older age groups.

STRATEGIC PRIORITY 5.

Outbreaks & emergencies

Goal

Immunization programmes can (1) anticipate, prepare for, detect and rapidly respond to of vaccine-preventable and emerging disease outbreaks, and (2) ensure immunization service delivery during acute emergencies and among communities affected by conflict, disaster and humanitarian crisis.

Objectives

- Ensure preparation for, detection of and rapid, high-quality response to vaccine-preventable disease outbreaks.
- Establish timely and appropriate immunization services during emergencies, and in communities affected by conflict, disaster and humanitarian crisis.

Key areas of focus

Coordination and integration: Strengthen coordination of implementation of vaccination and outbreak preparedness, detection and activities in the overall humanitarian response and in conformity with the International Health Regulations (2005) and health systems development programming, with the participation of all relevant stakeholders, including civil society, national and international organizations, humanitarian and development partners and the private sector.

Local capacity: Invest in and sustain local capacity and health systems to ensure timely detection of and response to vaccine-preventable disease outbreaks; identify and address the underlying causes of outbreaks; ensure that communities affected by outbreaks, other emergencies and humanitarian crises have continual access to a package of health services that includes immunization; and ensure that immunization recovery is embedded into outbreak and emergency response plans.

Comprehensive health response: Ensure that global, regional, national and subnational coordination and governance mechanisms effectively support equitable, transparent, timely decision-making on the allocation of essential supplies and vaccines and mobilization of trained human resources.

Integrated surveillance: Rebuild national, regional and local capacity for rapid, integrated surveillance of priority and emerging infectious diseases after an emergency or humanitarian event, maximizing opportunities to monitor and characterize multiple pathogens to ensure early detection of outbreaks. Strengthen integrated disease surveillance for epidemic-prone vaccine-preventable diseases to enhance prevention and response.

Outbreaks & emergencies	
Key areas of focus	**Tailored approaches and innovation:** Develop, implement and evaluate innovative, tailored approaches and relevant frameworks and tools for safe, ethical, equitable vaccination of populations during outbreaks and in settings of humanitarian aid. Re-establish vaccination services after acute emergencies as part of broader early recovery and in line with disaster risk-reduction principles. **Community engagement:** Prioritize two-way communication and engagement with communities and health workers during outbreaks and in settings of humanitarian aid to effectively limit health emergencies and outbreaks and promote participation in decision-making; ensure access to and use of services, and identify and fill unmet health needs.
Application of the core principles	**People-centred.** Anticipation of, preparedness for and response to outbreaks and emergencies will include adaptation of interventions to meet all the needs of affected individuals, including mobile and displaced populations, and tailored interventions based on local knowledge. Mechanisms to ensure accountability to affected people should be in place for continual improvement of emergency vaccination interventions and transition to longer-term services.
	Country-owned. National authorities will coordinate efforts to handle emergencies and outbreaks with local authorities, and services will be delivered by trained local staff and community mobilization networks. In crises in which national authorities do not coordinate provision of services, access to impartial, independently provided health care will be ensured.
	Partnership-based. Partnerships will be built to prioritize and support capacity-building, planning and leadership of local and national organizations for coordinated provision of health care, including vaccination, in such a way as to support existing health systems and surveillance strategies during outbreaks and other acute emergencies and also in settings of humanitarian aid.
	Data-guided. Routine, systematic collection of disaggregated data will be promoted to target vaccination to the most vulnerable populations and those at risk of exclusion. Research and evaluation will be conducted to generate evidence on novel approaches to identifying outbreaks early and to deliver vaccination and health services during outbreaks, other acute emergencies and in settings of humanitarian aid.

STRATEGIC PRIORITY 6.

Supply & sustainability	
Goal	All countries have a reliable supply of appropriate and affordable vaccines of assured quality, and sustainable financing for immunization programmes.
Objectives	• Build and maintain healthy global markets across all vaccine antigens. • Ensure sufficient financial resources for immunization programmes in all countries. • Increase immunization expenditure from domestic resources in aid-dependent countries, and when transitioning away from aid, secure government funding to achieve and sustain high coverage for all vaccines.
Key areas of focus	**Innovation and affordability:** Ensure that the supply of and access to new vaccines meet country needs and that vaccines are introduced in a timely manner, regardless of a country's wealth, and at a price that is affordable, to ensure the supply. **Vaccine forecasting, procurement and supply:** Improve national and global forecasting, planning and procurement capability to safeguard affordable, sustainable supplies, and strengthen relations with manufacturers to ensure that vaccine production and supply meet national needs in all countries. **Sources of assured quality vaccines:** Strengthen regulatory capacity in all countries to improve timely access to vaccines of assured quality and to allow diversification of manufacturing sources. **Supply for emergency situations:** Strengthen mechanisms for rapid access in emergencies, outbreaks or pandemics and for people who require humanitarian aid. The mechanisms include sustainable manufacture and new means for rapid scaling-up of production to meet surge requirements and rapid access. **Sufficient, predictable resources:** Ensure that funding from all sources is sufficient to procure and deliver recommended vaccines universally. **Immunization financing:** Ensure good governance, stewardship and accountability of financing for immunization programmes for optimal performance and best value for money.

Supply & sustainability	
Key areas of focus	**Partner alignment:** Streamline and align partnerships for immunization, primary health care or integrated financing, and ensure effective global collaboration in which the roles, responsibilities and accountability of all partners are clearly defined, transparent and monitored. **Sustainable transitions:** Ensure mechanisms for smooth transition of countries from donor-supported programmes, while maintaining and enhancing their immunization programmes.
Application of the core principles	**People-centred.** A strong focus on developing local capacity to govern and manage immunization financing and to increase understanding of choices for better forecasting of current and future vaccine markets.
	Country-owned. Adequate country capacity to plan for and secure the financing required for their immunization programme will reduce reliance on external support. Countries will be able to plan, forecast, budget for and procure the required vaccines and ensure their quality.
	Partnership-based. Better partnerships will be built to plan for and ensure long-term, sustainable financing, and all partners will have clear roles and responsibilities and be accountable. Enhanced collaboration among stakeholders will support healthy vaccine markets.
	Data-guided. Data systems will be upgraded to better allocate resources within national immunization programmes, monitor use of resources and forecast vaccine demand, supply and pricing.

STRATEGIC PRIORITY 7.

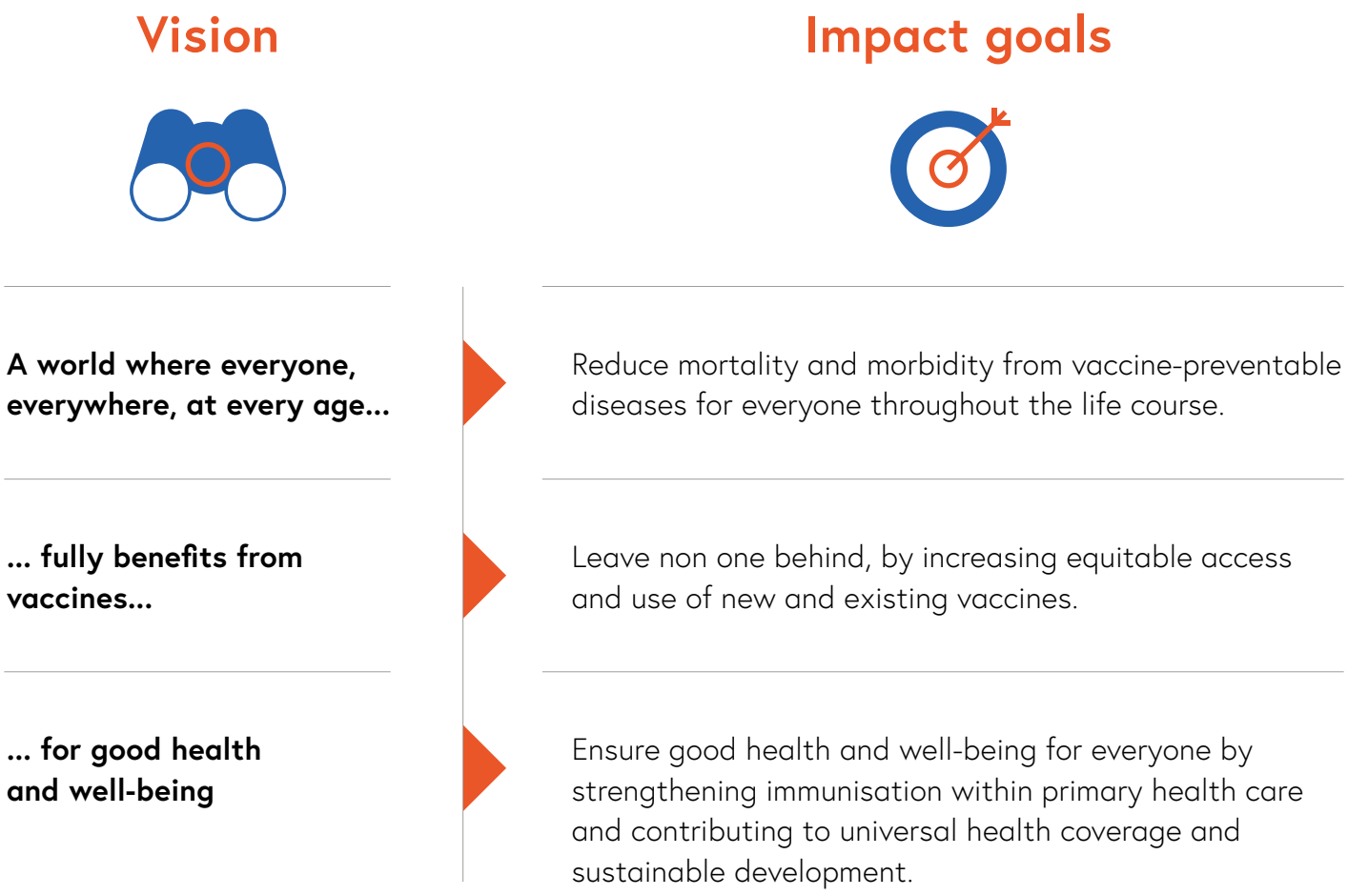
Research & innovation	
Goal	Innovations to increase the reach and impact of immunization programmes are rapidly made available to all countries and communities.
Objectives	• Establish and strengthen capacity at all levels to identify priorities for innovation, and to create and manage innovation. • Develop new vaccines and technologies, and improve existing products and services for immunization programmes. • Evaluate promising innovations and scale up innovations, as appropriate, on the basis of the best available evidence.
Key areas of focus	**Needs-based innovation:** Strengthen mechanisms to identify vaccine-related research and priorities for innovation according to community needs, particularly for underserved populations, and ensure that the priorities inform innovations in immunization products, services and practices. **New and improved products, services and practices:** Accelerate the development of new vaccines, technologies and improved products, services and practices, while ensuring continued progress in the development of vaccines for priority targets, including HIV, TB, malaria and emerging infectious diseases. **Evidence for Implementation:** Shorten the path to maximum vaccine impact by implementation and operational research and through evidence-informed decisions on policy and implementation based on sound evidence of needs, benefits and risks. **Local innovation:** Build local capacity to address programme challenges and maximize impact by cooperative creation, sourcing, adopting and scaling-up of innovations.
Application of the core principles	**People-centred.** Innovations in products, services and practices will be client-focused and address community and provider needs and preferences.
	Country-owned. Countries will be able to identify, source and manage innovations in vaccines and immunization, including determining, documenting and communicating their priorities and identifying, evaluating and using local and global innovations. Country priorities will inform the global innovation agenda.
	Partnership-based. Partners will devise ways to support the development, evaluation, use and sustainability of suitable immunization solutions, drawing on the complementary expertise of national and global stakeholders.
	Data-guided. Evidence of unmet needs and the value of innovations in all aspects of immunization will be rigorously collected and shared to promote evidence-based research, development, execution and scale-up.

IMPACT AND STRATEGIC GOALS

4

Realizing the IA2030 vision will require achievement of the impact goals (Fig. 4).

Figure 4. Impact goals for the IA2030 vision



In addition, each strategic priority will have specific goals and objectives for evaluating progress in meeting the priorities (Table 2). The goals and objectives will complement existing disease-specific goals and also the broader health goals and the SDGs. They will mirror the ambition of existing commitments and galvanize work to make important gains in immunization over the coming decade.

Table 2. IA2030 strategic priority goals and objectives

Goals and objectives
Strategic priority goal 1 Effective, efficient and resilient immunization services are accessible to all people as an essential part of primary health care, and thereby contribute to universal health coverage.
Objectives 1. Reinforce and sustain strong leadership, management and coordination of immunization programmes at all levels. 2. Ensure the availability of an adequate, effective, sustainable health workforce. 3. Build and strengthen comprehensive vaccine-preventable disease surveillance as a component of national public health surveillance system, supported by strong, reliable laboratory networks 4. Ensure high-quality supply chains for vaccines and related commodities and effective vaccine management, within the primary health care supply system. 5. Strengthen immunization information within a robust health information system, and promote use of high quality, and "fit-for-purpose" data for action at all levels. 6. Establish and maintain a well-functioning vaccine safety system involving all stakeholders.
Strategic priority goal 2 Immunization is valued and actively sought by all people, and health authorities commit to ensuring that immunization is available as a key contributor to enjoyment of the highest attainable standard of health as a fundamental right.
Objectives 1. Build and sustain strong political and financial commitment for immunization at all levels. 2. Ensure that all people and communities value, actively support, and seek out immunization services.
Strategic priority goal 3 Everyone is protected by full immunization, regardless of location, age, socioeconomic status or gender-related barriers.
Objectives 1. Extend immunization services to regularly reach "zero-dose" and under-immunized children and communities. 2. Advance and sustain high and equitable immunization coverage nationally and in all districts.

Goals and objectives

Strategic priority goal 4

All people benefit from recommended immunizations throughout the life course, effectively integrated with other essential health services.

Objectives

1. Strengthen immunization policies and service delivery throughout the life course, including for appropriate catch-up vaccinations and booster doses.
2. Establish integrated delivery points of contact between immunization and other public health interventions for different target age groups.

Strategic priority goal 5

Immunization programmes can 1) anticipate, prepare for, detect, and rapidly respond to vaccine-preventable and emerging disease outbreaks, and 2) ensure immunization service delivery during acute emergencies and among communities affected by conflict, disaster and humanitarian crisis.

Objectives

1. Ensure preparation for, detection of, and rapid, high-quality response to vaccine-preventable disease outbreaks.
2. Establish timely and appropriate immunization services during emergencies, and in communities affected by conflict, disaster and humanitarian crisis.

Strategic priority goal 6

All countries have a reliable supply of appropriate and affordable vaccines of assured quality, and sustainable financing for immunization programmes.

Objectives

1. Build and maintain healthy global markets across all vaccine antigens.
2. Ensure sufficient financial resources for immunization programmes in all countries.
3. Increase immunization expenditure from domestic resources in aid-dependent countries, and when transitioning away from aid, secure government funding to achieve and sustain high coverage for all vaccines.

Strategic priority goal 7

Innovations to increase the reach and impact of immunization programmes are rapidly made available to all countries and communities.

Objectives

1. Establish and strengthen capacity at all levels to identify priorities for innovation, and to create and manage innovation.
2. Develop new vaccines and technologies, and improve existing products and services for immunization programmes.
3. Evaluate promising innovations and scale up innovations, as appropriate, based on the best available evidence.

As the IA2030 framework is adaptable and flexible, goals may be revised in response to major changes during the decade. The goals and objectives will be further refined in the monitoring and evaluation framework and will include indicators, targets and methods for evaluating progress.

The IA2030 goals will inspire action. In countries, action might include setting evidence-based, ambitious national targets and milestones for the decade. Regions might make plans to achieve the global goals by setting targets and milestones in regional vaccination action plans. Partner organizations might align their strategies and indicators towards attainment of the IA2030 goals.

Global, regional and national goal- and target-setting should be:

- aligned with the vision of IA2030;
- responsive to changing trends and conditions;
- aligned with broader health agendas (SDG3, primary health care and universal health coverage);
- ambitious but achievable and measurable to ensure accountability;
- linked to an action and a work plan; and
- designed to reinforce previous commitments (for example, the disease-specific goals listed in Table 1).

OPERATIONALIZATION

5

IA2030 is an **overarching strategy** for establishing a **shared vision of and strategic priorities** for vaccines and immunization in order to guide the activities of countries and stakeholder organizations.

IA2030 must be contextualized within the global focus on improving access to good-quality, affordable primary health care as a foundation for achieving universal health coverage. The vision and strategy of IA2030 do not exist in isolation. It is backed by technical analyses and documentation, complementary strategies of stakeholder organizations, disease-specific initiatives and other global health and development programmes for steering national strategies and plans for vaccination.

Further, development of IA2030 will be a **multistep process**, starting with agreement on the vision, strategic priorities and high-level goals. The second step, translating the strategy into concrete actions, will require the development of regional and national operational plans; a mechanism to ensure ownership and accountability; and a monitoring and evaluation framework.

IA2030 will be adaptable to regional and national contexts. Thus, countries will prioritize various focus areas in each IA2030 strategic priority according to their situation. IA2030 will enable partners and stakeholders at all levels to align their work to ensure that all actions reinforce each other, in the pursuit of common goals.

5.1 Operational plans

The global strategy will become operational nationally, regionally and globally through its seven strategic priorities and four core principles.

Nationally, the IA2030 vision and strategies can be incorporated into national immunization strategies within national health planning. Countries will define their own targets and timelines to achieve IA2030 goals. Support from partners will be tailored to each context and integrated as much as possible into the strengthening of primary health care, achievement of universal health care and attainment of the SDGs.

Regional vaccine action plans will be updated to align them with the IA2030 vision and strategic priorities. Tailored support will be provided to countries according to the needs of national immunization programmes. Regional collaboration will involve stakeholders within and outside of immunization, to take advantage of synergies and promote integration.

Globally, operationalization of the IA2030 vision and strategy will focus on those components that are best coordinated globally, with alignment among stakeholders. It will require communication and advocacy to maintain momentum, mobilize support for IA2030 and for immunization more generally and promote acceptance of the IA2030 principles and strategic priorities.

5.2 Ownership and accountability

A mechanism will be necessary to ensure ownership accountability and definition of the roles and responsibilities of all stakeholders in delivering IA2030 vision and strategies. This will be a key objective in the second phase of IA2030 development.

5.3 Monitoring and evaluation framework

Drawing on the lessons learnt from GVAP, a robust monitoring and evaluation framework will be developed to measure progress towards the IA2030 vision and goals. It will be closely aligned with operational plans to ensure the greatest possible transparency and accountability.

The approach to achieving the IA2030 vision will be dynamic and responsive. While the vision and strategy will be constant throughout the decade, operational plans at national, regional and global levels will evolve with changing circumstances. Just as the battle against infectious diseases requires agile, flexible immunization programmes, a global vaccine and immunization strategy must also constantly adjust to changing needs and opportunities to respond to rapid shifts in disease epidemiology, technological advances, community needs, financial realities and political contexts.

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IA2030

IMPLEMENTING THE IMMUNIZATION AGENDA 2030:

Draft Framework for Action through Coordinated Planning, Monitoring & Evaluation, and Ownership & Accountability

A Briefing Paper for discussion with the WHO Member States on 2 December 2020

25 November 2020

Contents

IMPLEMENTING THE IMMUNIZATION AGENDA 2030:

A Framework for Action through Coordinated Planning, Monitoring & Evaluation, and Ownership & Accountability

1. Introduction

1.1. In August 2020, the Seventy-Third World Health Assembly endorsed **the Immunization Agenda 2030: A Global Strategy to Leave No One Behind (IA2030)** in resolution WHA73/(9). IA2030 defines what needs to happen to achieve the IA2030 vision of a world where everyone, everywhere, at every age fully benefits from vaccines for good health and well-being.

1.2. IA2030 states that it will become operational through regional and national strategies (operational planning), a mechanism to ensure ownership and accountability (O&A), and a monitoring and evaluation (M&E) framework to guide country implementation.

Purpose

1.3. The purpose of this document is to describe how each of these three critical elements will be integrated to enable a successful translation of the strategy into its implementation phase to achieve the IA2030 vision.

1.4. The document first summarizes a set of overarching considerations, and then addresses the following aspects:

- How each of the three critical elements work together as a **"Framework for Action"** (Section 2);
- How these are further **translated into implementation** at country, regional and global levels (Section 3);
- Additional considerations given the current context of **COVID-19** (Section 4); and
- How a **Learning Agenda** (Section 5) will help inform the path ahead.

1.5. An Annex provides a more detailed description of the M&E component.

1.6. This document has been prepared to facilitate the IA2030 presentation and discussion with the **WHO Member States** ahead of the Executive Board session to take place in the first quarter of 2021 and subsequently at the World Health Assembly in May 2021.

1.7. After incorporating feedback from Member States, the document will be available on the IA2030 website by April 2021. It is intended to be a **living document** that is available as guidance at all levels to operationalize IA2030, and will be updated based on new priorities, challenges and needs during the next decade. For example, IA2030 indicators will require critical review and adaptation in light of the evolving COVID-19 pandemic and its effect on immunization programmes.

IA2030 Co-development

1.8. During 2019, the IA2030 Strategy and Vision core document was co-developed with Member States and partners throughout the international community. This co-development approach has

been carried forward into 2020 and underpins development of the operational elements described in this paper.

1.9. Implementation planning also draws on the lessons learned from the implementation of the Global Vaccine Action Plan (GVAP) so that elements that worked well are retained; others seen as less effective have been rethought.

1.10. Each of the three operational elements has been shaped by broad stakeholder inputs:

- The **Ownership & Accountability** design and **operational planning** guidance have been led by the core team of IA2030 partners[1] and included extensive consultations in July and August 2020 with a diverse range of stakeholders, including senior government officials, national immunization programme managers, and representatives from National Immunization Technical Advisory Groups (NITAGs), academia, non-health sectors, civil society organizations (CSOs) and development partners from 26 low-, middle- and high-income countries.
- The **Monitoring & Evaluation** approach was developed by a taskforce with representatives from countries and regions, in collaboration with core IA2030 partners, the seven IA2030 strategic priority content working groups, and in consultation with a "sounding board" that included additional representatives from countries, WHO Regional Offices, the WHO Strategic Advisory Group of Experts (SAGE), academia and CSOs.

1.11. Draft design options for O&A and M&E were reviewed at the October 2020 meeting of SAGE. This document incorporates revisions recommended by SAGE as well as additional input from development partners.

1.12. In addition, options for **Communications and Advocacy (C&A)**, including an IA2030 launch in 2021 and continuous engagement throughout the decade, are being developed with input from development partners, Member States and CSOs.

Guiding principles

1.13. The development of the Framework for Action draws on the following principles:

- **Invite broad ownership to achieve the IA2030 vision** by all immunization and non-immunization stakeholders, including both health system strengthening and disease-specific initiatives. Country ownership is key to achieving the IA2030 vision because the most important actions will be the responsibility of individual countries.
- **Leverage and strengthen existing mechanisms** at country, regional and global levels that provide coordinated ownership and accountability, operational planning, M&E, and communications and advocacy.

[1] IA2030 Core Team has been co-led by WHO and UNICEF, with representation from the Wellcome Trust, Bill and Melinda Gates Foundation, Gavi, US Centers for Disease Control and Prevention, and civil society.

- **Promote continuous quality improvement cycles** for immunization programmes using reliable, timely, high-quality and fit-for-purpose data to focus actions where immunization programme improvement decisions are made and resources are allocated.

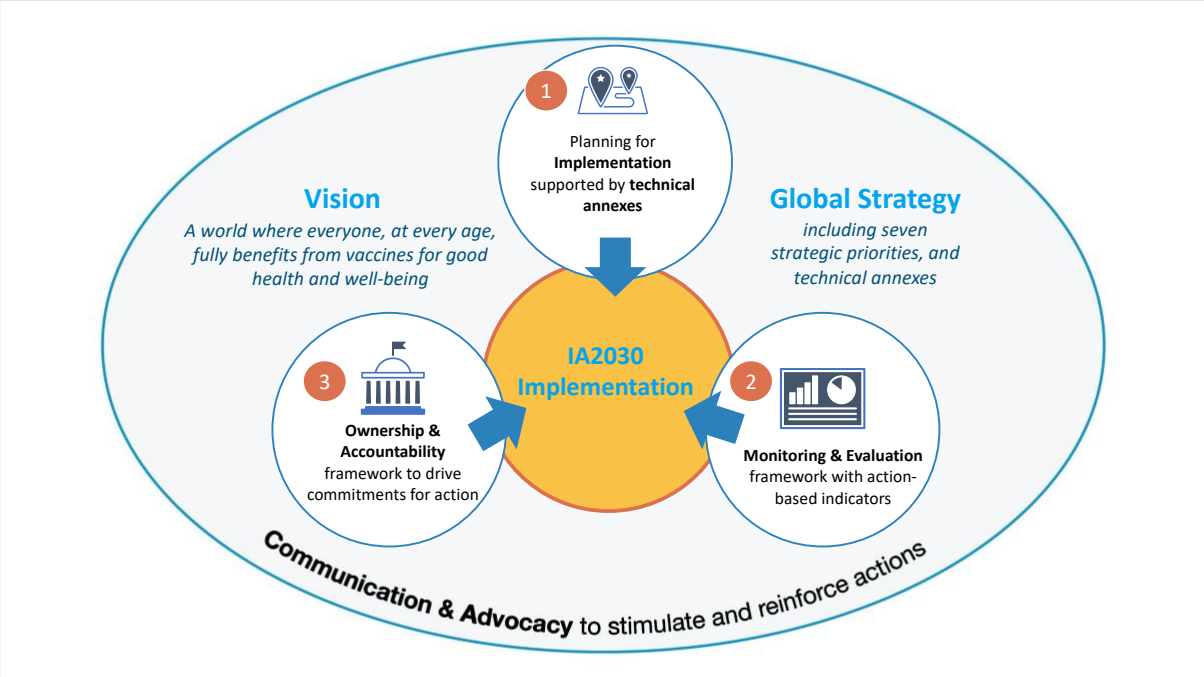
- **Build and strengthen** stakeholder accountability and technical alignment to address country needs for IA2030 strategic priorities.

- **Align and harmonize** with existing regional and national plans and global strategies, including the Sustainable Development Goals (SDGs), Universal Health Coverage (UHC) and Gavi 5.0.

2. IA2030 Framework for Action

2.1. Three key operational elements will be integrated to ***empower and drive actions*** to advance the implementation of IA2030 (**Figure 1**).

Figure 1: IA2030 Framework for Action with three operational elements to drive implementation



2.2. Each of these elements is seen as critical for continuous quality improvement of immunization programmes to achieve the IA2030 vision:

1. **Coordinated Operational Planning** with prioritized actions for implementation by countries, regions and partners and supported by guidance provided in technical annexes for each of the seven IA2030 strategic priorities.

2. **Monitoring & Evaluation (M&E)** with action-based indicators to monitor and evaluate progress toward IA2030 goals and strategic priority objectives, and to inform corrective actions when needed.

3. **Ownership & Accountability (O&A)** with structures and platforms to ensure commitments by stakeholders are captured, technical dialogue is facilitated and aligned, and progress is tracked.

2.3. **Communication and Advocacy** (C&A) is an important cross-cutting enabler for these operational elements, by helping to create the messaging to stimulate and reinforce the required actions by stakeholders.

Coordinated Operational Planning

2.4. Operational planning by Member States, development partners and civil society will translate the vision of IA2030 into concrete actions over the coming decade. Member States will build upon national context and expertise to incorporate tailored aspects of IA2030 into their national strategies and plans as they are updated.

2.5. The operational planning of IA2030 is fully coordinated within existing mechanisms used by Member States as they set national priorities and develop implementation plans to deliver on health-related SDG targets. While these processes will vary across countries and regions, they aim to follow similar key steps to ensure that immunization needs are fully understood, gaps are covered, realistic and meaningful targets are set, and resources are committed.

2.6. These key planning steps include assembling relevant stakeholders from within and beyond immunization and health, reviewing evidence and lessons learned, understanding root causes and improvement needs, referring to best practice, applying up-to-date technical guidance as provided in the IA2030 technical annexes, and shaping the programme according to national priorities. To support country planning, WHO is releasing updated guidance on developing National Immunization Strategies. It will also be essential that CSOs and development partners (where they are present) align their contributions to achieving these goals and targets.

2.7. IA2030 operational planning will also reinforce integration across disease control initiatives, such as those for polio and measles and rubella. As it defines its new endgame strategy, the Global Polio Eradication Initiative (GPEI) should articulate its commitments to IA2030 and demonstrate how the integration of polio eradication and essential immunization activities will contribute to IA2030 strategic priorities. The Measles & Rubella Initiative has released its ten-year Measles and Rubella Strategic Framework, which explicitly identifies contributions to each IA2030 strategic priority, facilitating integration into national and regional planning processes. Regional planning processes should reflect commitments to disease control, elimination and eradication targets endorsed by regional and global bodies.

Monitoring & Evaluation

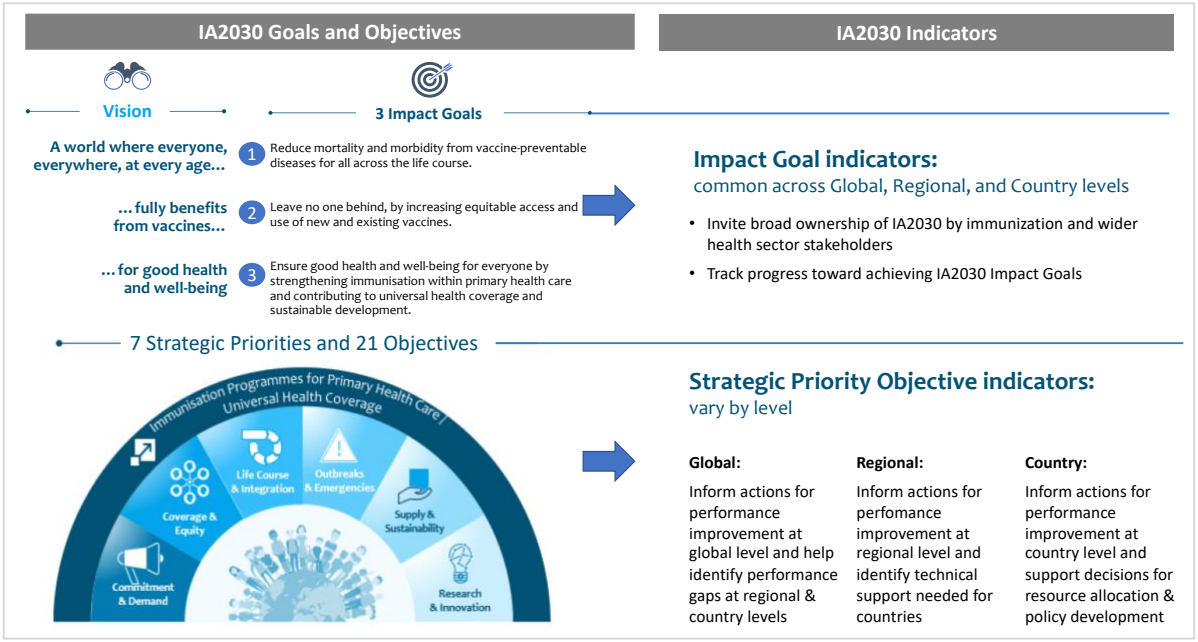
2.8. The IA2030 **Monitoring & Evaluation (M&E) Framework** has action-based indicators intended to empower implementation of monitoring, evaluation, and action (ME&A) cycles, including effective feedback loops at country, regional and global levels.

2.9. These ME&A cycles encourage immunization programme stakeholders to continuously ask the questions:

- *How are we doing?* **(Monitor)**
- *How can we do it better**?*** **(Evaluate)**
- *Who is responsible for doing what to make improvements?* **(Act)**

2.10. The M&E Framework includes **tailored indicators** to ensure the use of data for action to continuously improve immunization programmes at all levels and it provides indicators to monitor progress to achieve the three IA2030 impact goals and the 21 objectives within its seven strategic priority areas (Figure 2).

Figure 2. IA2030 Monitoring & Evaluation Framework Overview



Impact Goal Indicators

2.11. There are six proposed impact goal indicators (Table 1) that are outcome and impact measures common across all levels (global, regional, and country) and designed to track progress toward achieving the three IA2030 impact goals. Progress in impact goal indicators will be evaluated against pre-determined global targets and will be defined by WHA in 2021. A detailed description of each impact goal indicator, including target-setting methods and key uses of the indicator for monitoring, evaluation and action, is provided in Annex 1.

Table 1. Proposed IA2030 Impact Goal Indicators and Targets

Impact Goals	Proposed Indicators		Proposed Targets
1	Save lives	1.1 Number of deaths from vaccine-preventable diseases averted	**TBD** (based on coverage targets & ongoing modelling)
	Control, eliminate & eradicate VPDs	1.2 Number of countries that have achieved global or regional VPD control, elimination and eradication targets	**TBD** (based on updated regional & global commitments)
	Reduce VPD outbreaks	1.3 Number of large outbreaks of vaccine-preventable diseases	**Annual improvement**
2	Leave no child behind	2.1 Number of zero dose children	**Reduce by 50%**
	Deliver across the life course	2.2 Coverage of vaccines included in national immunization schedules (DTP3, MCV2, HPVc, PCV3)	**Global target:** 90% **Country target:** limit drop-out from DTP1 to <5%; introduce vaccines not included in national schedule
3	Strengthen PHC/UHC coverage	3.1 Difference between DTP3 coverage and Universal Health Coverage Service Coverage index	**TBD** (based on analysis of historical trends for UHC index of service coverage)

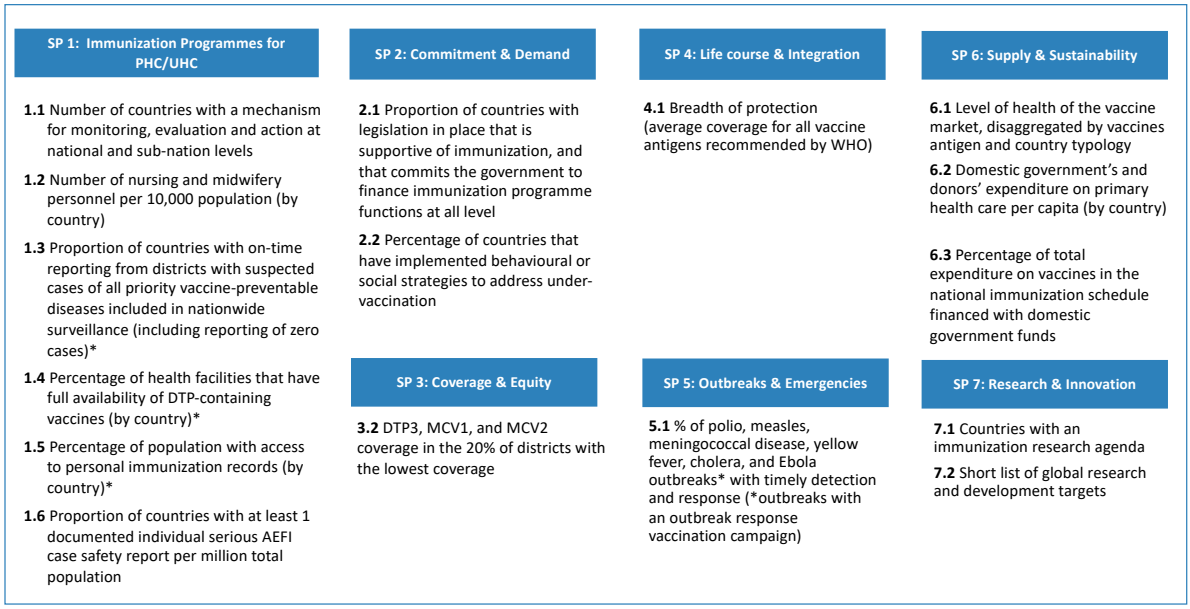
Strategic Priority Objective Indicators

2.12. Strategic priority objective indicators are designed to track performance towards achieving the IA2030 21 SP Objectives and to help identify potential root causes of success and failure so that actions to improve programme performance can be recommended and implemented. These indicators are input, process, output and outcome measures reflecting the need for performance monitoring at global, regional and country levels. Targets are not provided for strategic priority objective indicators, due to wide country and regional variations. Regions and countries are encouraged to assess the baseline for each indicator and to consider setting targets for these indicators that reflect local context.

- **Global strategic priority objective indicators** are intended to assess progress, and to recommend actions for performance improvement at the global level, and to highlight critical performance gaps that need to be addressed at regional and country levels (Table 2). A detailed description of each indicator is provided in **Annex 1**.
- **Regional strategic priority objective indicators**[2] are intended for use by regional bodies to assess progress, recommend actions for performance improvement and to inform tailored technical support to countries.[2] To supplement global indicators, WHO and UNICEF Regional Offices are encouraged to select additional strategic priority objective indicators that are tailored to regional needs and context.
- **Country strategic priority objective indicators**[2] are intended to be used by country bodies to assess progress, recommend actions for immunization performance improvement, and to inform prioritization and allocation of resources and policy development at facility, sub-national and national levels. To supplement global and regional indicators, WHO and UNICEF Country and Regional Offices are encouraged to support Member States to select additional strategic priority objective indicators for country M&E of National Health or Immunization Plans and Strategies that are tailored to local needs and context.

[2] Guidance for selection of regional and country strategic priority objective indicators is provided in Annex 1.

Table 2 Proposed IA2030 Global Strategic Priority Objective Indicators



**Selection of indicator as a global level indicator is under discussion*

2.13. Monitoring of strategic priority objective indicators will signal areas for further in-depth evaluation (e.g. root cause analysis) and facilitate evaluation of immunization programme performance that leads to recommendations for quality improvement. Evaluation of strategic priority objective indicators will focus on monitoring trends through data dashboards. Mechanisms for analysis and interpretation of indicator data (e.g. use of data visualization and scorecards to track progress) will be developed, and platforms for regular evaluation (e.g. SAGE meetings, RITAG meetings, NITAG meetings) will need to be identified. IA2030 technical annexes (under publication at IA2030 website and in Vaccine Supplement) provide guidance for actions needed when M&E identifies areas for improvement.

2.14. Some strategic priority objective indicators identified as "critical but not yet available" are included in the learning agenda and could be included in M&E Framework updates and to inform capacity building at the country level. In addition, indicators will be reviewed and updated during the decade to make sure they continue to be useful for informing action in a changing environment.

Ownership & Accountability

2.15. The vision laid out in the ten-year IA2030 strategy is dependent on numerous and varied stakeholders, each taking on agreed responsibilities to achieve the stated goals (**ownership**). To ensure these contributions are understood, executed and monitored, a process for checking the responsibilities across stakeholders (**accountability**) will ensure partners remain on track.

2.16. As such, the O&A model for IA2030 makes visible the commitments made by different stakeholders and ensures accountability by regular monitoring. Supported by the IA2030 M&E Framework, partners at all levels will have the data to review progress and performance against milestones so that they can take remedial actions when required.

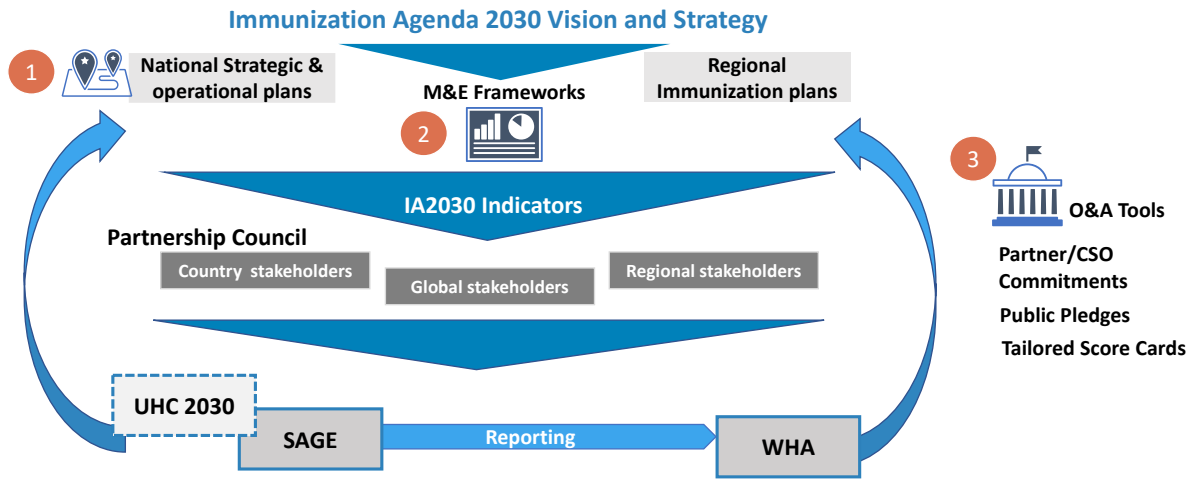
2.17. As highlighted by the UN's Independent Accountability Panel's 2020 Report[3], an effective accountability framework relies on four interconnected pillars, prompting the following questions:

- **Commit:** Have we committed to specific goals, defined responsibilities and required resources?
- **Justify:** Have our decisions and actions to strengthen the achievement of goals and rights been justified by evidence, rights and rule of law?
- **Implement:** Will we monitor and review data, including through independent review, enact remedies, and take necessary action?
- **Progress:** Will we continuously make effective, efficient and equitable progress toward agreed rights and goals?

2.18. This "good practice" framework guides the design of an O&A approach, integrating the necessary tools, structures and information systems. The information flow and use of structures and tools is presented below in Figure 3.

2.19. In creating the approach to O&A, Member States and development partners have called for more systematic and coordinated use of existing structures across country, regional and global levels. In addition, the shared contributions of development partners (including the private sector) and CSOs should be tailored to specific country and regional contexts, with increased visibility and consolidation of vaccine-preventable disease-specific initiatives.

Figure 3. IA2030 Information flow, supported by three operational elements



A Partnership Council for IA2030

2.20. The **Partnership Council**, with membership from a diverse and representative group of stakeholders from across the immunization community, is designed as a new accountability mechanism (or governance structure) put in place to jump start the IA2030 decade with three key objectives:

[3] UN Secretary-General's Independent Accountability Panel (IAP) for Every Woman Every Child. 2020 Report. Geneva: World Health Organization; 2020

- To develop, coordinate and advocate for additional technical support in IA2030 strategic priority areas;
- To mobilize global partner action to achieve IA2030 targets through global-level agenda setting – to focus on and prioritize identified gaps; and
- To monitor global partner support against commitments.

2.21. The IA2030 Partnership Council addresses the current lack of an 'umbrella' forum for all countries regardless of income levels and covering all vaccine-preventable diseases. The design of the Partnership Council will retain many aspects established during collaborative development of the IA2030 vision and strategy.

2.22. Partners involved in development of IA2030 also recognize the complex and ever-evolving global health landscape, with its myriad of initiatives and numerous partner mechanisms. For that reason, the Partnership Council will have a limited term of 3 years, followed by a full review to assess its efficacy and determine its future.

2.23. The following principles are regarded as critical to the functioning of the Partnership Council:

- **Offer stakeholders something different** – to avoid duplication, the Partnership Council should maintain a focus on immunization, while also ensuring close engagement with broader health agendas, such as UHC or maternal, neonatal and child health.
- **Give voice to all countries, regions and communities** – ensure that all stakeholder groups can engage meaningfully as representative members in the council.
- **Leverage country and regional structures** – as fora for reviewing development partner, CSO and Member State progress against pledges and targets, as captured in scorecards
- **Focus on priorities** – ensure that dialogue and resulting actions target priority countries and priority topics.
- **Keep a technical focus** – content working groups, seen as valuable collaborations in the development of IA2030 strategic priorities, will meet routinely to facilitate technical alignment in key strategic priority areas.
- **Meet on an annual basis –** maintain momentum at the start of decade by convening each year, before considering any changes to meeting frequency.

2.24. Co-chaired by WHO and UNICEF, the Partnership Council will comprise approximately 30-35 members (with 2-year appointments made on a rotating basis), including:

- Member State representatives (Ministry of Health or ministry lead for EPI);
- Senior technical/immunization leads from key development partners (e.g. Gavi, BMGF, CDC, Wellcome)
- Civil society representatives, including from a youth constituency
- Private sector representatives
- Content Working Group leads (ensuring roles are filled by non-UN technical experts)
- Directors of disease-specific initiatives (GPEI, M&RI, YF etc.)
- SAGE/RITAG representatives

2.25. A small Secretariat team will be established on a rotating basis between partners, led by a small management committee.

2.26. Content working groups used to develop IA2030 strategic priorities will continue to convene partners on a regular basis. In addition, working groups for M&E, resource mobilization, and communications and advocacy will be established, each to be led by different partners and coordinated by the Secretariat team.

Public Pledging

2.27. Development partners and CSOs will pledge contributions, aligned to their technical roles and the IA2030 strategic priorities to ensure greater transparency and facilitate monitoring of development partner and CSO contributions as well as accountability for the achievement of IA2030 goals.

2.28. Pledging can take the form of financial, human resource or time commitments (e.g. the management of the Partnership Council Secretariat),commitments to take the technical lead on specific IA2030 strategic priority areas at the global, regional or Member State level, or commitments towards regional communication and advocacy mechanisms.

2.29. At the global level, development partners and CSOs will pledge multiyear commitments in advance of the first IA2030 Partnership Council. The pledges will be collected and made available on the IA2030 public website. Each year the Partnership Council will review progress against these pledges, with updates expected every 3-5 years . At the regional and Member State level, the frequency of pledging will be adjusted to regional and Member State planning cycles and will take place within existing coordination mechanisms .

Tailored Scorecards

2.30. Scorecards will be used to track progress as reported against pledged commitments and IA2030 targets. IA2030 scorecards have two distinct objectives:

- To measure progress against publicly pledged commitments by development partners and CSOs at the global, regional and Member State levels; and
- To measure progress against targets from the IA2030 M&E Framework at the global, regional and Member State levels.

2.31. The scorecards will be tailored for use by Member States, regions and global-level actors to inform decision-making and focus attention on priorities to drive remedial action. The tailored approach will support greater accountability of Member States, development partners and CSOs.

2.32. WHO will facilitate the development of global and regional scorecards annually, using triangulated data from routine M&E, primary and complementary sources. Scorecards will be reviewed at the global level by the IA2030 Partnership Council and by existing coordination mechanisms at the Member State and regional level.

2.33. Scorecards will be used to support and strengthen accountability of key actors at all levels, as well as being a management tool for regular progress monitoring, planning and collaboration, for example between ministries of health and partners at the Member State level.

Communications & Advocacy as a cross-cutting enabler

2.34. **Communications and Advocacy (C&A)** will drive political commitment, country ownership and awareness of IA2030. With input from Member States, development partners and CSOs, a set of options is currently being developed for the launch of IA2030 and to strengthen continuous engagement throughout the decade.
2.35. The key objectives guiding the development of the C&A strategy are to:

- Ensure that immunization remains high on the global health agenda and integrated with broad themes such as SDGs and PHC/UHC.
- Ensure strong Member State ownership of IA2030 to drive prioritization and progress on immunization.
- Reinforce accountability for progress on immunization goals and recognition of success.
- Develop an approach that is acceptable, both technically and culturally, in different regional and Member State contexts and useful in support of a broad social movement for immunization.

2.36. The launch of IA2030, planned for the first half of 2021, will signal to the global health and development community and Member States the beginning of the new immunization decade. The key objectives of the launch will be to drive Member State and global political commitment and create public awareness around continued commitment to immunization. The launch will account for the reduced ability for face-to-face interaction by relying on a variety of media platforms.

2.37. Key to successful ongoing commitment will be maintaining momentum beyond the launch. The C&A Strategy lays out options for continuous engagement that will ensure that immunization remains high on global and regional health agendas. Flexible, adaptable initiatives, tailored to a range of audiences, will also help regions and Member States to contextualize data and evidence, and advance messages across a variety of platforms to maintain a national drumbeat of support and accountability for immunization.

3. IA2030 Implementation by Level

3.1. The IA2030 Framework for Action will be taken forward at country, regional and global levels, supported by the following key tools, structures and processes.

Country-level implementation

3.2. Member States are ultimately responsible for implementing IA2030 through commitments to achieve and sustain national immunization targets and goals contributing to the shared IA2030 vision.

3.3. Member States will prioritize elements in IA2030 according to their national and regional contexts. For example, some countries with high coverage and well-resourced programmes may focus primarily on managing international disease outbreaks (COVID-19, flu) or rebutting efforts to undermine confidence in vaccines on social media platforms. Other countries may also prioritize access to affordable, quality-assured vaccine supplies or strategies to target children being missed by

integrated health services. Each country working to address its respective priorities within IA2030 will contribute to achieving shared global impact.

3.4. Member State implementation of IA2030 through their respective national strategies and plans (Table 3) will build upon:

- **Technical input from experts:** National and regional technical advisory groups (e.g., NITAGs, RITAGs) will build upon guidance from SAGE to help Ministries of Health prioritize programmatic areas. Technical annexes for each IA2030 Strategic Priority assist Member States to identify actions to address programmatic priorities.

- **Updated national immunization strategies and operational plans.** Member States will progressively update national strategies and operational plans reflecting their emerging priorities in the context of IA2030.

- **Monitoring, evaluation and action (ME&A) cycles:** Member States will be encouraged to implement ME&A cycles (including effective feedback loops) at all levels to: (1) measure and review IA2030 impact goal and strategic priority objective indicator data on a regular basis; (2) assess national/subnational and partner/CSO progress using tailored indicator scorecards or dashboards, identify potential root causes of success and failure, and identify areas for improvement; and (3) recommend, plan and implement and review actions to improve programme performance.

- **Strengthened, tangible contributions of different in-country stakeholders:** Some countries may establish formal national accountability frameworks or build on independent health observatories that monitor progress on UHC. Other countries may build on existing and strengthened mechanisms such as inter-agency or health sector coordinating committees (ICCs, HSCCs), NITAGs or the Gavi Joint Appraisal process. Whether through new or existing platforms, partners will need renewed focus on holding each other accountable. This increased accountabilty for contributions across different in-country partners will support more effective and coordinated implementation of national priorities. CSOs play a growing role, for example connecting national strategies to communities, to strengthen confidence in immunization and identify marginalized populations with low inmmunization rates. Countries are encouraged to include CSOs in accountability mechanisms.

Table 3. Country Implementation of IA2030

Country Implementation of IA2030		
Commitment	*To achieve and sustain national and regional immunization goals & targets*	
Differentiated IA2030 Priorities	According to country context (e.g.. coverage & equity, hesitancy, integration of services, outbreaks, quality assured vaccine supply, sustainability)	
Advocacy & Communications	National communication and advocacy platforms	
Coordinated Operational Planning	**Monitoring & Evaluation**	**Ownership & Accountability**
Tools & Structures		
• National Health Strategy • National Immunization Strategy • Prioritized operational plans informed by experts (e.g., SAGE, RITAGs)	• IA2030 IG indicators, Global and Regional SP Objective indicators, and additional SP Objective indicators selected by countries tailored to needs and context • Scorecards or dashboards to measure national/subnational & partner/CSO progress • Monitoring frameworks (e.g., National Health Observatory; WHO-UNICEF JRF)	• WHA representation • Regional Committee representation • NITAGs • ICCs/ HSCCs • Civil Society platforms
Processes		
• Coordination through country structures with inclusion of CSOs (e.g. Stakeholder engagement groups, Gavi Joint Appraisal process, Health Sector Coordinating Committee)	Monitoring, Evaluation cycles (including effective feedback loops) at all levels: • Monitor: measure and review IA2030 indicator data on a regular basis • Evaluate: assess progress using tailored indicator scorecards and identify potential root causes of success and failure • Act: recommend actions for implementation, resource allocation and policy development	• Processes to increase accountability of government, partners & CSOs (e.g., Joint Appraisal in Gavi countries, National Accountability Frameworks)

Regional collaboration and support

3.5. Member States, development partners and civil society will work together to advance coordinated IA2030 implementation through regional technical and political fora. They will work together to optimize cooperation to drive results and ensure country programmes meet regional goals and targets. Communication and advocacy focal points will contribute to generating and maintaining support for immunization and IA2030's goals.

3.6. Regional cooperation and support (Table 4) will be implemented by:

- **Tailoring IA2030 strategic priorities to regional priorities.** Regional public health experts (e.g. RITAGs facilitated by development partners) will recommend key technical areas for focus across Member States and means to strengthen integration of immunization across disease control initiatives and within UHC/PHC. Regional priorities will be reflected in strategies, operational plans and M&E frameworks, contributing to global impact goals. Regional structures will assist Member States, development partners and CSOs to regularly monitor progress and systematically identify emerging priorities.

- **Member States determining regional priorities.** Member states will review and decide on the recommendations from various regional structures (e.g., RITAG) through Regional Committees.

- **Monitoring, evaluation and action (ME&A) cycles:** Regions will be encouraged to implement ME&A cycles to: (1) measure and review IA2030 indicator data from countries on a regular basis; (2) assess regional/national and partner/CSO progress using tailored indicator scorecards, identify potential root causes of success and failure, and identify areas for improvement; and (3) recommend actions for improvement of regional perfomance and identify technical support needed for countries to plan and implement actions to improve programme performance

- **Development partner coordination.** Regional priorities will be reflected in 3-5 year operational plans with key focus areas for support across Member States. Development partners will pledge their commitments (e.g. support for specific technical functions) to IA2030, contributing to efficient and effective and coordinated support to Member States. Strengthened Regional Interagency Coordinating Committees can align development partner strategies to regional IA2030 priorities. Regional working groups coordinating development partner operational support to countries can be strengthened with expanded remits and more systematic inclusion of CSOs.

- **CSO commitments.** CSOs will increase the transparency of commitments, roles and contributions to immunization, and its ability to protect the lives of family and neighbours. They will reflect their commitments in pledges.

- **Shared commitments through regional political and economic mechanisms.** Member States will guide the process of seeking commitments and monitoring progress through mechanisms at regional (e.g. African Union, European Union, Association of South-East Asian Nations) or sub-regional (e.g. Southern African Development Community) levels. These will strengthen the impact of technical commitments and contribute to wider ownership and accountability by partners beyond immunization and health.

Table 4. Regional Implementation of IA2030

Regional Implementation of IA2030		
Commitment	*To achieve and sustain national and regional immunization goals & targets*	
Differentiated IA2030 Priorities	According to country context (e.g.. coverage & equity, hesitancy, integration of services, outbreaks, quality assured vaccine supply, sustainability)	
Advocacy & Communications	National communication and advocacy platforms	
Coordinated Operational Planning	**Monitoring & Evaluation**	**Ownership & Accountability**
Tools & Structures		
• Regional Strategic Plans • 3-5 year regional operational plans with selected programmatic key focus areas for support across Member States • Regional Working Groups (e.g., strengthening of existing Gavi groups to include CSOs and coordinate support to non-Gavi countries) • Regional Interagency Coordinating Committees	• IA2030 Impact Goal indicators, Global and Regional SP Objective indicators, and additional SP Objective indicators selected by regions tailored to needs and context • Scorecards with country and regional progress • Scorecards for partner/CSO progress • WHO-UNICEF Joint Reporting Form • WHO Immunization Information System	• **RITAGs** • **Regional Committees** • **Regional Working Groups** • **Other Regionally tailored structures** (e.g., Regional Cooperation Organizations, Regional Accountability Councils)
Processes		
• RITAGs facilitated by development partners recommend key technical areas for focus across Member States • Coordination with UHC and PHC • Coordination with disease-specific initiatives	• Monitor: compile country data to report on indicators • Evaluate: assess regional/national & partner/CSO progress using tailored indicator scorecards and identify potential root causes of success and failure • Act: Recommend actions for regional perfomance improvement and identify technical support needed for countries	• Multi-year pledges from Partners/CSOs

Global commitments

3.7. Member States, development partners and civil society will work together at the global level to ensure the highest level of financial, technical and political commitment to IA2030 and to coordinate responses to priority areas with a global reach, such as advocacy, vaccine supply, innovation and technical guidance. Global-level stakeholders will monitor global partner support to the implementation of IA2030 and progress towards IA2030 global impact goals and indicators.

3.8. As presented above in Section 2 on O&A, global cooperation and monitoring (**Table 5**) will be implemented through:

- **Global coordination through a Partnership Council** established to support technical alignment in IA2030 strategic priority areas, monitor targets and progress globally, and to mobilize and monitor partner commitments and pledges to IA2030.

- **Public pledging** of development partner and CSO commitments aligned to IA2030 strategic priorities. Pledging of multiyear commitments to the achievement of IA2030 goals will ensure greater transparency and monitoring of development partner and CSO accountabilities and contributions.

- **Monitoring, evaluation and action (ME&A) cycles:** Global partners and CSOs will be encouraged to implement regular ME&A cycles to: (1) measure and review IA2030 indicator data from countries and regions on a regular basis; (2) assess regional/national and partner/CSO progress using tailored indicator scorecards, identify potential root causes of success and failure, and identify areas for improvement; and (3) inform actions for performance improvement at the global level and identify performance gaps at regional and country levels.

- **Strengthened links to non-immunization sectors and actors** will be achieved by establishing links to structures and processes associated with PHC/UHC. A proposal is under consideration for the IA2030 Partnership Council to contribute to the UHC2030 agenda and governing bodies by targeted contributions in the Steering Committee and integration of immunization into thematic task teams..

Table 5. Global Commitments of IA2030

Global Implementation of IA2030		
Commitment	*To sustain the highest level of technical and financial commitment to IA2030*	
Differentiated IA2030 Priorities	According to global function (e.g., coordination, vaccine supply, normative guidance, research & innovation, financing)	
Advocacy and communication	Global Communication and Advocacy Focal Points	
Coordinated Operational Planning	**Monitoring & Evaluation**	**Ownership & Accountability**
Tools & Structures		
Partnership Council IA2030 Content Working Groups Disease-specific strategies and road maps (e.g., GPEI, MRI) Partner strategies (e.g., Gavi 5.0)	• IA2030 IG indicators and Global SP Objective indicators • WHO-UNICEF JRF • WHO Immunization Information System • Scorecards with country and regional progress • Scorecards for partner/CSO progress	• Partnership Council • UHC2030 (exploring) • WHO Strategic Advisory Group of Experts • World Health Assembly
Processes		
Operational plans by topics or SP as need arises	• Monitor: compile country and regional data to report on IG and SP Objective indicators; compile partner/CSO data to report on progress • Evaluate: assess regional and national progress using tailored indicator scorecards and identify potential root causes of success and failure • Act: inform actions for performance improvement at global level and identify performance gaps at regional & country levels	• Multi-year pledges from Partners/CSOs

4. IA2030 in the context of COVID-19

4.1. Emerging global health challenges, such as the COVID-19 pandemic, reinforce the value of immunization and the need for a flexible and sustainable approach to build country, regional and global immunization capacity.

4.2. IA2030 was written to anticipate pandemics and regional outbreaks while maintaining a focus on progressive improvement in immunization programmes over a decade. The IA2030 Strategy's **technical annexes**[4] provide guidance that can be applied to COVID-19 responses, such as:

IA2030 strategic priorities in light of the COVID-19 pandemic:

- **Outbreaks & Emergencies (SP5):** Guidance on the immediate responses needed, including aspects of surveillance, maintaining immunization and other primary health care services, and engaging communities.

- **Vaccine Supply & Sustainability (SP6):** Guidance on the innovative incentives needed to engage manufacturers to develop products for an emerging pathogen.

Recovery and ongoing prevention:

- **Immunization within PHC/UHC(SP1):** Guidance on vaccine safety monitoring, supply chain and logistics, and availability of skilled health workforce.

- **Life Course & Integration (SP4):** Guidance on implementation of vaccination strategies for older age groups, including adults.

- **Research & Innovation (SP7):** Guidance on implementation and operational research supporting immunization services in the context of emerging challenges.

4.3. In particular, COVID-19 is impacting on regional planning to operationalize IA2030 and M&E processes. A number of plans for 2020 have been postponed until 2021 as development partners in each region revise schedules in the context of COVID-19 for engaging technical experts and Regional Committees.

4.4. COVID-19 is also likely to impact the development of M&E Frameworks of countries and regions. For example, baseline data and targets are likely to need adjustment as more is learned about the impact of COVID-19 on services and how quickly services recover.

5. Learning Agenda for the Path Ahead

5.1. IA2030 is a living and evolving strategy for the decade ahead. Member States, development partners and CSOs will need to build from the initial operationalization of elements outlined in this document to address emerging challenges and contextual changes.

[4] To be released on the IA2030 website shortly

5.2. In particular, the IA2030 M&E Framework should remain fit for purpose for the new decade. Thus, the Framework should be reviewed and updated at least once every three years in response to changing needs and improvements in M&E methods to ensure it delivers the data required to improve programme performance. Similarly, the IA2030 technical annexes will also require regular updates over the decade. This need for flexibility is highlighted by the uncertainty associated with recovery from the COVID-19 pandemic.

5.3. Mechanisms will need to be created (for example with support from the Partnership Council) to capture the learning and associated recommendations. Specific elements for learning during IA2030 are likely to include:

Ownership & Accountability

- Implications of changing political and financial commitments to immunization, and IA2030 more broadly, in the context of COVID-19 and implementation of COVID-19 vaccines.
- Most efficient means to engage diverse CSOs to strengthen community-level ownership and accountability for immunization.
- Added value of strengthened fora (e.g. Regional Working Groups) or new mechanisms (e.g. IA2030 Partnership Council) and tools designed to secure and sustain stronger ownership and improve accountability (e.g., public pledges and tailored scorecards).

Operational Planning

- Planning and review processes that extend beyond the traditional WHO/UN mechanisms and engage diverse development partners and CSOs.
- Opportunities for more efficient, timely and reliable data collection and use through digital innovations.

Monitoring & Evaluation

- Means to strengthen capacity on an on-going basis to implement ME&A cycles at country, regional and global levels.
- Strengthening both the quality and the use of data, including creation of data visualization dashboards for M&E Framework indicators at global, regional and country levels.
- Ways to link the JRF process and other data sources to IA2030 ME&A cycles, including use of the WHO Immunization Information System (WIISE) (add link to website). These efforts should ideally include identifying owners and actions for all M&E indicators and decreasing the data-reporting burden for countries by having only relevant indicators which drive improvement action.
- Need for any additional indicators to identify and track severe gaps in health system performance so support is provided to countries with the biggest needs.

Communication & Advocacy

- Responsiveness to changing attitudes to immunization and adaptation of strategies as appropriate
- Ways to solicit and secure greater community-driven commitment to immunization through CSOs and the subsequent translation into increased national and regional commitments.
- Means to respond to misinformation about vaccines disseminated through changing social media platform.

List of Acronyms

BMGF	Bill and Melinda Gates Foundation
C&A	Communications and Advocacy
CDC	Centers for Disease Control
CSO	Civil Society Organisation
EPI	Expanded Programme for Immunisation
GPEI	Global Polio Eradication Initiative
GVAP	Global Vaccine Action Plan
HSCC	Health Sector Coordinating Committee
ICC	Inter-agency Coordinating Committee
IG	Impact Goal
JRF	Joint Reporting Form
ME&A	Monitoring, Evaluation and Action
M&RI	Measles and Rubella Initiative
NITAG	National Immunization Technical Advisory Groups
O&A	Ownership and Accountability
PHC	Primary Health Care
RITAG	Regional Immunization Technical Advisory Group
SAGE	WHO Strategic Advisory Group of Experts
SDGs	Strategic Development Goals
SP	Strategic Priority
UHC	Universal Health Coverage
WIISE	WHO Immunization Information System
YF	Yellow Fever

Annex 1 – Monitoring and Evaluation Framework

Impact Goal (IG) Indicators:

This section is under development.

INDICATOR 1.1 Number of deaths from vaccine-preventable diseases averted		
MONITOR ***How will progress be monitored?***	**EVALUATE** ***How will results of monitoring be evaluated?***	**ACT** ***How will evaluation be used for action?***
Definition: (1) Deaths that would have occurred without the achieved immunization coverage and (2) potential deaths that could be averted due to scale-up of coverage additional to (1). **Measurement approach**: A modelling approach is used, with immunization coverage as key input, to estimate the number of deaths averted for achieved coverage compared to baseline scenarios. Calibration of impact parameters is done using the cohort component method of population projection, which allows calculation of deaths averted at any point in vaccine's lifetime. Measurement is at global and regional levels. **Calculation:** Number of deaths due to vaccine-preventable diseases (VPDs) occurring at defined baseline – number of deaths occurring due to VPDs at achieved level of immunization coverage. $\mu_{c,t} = f_c(cov_t, prev_t, \eta_t, \gamma_t)$ Calibration of the cohort component projection model (CCPM) using various input data. $\mu_{c,t}$ = VPD mortality for some antigen related cause-of-death cov_t= function of coverage $prev_t$=prevalence of the condition η_t =case-fatality rate γ_t = mortality reduction due to vaccination **Data source:** WUENIC coverage estimates, VIMC model outputs, and other sources as relevant. **Stakeholder(s) responsible for measurement:** WHO Immunization, Vaccines and Biologicals (IVB) and DDI project team, stakeholder committee for vaccine impact estimates for IA2030, and Vaccines-related Implementation Research Advisory Committee (IVIR-AC).	**Baseline:** Deaths occurring according to 2019 coverage level the most recent year for which WUENIC estimates are available extended to the time period 2020-2030 (the remaining years until 2030) **Target:** Estimated deaths averted relative to the baseline: (1) No vaccination scenario, (2) aspirational coverage target scenario by vaccine; initial set of targets for the VIMC 10 pathogens, diphtheria, tetanus, pertussis, and TB (BCG) are used as the primary targets for IA2030 time period. Targets for other diseases are set as models are available. **Analysis and interpretation:** • Analysis conducted by modelling team; results displayed on shared dashboard; reviewed at global, and regional level • Results disaggregated by vaccine and cohort year for investigation of specific diseases or year where progress is not achieved. • Disaggregation by country considered **Frequency of evaluation:** Annual.	Global, regional, and country partners can use evaluation findings for advocacy in securing commitment and resources for immunization programmes. Specific recommendations by vaccine highlighted in evaluation may be used to plan disease specific interventions at global, regional, or country level

Frequency of reporting: Annual, with different diseases to be phased in across several years: **2021-2030**: VIMC 10 pathogens (hepatitis B, Hib, HPV, JE, measles, MenA, *Streptococcus pneumoniae*, rotavirus, rubella, yellow fever), diphtheria, tetanus, pertussis, TB (BCG) **2022-2030**: Polio, typhoid, influenza, cholera, multivalent meningitis, COVID-19 **2023-2030**: Varicella, dengue, mumps, rabies, hepatitis A, hepatitis E, other new vaccines. **2024-2030**: Other new vaccines		

INDICATOR 1.2 Number of countries that have achieved global or regional VPD control, elimination and eradication targets		
MONITOR ***How will progress be monitored?***	**EVALUATE** ***How will results of monitoring be evaluated?***	**ACT** ***How will evaluation be used for action?***
Definition: Achievement of VPD control, elimination and eradication targets that have been endorsed by a global or regional body of WHO Member States. **Measurement approach**: WHO Regional Offices will: (1) conduct an annual assessment to identify all VPDs with established control, elimination or eradication targets (i.e. endorsed and up-to-date); and (2) establish a process to assess achievement of all established VPD control, elimination and eradication targets by countries (e.g. verification/certification commissions). **Calculation:** Number of countries that achieve targets for VPD control, elimination and eradication that have been endorsed by global or regional body. **Data Source:** Verification and certification commission reports. **Stakeholder(s) responsible for measurement:** Verification and certification commissions established by WHO Regional Offices with technical assistance from VPD control, elimination and eradication initiatives.[5] **Frequency of reporting:** Annual.	**Baseline:** The baseline will be the number of countries that have achieved each VPD control, elimination or eradication target by the end of 2021. **Targets:** VPD control, elimination and eradication target definitions as described when they are set by regional or global bodies of Member States. **Analysis and interpretation:** The achievement status of each VPD control, elimination and eradication target will be monitored annually for each country. Cumulative progress will be tracked over the decade by monitoring annual trends in the number of countries that have achieved each VPD control, elimination and eradication target. **Frequency of evaluation:** Annual.	Global, regional, and country partners can use evaluation findings for operational planning, and for communication and advocacy to: • ensure needed support to countries to achieve VPD control, elimination and eradication initiatives; • highlight and reinforce coordination of strategies to link VPD control, elimination and eradication initiatives with health system strengthening initiatives.

[5] Disease-specific initiatives include: Polio Endgame Strategy 2019–2023; Measles and Rubella Strategic Plan 2012–2020; Ending Cholera – A Global Roadmap to 2030; Global Health Sector Strategy on Viral Hepatitis 2016–2021; Defeating Meningitis by 2030 Roadmap; Global Influenza Strategy 2019–2030; Zero deaths from dog-mediated rabies by 2030 (Zero by 30: The Global Strategic Plan); Achieving and sustaining maternal and neonatal tetanus elimination: Strategic Plan 2012-2015; Global Vector Control Response 2017–2030; Eliminate Yellow Fever Epidemics

INDICATOR 1.3 Number of large outbreaks of vaccine-preventable diseases		
MONITOR ***How will progress be monitored?***	**EVALUATE** ***How will results of monitoring be evaluated?***	**ACT** ***How will evaluation be used for action?***
Definition: A VPD outbreak* meeting at least one criterion from Annex 2 of the International Health Regulations (https://www.who.int/ihr/annex_2/en/) and with national spread into multiple regions, or with spread into multiple countries. ***including cholera, Ebola, meningococcus, measles, polio, rubella, typhoid, yellow fever; the list could be revised as additional diseases become vaccine preventable. **Measurement approach**: Large VPD outbreaks will be identified using data from the WHO World Health Emergencies Event Based Surveillance system and from VPD-specific outbreak data. Different criteria will be applied for each disease. For multi-country outbreaks, each country's portion of the outbreak will be counted separately. The overall indicator will function as a composite combining data across the different diseases. **Calculation:** A count of outbreaks of epidemic prone diseases that meet set criteria in terms of number of cases and geographic extent. **Data Source:** WHO World Health Emergencies Event Based Surveillance system and VPD-specific outbreak data. **Stakeholder(s) responsible for measurement:** International Coordinating Group for Vaccine Provision	**Baseline:** The proposed baseline year for measurement of large VPD outbreaks is 2021. **Target:** An initial proposed target is an annual reduction in the number of "large VPD outbreaks" for each VPD; an aspirational target of decreasing the number of large VPD outbreaks to zero might be considered during the decade. **Analysis and interpretation:** Annual trends in the number and size of outbreaks of each VPD assess progress of country, regional, and global efforts to prevent and control VPD outbreaks **Frequency of evaluation:** Annual	Global, regional, and country partners can use evaluation findings for operational planning, and for communication and advocacy to: • ensure timely availability and strategic allocation of vaccines and supplies, mobilization of trained human resources for outbreak response • ensure capacity of immunization programmes to anticipate, prepare for, detect and rapidly respond to VPD and emerging disease outbreaks • ensure capacity of immunization programmes to establish timely and appropriate immunization service delivery during emergencies and in communities affected by conflict, disaster and humanitarian crisis • ensure vaccine introduction and scale up of coverage to prevent newly emerging VPDs • use measles cases and outbreaks as a tracer to identify weaknesses in immunization programmes, and to guide programmatic planning in identifying and addressing these weaknesses.

WHO Headquarters and WHO Regional Offices with technical assistance from VPD control, elimination and eradication initiatives[6] **Frequency of reporting:** Annual		

[6] Disease-specific initiatives include: Polio Endgame Strategy 2019–2023; Measles and Rubella Strategic Plan 2012–2020; Ending Cholera – A Global Roadmap to 2030; Global Health Sector Strategy on Viral Hepatitis 2016–2021; Defeating Meningitis by 2030 Roadmap; Global Influenza Strategy 2019–2030; Zero deaths from dog-mediated rabies by 2030 (Zero by 30: The Global Strategic Plan); Achieving and sustaining maternal and neonatal tetanus elimination: Strategic Plan 2012-2015; Global Vector Control Response 2017–2030; Eliminate Yellow Fever Epidemics

INDICATOR 2.1. Number of zero dose children		
MONITOR ***How will progress be monitored?***	**EVALUATE** ***How will results of monitoring be evaluated?***	**ACT** ***How will evaluation be used for action?***
Definition: Zero-dose children are defined as those that lack access to or are never reached by routine immunization services. They are operationally measured as those who lack a first dose of a DTP-containing vaccine. **Measurement Approach**: This indicator is calculated as the difference between the estimated number of surviving infants and the estimated number of children vaccinated with DTPcv-1. The number of zero-dose children will be determined at country, region and global level using WHO and UNICEF estimates of national immunization coverage (WUENIC) and UNPD population estimates of birth cohorts, adjusted for surviving infants. At the national and subnational level, administrative reporting systems can also be used, together with any in-country survey results and other information sources that can help countries establish estimates for zero-dose children. **Calculation:** This indicator is calculated as the difference between the estimated number of surviving infants and the estimated number of children vaccinated with DTPcv-1. **Data Source:** WUENIC, UNPD population estimates **Stakeholder(s) responsible for measurement:** WHO IVB, National Immunization programmes **Frequency of reporting**: Annual at regional and global level, monthly at national and subnational levels	**Baseline:** 14 million children (2019) **Target:** Reduction in the number of zero-dose children by 50% (all levels). In countries where DTP1 coverage already reaches 99%, the target is to maintain coverage. **Analysis and interpretation:** The level and trend of the number of zero-dose children needs to be analysed with an equity lens, aiming to find out where inequalities might point to barriers to immunization across specific populations and geographies. This requires disaggregation by subnational levels and other dimensions (socio-economic, language group, ethnicity) as available. In this context, the number of zero-dose children needs to be used to identify underserved, undervaccinated communities. **Frequency of evaluation:** Annual at global and regional level. Ideally quarterly at national and subnational level.	At the global and regional level, the number of zero dose children by region and country will lead to a prioritization of efforts,and can be used to create accountability for countries that do not reach targets, or backslide from previously attained targets. Furthermore, it can be used to communicate about immunization gaps that exist in the world, and advocate for concerted efforts to bridge them. At the country and subnational level, identifying zero-dose children and underserved communities should facilitate a root cause analysis of the reasons for under-vaccination, and identification of the barriers that exist for certain communities and geographies. From a communication perspective, the importance of this indicator will highlight the need to focus on equity in immunization.

INDICATOR 2.2. SDG 3.b.1 - Coverage of vaccines included in national immunization schedules (DTP3, MCV2, HPVc, PCV3)		
MONITOR ***How will progress be monitored?***	**EVALUATE** ***How will results of monitoring be evaluated?***	**ACT** ***How will evaluation be used for action?***
Definition: Immunization coverage for DTPcv-3, MCV-2, PCV3 and HPVc **Measurement approach**: Immunization coverage for a certain year is defined as the proportion of the targeted population that received the relevant vaccine and dose in that year. Coverage will be determined at country, region and global level, using WHO and UNICEF estimates of national immunization coverage (WUENIC). Note that for WUENIC, the annually targeted population for globally recommended vaccines comprises the entire global cohort of surviving infants, regardless of whether the vaccine was introduced in their country. At the national and subnational level, administrative reporting systems can also be used, together with any in-country survey results and other information sources that can help countries establish coverage estimates. **Calculation:** Denominator is estimated population of target group of children that should receive DTPcv-3, MCV-2, PCV3 and HPVc. Numerator consists of target population who have received DTPcv-3, MCV-2, PCV3 and HPVc. Target population of children and their appropriate age for last dose is determined by national immunization schedule. **Data Source:** WHO and UNICEF estimates of national immunization coverage (WUENIC) **Stakeholder(s) responsible for measurement:** WHO IVB, National Immunization programmes **Frequency of reporting**: Annual at regional and global levels, monthly at national and subnational levels.	**Baseline: 85%** DTPcv-3, **71%** MCV-2, **48%** PCV3 and **15%** HPVc (2019) **Target:** Global level: **90%** coverage for all by 2030 Country level: • Plan introduction of all globally recommended vaccines by 2030 • Ensure coverage for each vaccine reaches levels within a 5% range from DTPcv-1 **Analysis and interpretation:** Level and trend, disaggregated by geography and other dimensions (socio-economic, language group, ethnicity) as available. **Frequency of evaluation:** Annual at global and regional levels. Ideally quarterly at national and subnational levels.	At the global and regional level, coverage estimates will be used for prioritization, and to create accountability for countries that don't reach targets, or backslide from previously attained targets. Furthermore, coverage estimates can be used to communicate about immunization gaps that exist in the world, and advocate for concerted efforts to bridge them. At the country and subnational level, measuring the level and trend of coverage, as well as estimates of vaccinated people (numerators), can help establish whether: • Immunization programmes are showing desired progress overall, by geography, and by population group. • Immunization platforms for the different age groups perform adequately. • Vaccine-specific barriers exist. Immunization programmes can then implement any corrective action.

INDICATOR 3.1. Difference between national DTP3 coverage & Universal Health Coverage Service Coverage index

MONITOR ***How will progress be monitored?***	**EVALUATE** ***How will results of monitoring be evaluated?***	**ACT** ***How will evaluation be used for action?***
Definition: The gap between national DPT3 coverage and the Universal Health Coverage Service Coverage Index (UHC SCI). **Measurement Approach:** National DPT3 coverage is available through WHO UNICEF Immunization Coverage estimates. The UHC SCI is indicator 3.8.1 for the Sustainable Development Goals. The indicator is constructed from four categories of tracer indicators: 1) reproductive, maternal, newborn and child health; 2) infectious diseases; 3) non-communicable diseases; and 4) service capacity and access. For each country, narrowing of the gap between DPT3 coverage and the UHC SCI will be calculated by comparing changes in both measures independently: • DPT3 coverage will be required to be ≥90% • UHC SCI annual improvement will be required to be equal to or greater than historic performance (From 2015 to 2017, 75% of countries had an average increase of 1% per year). In addition, differences between the two indices will be calculated. **Stakeholder(s) responsible for measurement:** • Primary Health Care Performance Initiative • WHO Department of Service Delivery and Safety • WHO Department of Immunization, Vaccines and Biologicals **Data Sources:** WHO UNICEF Immunization Coverage Estimates and Universal Health Coverage Service Coverage Index. **Frequency of reporting:** Annual.	**Baseline:** Baseline and targets are based on data from 2015 to 2017. During this period: • 67% (123 of 183) countries had ≥90% national DPT3 coverage (maximum value from 2015 and 2017) • 75% (138 of 183) countries had an average increase of 1% per year improvement in the UHC SCI • 51% (93 of 183) countries had both national DPT3 coverage ≥90% and an average increase of 1% per year improvement in the UHC SCI **Target:** TBD; a target for the indicator would be considered when the target for the Sustainable Development Goal indicator 3.8.1 is determined. **Analysis and interpretation:** Progress against the global DTP3 target of 90% will be evaluated for all countries annually. Annual (or as frequent the UHC SCI is published) improvement in the SCI will be evaluated against the expected 1% increase per year. The threshold of 90% will be applied to both measures. Therefore, for countries which have national DTP3 coverage of ≥90% the UHC SCI is the driving factor for reducing the gap. **Frequency of evaluation:** Annual	Global, regional, and country partners can use evaluation findings for communication and advocacy to: • promote alignment of IA2030 & UHC/PHC system strengthening efforts • promote efforts to integrate delivery of immunization & other UHC/PHC services

Strategic Priority Objective Indicators Summary

This section is under development. Additional regional and country indicators for monitoring SP Objectives will be developed by regions and countries for inclusion in their IA2030 M&E plans.

SP Objective	Global monitoring	Options for regional monitoring	Options for country monitoring
1.1 Leadership, Management, and Coordination	Number of countries with a mechanism for monitoring, evaluation and action at national and sub-national levels	Number of countries with a mechanism in place for evaluating immunization programme performance at least once/yr	**Needed for reporting up:** • Mechanism in place for monitoring, evaluation and action at national, sub-national levels **Additional action-based indicators:** • % districts (or equivalent at subnational level) with a process in place to monitor, evaluate and drive action cycles to continuously improve immunization programme quality • % of district health management committees (or equivalent at subnational level) that review immunization performance as part of primary health care performance at least annually
1.2 Health Workforce	Number of nursing and midwifery personnel per 10,000 population (by country)	Number of nursing and midwifery personnel per 10,000 population (by country)	**Needed for reporting up:** • Number of nursing and midwifery personnel per 10,000 population (by country) **Additional action-based indicators:** • Vaccinators per 10,000 population per region • PHC team members per 10,000 population per region • Positions filled vs vacant (% vacant positions of nursing and frontline health workers) • Percentage of facilities that are led by a manager(s) who has official management training (for example, a certification, diploma, or degree) • Health workforce competencies are established

SP Objective	Global monitoring	Options for regional monitoring	Options for country monitoring
1.3 Surveillance	Proportion of countries with on-time reporting from districts with suspected cases of all priority vaccine-preventable diseases included in nationwide surveillance (including reporting of zero cases)	Proportion of countries with on-time reporting from districts with suspected cases of all priority vaccine-preventable diseases included in nationwide surveillance (including reporting of zero cases)	**Needed for reporting up:** • % of districts not reporting any suspected vaccine-preventable diseases (i.e., "silent" districts) in a 12-month period **Additional possible action-based indicators:** • % of districts reporting at least 90% on time during a one-year period for suspected cases for all priority VPDs under nationwide surveillance, including reporting of zero cases. • Non-polio acute flaccid paralysis rate of >1/100,000 among <15 years population in a 12-month period • Non-measles/non-rubella discard rate of ≥2/100,000 persons
1.4 Supply chains	Percentage of health facilities that have full availability of DTP containing vaccine (by country)	Percentage of health facilities that have full availability of DTP containing vaccine (by country) EVMA score	**Needed for reporting up:** • % of health facilities that have full availability of DTP containing vaccine **Additional possible action-based indicators:** • All 7 DISC indicators • % districts reporting stock availability (vaccines and supplies) at a service delivery level • % districts having electronic vaccine and supply stock management system in place
1.5 Information systems	Percentage of population with access to personal immunization records (by country)	Percentage of population with access to personal immunization records (by country) Evaluation score (e.g. EISQ)	**Needed for reporting up:** • % of population with access to personal immunization records **Additional possible action-based indicators:** • Availability of sustainable and effective immunization information system integrated within a robust national health information system (HIS) • % of districts with on-line access to HMIS • Completeness and timeliness of reporting

SP Objective	Global monitoring	Options for regional monitoring	Options for country monitoring
			• Micro plans based on evidence
1.6 Vaccine safety	Proportion of countries with at least 1 documented (with reporting form and/or line listed individual serious AEFI case safety reports per million total population	Proportion of countries with at least 1 documented (with reporting form and/or line listed) individual serious AEFI case safety reports per million total population	**Needed for reporting up:** • Individual AEFI case safety reports above threshold per million total population **Additional possible action-based indicators:** • Functional AEFI system exists
2.1 Political and financial commitment	Proportion of countries with legislation in place that is supportive of immunization, and that commits the government to finance immunization programme functions at all levels	Proportion of countries with legislation in place that is supportive of immunization, and that commits the government to finance immunization programme functions at all levels	**Needed for reporting up:** • Legislation is in place that is supportive of immunization, and that commits the government to finance immunization programme functions at all levels **Additional possible action-based indicators:** • High-level document (e.g. national policy, law, decree) making childhood immunizations a national priority/child right • Commitment tracking and accountability frameworks used at country and subnational levels
2.2 Demand for immunization	Percentage of countries that have implemented behavioural or social strategies (i.e., demand generation strategies) to address under-vaccination	Percentage of countries that have implemented behavioural or social strategies (i.e., demand generation strategies) to address under-vaccination	**Needed for reporting up:** • Implementation of behavioural or social strategies (i.e., demand generation strategies) to address under-vaccination in the previous year **Additional possible action-based indicators:** • Civil societies, private sector, and communities actively participating to ensure high immunization uptake • Existence of immunization-specific regulation to address hesitancy • Percentage of schools teaching the importance of vaccination

SP Objective	Global monitoring	Options for regional monitoring	Options for country monitoring
			• Percentage of population affirming confidence in vaccination (E.g., Wellcome Global Monitor data on trust in vaccines) • All Health Facility microplans include flexible service delivery strategy with monitored engagement with community and private sector stakeholders
3.1 Reach of Immunization services	None	Number of countries with evidence-based and funded plan to address coverage of high-risk communities	**Needed for reporting up:** • Evidence-based and funded plan to address coverage of high-risk communities exists **Additional possible action-based indicators:** • % of districts with (micro) plans that specifically target under-immunized communities • % of districts in which at least 80% of planned (outreach) sessions are also held • >90% of eligible children in the disadvantaged population are reached and vaccinated according to national schedule.
3.2 High & equitable coverage	DTP3, MCV1, and MCV2 coverage in the 20% of districts with the lowest coverage (by country)	DTP3, MCV1, and MCV2 coverage in the 20% of districts with the lowest coverage (by country)	**Needed for reporting up:** • DTP3, MCV1, and MCV2 coverage in the 20% of districts with lowest coverage **Additional possible action-based indicators:** • Dropout rates between first dose (DTP1) and third dose (DPT3) of DTP-containing vaccine
4.1 Life-course vaccination	Breadth of protection (mean coverage for all vaccine antigens recommended by WHO by country)	Breadth of protection (mean coverage for all vaccine antigens recommended by WHO by country)	**Needed for reporting up:** • Proportion of WHO recommended vaccines present within their national immunization schedule**.**

SP Objective	Global monitoring	Options for regional monitoring	Options for country monitoring
			Additional possible action-based indicators: • Available policies and laws for mandatory vaccination throughout life course • Activate adult vaccination in patients who have NCDs and are at risk of dying from vaccine preventable diseases including influenza and PCV
4.2 Integrated delivery points	None	Number of countries with national policies or standard operating procedures in place to strengthen delivery of immunization services integrated with primary health care, across the life course	**Needed for reporting up:** • National policies or standard operating procedures in place to strengthen delivery of immunization services integrated with primary health care, across the life course **Additional possible action-based indicators:** • % of PHC Centers integrating immunization services with other PHC services • % of Tertiary health care providing daily immunization service • Countries have formal engagement of vaccination services with the following health and development sectors/services to strengthen provision of vaccinations throughout the life course: schools, antenatal care services, labor & delivery care services, and private healthcare providers • Use of birth registration boost via immunization services
4.3 New vaccine introduction	None	Number of countries with all newly recommended vaccine antigens by WHO in the national immunization schedule	**Needed for reporting up:** • Proportion of all newly recommended WHO vaccines within their national immunization schedule within X years of WHO policy recommendation. **Additional possible action-based indicators:** • Proportion reached with the last dose of WHO recommended vaccines

SP Objective	Global monitoring	Options for regional monitoring	Options for country monitoring
5.1 Outbreak detection and response	Percentage of polio, measles, meningococcal disease, yellow fever, cholera, and Ebola outbreaks with timely detection and response (includes outbreaks with an outbreak response vaccination campaign)	Percentage of polio, measles, meningococcal disease, yellow fever, cholera, and Ebola outbreaks with timely detection and response (includes outbreaks with an outbreak response vaccination campaign)	**Needed for reporting up:** • % of polio, measles, meningococcal disease, yellow fever, cholera, and Ebola outbreaks with timely detection and response **Additional possible action-based indicators:** • Annual number of laboratory-confirmed epidemic-prone vaccine preventable disease outbreaks • Annual number of laboratory-confirmed epidemic-prone vaccine preventable disease outbreaks that have expanded geographic spread or number of cases • For epidemic-prone vaccine preventable diseases, average coverage achieved by outbreak response vaccination campaigns
5.2 Immunization services during emergencies	None	Percentage of children who have age-appropriate vaccination for DTP3, MCV (last dose), and PCV (last dose) in settings with humanitarian crises or emergencies	**Needed for reporting up:** • Annual % of children who have age-appropriate vaccination coverage for DTP3, MCV (last dose), and PCV (last dose) in settings with humanitarian crises or emergencies **Additional possible action-based indicators:** • Annual % of children aged 12 to 24 months of life who have had three doses of DPT/Penta across countries which have experienced humanitarian crises in that year • Annual % of children aged 6mo to 15y who have received measles vaccination across countries which have experienced humanitarian crises in that year • SMART or equivalent vaccine surveys carried out during a year of crisis
6.1 Healthy global markets for vaccines	Level of health of the vaccine market, disaggregated by vaccines antigens and country typology	None	None

SP Objective	Global monitoring	Options for regional monitoring	Options for country monitoring
6.2 Financial resources for immunization programmes	Domestic government's and donors' expenditure on primary health care per capita	Domestic government and donor expenditure on primary health care per capita	**Needed for reporting up:** • Domestic government and donor expenditure on primary health care per capita **Additional possible action-based indicators:** • Government expenditure on routine immunization per live birth (person targeted)
6.3 Immunization expenditure from domestic resources	Percentage of total expenditure on vaccines in the national immunization schedule financed with domestic government funds	Percentage of total expenditure on vaccines in the national immunization schedule financed with domestic government funds	**Needed for reporting up:** • Percentage of total expenditure on vaccines in the national immunization schedule financed with domestic government funds **Additional possible action-based indicators:**
7.1 Capacity for innovation	Number of countries with an immunization research agenda	Number of countries with an immunization research agenda	**Needed for reporting up:** • Immunization research agenda exists **Additional possible action-based indicators:**
7.2 New vaccine development	Short list of global R&D targets	None	None
7.3 Evaluation & and scale up of innovations	None	Proportion of countries with at least one implemented recommendation from a NITAG or other relevant independent technical advisory group	**Needed for reporting up:** • At least one implemented recommendation from a NITAG or other relevant independent technical advisory group implemented **Additional possible action-based indicators:**

Strategic Priority Objective Indicators Metadata

Global Strategic Priority Objective Indicators

This section is under development. Each Global SP Objective Indicator will be defined with the following characteristics:

Indicator ID, Name	SP 1.1- Number of countries with a mechanism for monitoring, evaluation and action at national and sub-national levels
Definition	Mechanism that drives monitoring, evaluation and action cycles at national and sub-national levels is defined according to the following criteria. Possible criteria include: 1. Presence of NITAG or equivalent technical advisory group to provide guidance for monitoring, evaluation and action cycles 2. Indicators and targets are set at national and sub-national levels (based on needs and priorities) 3. Indicator results are available at all levels 4. Roles and responsibilities of stakeholders (government + others) to drive continuous quality improvement are defined 5. Feedback loop is in place to communicate assessments of progress, and recommendation actions from sub-national to national and from national to sub-national level 6. Schedules for performance review at sub-national and national level are defined and reviews conducted according to schedule
Calculation and operational considerations	This data is currently not collected at the global level so will need to be added to the JRF in 2021. The indicator will be self-reported according to the available six criteria above. Meeting each criterion gives 1 point, with a maximum score of 6 points. Data-driven decision-making is an indication of strong leadership and management. The indicators set in each country should unite the key stakeholders to drive actions in an accountable manner. Information from ME&A exercises is reported to higher levels, recommendations to lower levels are fed back. Actions planned and being taken reported to higher levels and from higher to lower levels.
Method of measurement	- Operational document describing the ME&A process at all levels - Evidence of implemented actions to strengthen immunization programme performance at all levels
Data source	To be proposed for JRF

Indicator ID, Name	SP 1.2- Density of nursing and midwifery personnel
Definition	Number of nursing and midwifery personnel per 10,000 population

Calculation and operational considerations	Numerator: Number of nursing personnel and midwifery personnel, defined in headcounts Denominator: Total population Nursing and midwifery personnel comprise the following occupations: nursing professionals, nursing associate professionals, midwifery professionals, midwifery associate professionals and related occupations. The International Standard Classification of Occupations (ISCO) unit group codes included in this category are 2221, 2222, 3221 and 3222 of ISCO-08.
Method of measurement	In response to WHA resolution, WHA 69.19, an online National Health Workforce Accounts (NHWA) data platform was developed to facilitate reporting. Complementing national reporting through the NHWA data platform, additional sources such as the National Census, Labour Force Surveys and key administrative national and regional sources are also employed. In general, the denominator data for workforce density (i.e. national population estimates) are obtained from the United Nations Population Division's World Population Prospects database. In cases where the official health workforce report provides density indicators instead of counts, estimates of the stock were then calculated using the population estimated from the United Nations Population Division's World population prospects database. Further information: https://www.who.int/data/gho/data/indicators/indicator-details/GHO/nursing-and-midwifery-personnel-(per-10-000-population) https://www.who.int/activities/improving-health-workforce-data-and-evidence
Data source	Numerator: WHO National Health Workforce Accounts (NHWA) Denominator: United Nations Statistics Division population data

Indicator ID, Name	**SP 1.3- Proportion of countries with on time reporting from districts with suspected cases of all priority vaccine-preventable diseasees included in nationwide surveillance (including reporting of zero cases)**
Definition	Countries with on time reporting from districts of suspected cases of all priority VPDs included in nationwide surveillance (including reporting of zero cases) *suspected cases for all priority VPDs under nationwide surveillance. Priority VPDs include at a minimum, polio, measles, rubella, neonatal tetanus, yellow fever (for endemic countries), meningitis (for endemic countries) and other diseases under nationwide surveillance.
Calculation and operational considerations	Denominator for country level is every secondary administrative unit (e.g. district or equivalent) in a country. Numerator consists of all districts that, for all vaccine preventable diseases mentioned above reported suspected cases on time at least 90% of the time - Report the number of cases for all suspected cases of the predefined VPDs to the provincial or national level. The number of cases can be zero - Submit those reports in a timely manner as defined by the country's internal deadlines for reporting.

	- To achieve 90% reporting per year: If a country expects weekly reporting for a given disease then the district needs to report ≥47 times by the deadline set by the country. If they have monthly reporting for a disease, then reporting should be ≥11 times in a calendar year. Districts will not count in the numerator if they: - Report the number of suspected cases for some, but not all, of the predefined VPDs - Do not report on time - Report less than 90% of the time. Countries that are small can use their primary administrative unit or health facilities as their unit of measure
Method of measurement	This would monitor vaccine preventable disease designated by country for nationwide surveillance, including: polio, measles, rubella, neonatal tetanus, meningococcus, and yellow fever
Data source	To be proposed for JRF

Indicator ID, Name	**SP 1.4- Percentage of health facilities that have full availability of DTP-containing vaccines (for example, pentavalent vaccines) (by country)**
Definition	% of health facilities that have full availability of DTP-containing vaccine, for example pentavalent vaccines (by country)
Calculation and operational considerations	Countries to report the % of facilities that had sufficient supply of DTP-containing vaccine to cover all the need for routine immunization service delivery over the year. Calculation: No. of facilities with full availability of DTP over the year / total number of facilities x 100. Countries to consolidate facility level data and calculate yearly average % of facilities that had no DTP stock out over the year.
Method of measurement	Countries to monitor and collect facility-level data on DTP-containing vaccine stock availability over a year using existing information system (e.g. LMIS, HMIS, DHIS2, wVSSM or other available information management platforms). Countries that lack this data (e.g. no reporting of the indicator, no system to keep track of stock at service delivery level) indicate NA.
Data source	Proposed to be collected using eJRF

Indicator ID, Name	SP 1.5 – Percentage of population with access to personal immunization records (by country)*
Definition	Percentage of population with access to personal records (by country) (paper or electronic)
Calculation and operational considerations	Measured during household surveys. Several data points are collected during these surveys: - % cards seen during survey - % of children for whom a HBR exists - % of children who ever got a HBR Need to define for electronic records
Method of measurement	Household surveys
Data source	Household surveys, JRF

Indicator ID, Name	SP 1.6- Proportion of countries with at least 1 documented (with reporting form and/or linelisted) individual serious AEFI* case safety reports per million total population
Definition	Countries with documented (with reporting form and/ or line-listed) individual serious AEFI case safety reports per million total population
Calculation and operational considerations	Annual number of individual AEFI case safety reports available in the WHO global database for safety monitoring Threshold: All countries with at least 1 AEFI individual case safety report/1, 000 000 population Total population: UN Population Division's World Population Prospects for e.g. https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf * WHO global database – VigiBase: https://www.who-umc.org/vigibase/vigibase/
Method of measurement	Individual serious AEFI reporting rate in million total population per year= Number of individually documented serious AEFI cases reported from country/sub-national area per year / Total population in the same country/sub-national area per year * 1,000,000

	$$\text{Individual serious AEFI reporting rate in million total population per year} = \frac{\text{Number of individually documented serious AEFI cases reported from a country/ sub-national area per year}}{\text{Total population in the same country/ sub-national area per year}} \times 1{,}000{,}000$$
Data source	Primary data source: WHO global database VigiBase: https://www.who-umc.org/vigibase/vigibase/ . To be discussed for countries that don't have access to Vigibase.

Indicator ID, Name	**2.1 Number of countries with legislation that is supportive of immunization, and that commits the government to finance immunization programme functions at all levels**
Definition	Number of countries with legislation that is supportive of immunization, and that commits the government to finance immunization programme functions at all level
Calculation and operational considerations	This data is currently not systematically collected at the global level so will need to be added to the JRF in 2021. Calculation will be through self-report (Yes/No) by countries and request to upload a copy or link to the relevant legislation. Language will be a potential barrier to verification.
Method of measurement	The existence (or not) of a legislative basis underlying the commitment to provide government-funded immunization to the population. This will be measured through self-report (Yes/No) and a request to provide supporting documentation.
Data source	To be included in JRF

Indicator ID, Name	**2.2 Percentage of countries that have implemented behavioural or social strategies (i.e. demand generation strategies) to address under-vaccination**
Definition	Percentage of countries that have implemented behavioural or social strategies (i.e. demand generation strategies) to address under-vaccination

Calculation and operational considerations	This data is currently not collected at the global level so will need to be added to the JRF in 2021. Calculation will be through self-report by countries to the following question: In [insert previous year] did the country implement any behavioural or social strategies (i.e., demand generation strategies) to address under-vaccination? Choose all that apply: • Interventions to improve access to vaccination • Interventions to improve service quality • Interventions to build capacity among healthcare workers • Community engagement • Interventions to communicate or educate the public • Interventions to manage misinformation based on social or digital listening data • Interventions at the policy level (e.g. incentives) • Other, please specify:
Method of measurement	Indicator to be reported by countries through the JRF and will replace former demand questions in the JRF
Data source	To be included in JRF

Indicator ID, Name	**3.2: DTP3, MCV1, and MCV2 coverage in the 20% of districts with lowest coverage (by country)**
Definition	Immunization coverage for DTP3, MCV1, and MCV2 in the lowest 20% of districts with lowest coverage
Calculation and operational considerations	Average coverage in lowest performing quintile for each country that reports district level coverage.
Method of measurement	Analysis of district level coverage reported by member states.
Data source	Annual member state reporting of district level coverage data through the Joint Reporting Form process

Indicator ID, Name	4.1 Breadth of protection: mean coverage for all vaccine antigens recommended by WHO
Definition	Breadth of protection defined as mean coverage for all vaccine antigens recommended by WHO
Calculation and operational considerations	Analyse proportion of countries with WHO recommended vaccines within their national immunization schedules by life course stage. Aggregate proportion by regional and global level.
Method of measurement	Presence of all WHO recommended vaccines within country's national immunization schedule.
Data source	JRF

Indicator ID, Name	5.1 Percentage of polio, measles, meningococcal disease, yellow fever, cholera and Ebola outbreaks with timely detection and response (includes outbreaks with an outbreak response vaccination campaign)
Definition	% of polio, measles, meningococcal disease, yellow fever, cholera, and Ebola outbreaks* with timely** detection and response *Only applies to outbreaks for which there is an outbreak response vaccination campaign. **Acceptable time from onset of outbreak to campaign implementation to be defined for each disease
Calculation and operational considerations	Time from onset of outbreak to implementation of vaccination campaign should be determined for each polio, measles, meningococcal disease, yellow fever, cholera, and Ebola outbreak for which there is an outbreak response vaccination campaign. Proposed percentage of outbreaks that get a vaccine response within the maximum designated time should be defined for each vaccine (timelines and criteria for determining onset of outbreak to be defined by disease experts)
Method of measurement	National immunization and disease surveillance programs via the WHO/UNICEF Joint Reporting Form, supplemented by information from the International Coordinating Group on vaccine provision, Measles Rubella Initiative, Global Polio Eradication Initiative, and WHO World Health Emergencies group
Data source	ICG, MRI, GPEI, WHO, national immunization and disease surveillance programs. Information would need to be systematically collected from national immunization disease surveillance programs to provide data for regional and global level data.

Indicator ID, Name	6.1 Level of health of the vaccine market, disaggregated by antigen and country typology
Definition	Level of health of the market, disaggregated by antigen and country typology (Gavi-73, non-Gavi MICs, HICs)
Calculation and operational considerations	TBD
Method of measurement	A number of criteria have been defined to determine the level of health of a market. The number of criteria met determines the health of the market for each vaccine. More specifically the following attributes are measured: • supply meeting demand • country preferences are met • NRA diversification • individual supplier risk • buffer capacity • long term competition • innovation and total system effectiveness Semi-quantitative assessment of individual market health, will be undertaken by partners [WHO, UNICEF, Gavi, BMGF]. Based on assessments of individual the above attributes and a wholistic overview of each market's programmatic context, markets will be assessed based on the following categories: - Insufficient and requires further intervention: severe supply security challenges and risks exist, no improvement is expected without intervention - Insufficient with conditions for improvement: severe supply security challenges and risks exist, improvements possible but requiring further monitoring and lead time to materialize. - Sufficient with risks: limited supply security challenges with unacceptable risks of backsliding, interventions are required to mitigate risks. - Sufficient and sustainable: limited supply security challenges with acceptable risks, monitoring required to ensure risks do not increase.
Data source	TBD

Indicator ID, Name	6.2 Domestic government and donors expenditure on primary health care per capita (by country)
Definition	Domestic government's and donors' expenditure on primary health care (PHC) per capita (in constant prices) in US$
Calculation and operational considerations	Domestic government's and donors' expenditures on PHC, divided by population in constant US$ price
Method of measurement	See https://apps.who.int/nha/database/DocumentationCentre/GetFile/57752201/en
Data source	WHO GHED (health accounts data) https://apps.who.int/nha/database/Select/Indicators/en

Indicator ID, Name	6.3 Percentage of total expenditure on vaccines in the national immunization schedule financed with domestic government funds (by country)
Definition	Percentage of total expenditure on vaccines in the national immunization schedule financed with domestic government funds
Calculation and operational considerations	Total and domestic government public resources used to purchase vaccines consumed in a given year
Method of measurement	Total value of vaccines used for the provision of immunization. All the materials and services are to be fully consumed during the production activity period. Domestic public resources spent on all vaccines used in conformity with the national immunization programme, including routine doses of vaccines, and following each country's vaccination schedule. Includes the international market price, as well as transport and handling expenditures. Vaccines used in Child Health Days are included in routine vaccine expenditures, but expenditures related to doses of vaccine given through supplemental immunization activities (SIAs) are excluded

Data source	JRF

Indicator ID, Name	SP 7.1- Number of countries with national agenda for research on immunization
Definition	Number of countries with national agenda for research on immunization in national immunization strategy or other national strategy document
Calculation and operational considerations	The national agenda should identify priority research areas that increase the likelihood that the country will achieve its IA2030 targets. Research is defined as activities that span 5 areas: • measuring the magnitude and distribution of a health problem; • understanding the diverse causes or the determinants of the problem, whether they are due to biological, behavioral, social or environmental factors; • identifying and developing solutions or interventions that will help to prevent or mitigate the problem; • implementing or delivering solutions through policies and programmes; and • evaluating the impact of these solutions on the magnitude, level and distribution of the problem. Research agendas will vary depending on national context and priorities. Some countries may focus on disease burden and implementation/operational research to inform new product implementation, whereas others may have wider-ranging agendas.
Method of measurement	Review of national immunization strategy or other national strategy document
Data source	TBD

Indicator ID, Name	SP 7.2- Short list of global research and development targets
Definition	**Short list** of ***global*** targets for R&D in vaccines, other products, and services at the start of the decade
Calculation and operational considerations	WHO Product Development for Vaccines Advisory Committee (PDVAC) to define targets and monitor and evaluate progress at the global and regional level. Suggested short list should be presented during SAGE Oct 2021

Method of measurement	**Global**: Measurement will require landscape analysis by technical experts.
Data source	TBD

Indicators that are critical but not yet available for reporting

Particular emphasis is made to strengthen availability of the metrics to monitor SP Objectives 1.1, 2.1, and 7.2.

SP Objective 1.1: Reinforce and sustain strong leadership, management and coordination of immunization programmes at all levels

- Monitoring & Evaluation focusing on actions to continuously improve quality of immunization services is vital to know the progress, gaps and drive actions to improve the immunization programme. In this way, functioning ME&A processes will be a proxy indicator for strong leadership, management and coordination that drives actions. Monitoring of this critical but not yet available indicator will require a new mechanism and capacity building should be considered for implementation of ME&A cycles at all levels.

SP Objective 2.2: Ensure that all people and communities value, actively support and seek out immunization services

- The indicator to monitor SPO 2.2 is intended to drive national immunization programmes to allocate dedicated resources to assess and address barriers to vaccination. However, in view of country differences, it is difficult to get a single demand creation indicator that is applicable to all countries to be used as a global indicator. Data availability for measuring this objective is also a challenge and should be addressed throughout the decade.

SP Objective 7.2: Develop new vaccines and associated technologies, and improve existing products and services for immunization programmes

- The current proposed indicator follows the GVAP precedent, which defined a short list of global priority R&D targets. This is intended to be an interim step that will give the global immunization community time to establish a strategic approach for global and regional stakeholders to jointly set goals based on country needs and priorities, and a system to monitor and evaluate progress. These priorities will include the development of new vaccines and technologies, and improvements of existing products and services for immunization programmes. The proposed approach reflects the IA2030 Research & Innovation strategy, which “focuses on needs-based innovation and aims to strengthen mechanisms to identify research and innovation priorities according to community needs, particularly for the under-served, and ensure these priorities inform innovations in immunization products, services and practices.” It aligns with the IA2030 core principles of being people-focused, partnership-based, and data-enabled. The proposed approach has the potential to catalyse transformative change through global and regional mechanisms to identify R&D priorities and targets. These mechanisms would consider national agendas for research in immunization (SPO 7.1); identify innovative solutions to vaccine and immunization challenges; and weigh the relative feasibility, impact, and equity benefits of potential products. Building off of these key activities that address IA2030 core principles, regional R&D agendas will necessarily focus on vaccines and delivery technologies that are more likely to have greater impact in the region. These regional mechanisms would feed into the global mechanism, ensuring that global R&D is similarly anchored in the needs of communities. Once these mechanisms are established, the global priority R&D targets will more closely and transparently reflect country and regional priorities and needs.

http://www.newswire.ca/news-releases/iristel-ice-wireless-partner-with-pharmaceutical-innovation-to-bring-advanced-telehealth-services-to-canadas-north-594967501.html

Iristel, Ice Wireless partner with Pharmaceutical Innovation to bring advanced telehealth services to Canada's North

Bluetooth-enabled 'virtual caregiver' and other amenities within Iristel's secured cloud infrastructure will be part of the Ice Wireless LTE roll out in 2017

MARKHAM, ON, Sept. 27, 2016 /CNW/ - Ice Wireless, a mobile network operator in Canada's North, and its parent company Iristel Inc., a national telecom carrier, are joining forces with Pharmaceutical Innovation Ltd. to offer advanced telehealth services to rural and isolated Arctic and sub-Arctic areas, including amenities not yet available on other wireless networks across Canada.

"This is exciting to introduce such cutting-edge e-Health initiatives to Canada's North, an area filled with rural communities that historically find themselves on the backburner when it comes to technological advances," says Samer Bishay, president of both Iristel and Ice Wireless. "Using Iristel's secured cloud infrastructure and Pharm Innovation's robust products and services, Ice will begin its e-health pilot early in 2017."

It will mean doctors, nurses and family members can monitor patients and loved ones remotely and in real-time. For example, among the many varied applications, if an elderly person forgets to take her medication or her heartrate and blood pressure spike, caregivers hundreds or thousands of kilometres away will be alerted. Location-based technology will allow the app to locate the nearest hospital or health facility to the primary user and the app ensures that prescriptions are automatically refilled at the user's pharmacy of choice.

"Pharm Innovation has developed notable, original products that provide a holistic patient-centred approach to healthcare and medication management, insuring compliance and adherence," Mr. Bishay says. "And Iristel and Ice are delivering them in a secure environment, protecting individuals' private medical records."

One such service is *Health Espresso,* a Bluetooth-enabled app that acts as a virtual caregiver through innovative technology and a friendly interface that is equipped with verbal communication and speech recognition. The primary user, typically an elderly or physically-challenged individual, wears a Bluetooth-enabled medical data collection device. A secondary user, either a family member or doctor, is connected to the data from the app at all times. The app also populates and tracks medication intake and checks for any adverse drug-to-drug interaction.

"Working with Iristel and Ice is a great fit, not only culturally through shared vision of using technology to improve lives, but because we see it critically important to roll out e-health in rural areas where patients sometimes travel hours and hours to get medical attention we take for granted in urban areas," says Tamer Mikhail, president and founder of Pharmaceutical Innovation.

About Iristel and Ice Wireless

Iristel is Canada's largest and fastest-growing Competitive Local Exchange Carrier (CLEC) providing innovative communication services that are changing how consumers and businesses communicate. Founded in 1999 and licenced by the CRTC, Markham-based Iristel is Canada's only carrier with facilities in all 10 provinces and three territories and a network extending Coast-to-Coast-to-Coast.

Ice Wireless is a facilities-based mobile network operator that delivers state-of-the-art 3G/4G HSPA+ technology to rural and remote areas of Canada with LTE coming in 2017. Ice Wireless was launched in Inuvik, Northwest Territories in 2005. The Ice network covers 75% of the population of the Yukon and Northwest Territories and also provides service to Iqaluit, Nunavut and Northern Quebec.

For more information, please visit www.icewireless.ca or www.iristel.com.
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SOURCE Iristel Inc.

IRRADIATED

A comprehensive compilation and analysis of the literature on radiofrequency fields and the negative biological impacts of non-ionizing electromagnetic fields (particularly radiofrequency fields) on biological organisms

American English version

Edition 1.1

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Introduction

Today, wireless technology has become ubiquitous in many places. Since the 1980s, there has been an explosion in the popularity of mobile, wireless technology. At first, that sounds great, right? After all, what could be so bad about wireless? Sure, it isn't secure, it isn't reliable, it isn't fast and it interferes with your social life (as is acknowledged by motivational speaker Simon Sinek), but what's not to like about that?

Cell phones, cellular and radio towers, cordless phones, walkie-talkies, Wi-Fi, "smart"-meters, and all other wireless technologies and appliances, emit radiofrequency radiation, which the World Health Organization classified in 2011 as a **Class 2B carcinogen**, in the same category as neurotoxins such as lead and the omnipresent pesticide DDT. In the past five decades, there have been thousands of peer-reviewed studies released that state wireless technology has the ability to negatively affect health. Today, relatively few people know about this, because wireless companies that make trillions off of ignorant customers would like to keep their customers, well, ignorant. While 70% of non-industry studies have reported negative health effects associated with wireless, only 30% of industry studies report any such findings.

Today, a growing number of people are becoming aware of the health impacts. Wireless communications negatively affect organisms from all walks of life as we are all bioelectrical organisms whose cells communicate using fragile electrical impulses. The cells in our bodies are incredibly complex life forms that have evolved over thousands of years to the natural background levels of RF radiation in our environment. Today, we are exposed to 100 million to 10 billion times more radiation than our grandparents were, and this radiation has been shown to have biological implications in thousands of peer-reviewed studies. The FCC standards are essentially useless, being at least 3 million times higher than levels at which severe biological implications have been observed at the cellular level. Wireless can tamper with, or alter our internal chemistry, since we are essentially a giant antenna. Some of the negative health implications caused or exacerbated by wireless communications include sleep disorders, insomnia, calcium efflux, difficulty concentrating, headaches, heart palpitations, cardiac stress, cancer, brain tumors, neuron damage, migraines, fatigue, tinnitus, negative thoughts, digestive problems, brain fog, DNA damage, memory loss, ADHD, autism, depression, stress, dizziness, cell mutations, decreased brain activity, neutralized sperm, infertility, asthma, allergies, rashes, and electromagnetic hypersensitivity. Children are even more vulnerable, as their heads are smaller and they have higher water content, and thus they absorb more of the radiation – much of it penetrating deep into their brains; this is why people who begin to use cell phones on a regular basis before age 20 are five times more likely to develop malignant brain tumors throughout their lifetime. Brain tumor rates have increased fivefold since the 1980s, autism rates are exponentially increasing, and today's children complain of excessive fatigue and are more depressed than ever. Today's schools, with their tablets, laptops, cell phones and Wi-Fi, are doing little to remedy this situation.

There is also the safety concern – more people had landlines in the late twentieth century than do today – which may put countless lives in jeopardy – it is now easier than ever to reach 911 but harder than ever for them to find you. In an emergency, access to a landline telephone could be the difference between life and death.

Concerned? You should be. While the FCC and wireless carriers want to play games with your health, we think you should know the facts. Many scientists are already heading appeals urging schools to eradicate Wi-Fi from their facilities.

There are FOUR major shortcomings of wireless technologies:

- Health impacts
    - Physiological health (changes in the environment and biology)
    - Social health (increasing reliance on mobile devices for interaction and a lack of connection with the present)
    - Psychological health (wireless devices can cause functional impairments and change human behavior)
- Reliability
- Quality
- Safety

Don't believe that the FCC will protect you either – for many years, the government told us that tobacco and lead were perfectly safe – and the FCC doesn't even *deal* with health effects. Their job is to regulate electronic interference, not ensure your health or safety. An independent agency of the government, the FCC has the power to – in one fell swoop – remove barriers to harmful technologies with little, if any, accountability, has they have recently done with the opening of 5G frequencies for use by the wireless industry.

Tobacco, lead, and asbestos also present situations where the government advocated their safety and a serious body count was needed before policy was changed. Many renowned independent scientists from around the world agree that radiation from wireless devices is the next public health crisis; many spend much of their time appealing to governments and councils for changes in policy. Today, we are exposed to 100 million to 10 billion times more RF radiation than our grandparents were and 70% of non-industry funded peer-reviewed science has found this radiation to be biological hazardous. Tens of thousands of peer-reviewed studies have conclusively found that low-energy non-ionizing radiation (in particular, radiofrequency radiation, which consists of microwaves and radio waves) can lead to negative health implications in biological organisms. The science is being deliberately manipulated and obscured by both our elected officials and the industries that profit off of these technologies due to our ignorance.

No publication can encompass completely and accurate the full body of literature on this matter. This text aims to present some of the research on this issue, as well as testimonials, articles, and further resources for studies. Many excerpts are cited so that you can explore them further if necessary.

There are many hyperlinks in this publication. While some of them may display the URL for the linked resource, some do not. If you received a printed copy of this publication, you can access and download the electronic version of this publication anytime in order to access all hyperlinks, at the URL below:

https://wirelessaction.wordpress.com/irradiated/

This publication contains general information about medical conditions and treatments. The information presented herein does not constitute legal or medical advice, and should not be treated as such. If you have any specific questions about any medical matter you should consult your doctor or other professional healthcare provider. If you think you may be suffering from any medical condition you should seek immediate medical attention. Nothing in this disclaimer will limit any of our liabilities in any way that is not permitted under applicable law, or exclude any of our liabilities that may not be excluded under applicable law.

The Tip of the Truth

This section is a compilation of news articles, primary sources, and secondary resources, and includes original research, interpretations from qualified scientists in the field, and releases by both government and scientific bodies. All excerpts included are cited whenever possible. All excerpts are included in their original form, although some spelling and grammatical errors may have been corrected. Excerpts from external publications are not necessarily provided in any particular order.

Actual research is sprinkled throughout the entirety of this section, categorized depending on the nature or topic of the study; there is no separate section for scientific studies.

General

The EMF Controversy - Common Misconceptions

It is NOT a myth that EMF can have health effects. The World Health Organization has declared both powerline magnetic fields and radiofrequency fields to be a Group 2B possible carcinogen in the same category as lead and DDT. There are thousands of scientific studies on the biological effects of EMF. Below are some common misunderstandings which lead people to believe in the false dogma that nonionizing nonthermal radiation is safe.

An analysis of the scientific studies found that the majority of industry-funded studies found no effects, whereas the majority of independent studies did find effects. This is the same thing that had happened for the tobacco and lung cancer studies. It is important, therefore, not only to consider the conclusions of a study, but also its sources of funding.

The media typically presents an undecided viewpoint, one moment raising concerns, and the next moment saying that those concerns are unfounded. Stories are sometimes altered to soften the blow to the wireless industry. When Fortune magazine first reported on electromagnetic hypersensitivity in 1993, Motorola stopped advertising with Fortune magazine for a long time, resulting in hundreds of thousands of dollars of lost income, according to Microwave News. The media can also have a conflict of interest.

Similarly, the government suffers from a conflict of interest. The wireless industry is reported to be the government's #2 source of revenue, and has reportedly spent $2.3 billion in political lobbying. (*Public Health SOS, The Shadow Side of the Wireless Revolution*). Billions of dollars are paid for the allocation of the wireless spectrum.

Even health organizations like the World Health Organization suffer from conflicts of interest, and industry sometimes works to reverse judgments on the danger of electromagnetic fields. See Don Maisch's article, Conflict of Interest & Bias in Health Advisory Committees. Conflicts of interest can prevent health advisory bodies from sounding the alarm on health hazards.

Funding	Effect	No Effect
Industry	27 (32%)	57 (68%)
Non-Industry	96 (70%)	41 (30%)
Total	123 (56%)	98 (44%)

Source: Prof. Henry Lai, Univ. Washington
*(**Table from Dr. Martin Blank on Electromagnetic Fields**)*

There are many scientists who have had their funding or positions threatened because they found or spoke out on harmful effects from wireless radiation. These scientists include Henry Lai of University of Washington, Allan Frey, Robert Santini, Carl Blackman of the EPA, Ross Adey, Olle Johansson, Gerald Hyland, Olle Johansson, Annie Sasco, Dimitris J. Panagopoulos, and others. Although their credibility has been challenged, their findings have in many cases been reproduced by other scientists.

For example, Henry Lai, who found DNA effects in response to microwaves, was challenged and threatened. However, similar effects on DNA were later observed by the 7-nation European REFLEX study and by the University of Vienna. There is another interesting story shared by Devra Davis that the Adlkofer study was called a fraud in Science magazine, but that this story of fraud was later ruled to be a fraud itself. There are now approximately 11 studies now pointing towards DNA breaks.

Similarly, Allan Frey discovered blood-brain barrier leakage as a result of microwave radiation, which was challenged. However, Leif Salford expanded upon the work, and also showed that rodents' brain cells were dying as a result of microwave radiation.

Common Misconceptions

Common Misconceptions	**Did you know?**
***Myth*:** There is no consistent evidence that wireless radiation is harmful. ***Misleading*:** The weight of the evidence points towards no harm.	***Fact*:** While the majority of industry-funded studies do not find health effects, the majority of independent studies do. The same thing had happened for the Tobacco industry. Anyone studying the research must be careful to "follow the money trail." Read more below. Many of the adverse biological effects of wireless technologies have been confirmed by more than one scientific group, including DNA breaks, the increase of free radicals, and the opening of the blood brain barrier. These studies include high profile studies like the 7-nation European REFLEX study. Oftentimes, such findings are followed with an attempt to discredit the scientists involved. However, other scientists later confirm the findings. When we talk about the "weight of the evidence", we cannot just compare the number of studies finding an effect versus the number of studies not finding an effect. It's very easy in principle to design a study so that it does not find an effect, e.g., by limiting the time period of exposure and follow-up in the study, but this does not "balance out" the studies that do find an effect. See Study Design Variables which may be Manipulated by Science.
***Myth*:** Being classified as a Group 2B possible carcinogen is no reason for concern, because coffee is also a Group 2B carcinogen.	***Fact*:** While those concerned about EMF emphasize that radiofrequency radiation (RF-EMF) and extremely low frequency EMF (ELF-EMF) have been categorized by the World Health Organization/IARC as a Group 2B possible carcinogens, in the same category as lead, DDT, and chloroform, industry advocates on the other hand downplay the classification of EMF as a Group 2B possible carcinogen by reminding us that coffee is also a Group 2B carcinogen.

	In June 2016, that changed when the IARC removed coffee from the list of Group 2B carcinogens. Meanwhile, there are scientists who now believe EMF's should be considered a Group 2A probable carcinogen.
***Myth*:** Only ionizing radiation and thermal levels of microwaves can cause damage.	***Fact*:** There are now many studies showing biological effects from nonionizing nonthermal radiation. Recently, it became known that a large $25 Million NIH Cell Phone Radiation study found increased brain and heart tumors in rats after only 2 years of exposure to nonionizing radiation at nonthermal levels of exposure. See also a list of studies by power level. It is time to listen to the science, rather than sticking to outdated dogmas. There are thousands of studies. Multiple scientific studies have confirmed that wireless radiation can damage DNA (at least 11), and one possible mechanism is by increasing free radicals, which was also found in at least 24 scientific papers on wireless radiation. For more scientific mechanisms, refer to Genotoxic Effects and Cancer. Graham Philips explains that even for ionizing radiation, 25% of DNA breaks are caused by direct damage, but another 75% is caused by ionizing radiation's ability to form free radicals.
***Myth*:** Since cell towers, Wi-Fi, and cell phones are many times weaker than international safety standards, there is no reason for concern.	***Fact*:** International safety standards are still based upon the outdated dogma that only ionizing or thermal levels of radiation are dangerous. Because of that, they are in fact, at least 9000 times higher than levels at which science has demonstrated non-ionizing, nonthermal effects. Because cell towers, Wi-Fi, and cell phones exceed the radiation levels that science has demonstrated to cause biological effects, there is indeed reason for concern.
***Myth*:** Despite the rise of wireless technologies, brain cancer has not been on the increase.	***Fact*:** Studies that look at 10 or more years of use, such as the Leonnart Hardell studies and the Interphone study, do in fact show an increased risk of brain cancer. It has been reported that the heavy use category in the Interphone study included usage as little as 30 minutes a day. Studies that look at less than ten years are not looking long enough. Cancer from environmental causes often has latencies that take several decades. Dr. Devra Davis explains that it can take decades before cancer becomes apparent in the population. Compare an average of 2 decades for smoking

	and lung cancer. The worst is yet to come. She explains that widespread *heavy use* only began a few years ago. All the same, brain cancers are happening to people at much younger ages than before, and have been increasing in the last 10 years for young adults, in particular 20-29 year-olds. According to Leonnart Hardell's studies, children may have a risk that is much greater than adults. British neurosurgeon Kevin O'Neill, MD reports in April 2009 that brain tumors are increasing at approximately 2% per year (and in particular have doubled for his unit in the last year). See also what other neurosurgeons are saying. The Danish Cancer Registry indicates an increase in brain tumors between 2001 and 2010. Dr. Devra Davis also points out that there are other cancers besides brain cancer that may be related to cell phone use, such as salivary gland tumors, since the salivary gland is close to where the cell phone is held. Some women who keep their cell phones under their bras are finding breast tumors in precisely the spot where they put their cell phone. For more information, see the Environmental Working Group's Executive Summary.
***Myth*:** We've had TV and radio towers broadcast microwaves for years, and they have been safe..	***Fact*:** Epidemiological and survey studies find cancer & other health issues near TV and radio broadcasting towers in addition to cell towers. One of the latest high profile cases is the court-ordered epidemiological study for the Vatican radio tower and cancer. Increased risks of cancer were reported within a 5.5 mile radius. This large radius can be explained by the higher output power of radio/TV towers. In contrast, the critical range for a cell tower is usually within 400 meters. See calculations of power reduction with distance.
***Myth*:** We get more radiation from cosmic radiation than from wireless technologies..	***Fact*:** Cosmic microwave radiation is relatively negligible, (<0.000001 μW/m^2, MAES 2000) since the sources are so distant. Our exposures to manmade microwave radiation is thousands of times greater than the natural background levels. Even for ionizing radiation, radon in homes is said to be a greater source of ionizing radiation than cosmic radiation. Even at the EPA limit for radon of 4pCi/L, it has been compared to the equivalent of 200 chest X-rays a year. Local sources are usually a more significant concern than cosmic sources, which by the inverse square law, become less of a threat over distance.

***Myth*:** The wattage of a cell tower is not more than a light bulb, so it must be safe..	***Fact*:** Even though light and EMF are both frequencies of the electromagnetic spectrum, they have different characteristics, so we cannot use the safety standards that apply to light and apply them to EMF. For example, even though both water H_2O and hydrogen peroxide H_2O_2 are made of the same elements, they have completely different characteristics and thus different safety levels for ingestion. How is the light of an incandescent light bulb different from the EMF of wireless communications? Microwaves can penetrate walls that are opaque to light, and go right through our clothes and skin. Microwaves have also been shown to damage DNA, a fractal antenna, and increase free radical activity, but an incandescent lightbulb has no such effect. Therefore, we cannot use the wattage of a safe incandescent lightbulb to determine the level of safety of microwave EMF. They are simply different. There is also a recent study on electrosensitivity that suggests the on/off and off/on transitions may be responsible for biological effects. This pulsing signal, may also differentiate pulsed wireless radiation from a regular light bulb. It is interesting to note, however, that some people do in fact respond to light which flashes at a certain frequency, in a condition known as Photosensitive Epilepsy. This might also be why modulated wireless radiation may be more biologically active than umodulated wireless radiation. Devra Davis compares pulsing radiation to a car that lurches to a halt and then continues again, and then lurches to a halt again. This on-off-on-off sequence may be more disruptive than steady radiation, just as it is more disruptive to sit on a car that continually starts and lurches to a halt than one that is driving non-stop.
***Myth*:** The authorities say there is no known health effect at this time.. ***Myth*:** If it were dangerous, people would have known a long time ago..	***Fact*:** While not all authorities say there are health effects from wireless technologies, an increasing number of government health organizations are now calling for precautions in light of the growing scientific concerns. This is remarkable given the conflicts of interest. Industry-funded scientists have had their funding taken away when they found biological health effects, and industry has lobbied to reverse judgments on electromagnetic fields' danger. In the media, management sometimes intervenes

	because of advertisement money that is at stake. See Conflicts of Interest. Nevertheless, the truth is making its way into official government recommendations despite all the efforts to the contrary. In the last 5 years, many countries' governments have made wireless health recommendationscalling for precautions.
***Myth*:** Double-blind studies show that people who claim to be sensitive, cannot tell whether the signal is on or off.. Therefore, it must be a psychological "nocebo" effect -- Otherwise, it is a real, but unrelated health problem.	***Fact*:** In one study funded by industry, some of the most sensitive people in the double-blinded studies, were extremely accurate, but had to drop out of the study before its conclusion because of severe health issues. Many design flaws have also been pointed out in industry-funded double-blind studies. We are now beginning to see independent double-blind studies showing objective effects from EMF like arrhythmia and high blood pressure. Even animals, plants, and microbes are reacting to the radiation, and more than one in vitro study has found an increase in DNA double-strand breaks, which can lead eventually to cancer. Studies show that microwaves can open the blood-brain barrier and trigger arrhythmia in animals. These findings are not satisfactorily explained by psychology alone.

Study design is often manipulated in a way such that effects are not found. For example, children and heavy business users may be omitted from a study due to their increased vulnerability, or the study length is sometimes shortened, knowing that the average time lag can be over 10 years before cancer occurs. (For reference, the approximate time lag for lung cancer with respect to cigarette smoking is 20 years.) For more examples of study design flaws, see:

- Cellphones and Brain Tumors 15 Reasons for Concern: Science, Spin and the Truth Behind Interphone
- Interphone Brain Tumors Studies To Date: An Examination of Poor Study Design Resulting in an UNDER-ESTIMATION of the Risk of Brain Tumors.
- Why are epidemiologists (mis)leading us about cell phone radiation exposure?

For examples of deceptions in science, listen to an interview with Magda Havas, "Deceptions with Science", where she discusses deception through study design, interpretation, and presentation.

The following are some ways in which science can be manipulated:

- Defining a regular cell phone user as at least one call per week for at least 6 months (Interphone)--thus failing to study the difference between heavy users and light users. See "Heavy mobile users risk cancer".

- Reducing the time of the study, knowing that the normal latency for cancer is over a decade.
- Not controlling for other wireless exposures, such as DECT cordless phones, mobile phone base stations, and Wi-Fi. Users of these technologies may be counted as controls whereas in reality they are also exposed to Radiofrequency Radiation.
- Removing more vulnerable populations (business users in the Danish study, and children in Interphone). Business users are likely to be the heaviest users, and children are vulnerable for reasons mentioned in The Greater Vulnerability of Children.
- Only studying brain tumors and not other diseases (e.g., studies suggest higher salivary gland cancer risks, higher prostate cancer for men wearing mobile phones on their belt, symptoms related to infertility in men, and anecdotes are indicating breast cancer for women who hide their cell phone near their breasts).
- Testing with unmodulated wireless exposures when modulated wireless exposures are believed to be worse.
- Using sub-groups of animals or cell types with lower levels of susceptibility.
- Avoiding particular power density windows found in which calcium would be removed from brain tissue.
- Not taking into account different cell phones with different exposure levels.

Studies trying to disprove electrosensitivity often suffer from the following deficiencies:

- Insufficient population size and poor adherence of selection criteria as a result.
- Excluding subjects who had to drop out because of health reasons (they were made too ill to continue).
- Not properly accounting for the time lags between initial exposure and onset of symptoms, e.g., some symptoms last for days. Other symptoms take time to appear.
- Not taking into account the individualized nature of responses. It was found that different people may react to different signal types and power density levels with different symptoms, just as people react to allergens differently.
- Not controlling for other exposures such as power line magnetic fields and chemicals, which electrosensitive people sometimes suffer in addition to microwaves. The microwaves may even contribute to their weakened resistance.
- Not acknowledging that nocebo effects can happen, but do not disprove an effect. Similarly, placebo effects do happen, but do not disprove that a medicine really helps.
- Not acknowledging that survey studies do find that people are affected with subjective symptoms, even when they do not believe the cell tower is related Even people who do not think they are affected often show higher symptoms around wireless technologies, even though they cannot detect it.
- Not acknowledging the objective biological effects that have been found by scientific studies.

http://www.emfwise.com/myth.php

Non-industry studies vs industry studies show vast difference in the harmful effects of microwave radiation

March 17, 2017

We are drowning in a sea of electromagnetic pollution, and the scientific priesthood is determined to keep us in the dark about the threat of microwave radiation to our health, well-being, and survival. A handful of scientists are willing to speak up, and have risked everything to inform the world about it. Some refer to this EMF poisoning as covert electronic warfare, some call it genocide.

At the very least, vested interests tell us that microwave radiation exposure is not a health concern, when it really is. Stop The Crime website lists fifty symptoms of microwave radiation that includes memory loss, confusion, headaches, anxiety, depression, and suicide. With the pervasive use of mobile phones, wearable devices, Bluetooth, Wi-Fi, smart meters, smart appliances, hotspots, cellular towers, laptops, tablets, routers, cordless phones – we are being fried alive.

Conflicting conclusions show a clear bias against reporting the facts on microwaves

In a damning article Natural Blaze attempts to deconstruct the tangled mess of subterfuge that characterizes the issue of microwave safety: "If smart technology gadgets don't heat your skin, then they are safe, which is the standard 'tobacco science' pap disseminated by industrial professional societies such as IEEE, the American National Standards Institute (ANSI), the National Council of Radiation Protection (NCRP), and the International Commission on Non-Ionizing Radiation Protection (ICNIRP), who fund and/or perform the studies the World Health Organization and global government health agencies cite as 'factual' science. Basically, microwave technology industrial professional societies state emphatically there is no such effect as non-thermal radiation adverse health effects, which contribute to and/or cause electromagnetic hypersensitivity (EHS) or what physicians call idiopathic environmental intolerance (IEI) in sensitive people around the world."

Further, Natural Blaze reports that despite efforts at a cover-up, a significant one-third of industry studies do show harmful effects from microwave radiation beyond skin heating. Additionally, 70% of non-industry studies show definitive non-thermal damage to humans. Natural Blaze cites an article published in December 2016 by Sarah J. Starkey of Independent Neuroscience and Environmental Health Research, London, U.K. The article is entitled "Inaccurate official assessment of radiofrequency safety by the Advisory Group on Non-ionizing Radiation." Starkey writes:

"The microwave industry considers 'cancer' a four-letter-word and does everything within its financial and political prowess to disassociate anyone from proving or even associating cancer etiologies with microwave EMFs/RFs/ELFs, thermal and non-thermal wave radiation…The denial of the existence of adverse effects of RF fields below ICNIRP guidelines in the AGNIR report conclusions not supported by the scientific evidence."

Our genetic legacy, our children, should be listed as an endangered species

The most obscene aspect of this ever-present technology is the unrestrained proliferation of Wi-Fi in schools (the use of Wi-Fi is not even necessary; schools can be wired with telecommunication cables, as has been used for decades). If after exposure at school, children go home to another wireless environment, then they are exposed day and night. Children are more harmed by RF than adults; in essence we are destroying the future potential of our collective gene pool.

Damage to DNA and cancer result from oxidative stress, and microwaves cause oxidative stress. Due to widespread and growing use of wireless devices, microwave radiation is blanketing the entire planet, and all living things are at risk for genetic deterioration. The human tissue that is most vulnerable to the effects of microwave radiation is a fetus of under 100 days. Recall from your high school biology course that a baby girl is born with one to two million eggs; not yet matured, but nevertheless all present. Appallingly, this means that the full extent of the damage we are taking on today won't be apparent until it shows up in our grandchildren. Will we one day ask in mourning and disbelief, my God, what have we done?

http://newstarget.com/2017-03-17-non-industry-studies-vs-industry-studies-show-vast-difference-in-the-harmful-effects-of-microwave-radiation.html

Wireless radiation causes cancer, according to the latest scientific findings

The National Association for Children and Safe Technology (NACST) is calling on children's health and cancer prevention organizations to make the issue of children's exposure to wireless radiation in educational facilities a priority for 2015.

A 2014 study on wireless radiation, by the Hardell Group in Sweden, found a 3-fold risk with twenty-five years or more of cordless and cell phone use. Perhaps more worrying is the finding that people who first used cell or cordless phones before the age of twenty had the highest risk.

The science is clear: Cell phone use increases our risk of cancer

Another study by the same researchers found a correlation between wireless phone use and lower survival rates for people diagnosed with the most malignant form of brain tumor, gliomas. These two studies followed the CERENAT study which found that, "risks were higher for gliomas, temporal tumors, occupational and urban mobile phone use. "

The biggest wireless study carried out, the $25 million Interphone Study, found that: "regular use of a cell phone by adults can significantly increase the risk of gliomas by 40% with 1640 hours or more of use (this is about one half hour per day over ten years)." Given the established and emerging science, the NACST calls for students to be provided with a safe learning environment, free from wireless radiation.

The nation's schools are now rife with wireless exposures because, as the NACST states, "there has been a national movement to digitalize learning in our schools". The NACST points out these high exposures in classrooms are caused by:

- Industrial strength routers
- Thirty or more handheld devices or laptops – which all emit radiation

These exposures represent an unprecedented health risk to children because they are being exposed 6 hours a day, 5 days a week, for their entire school careers. This is in addition to their exposures outside of the educational setting, which given that most children now have cell phones and most homes are equipped with Wi-Fi is not inconsequential.

Children are more vulnerable than adults to the effects of wireless radiation for a variety of reasons:

- Their bodies are still developing and the impacts of chronic exposure to radiation are more profound.
- Research shows children absorb up to ten times more radiation than adults.
- Safe limits for children have never been established.

http://www.naturalhealth365.com/wireless-radiation-cancer-prevention-1316.html

Expressions of Concern from Scientists, Physicians, Health Policy Experts & Others

William Rea, MD

Founder & Director of the Environmental Health Center, Dallas
Past President, American Academy of Environmental Medicine
"Sensitivity to electromagnetic radiation is the emerging health problem of the 21st century. It is imperative health practitioners, governments, schools and parents learn more about it. The human health stakes are significant".

Martin Blank, PhD

Associate Professor, Department of Physiology and Cellular Biophysics,
Columbia University, College of Physicians and Surgeons; Researcher in Bioelectromagnetics; Author of the BioInitiative Report's section on Stress Proteins.
"Cells in the body react to EMFs as potentially harmful, just like to other environmental toxins, including heavy metals and toxic chemicals. The DNA in living cells recognizes electromagnetic fields at very low levels of exposure; and produces a biochemical stress response. The scientific evidence tells us that our safety standards are inadequate, and that we must protect ourselves from exposure to EMF due to power lines, cell phones and the like, or risk the known consequences. The science is very strong and we should sit up and pay attention."

Olle Johansson, Ph.D.

Associate Professor, The Experimental Dermatology Unit, Department of Neuroscience, Karolinska Institute, Stockholm, Sweden; Author of the BioInitiative Report's section on the Immune System.
"It is evident that various biological alterations, including immune system modulation, are present in electrohypersensitive persons. There must be an end to the pervasive nonchalance, indifference and lack of heartfelt respect for the plight of these persons. It is clear something serious has happened and is happening. Every aspect of electrohypersensitive peoples' lives, including the ability to work productively in society, have healthy relations and find safe, permanent housing, is at stake. The basics of life are becoming increasingly inaccessible to a growing percentage of the world's population. I strongly advise all governments to take the issue of electromagnetic health hazards seriously and to take action while there is still time. There is too great a risk that the ever increasing RF-based communications technologies represent a real danger to humans, especially because of their exponential, ongoing and unchecked growth. Governments should act decisively to protect public health by changing the exposure standards to be biologically-based, communicating the results of the independent science on this topic and aggressively researching links with a multitude of associated medical conditions."

David Carpenter, MD

Professor, Environmental Health Sciences, and Director, Institute for Health and the Environment, School of Public Health, University of Albany, SUNY
Co-Editor, The BioInitiative Report (www.BioInitiative.org)
Electromagnetic fields are packets of energy that does not have any mass, and visible light is what we know best. X-rays are also electromagnetic fields, but they are more energetic than visible light. Our concern is for those electromagnetic fields that are less energetic than visible light, including those that are associated with electricity and those used for communications and in microwave ovens. The fields associated with electricity are commonly called "extremely low frequency" fields (ELF), while those used in communication and microwave ovens are called "radiofrequency" (RF) fields. Studies of people have shown that both ELF and RF exposures result in an increased risk of cancer, and that this occurs at intensities that are too low to cause tissue heating. Unfortunately, all of our exposure standards are based on the false assumption that there are no hazardous effects at intensities that do not cause tissue heating. Based on the existing science, many public health experts believe it is possible we will face an epidemic of cancers in the future resulting from uncontrolled use of cell phones and increased population exposure to Wi-Fi and other wireless devices. Thus it is important that all of us, and especially children, restrict our use of cell phones, limit exposure to background levels of Wi-Fi, and that government and industry discover ways in which to allow use of wireless devices without such elevated risk of serious disease. We need to educate decision-makers that 'business as usual' is unacceptable. The importance of this public health issue can not be underestimated."

Magda Havas, PhD

Associate Professor, Environment & Resource Studies, Trent University, Canada.
Expert in radiofrequency radiation, electromagnetic fields, dirty electricity and ground current.
"Radio frequency radiation and other forms of electromagnetic pollution are harmful at orders of magnitude well below existing guidelines. Science is one of the tools society uses to decide health policy. In the case of telecommunications equipment, such as cell phones, wireless networks, cell phone antennas, PDAs, and portable phones, the science is being ignored. Current guidelines urgently need to be re-examined by government and reduced to reflect the state of the science. There is an emerging public health crisis at hand and time is of the essence."

Whitney North Seymour, Jr., Esq.

Retired Attorney; Former New York State Senator & United States Attorney, Southern District of NY
Co-Founder, Natural Resources Defense Council
"Electromagnetic radiation is a very serious human and environmental health issue that needs immediate attention by Congress. The BioInitiative Report is a major milestone in understanding the health risks from wireless technology. Every responsible elected official owes it to his or her constituents to learn and act on its finding and policy recommendations."

B. Blake Levitt

Former New York Times journalist and author of *Electromagnetic Fields*, A Consumer's Guide to the Issues and How to Protect Ourselves, and Editor of *Cell Towers, Wireless Convenience? Or Environmental Hazard?*
Ambient man-made electromagnetic fields (EMFs), across a range of frequencies, are a serious environmental issue. Yet most environmentalists know little about it, perhaps because the subject has been the purview of physicists and engineers for so long that biologists have lost touch with electromagnetism's fundamental inclusion in the biological paradigm. All living cells and indeed whole living beings, no matter what genus or species, are dynamic coherent electrical systems utterly reliant on bioelectricity for life's most basic metabolic processes. It turns out that most living things are fantastically sensitive to vanishingly small EMF exposures. Living cells interpret such exposures as part of our normal cellular activities (think heartbeats, brainwaves, cell division itself, etc.) The problem is, man-made electromagnetic exposures aren't "normal." They are artificial artifacts, with unusual intensities, signaling characteristics, pulsing patterns, and wave forms, that don't exist in nature. And they can misdirect cells in myriad ways. Every aspect of the ecosystem may be affected, including all living species from animals, humans, plants and even microorganisms in water and soil. We are already seeing problems in sentinel species like birds, bats, and bees. Wildlife is known to abandon areas when cell towers are placed. Radiofrequency radiation (RF)—the part of the electromagnetic spectrum used in all-things-wireless today—is a known immune system suppressor, among other things. RF is a form of energetic air pollution and we need to understand it as such. Humans are not the only species being affected. The health of our planet may be in jeopardy from this newest environmental concern—added to all the others. Citizens need to call upon government to fund appropriate research and to get industry influence out of the dialogue. We ignore this at our own peril now."

Eric Braverman, MD

Brain researcher, Author of *The Edge Effect*, and Director of Path Medical in New York City and The PATH Foundation. Expert in the brain's global impact on illness and health.
"There is no question EMFs have a major effect on neurological functioning. They slow our brain waves and affect our long-term mental clarity. We should minimize exposures as much as possible to optimize neurotransmitter levels and prevent deterioration of health".

Abraham R. Liboff, PhD

Research Professor
Center for Molecular Biology and Biotechnology
Florida Atlantic University, Boca Raton, Florida
Co-Editor, Electromagnetic Biology and Medicine
"The key point about electromagnetic pollution that the public has to realize is that it is not necessary that the intensity be large for a biological interaction to occur. There is now considerable evidence that extremely weak signals can have physiological consequences. These interactive intensities are about 1000 times smaller than the threshold values formerly

estimated by otherwise knowledgeable theoreticians, who, in their vainglorious approach to science, rejected all evidence to the contrary as inconsistent with their magnificent calculations. These faulty estimated thresholds are yet to be corrected by both regulators and the media.

The overall problem with environmental electromagnetism is much deeper, not only of concern at power line frequencies, but also in the radiofrequency range encompassing mobile phones. Here the public's continuing exposure to electromagnetic radiation is largely connected to money. Indeed the tens of billions of dollars in sales one finds in the cell phone industry makes it mandatory to corporate leaders that they deny, in knee-jerk fashion, any indication of hazard.

There may be hope for the future in knowing that weakly intense electromagnetic interactions can be used for good as well as harm. The fact that such fields are biologically effective also implies the likelihood of medical applications, something that is now taking place. As this happens, I think it will make us more aware about how our bodies react to electromagnetism, and it should become even clearer to everyone concerned that there is reason to be very, very careful about ambient electromagnetic fields."

Lennart Hardell, MD, PhD

Professor at University Hospital, Orebro, Sweden.
World-renowned expert on cell phones, cordless phones, brain tumors, and the safety of wireless radiofrequency and microwave radiation.
Co-authored the BioInitiative Report's section on Brain Tumors by Dr. Hardell
"The evidence for risks from prolonged cell phone and cordless phone use is quite strong when you look at people who have used these devices for 10 years or longer, and when they are used mainly on one side of the head. Recent studies that do not report increased risk of brain tumors and acoustic neuromas have not looked at heavy users, use over ten years or longer, and do not look at the part of the brain which would reasonably have exposure to produce a tumor."

Samuel Milham MD, MPH

Medical epidemiologist in occupational epidemiology.
First scientist to report increased leukemia and other cancers in electrical workers and to demonstrate that the childhood age peak in leukemia emerged in conjunction with the spread of residential electrification.
"Very recently, new research is suggesting that nearly all the human plagues which emerged in the twentieth century, like common acute lymphoblastic leukemia in children, female breast cancer, malignant melanoma and asthma, can be tied to some facet of our use of electricity. There is an urgent need for governments and individuals to take steps to minimize community and personal EMF exposures."

Libby Kelley, MA

Managing Secretariat International Commission For Electromagnetic Safety; Founder, Council on Wireless Technology Impacts; Co-Producer of documentary, "Public Exposure: DNA, Democracy and the Wireless Revolution"; EMF environmental consultant and leading appellant in challenging the FCC Radio Frequency Radiation human exposure guidelines, 1997-2000. (www.icems.eu)
"Radiofrequency radiation human exposure standards for personal wireless communications devices and for environmental exposure to wireless transmitters are set by national governments to guide the use of wireless communications devices and for wireless transmitters. In the U.S., the Food and Drug Administration and the Federal Communications Commission set these standards. The Council on Wireless Technology Impacts considers these exposure standards to be inadequate as they are based on heating effects and do not accommodate the low level, cumulative exposure conditions in which the public now lives. These standards are also designed for acute, short term exposure conditions and do not acknowledge the medical evidence pointing to increased risks and actual harm that results from chronic, intermittent exposure. Federal and State public heath agencies are not officially addressing what many concerned scientists and medical doctors now see as an emerging public health problem. There are no health surveillance or remedial response systems in place to advise citizens about electromagnetic radiation exposure (EMR). As wireless technology evolves, ambient background levels increase, creating electrical pollution conditions which are becoming ubiquitous and more invasive. We strongly encourage consumers, manufacturers, utility providers and policymakers to reduce, eliminate and mitigate EMR exposure conditions and to support biologically based standards."

James S. Turner, Esq.

Chairman of the Board, Citizens for Health
Co-author, *Voice of the People: The Transpartisan Imperative in American Life*
Attorney, Swankin-Turner, Washington, DC

"*According to the BioInitiative Report: A Rationale for a Biologically-Based Public Exposure Standard for Electromagnetic Fields*—from electrical and electronic appliances, power lines and wireless devices such as cell phones, cordless phones, cellular antennas, towers, and broadcast transmission towers—we live in an invisible fog of EMF which thirty years of science, including over 2,000 peer reviewed studies, shows exposes us to serious health risks such as increased Alzheimer's disease, breast cancer, Lou Gehrig disease, EMF immune system hypersensitivity and disruption of brain function and DNA. The public needs to wake up politicians and public officials to the need for updating the decades old EMF public health standards. This report tells how."

Camilla Rees, MBA

CEO, Wide Angle Health, LLC
Patient education and advocacy

"The U.S. spends over $2 trillion dollars on health care each year, of which about 78% is from people with chronic illnesses, without adequately exploring and understanding what factors—including EMF/RF—contribute to imbalances in peoples' bodies' in the first place. After reading The BioInitiative Report, it should come as no surprise to policymakers, given the continually increasing levels of EMF/RF exposures in our environment, that close to 50% of Americans now live with a chronic illness. I grieve for people who needlessly suffer these illnesses and hold out the hope that our government leaders will become more cognizant of the role electromagnetic factors are playing in disease, health care costs and the erosion of quality of life and productivity in America."

L. Lloyd Morgan, BS Electronic Engineering

Director Central Brain Tumor Registry of the United States, Member Bioelectromagnetics Society, Member Brain Tumor Epidemiological Consortium *

"There is every indication that cell phones cause brain tumors, salivary gland tumors and eye cancer. Yet, because the cell phone industry provides a substantial proportion of research funding, this reality is hidden from the general public. The Interphone Study, a 13-country research project, substantially funded by the cell phone industry has consistently shown that use of a cell phone protects the user from risk of a brain tumor! Does anything more need to be said? It is time that fully independent studies be funded by those governmental agencies whose charter is to protect its citizens so that the truth about the very damaging health hazards of microwave radiation becomes clear and well known."

**For identification purposes only: All statements are mine and mine alone and do not represent positions or opinions of the Central Brain Tumor Registry of the United States, the Bioelectromagnetics Society or the Brain Tumor Epidemiological Consortia.*

Janet Newton

President, The EMR Policy Institute
www.EMRPolicy.org

"The radiofrequency radiation safety policy in force in the United States fails to protect the public. Currently in the US there are more than 260 million wireless subscribers, the demand that drives the continuing build-out of antenna sites in residential and commercial neighborhoods, including near schools, daycare centers, and senior living centers and in the workplace. The January 2008 report issued by the National Academy of Sciences committee whose task was to examine the needs and gaps in the research on the biological effects of exposure to these antennas points out that the research studies to date do not adequately represent exposure realities. Specifically, the studies 1) assume a single antenna rather than the typical arrangements of a minimum of four to six antennas per site, thereby underestimating exposure intensities, 2) do not pertain to the commonly used multiple-element base station antennas, thereby not taking into account exposures to multiple frequencies, 3) lack models of several heights for men, women, and children of various ages for use in the characterization of Specific Absorption Rate (SAR) distributions for exposures from cell phones, wireless PCs, and base stations and 4) do not take into consideration absorption effects of exposures from the many different radio frequency

emitting devices to which the public is often simultaneously exposed. A federal research strategy to address these very serious inadequacies in the science on which our government is basing health policy is sorely needed now."

Prof. Livio Giuliani, PhD

Spokesperson, International Commission for Electromagnetic Safety (www.icems.eu)
Deputy Director, Italian National Institute for Worker Protection and Safety, East Venice and South Tyrol; Professor, School of Biochemistry of Camerino University, Italy

The Venice Resolution, initiated by the International Commission for Electromagnetic Safety (ICEMS) on June 6, 2008, and now signed by nearly 50 peer reviewed scientists worldwide, states in part, "We are compelled to confirm the existence of non-thermal effects of electromagnetic fields on living matter, which seem to occur at every level of investigation from molecular to epidemiological. Recent epidemiological evidence is stronger than before. We recognize the growing public health problem known as electrohypersensitivity. We strongly advise limited use of cell phones, and other similar devices, by young children and teenagers, and we call upon governments to apply the Precautionary Principle as an interim measure while more biologically relevant exposure standards are developed."

Professor Jacqueline McGlade

Executive Director, European Environmental Agency
Advisor to European Union countries under the European Commission

"There are many examples of the failure to use the precautionary principle in the past, which have resulted in serious and often irreversible damage to health and environments. Appropriate, precautionary and proportionate actions taken now to avoid plausible and potentially serious threats to health from EMF are likely to be seen as prudent and wise from future perspectives."

Paul J. Rosch, MD

Clinical Professor of Medicine and Psychiatry, New York Medical College; Honorary Vice President International Stress Management Association; Diplomate, National Board of Medical Examiners; Full Member, Russian Academy of Medical Sciences; Fellow, The Royal Society of Medicine; Emeritus Member, The Bioelectromagnetics Society

Claims that cell phones pose no health hazards are supported solely by Specific Absorption Rate (SAR) limits safety standards written by the telecommunications industry decades ago based on studies they funded. These have made the erroneous assumption that the only harm that could come from cell phone radiofrequency emissions would be from a thermal or heating action, since such non thermal fields can have no biological effects. The late Dr. Ross Adey disproved this three decades ago by demonstrating that very similar radiofrequency fields with certain carrier and modulation frequencies that had insufficient energy to produce any heating could cause the release of calcium ions from cells. Since then, numerous research reports have confirmed that non thermal fields from cell phones, tower transmitters, power lines, and other man made sources can significantly affect various tissues and physiologic functions.

We are constantly being bathed in an increasing sea of radiation from exposure to the above, as well as electrical appliances, computers, Bluetooth devices, Wi-Fi installations and over 2,000 communications satellites in outer space that shower us with signals to GPS receivers. New WiMax transmitters on cell phone towers that have a range of up to two square miles compared to Wi-Fi's 300 feet will soon turn the core of North America into one huge electromagnetic hot spot. Children are more severely affected because their brains are developing and their skulls are thinner. A two-minute call can alter brain function in a child for an hour, which is why other countries ban their sale or discourage their use under the age of 18. In contrast, this is the segment of the population now being targeted here in a $2 billion U.S. advertising campaign that views "tweens" (children between 8 and 12 years old) as the next big cell phone market. Firefly and Barbie cell phones are also being promoted for 6 to 8-year-olds.

It is not generally appreciated that there is a cumulative effect and that talking on a cell phone for just an hour a day for ten years can add up to 10,000 watts of radiation. That's ten times more than from putting your head in a microwave oven. Pregnant women may also be at increased risk based on a study showing that children born to mothers who used a cell phone just two or three times a day during pregnancy showed a dramatic increase in hyperactivity and other behavioral and emotional problems. And for the 30% of children who had also used a cell phone by age 7, the incidence of behavioral problems was 80% higher! Whether ontogeny (embryonic development) recapitulates phylogeny is debatable, but it is clear that lower forms of life are also much more sensitive. If you put the positive electrode of a 1.5 volt battery in the Pacific

Ocean at San Francisco and the negative one off San Diego, sharks in the in between these cities can detect the few billionths of a volt electrical field. EMF fields have also been implicated in the recent massive but mysterious disappearance of honeybee colonies essential for pollinating over 90 commercial crops. As Albert Einstein warned, "If the bee disappeared off the surface of the globe, then man would only have four years of life left."

Finally, all life on earth evolved under the influence of solar radiation and geomagnetic forces that we have learned to adapt to and in some instances even utilize. The health of all living systems (ranging upward from a cell, tissue, organ or person, to a family, organization or nation) depends on good communication – good communication within, as well as with the external environment. All communication in the body eventually takes place via very subtle electromagnetic signaling between cells that is now being disrupted by artificial electropollution we have not had time to adapt to. As Alvin Toffler emphasized in Future Shock, too much change in too short a time produces severe stress due to adaptational failure. The adverse effects of electrosmog may take decades to be appreciated, although some, like carcinogenicity, are already starting to surface. This gigantic experiment on our children and grandchildren could result in massive damage to mind and body with the potential to produce a disaster of unprecedented proportions, unless proper precautions are immediately implemented. At the same time, we must acknowledge that novel electromagnetic therapies have been shown to benefit stress related disorders ranging from anxiety, depression and insomnia, to arthritis, migraine and tension headaches. As demonstrated in Bioelectromagnetic Medicine, they may also be much safer and more effective than drugs, so we need to avoid throwing the baby out with the bathwater."

Scientist replies to Quebec opinion on RF health impacts

30 Jan 2017

Ten years ago, in 2006, a report from the Quebec National Institute of Public Health (Institut national de santé publique du Québec – INSPQ) recommended "to set up a task force grouping the main organizations concerned with this issue (…)" in order to evaluate and propose, if deemed necessary, reasonable and proportionate electromagnetic fields (EMFs) mitigation measures in Quebec.

The 2006 report states : "The proposed approach will be based on the terms of reference in the management of health risks of the INSPQ which advocates the reduction and elimination of risks both in a context of relative uncertainty and one of scientific uncertainty" (bold type is mine). I don't know if the task force was created, but ten years later, the INSPQ released another report entitled Évaluation des effets sur la santé des champs électromagnétiques dans le domaine des radiofréquences (Evaluation of the health effects of the electromagnetic fields in the radio frequency field). This report includes reviews of scientific studies and individual studies, along with positions of international agencies regarding standards of exposure to electromagnetic fields. The authors, Mathieu Gauthier and Denis Gauvin, clearly relegate to oblivion the precautionary principle which the 2006 report highlighted: "The Institut national de santé publique du Québec (INSPQ) also considers that the Government of Quebec should develop a policy that ensures the application of the precautionary approach regarding exposure to EMFs."

What logic led to the choice of the included studies?

The report published in the Spring of 2016 includes literature reviews and studies mainly published between 2009 and 2013.The authors conclude that "even if the limits of current research do not exclude any possibility of risks, no harmful effects on health in the short or long term have been shown for exposure to radiofrequencies (RFs) within the established limits" (bold type is mine).

The authors mention, however, that they have revised some "important publications produced until 2015". The list of references shows they also retained some studies published prior to 2009, including several co-authored by Denis Gauvin (first author of the 2006 report). The logic behind the choice of texts is really not obvious, and this reference list leaves me unsatisfied. Being concerned by EMFs health effects for the last two years, particularly with respect to possible biological effects related RF exposure from mobile phone antennas, I have noted an increase in the number of studies on the effects of EMFs published in recent years in peer-reviewed scientific journals. About half of the documents retained by the authors of the INSPQ report comes from international organizations such as the WHO (World Health Organization) and the ICNIRP (International Commission on Non-Ionizing Radiation Protection), including some from government agencies such as Industry Canada, the wireless industry, the Canadian Wireless Telecommunications Association and the International Communications Union. The other half is composed of reviews or individual studies that are, again, a small sample of what has been published own this field since 2009.

Moreover, I find it strange that instead of including a larger number of studies, which would have given their report more weight, the authors preferred including several articles by the same authors, for example Frei, Baliatsas, Joseph, Röösli, Rubin, who generally deny the existence of harmful biological effects from RFs. I also noticed that these authors often co-author the same articles (ex: Röösli and Frei, Röösli and Joseph, Joseph, Frei and Röösli, Baliatsas and Rubin). The INSPQ report does not specify the

selection criteria for the studies, merely saying: "This report analyzes primarily studies published between 2009 and 2013." No details on the type of studies selected, for instance. It's up to the readers to judge!

The thermal effect of microwaves: not the only type of effects to consider!
However, I liked the second chapter of the report, which explains what are radio frequencies, how we measure them, etc. I found explanations clear because this chapter helps to understand what it is. But the good news ends at this point. If the rest of the report is well written and well structured, it remains that the entire argument is built in reference to organizations such as Health Canada that totally deny that RFs can have harmful biological effects, with the exception of the WHO, which remains very cautious, however. This argument is based on the studies selected, which do not reflect the overall state of science on the subject.

When an international body such as ICNIRP, which establishes guidelines to limit RF exposure, relies on the sole basis of thermal effects (heating of tissue), it is an aberration. This is notably denounced by several scientists and Canadian Physicians concerned by the biological effects of RFs and also, in 2015, by the Canadian Legislature's Standing Committee of Health, whose report is not mentioned by Gauthier and Gauvin. This aberration, which leads to deny the bioeffects RF exposure levels well below limits recommended by Canada's Safety Code 6, is also endorsed by the Institute of Electrical and Electronic Engineers.

Countries taking precautions ignored or ridiculed
In addition, the authors of the report hardly mention that in 20 countries (especially in Europe), various levels of governments have adopted measures based on the precautionary principle, particularly to limit the RF exposure of vulnerable populations or the general public. France, for example, recently banned the use of Wi-Fi connections in daycares and kindergartens, and limits their use in elementary schools.

The authors of the INSPQ report prefer mentioning only two countries that adopted a more cautious approach than ours: Russia and Italy. They point out, though, that the research carried out in Russia on the immune system was published a long time ago (20 to 40 years) and that studies were made in 'medieval' times (the term is mine) with respect to laboratory techniques and standards of quality in experimental research. It's a harsh judgment to make about a country where scientists pioneered studies on the bioeffects of microwaves in the 1960s.

As well, Gauthier and Gauvin quote ANSES, the French Agency for Food, Environmental and Occupational Health and Safety, which stated that Italy's stricter RF exposure limits lack any scientific basis. They also claim that this cautious approach gives Italians cause to worry, and that the adoption of such an approach undermines "public trust in scientifically established standards." So much for the precautionary principle! It seems that neglecting this internationally-recognized principle is preferable to considering it!

Studies linking RF exposure and cancer criticized or ignored
While the INSPQ report also includes some studies linking exposure to RF to biological effects, it hastens to downplay their results and scope, and forgets to mention other studies establishing the same link. For example, the authors write about a Brazilian study that compares, for the city of Belo Horizonte, the location of cancer deaths and those of mobile phone base stations (towers/antennas). The authors discovered a strange similarity between the two: the location of "cancer clusters" reveals a much higher

mortality rate within 500 meters of cell towers. Gauthier and Gauvin downplays these findings by saying "methodological weaknesses of this study limit its conclusions". What methodological weaknesses? They don't specify. And they make sure to omit studies revealing similar results, for example a German study published in 2004. Its authors examined the medical records (dating between 1994 and 2004) of 1,000 patients of four physicians practicing in the same municipality, or 90% of its population. They found cancer rates triple among people living within 400 meters of base stations during that decade, compared to those living further away. On average, the patients living in the 400 m zone developed cancer eight years younger than the control group. The increase in cancer cases appeared only five years after the base stations were commissioned, and the authors believe the true cancer rate is probably underestimated because theeir study excluded older patients.

Scientists the report did not like

I don't understand why the INSPQ report excluded papers from scientists such as Martin Pall, a professor emeritus of biochemistry and sciences at Washington State University (United States). Pall explains an important mechanism involved in microwaves's biological effects. I also wonder why studies published in 2013, 2014 and 2015 by a prominent Swedish scientist Lennart Hardell, who authored several pioneering cell phone/cancer studies since 1999, were also excluded. Could it be because Hardell and his colleague Carlberg, in their most recent analysis, confirmed the link between cell phone or cordless phone radiation and gliomas (a rare but deadly type of brain cancer)? Or is it because, in a very detailed letter dated August 4th 2015, Hardell and Carlberg explained to WHO why it should update the current classification of RFs to include them in Category 1, "Carcinogenic to humans"?

Several individual studies and pooled analyses have been published on the noxious effects of mobile phone base stations. For example, a cohort study that followed subjects for 6 years concluded that RF exposure affects the pituitary and adrenal glands by decreasing levels of hormones (ACTH cortisol, thyroid hormones, prolactin in women and testosterone). For its part, the paper by Abdel Rassoul and colleagues, published in 2007 in Neurotoxicology, concluded that people living in the vicinity of cell towers/antennas are significantly more at greater risk of developing neuropsychiatric problems (headaches, dizziness, tremors, symptoms of depression, memory problems and sleep disorders). This study concludes that their neurobehavioral performance was poorer than that of the control group.

Noteworthy is a review of ten epidemiological studies by Khurana and colleagues, published in 2010 by the International Journal of Occupational and Environmental Health. The authors concluded that eight out of ten studies on the long-term effects of RF exposure within 500 m of cell phone base stations showed an increase in neurobehavioral symptoms or in cancer. Yet it was also excluded from INSPQ's report!

While some papers published after 2013 were mentioned in the INSPQ report, it overlooks a French study of 727 subjects (Dominique Belpomme, 2015) which found that patients diagnosed as bona fide electrohypersensitive had abnormal blood and urine marker levels (histamine, melatonin, stress proteins, vitamin D, etc.) and poor cerebral vascularisation in ultrasound imaging.

INSPQ must value the precautionary principle once again!

I could quote several other studies highlighting RF bioeffects that were ignored by Gauthier and Gauvin, including research on cells and animals. But I will conclude by saying that globally denying such effects based on a limited study sample invalidates the results of the report, even if it concludes that scientific "uncertainty" persists in this area.

If the question of RF health effects was only controversial, one might wonder if "the reduction and elimination of risks both in a context of relative uncertainty and one of scientific uncertainty" (INSPQ 2006 report) was truly considered by the authors of the 2016 report. I doubt it was because, in the few recommendations they make, there is no mention of the precautionary principle which is the main focus of the 2006 report.

It would be wise to adopt this principle regarding the use and development of wireless equipment, notably because in their 2016 report abstract, the authors admit that there is still "some scientific uncertainty about long term exposure to cell phones". A change of attitude by INSPQ is urgent. It is the health of our population that is at stake here.

https://maisonsaine.ca/sante-et-securite/electrosmog/scientist-replies-to-quebec-opinion-on-rf-health-impacts.html

Over 2,000 Studies Confirm TOXIC Effects of EMF From Cell Phones and Household Appliances

All electrical appliances and wiring in your home emit EMFs: Electrical Magnetic Fields.

Electromagnetic Radiation is a form of energy that can cause changes in the space surrounding electronic devices. The invisible fields impacts your cells and can cause debilitating health effects. In modern homes, this kind of radiation is ever-present (1).

These fields are linked to cancer, reproductive malfunction, cataracts and changes in behavior in children (2). This is because all types of EMFs react with your DNA (3).

Other health effects include (4):

- Blood cells damage
- Nerve damage
- Elevated risk of autism and Alzheimer's
- Eye & ear damage
- Sleep disruption
- Headaches
- Salivary gland tumors
- Decreased bone density
- Electromagnetic hypersensitivity
- Abnormal heart rate
- Unstable blood pressure
- Seizures

In 2007, the Bioinitiative Working Group, an international collaboration of scientists and public health experts from the Austria, China, Denmark, Sweden and the United States, released a 650-page report which cites more than 2,000 studies that chronicle the toxic effects of EMFs.

They found that chronic exposure to even low-level radiation can cause a variety of cancers, impair immunity, and contribute to Alzheimer's disease and dementia, heart disease, and many other ailments (4).

The number of studies published on the subject have now reached 8,000.

In fact, the World Health organization has even classified radio frequency radiation as "possibly carcinogenic" to humans and the IARC has classified radiofrequency electromagnetic fields as the same.

As it stands, multiple studies link these kind of radiation to increased instances of childhood leukemia and brain tumors. The younger you are when you're exposed to EMFs, the more likely you are to develop these health conditions (5).

And while many countries have yet to instill protective measures to keep their citizens safe, nearly all developed nations have documented the phenomena.

In 2001, Sweden even recognized Electromagnetic Hypersentistivity (EHS) as a functional impairment. The country estimated that over 3% of the population experiences severe symptoms related to EMF exposure. In other developed nations, this number fluctuates between 3-8%.

And that's not all, another 35-50% of the population experiences these symptoms moderately. The World Health Organization now recognizes the condition as a growing world health concern (6).

Nowadays, many schools are equipped with computers, tablets and smart boards meant to facilitate learning. Unfortunately, these new technologies used in schools are increasing EMF exposure for students and personnel.

In one California school, these technologies began taking a toll of the health of its teachers. In 1990, sixth-grade teacher named Gayle Cohen found that the onset of technology in her classroom left her and her colleges feeling weak and dizzy (7).

For months she struggled to understand the connection between her fatigue and the environment in her classroom. However, just a few years after the arrival of the computers, one of her fellow teachers developed cancer and died.

It wasn't long before another colleague was diagnosed with throat cancer. As the years went by, more faculty members and students developed strange diseases. Eventually, Cohen was diagnosed with breast cancer.

"That's when I sat down with another teacher, and we remarked on all the cancers we'd seen," she says. "We immediately thought of a dozen colleagues who had either gotten sick or passed away."

In just 15 years, 16 staff members among the 137 who'd worked at the new school had been diagnosed with 18 cancers. This ratio was 3 times higher than average. Additionally, a dozen cancers had been detected in former students. Some had even died from the disease.

When EMF levels were examined by Sam Milham, MD, an epidemiologist, he found that the the surges of transient pollution exceeded his meter's ability to gauge them.

this led to a complaint filed to the Occupational Safety and Health Administration, which in turn lead to a full investigation by the California Department of Health Care Services.

The result was shocking: exposure to the fields in Cohen's school increased the likelihood a teacher would develop cancer by 64%. In just the first year of working with computers in her classroom, Cohen had increased her risk of cancer by 21%. That's not all, the faculty member's risks of developing melanoma, thyroid cancer, and uterine cancer were up to 13 times higher than the national average.

https://dailyhealthpost.com/emf-radiation-dangers/

Study Proves Microwave Radiation Directly Affects Your Heart

Have you ever wondered why some restaurants post warning signs for customers with pacemakers that the establishment uses a microwave oven?

A pacemaker is an electrical device implanted in the chest to maintain proper heart rhythm. Microwaves can interfere with the electrical impulses of the pacemaker.

The human heart is also an electrical device that naturally maintains the appropriate rhythm. Microwave radiation has the same effect on the real organ as it does on the plastic implant.

Dr. Magda Havas of Trent University in Ontario has conducted several studies on the effects of microwave radiation in the human body. Her 2010 study began with the question, "Does radiation from a cordless phone affect the heart?"

She and her colleagues tested the effects of 3 minutes of exposure from a common cordless telephone running at 2.4 GHz (gigahertz) with 25 people. Forty percent of the subjects experienced changes to their heart rate.

Her conclusion:"arrhythmia, heart palpitations, heart flutter, or rapid heartbeat and/or vasovagal symptoms such as dizziness, nausea, profuse sweating and syncope when exposed to electromagnetic devices. It is the first study to demonstrate such a dramatic response to pulsed MW [microwave] radiation at 0.5% of existing federal guidelines (1000 microW/cm^2) in both Canada and the US." (1)

A cordless telephone uses about 3 watts of power. Microwave ovens work at 2.5 GHz frequency but are run with the power of 1000 watts. Hence, the harmful effects of microwave ovens are all too real for patients with pacemakers.

Havas' subsequent study in 2013 expanded the research into "electrosmog", the miasma of electromagnetic radiation emitted by wireless technology that constantly surrounds us. Devices that contribute to electrosmog are cell phones, smart meters, wireless routers, baby monitors, computers, gaming consoles, radios, television, and the like.

Electrohypersensitivity is the term used for the vast number of people who experience debilitating physical consequences from exposure to radio frequency (microwave) emissions—it is also called "rapid aging syndrome". That doesn't sound very appealing.

The most common symptoms experienced by the subjects involved in the study were:

- Fatigue
- Sleep disturbance
- Headaches
- Feeling of discomfort
- Difficulty concentrating
- Depression
- Memory loss
- Visual disruptions
- Irritability
- Hearing disruptions
- Skin problems

- Cardiovascular
- Dizziness
- Loss of appetite
- Movement difficulties
- Nausea

Electrosmog affects the blood, heart, and entire autonomous nervous system. The closer the source of the radiation, the more severe and chronic the effects. Any one device wouldn't be a problem but we are bombarded with this radiation virtually everywhere.

"EHS [electrohypersensitivity] may be viewed as a contentious issue, yet a growing number of international experts, scientists, and medical doctors have been asking governments and international agencies for decades to lower existing guidelines for RF [radio frequency] radiation because the current guidelines do not protect public health…The information provided in this article is not new. Reviews as far back as 1969 summarized the effects of microwave radiation and identified many of the same symptoms." (2)

Microwave ovens aren't wireless—they require too much power for that. But the type of radiation used to cook food is the same as the kind used to make a call. The danger they present isn't from the oven itself but microwaved foods.

A microwave oven works by flooding food with electromagnetic radiation; the molecular structures of the food are changed by the radiation. When we eat food cooked (or even warmed) by microwaves, our physiology changes too.

In fact, microwave ovens were banned in Russia after results of extensive research found (among other things):

- Cooking vegetables with microwave radiation releases free radicals (which, as we know, cause cancer)
- Degeneration of immune responses due to a compromised lymphatic system
- Significant decreases in the nutritional value of all foods cooked in this way
- Changes in how sugars break down
- Molecular changes in foods caused digestive disorders, including stomach and intestinal cancer
- Proteins were broken down into abnormal formations (3)

Still not convinced? Consider this from a forensic review of 28 studies performed in different countries of the effects of microwaved food in humans:

"From the twenty-eight above enumerated indications, the use of microwave apparatus is definitely not advisable…Due to the problem of random magnetic residulation and binding within the biological systems of the body…which can ultimately effect the neurological systems, primarily the brain and neuroplexuses (nerve centers), long term depolarization of tissue neuroelectric circuits can result. Because these effects can cause virtually irreversible damage to the neuroelectrical integrity of the various components of the nervous system (I. R. Luria, Novosibirsk 1975a), ingestion of microwaved foods is clearly contraindicated in all respects." (4)

https://dailyhealthpost.com/microwave-oven/

Press Release by the Health Protection Agency on 15th Sept 2009 entitled "Scientist probe laptops Wi-Fi Emissions.

Comments by Andrew Goldsworthy on 20th Sept 2009

The following quote from the notes to editors is muddled and deeply misleading. "There is no consistent evidence to date that exposure to RF signals from Wi-Fi and WLANs adversely affect the health of the general population". It is muddled because it confuses two completely separate issues.

1. Is there any evidence that Wi-Fi is harmful to health? The answer to this is DEFINITELY YES.
2. Is the whole population affected? The answer to this is SEEMINGLY NOT.

It is misleading because it is written in such a way as to imply that Wi-Fi is safe for EVERYONE and there is no reason why it should not be used universally in schools. What about the health of the students and staff who are affected? Do they not care?
The use of the word "consistent" in the quote is also worrying since it suggests that physicists and engineers, possibly from the mobile phone and Wi-Fi industries, rather than biologists and health experts, are in control.

No trained biologist or medical practitioner would ever expect the same level of consistency from experiments with complex living organisms as is possible with simple physical systems.
Apart from identical twins, each one of us is genetically and physiologically unique and we do not all respond in the same way to metabolic insults. Not everyone who smokes dies of cancer, and we do not all suffer the same side effects from taking a medicinal drug. Even the same person may not be equally susceptible all of the time. For example, if we are ill, our resistance to further infections is usually lowered. Anyone who says that we must all show the same response to electromagnetic radiation before its effects can be regarded as real must have a very limited knowledge of biology. They are certainly not qualified to sit in judgment on important health issues that are likely to affect billions of people worldwide, let alone the health of unsuspecting UK school children and staff who have no choice.

Not every country agrees on the Safety Guidelines
The press release is also misleading when it says that the electromagnetic radiation from wireless laptops and mobile phones fall within internationally agreed Safety Guidelines. It says nothing about the fact that THESE GUIDELINES ARE NOT UNIVERSALLY AGREED and many other countries such as Russia, China, Italy, Switzerland and the USA (i.e. much of the industrialized world) are much more cautious than the UK, and set their safety limits between ten and one thousand times lower (www.bioinitiative.org).

These guidelines do not include non-thermal effects
The guidelines that the UK Health Protection Agency refers to are based on those proposed by ICNIRP, using research that is at least a decade out of date. In particular, they make the assumption that the only way that non-ionizing radiation can damage living cells is due to its heating effect. They do not include the direct electrical effects on cell membranes, which can occur at radiation levels that are hundreds or even thousands of times lower.

It just should not have happened
Many of these non-thermal effects are catalogued in the BioInitiative Report, which was drawn up by a team of expert scientists in 2007. They examined over two thousand peer-reviewed scientific papers on

the effects of non-ionizing radiation and found that over two thirds of them showed some sort of biological effect that could not be explained by heating (www.bioinitiative.org). Not all were directly concerned with health, but if the ICNIRP guidelines were valid, none of them should ever have occurred. We cannot therefore assume that radiation that falls within the ICNIRP guidelines is necessarily safe.

What causes these non-thermal electrical effects?

Most of the non-thermal effects of electromagnetic radiation can be explained in terms of the leakage of cell membranes following the electromagnetic removal of structurally important calcium ions. It has been known since the work of Suzanne Bawin and her co-workers in 1975 (Bawin et al. 1975. Ann. N.Y. Acad Sci, 247: 74- 81) that otherwise harmless radio waves could remove calcium ions from brain cell membranes when they were amplitude modulated at a low frequency; i.e. when the strength of the radio signal rose and fell in time with the low frequency. These experiments have been repeated many times and also with other tissues such as heart muscle (For a review, see Blackman 2009. Pathophysiology, 16: 205-216).

The general conclusion from these and many similar experiments is that low frequency electromagnetic fields, or radio waves that are amplitude modulated at a low frequency, can remove calcium ions from the membranes of some but not all kinds of living cells. Pulses are more effective than sine waves, possibly because their sharp rise and fall times are more effective at jerking the calcium away from the membrane and also allow more time for it to be replaced by other ions before the field reverses. Pulses carried by microwaves should be particularly effective because the high frequency of the carrier permits faster rise and fall times for the pulses.

The Mechanism of calcium removal

Living tissues can absorb non-ionizing radiation and convert it into alternating electric currents, just like the antenna of a radio set. The only real difference is that, in living tissues, these currents are carried by ions (electrically charged atoms and molecules) rather than electrons. When these currents impinge on cell membranes, which are normally negatively charged, they vibrate like miniature loudspeakers in time with the signal. This loosens some of the positive ions bound to them since they are driven in the opposite direction.

If the signal is strong, all the ions bounce on and off the membrane more or less equally, but if the signal is weak, only the more strongly charged ions, such as calcium (which has a double charge) are pulled off. Ions with only one charge, such as potassium then take their place. Very little energy is needed, since the ions have only to be moved by molecular dimensions and the effect is simply to change the natural chemical equilibrium between the different ions bound to the membrane. However, the effect can be devastating.

Only weak signals do this

Only weak signals can *selectively* remove calcium in this way. Even then, it can only occur in narrow ranges of signal strength called amplitude windows, above and below which there is little or no effect. The exact positions of these windows are indeterminate since they depend on the nature of the membrane, the availability of other ions to replace the calcium and how well the tissue is acting as an antenna.

Cells are constantly moving in and out of their windows.

Living tissues are dynamic systems and their characteristics, including their electrical characteristics, are constantly changing, which means that they will not always be equally efficient as antennas. Also, as we go about our daily business, our exposure to electromagnetic fields and our orientation to them are constantly changing so that individual cells may not stay long enough in their windows to do significant harm.

However, all this changes when the source and orientation of the field is constant, such as when using a mobile phone or sleeping near a base station. Some cells may then be in their windows for long enough to do significant damage. The important thing to note is that any assertion that Wi-Fi and mobile phones must be safer than other forms of electromagnetic radiation just because the signal is weaker is both false and dangerous. Mobile phones and Wi-Fi laptops, by leaving individual cells for prolonged periods in their amplitude widows may do more damage than general electromagnetic pollution. Under some circumstances, a weaker signal may even drive more cells into their amplitude windows and make matters worse.

How calcium loss makes cell membranes leak

The calcium ions lost due to electromagnetic exposure were important. Because they have a double charge they have an especially strong attraction to the negatively charged membrane components on either side and bind them together just as mortar binds together the bricks in a wall. However, the ions with only one charge that replace them do this less well, so the membrane may now develop temporary pores and leak. This leakage can then cause all sorts of harmful effects.

The biological effects of membrane leakage

Many of the so-called “modern illnesses” that have increased, sometimes dramatically, in the last few decades can be linked to cell membrane leakage due to our increasing exposure to non-ionizing electromagnetic radiation.

Electromagnetic hypersensitivity (EHS)

Electromagnetic hypersensitivity is a condition in which people experience physical symptoms such as rashes and/or a wide range of unpleasant sensory disturbances during or shortly after exposure to electromagnetic fields. It can develop in previously healthy people after prolonged exposure and appears to be largely irreversible. It was first noticed in radar technicians, when it was called microwave sickness, but it has increased dramatically in recent years in the general population. About three percent of the population are now affected in this way, and its incidence often appears to be associated with prolonged exposure to microwave based telecommunications.

Virtually all of the symptoms can be explained by electromagnetically-induced cell membrane leakage. Sufferers are characterized by already having unusually leaky cell membranes as measured by skin conductance. This makes them more prone to the consequences of additional electromagnetically-induced leakage. When their skin cells leak, it can result in inflammation and rashes. When their sensory cells leak, it can result in numerous unpleasant sensory disturbances.

We all have many different kinds of sensory cells, but they all work by “deliberately” leaking ions through their membranes when they sense whatever they are programmed to sense. This reduces the natural voltage across their external membranes, which in turn triggers the release of neurotransmitters that stimulate neighboring nerve cells to send signals to the brain. Unscheduled leakage due to electromagnetic exposure can therefore trigger false sensations such as pins and needles, heat, pain and

pressure, depending on which cells are most affected. When the hair cells of the inner ear are affected, it can cause tinnitus, which is a false sensation of sound. When it affects those concerned with balance, it can cause dizziness and trigger symptoms of motion sickness, including nausea. Prolonged exposure to the radiation seems to damage these cells permanently so they become even more inclined to leak and the person becomes sensitized for life.

Brain Hyperactivity

When cells of the brain and nervous system leak, free calcium ions can enter the neurons from outside. In normal circumstances, neurons require a "deliberate" brief inflow of calcium ions to trigger the release of neurotransmitters so that they can send signals to neighboring neurons. Unscheduled steady calcium inflow due to electromagnetic radiation makes them more likely to release neurotransmitters, some of which will send false messages. This in turn can trigger brain hyperactivity leading, amongst other things, to sleep disturbances, loss of concentration (giving rise to ADHD) and stress headaches.

Autism

Electromagnetically-induced brain hyperactivity and confused thought during early childhood may cause autism (which has gone up 60-fold in the last thirty years). Basic social skills are learnt during the first 18-months of life, after which they become hard-wired into the child's psyche by pruning under-used synapses. This enables them to become automatic and require very little thought. However, this mass cull of under-used synapses is a normal stage in development that occurs only once at around 18 months. If the initial learning process has been disrupted by brain hyperactivity, many social skills may remain poorly learnt by the time the synapses are pruned, and the child may become irreversibly autistic. Babies exposed to the radiation from cordless baby monitors may be particularly at risk but this has not been tested.

Dementia

Dementia in the elderly also seems to be on the increase, and some of it can be attributed to electromagnetic exposure. Salford and co-workers (Salford et al. 2003. Environmental Health Perspectives 111: 881-883) showed that extremely weak electromagnetic radiation such as that from mobile phones could disrupt the blood brain barrier and allow unwanted materials, such as albumin from the blood stream to enter and kill neurons. Although the effect may not be immediately noticeable, prolonged exposure is likely to lead to early dementia.

Allergies

All of our body surfaces, both inside and out, are normally protected from unwanted materials entering by barriers similar to the blood-brain barrier, where the gaps between the cells are sealed, forming what are known as tight junctions. There is strong evidence that these too leak in response to weak electromagnetic radiation, which would allow the more rapid entry of allergens, foreign chemicals and other unwanted materials. This may account for the massive increases in asthma, allergies and multiple chemical sensitivities that have accompanied our increasing exposures to electromagnetic radiation in recent years.

Autoimmune diseases

These include type-1 diabetes, multiple sclerosis and celiac disease, all of which are on the increase. This has been attributed to an increased leakiness of the gut barrier (also known as leaky gut syndrome) and may be exacerbated by electromagnetic exposure. It allows particles of partially digested food to enter the bloodstream. From there, they may be engulfed by body cells by endocytosis, followed by an

attempt to digest them internally. However, some materials, e.g. gluten, are difficult to digest and may be mistaken for a virus. The cell responds by displaying it on its surface, which identifies it to the white blood cells of the immune system as a cell that must be killed to prevent the spread of the "infection". This triggers inflammation, which is both painful and attracts more white blood cells to the area, which may make matters worse and results in the death of perfectly healthy cells. Celiac disease is an autoimmune response, triggered by gluten, which causes inflammation of the gut, but autoimmune diseases in other parts of the body may have a similar aetiology.

Effects on internal membranes and DNA

There are at least two mechanisms by which the leakage of the cell's internal membranes can damage DNA. Living cells are divided into various internal compartments by membranes that are all variations of the same basic structure as the outer membrane. From our standpoint, the two most important compartments are the lysosomes and the mitochondria.

The lysosomes are membrane-bound structures full of digestive enzymes that digest cellular waste ready for recycling. Membrane leakage here releases these enzymes, which can digest and damage the rest of the cell, including its DNA.

The mitochondria are the cell's power stations. They carry out the controlled oxidation of materials derived from our food to generate ATP, which is the main energy currency of the cell. This oxidation actually goes on in groups of enzymes embedded in their membranes and involves highly reactive chemicals called free radicals. Damage to these membranes is likely to release of some of these free radicals that can then react with and destroy other cellular components, including DNA. It's like blowing up a furnace scattering burning embers everywhere.

There is even some similarity to blowing up a nuclear power station since, although no radioactivity is involved, the free radicals that are normally locked safely away in the mitochondrial membranes, have very similar activities to those that do most of the damage when a cell is irradiated with gamma rays. Indeed, many concerned scientists have noted the similarity between the biological effects of non-ionizing radiation and gamma rays. Non-ionizing radiation should therefore be treated with as much caution as ionizing radiation until much more is known about its biological effects.

Brain Cancer

DNA damage has been found in many experiments in many laboratories when cultured cells have been exposed to mobile phone radiation, even for less than a day (see www.bioinitiative.org). It can therefore account for the brain and other head cancers that we are now beginning to see in people who have been heavy users of mobile phones for ten years or more; with children being at greatest risk (Hardell et al. 2009 Pathophysiology 16: 113-122).

Thyroid cancer

There has also been an unexplained increase in thyroid cancer in recent years (the thyroid gland is in the neck; just inches from where you hold your mobile phone) and may have a similar aetiology to brain cancer.

Mobile phones may make you fat

Another consequence of DNA damage is a partial loss of function in the exposed organ. For example, Rajkovic and co-workers (Rajkovic et al. 2003 Tissue & Cell 35: 223–231) showed that exposing rats to

power line frequencies for over three months caused a seemingly permanent loss of thyroid function. If this were to occur in humans as a result of the radiation from wireless telecommunications, we would expect to see widespread symptoms of hypothyroidism, which include fatigue, loss of muscle tone and obesity. It may be no coincidence that about thirty percent of our population is now either overweight or clinically obese (with all the extra risks to health that this implies) and the number of teenagers on anti-obesity drugs has gone up 15-fold in the ten years since the use of mobile phones, DECT cordless phones and Wi-Fi became almost universal.

Effects on fertility

There have been several studies showing that mobile phone use reduces male fertility. One of the more recent, by Agarwal and co-workers (Agarwal et al. 2008 Fertil Steril 89: 124-8) showed that using a mobile phone for more than four hours a day caused a reduction in sperm numbers, motility and viability, each of around 25 percent. The prolonged use of a Wi-Fi laptop computer on or near the lap could have even more serious consequences for male fertility. Effects on female fertility have not yet been studied but, since all the eggs that a woman will ever have were already in her ovaries before she was born, the cumulative effect could be considerable. All of these effects can be attributed to electromagnetic DNA damage, which could also lead to miscarriages, deformities in the offspring and genetic mutations that may not appear for several generations. Anyone who considers Wi-Fi to be safe should think again.

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http://www.radiationresearch.org/pdfs/20090926_hpa_Wi-Fi_ag_comments.pdf

Dispelling the Wireless Myths

With all of the recent coverage of Wi-Fi networks and mobile phone base stations, it seems appropriate to address some of the common microwave radiation exposure myths that get frequently promulgated by the pseudo-scientific, pseudo-intellectual technical community online.

Myth 1: We've been exposed to this radiation for years, it must be safe

From the Sun

Yes, we had heard quite a few people saying that standard cosmic background radiation has enough microwaves in it that we should already be being affected even before the appearance of TV and radio, let alone mobile phones. The background microwave radiation (by which we refer to frequencies ranging from 300 MHz to 30 GHz) from the Sun was almost non-existent, millionths of what can be found in your local wireless cafe. So even if the signals themselves were the same, this claim is nonsense.

Background on Radiation Frequencies

It is generally accepted now that X-rays can cause health problems via known mechanisms (e.g. DNA strand breaks). It is also generally accepted that visible light does not cause much harm (with the possible exception of eye-damage if the intensity is too great) during the daytime (caveat here as night-time visible light may cause health problems such as breast cancer indirectly by melatonin suppression). As any physicist could tell you, whilst both naturally occurring forms of radiation, they consist of very different wavelengths and are not comparable.

From Radio and TV

FM Radio tranmissions are at about 100 MHz, considerably lower than the 900 MHz and 1800 MHz of GSM mobile phone communications. Moreover, and we believe this is of critical importance, radio transmissions are continuous wave transmissions, and do not rely on pulsed signals to transmit data. Likewise, whilst the transmission frequency of TV is much closer (approximately 450 to 850 MHz), this is again close to continuous wave, and does not have anything like the amplitude modulation that mobile phone carriers do.

This is crucial, not because it guarantees that there must therefore be a risk, but because it highlights that this exposure is new. We are now being surrounded and bombarded by radiation that is unlike anything we have been exposed to previously. It may be safe, it may not be, but we cannot use the argument that it has been around for years as this is not the case.

Myth 2: People only got affected when the scare stories started, it must be psychosomatic

Again, this is a quickly dispelled myth (often also referred to as a 'nocebo' effect -- basically a negative 'placebo' effect). A quick look at some of the science:

Cell death induced by GSM 900-MHz and DCS 1800-MHz mobile telephony radiation
Panagopoulos DJ et al, January 2007 [View on Pubmed]

This study from the University of Athens in Greece found that DNA fragmentation of egg chamber cells could be created in fruit flies when exposed to a simulated phone call from a real digital mobile phone. Yes, this is not damaging human tissue, but it is clearly not a psychological response.

Effects of electromagnetic radiation from a cellular phone on human sperm motility: an in vitro study
Erogol O et al, October 2006 [View on Pubmed]

This study from Turkey found examined the sperm motility (a measure of fertility) in 27 male human subjects. They found that after exposure from a standard GSM 900-MHz mobile phone sperm motility was measurably decreased, and that this decrease was statistically signifcant. Again, not a psychological response.

Gene expression changes in human cells after exposure to mobile phone microwaves
Remondini D et al, September 2006 [View on Pubmed]

This *in vitro* study from the University of Bologna in Italy found that some (but not all) of the tested cell lines would react to 900 and 1800 MHz microwave radiation. This is again evidence that a non-thermal reaction can be found that is not psychological, and again can be replicated in lab conditions.

Possible Effects of Electromagnetic Fields from Phone Masts on a Population of White Stork (Ciconia ciconia)
Balmori A, October 2005 [View full paper on our site]

This time a study on animal populations in Spain, Balmori looked at the nesting and behavioural patterns of white storks located around a mobile phone base station near Valladolid. Some very startling results, such as the storks failing to start or half building their nests. It was also found that the number of storks without young rose from a consistent average of 5-10% before the mast was built up to 40% after the mast was built. Again this is not looking at humans, but it is also therefore not feasible to put this down to some form of psychosomatic phenomena.

Myth 3: Being on a phone for 20 minutes is equivalent to 1 year in a Wi-Fi classroom

This statement, very unhelpfully publicized by Mike Clark, senior spokesperson for the Health Protection Agency, is both factually incorrect and highly misleading.

Whist Mike Clark is right that a mobile phone, working on full power and with you talking continuously (not listening) can technically expose you up to about 50% of the SAR limits. In normal use, with a good number of signal strength bars showing on the display (say 75% signal level), the phone will be working at somewhere between one-thousandth and one-twentieth of this level. Let's average this at about one fiftieth as a reasonable level for the phone to be operating at most of the time. Then, if you are talking 50% of the time, this would reduce the transmitted pulses (using DTX) by another factor of 2. So, a typical exposure would not be 50% of the SAR limit but more like 0.5% of the SAR limit which we should assume to be 0.5% of the the ICNIRP limit (for a typical call).

11/10/2007 - This has been updated to more accurately reflect expected real life power outputs from Wireless access points in use.

Now we come to a slightly different exposure regime in the classroom in that you are not holding the wLAN card to your head. 2.4 GHz wLANs (most common in the UK) operate at 0.03 watts output power (5-6 GHz ones can use up to 20 times this). So we have one wLAN node in the classroom (0.03 W) and, say, 20 laptops all at 0.03 W. However, they are only transmitting much power when actually transferring files. So, let's say that we have the equivalent of one laptop operating absolutely continuously (actually the combined output of 20 may well be more that this), and that we are on

average 2 meters from the antennas. This seems reasonable based on the fact that there are 20 in the room. So E = (sq.root (30*0.03*2))/2 = 0.67 V/m equivalent continuous. Now the ICNIRP guidance at 2.4 GHz is 61.5 V/m. So the signal strength is about 1/100th of what is allowed. Power is proportional to signal strength squared so that would be around 1/10000th of the ICNIRP power level.

So, we have a mobile phone call next to head typically 0.5% (1/200th) of the ICNIRP guidance. We also have being in a 20 PC wLAN classroom being something in the order of 0.01% (or 1/10000th) of ICNIRP guidance, about a 50-fold difference.

Therefore 20 minutes on a mobile phone running at typical power levels would be equivalent to about 16 hours in a classroom with 20 wLAN PCs, approximately eight standard school days.

There are other differences. In the phone call situation, almost all the energy goes into the user's head and hand. In a classroom situation the whole body absorbs this lower level of power, so the "total body burden" if we were to compare it with ionizing radiation (for example), would actually be very similar.

We have no idea how Mike Clark can feel justified in claiming this completely unsubstantiated and unsupportable statistic.

Addendum:
The above calculations are based on absorbed power levels, which is based on the idea that the only thing that microwaves do is heat you. As we are looking at non-thermal effects we believe that signal strength is likely to be a more appropriate metric (measured in volts per metre). This has the advantage of not being averaged over time, and we can therefore tell the difference between exposure from a continuous wave signal and one where the signal consists of a number of short pulses with gaps.

Myth 4: The WHO factsheet says there is no cause for concern, and they should know

Whilst it would be great if this was true, it also appears that they have become quite the bureaucracy when it comes to actually keeping on top of the science. The wonderful factsheet that keeps getting quoted as evidence that there is no problem can be found here, and was last updated in June 2000, over 6 and a half years ago! They have not taken into account any of Hardell's work showing an increase in brain cancer from mobile phone usage, the INTERPHONE studies, nor did they assess any of the papers shown in the rebuttal of myth 2 (which, incidentally, is just the tip of the iceberg anyway). This factsheet is so hopelessly out of date with regards to the current state of science on this issue that it should now be simply ignored.

Important Update - 07/06/2007: Actually, this section is incorrect, the latest WHO factsheet on electromagnetic fields and health is Factsheet 304, from May 2006. So whilst it would still have ignored all 4 references in Myth 2, it is much more relevant. Sadly, some points made in the document are factually incorrect, such as "To date, the only health effect from RF fields identified in scientific reviews has been related to an increase in body temperature (> 1 °C) from exposure at very high field intensity found only in certain industrial facilities, such as RF heaters". The factsheet also states "Over the past 15 years, studies examining a potential relationship between RF transmitters and cancer have been published. These studies have not provided evidence that RF exposure from the transmitters increases the risk of cancer." So whilst it is a more recent report, I can only assume that this review also didn't look at the Hardell work that found a clear and statistically significant increase in some forms of brain cancer from extended mobile and cordless phone use.

The problem is that the sentences themselves are "enhanced" by the usage of highly subjective terminology. For example, the conclusions state "Considering the very low exposure levels and research results collected to date, there is no convincing scientific evidence that the weak RF signals from base stations and wireless networks cause adverse health effects." Everything in this sentence hinges around the word "convincing", without which the statement would be factually incorrect. However, convincing is both entirely subjective and also not justified in either the document itself nor the linked documents. It would be interesting to understand exactly what constituted "convincing", and in the meantime it would be better to have a less ambiguous description of what the correct science actually says.

http://www.powerwatch.org.uk/news/20070424_Wi-Fi_myths.asp

The Invisible Threat: Radiofrequency Radiation Risk

The wireless industry has experienced rapid growth since the first cell phone call was made in 1973. Today, there are more than 285 million wireless subscribers on commercial networks in the United States alone. To supply this vast consumer base (more than 90% of Americans) with coverage, the industry has dramatically expanded its networks. In 1996, there were fewer than 23,000 cell sites throughout the United States. Today, there are more than 247,000 commercial cell sites in the country, according to industry advocacy group CTIA. If you add in government-run sites, that number jumps to 600,000. In the near future, there will be more than one million. And each of these antennas creates a radiofrequency radiation hazard zone.

Decades of scientific research dating back to 1960 has determined that excessive exposure to radiofrequency radiation is hazardous to human health. In response, the Institute of Electrical and Electronics Engineers (IEEE), the world's largest professional association for the advancement of technology, developed the first standard for human exposure limits to radiofrequency radiation in 1966.

There have been revisions over the years as the issue has become better understood, and these standards have been widely adopted throughout the world by various groups. The American National Standard Institute, for one, adopted the IEEE limits as a national standard in 1992. The FCC incorporated the limits into its regulations in 1996.

All told, the present, multi-agency exposure guidelines have a lineage that dates back nearly half a century and is based on long-standing, uncontroverted science clearly demonstrating that radiofrequency radiation exposure causes "behavioral disruption," including reduced brain function and memory loss in laboratory subjects. In other words, science proves the causal link between radiofrequency radiation exposure and behavioral, cognitive and psychological injuries, such as depression, memory loss, mood disorders, sleep disorders and impaired cognitive function.

The Alaska Supreme Court has also recognized the link between radiofrequency exposures and psychological injuries. In AT&T Alascom v. Orchitt, satellite communications provider AT&T Alascom was forced to pay temporary total disability and medical benefits to John Orchitt, a company employee. Orchitt originally filed for workers compensation benefits claiming that he had suffered head, brain and upper-body injuries as a result of overexposure to radiofrequency radiation. AT&T tried to appeal the verdict in both state superior and supreme courts to no avail.

The lesson here is that while the disability benefits themselves may not have been huge in monetary terms, the case resulted in a string of expert witnesses on both sides, eight years of litigation, expensive legal fees for AT&T and, still, the company lost. Even if the scientifically proven risks of radiofrequency radiation do not scare you, this precedent alone should alarm any company that believes this liability is not worth worrying about.

The financial risk posed by the potential litigation that may be filed on behalf of workers may be significant for many employers, FCC licensees (commercial or governmental), property owners/managers, utility companies, local governments, school districts and universities. Of course, their insurance companies will also be subject to that same potential liability. And given that the number

of antenna sites in the United States is expected to double within the near future-not to mention the use of new, stealth and collocated antennas-the financial fallout could rise exponentially.

For potential plaintiffs, proving overexposure to radiofrequency radiation is not difficult. Counsel can easily show that a worker performed a specific task at an antenna site, noting the proximity to radiofrequency radiation transmitting antenna systems (which, these days, are located everywhere) and the length of exposure time. A subpoena would likely prove that, under current and historical business practices, most FCC licensees do not power-down radiofrequency transmitting antennas to protect third party workers.

Thus, proof of a violation of radiofrequency radiation above human exposure limits will be straightforward. And sympathetic juries could render substantial judgments. It is not out of the question to think that the potential litigation could be comparable to the fallout created by asbestos or mold. And as any company that has been subject to those claims can attest, such long-tail liabilities are not just expensive-they are huge internal resource drains.

Improving Safety

In order to prevent such a legal nightmare, radiofrequency radiation safety must be improved and implemented immediately. Current strategies and methodologies to protect workers have been outstripped and rendered obsolete by the rapid proliferation of wireless networks.

In the past, the limited number of systems were isolated and could be fenced-off with access only granted to radiofrequency-trained technicians. But today, wireless antennas are everywhere: on rooftops, the sides of buildings, utility poles, light standards and hidden entirely within the structures of buildings.

Workers who are required to perform their jobs in close proximity to radiofrequency radiation transmitters are no longer just trained industry technicians protected by the latest gear and equipment. Rather, they are now roofers, electricians, carpenters, maintenance personnel, HVAC technicians, painters, first-responders and many others. And they are routinely required to work in exposure zones without the benefit of safety training-and, often, without any knowledge that over-exposure to wireless systems can be dangerous in the first place.

Ultimately, these unsuspecting workers are regularly exposed to excessive levels of radiofrequency radiation because there is no comprehensive radiation safety system currently in operation. And given the health hazards and potential liabilities involved, the time for complacency and neglect to the safety of our nation’s workers has passed. A viable radiofrequency safety program must be implemented, and it must be characterized by independence, transparency and validation. It also must be implemented now.

First and foremost, education is crucial. Everyone at risk should be taught the exposure regulations and hazards associated with radiofrequency emissions. Workers must be given site-specific safety plans that combine with an updated database of antenna locations to establish a standardized national radiofrequency safety protocol that includes the participation of all required stakeholders (i.e., FCC

licensees, property owners hosting antenna sites, employers, local governments and the workers themselves).

A national, accessible registry of wireless antenna systems that identifies location and exposure zones throughout North America will end the wholesale addition of new claimants and significantly reduce the financial liability of all stakeholders. The registry will be similar to the "Call 811 before you dig" underground utility locator service and constitute an electronic repository of documentary evidence of use and compliance with radiofrequency safety.

For this to occur, the insurance industry must also demand the deployment of a meaningful loss-control tool to continue to provide affordable coverage to its customers. The industry should not be lulled into a false sense of security by the momentary dearth of claims and lawsuits brought on behalf of workers seeking compensation.

The risk is here, it is imminent and unless a loss-control tool is implemented to protect the insurance industry and its insured customers, an inevitable tidal wave of litigation with significant financial consequences is assured.

http://www.rmmagazine.com/2010/08/01/the-invisible-threat-radiofrequency-radiation-risk/

Radiation from Cell Phones and Wi-Fi Are Making People Sick -- Are You at Risk?

There are over 5 billion operating cell phones on the planet. These phones exchange signals with millions of cell phone towers. In your home, your favorite coffee shop, your local library and certainly in your office, you have WI-FI.

You probably also have a sprinkling of other wireless technologies, like a cordless phone, a wireless baby monitor or alarm system, or maybe even a USB-powered device that gives your cell phone Web access, which has been referred to as a "cell-phone tower for your pocket."

Even if you have opted out of such conveniences, there's a good chance your neighborhood has not. This means that, essentially, your environment is saturated with wireless technologies and the frequencies they emit – and you're being impacted whether you realize it or not.

The simple answer to this question is, no one knows. How could they? The technologies that have become so intertwined with what it means to live in the 21st century – cell phones, laptops, iPads, and so on – have never-before existed.

And as a species, we have embraced them fully, without understanding what types of risks they may ultimately present. As written in AlterNet:

"We now live in a wireless-saturated normality that has never existed in the history of the human race. It is unprecedented because of the complexity of the modulated frequencies that carry the increasingly complex information we transmit on our cell phones, smart phones and wi-fi systems.

These EMFs [electromagnetic fields] are largely untested in their effects on human beings. Swedish neuroscientist Olle Johansson, who teaches at the world-renowned Karolinska Institute in Stockholm, … [states] the mass saturation in electromagnetic fields raises terrible questions.

Humanity, he says, has embarked on the equivalent of "the largest full-scale experiment ever. What happens when, 24 hours around the clock, we allow ourselves and our children to be whole-body-irradiated by new, man-made electromagnetic fields for the entirety of our lives?"

There is reason for concern, not only because an outpouring of research is painting a very different picture about cell phone safety than the telecommunications industry would have you believe, but also because of a growing population of electrically sensitive individuals, the EMF canaries in the coal mine.

It is estimated that 3-8 percent of populations in developed countries experience serious electrohypersensitivity symptoms, while 35 percent experience mild symptoms, according to Dr. Thomas Rau, medical director of the world-renowned Paracelsus Clinic in Switzerland. Dr. Rau also believes that 'electromagnetic loads' lead to cancer, concentration problems, ADD, tinnitus, migraines, insomnia, arrhythmia, Parkinson's and even back pain.
You can listen to an audio interview with Dr. Rau on www.electromagnetichealth.org. For people with Electromagnetic Hypersensitivity Syndrome (EHS), just walking into a coffee shop that is WI-FI equipped can be debilitating, triggering a wide array of symptoms including headache, fatigue, nausea, burning and itchy skin, and muscle aches. Some students have to drop out of school or are unable to continue on

to graduate programs once they become electrically sensitive, irrespective of their intelligence and capabilities.
Even just briefly standing in line at the post office, or traveling on public transportation, can be a debilitating experience for some people, sometimes taking hours to restore balance. In this AlterNet article, you can read several examples from people who believe exposure to electromagnetic radio frequencies made them sick, including:

- The Rall family, whose farm animals became sick and developed tumors, and whose children suffered hyperactivity, skin rashes, and neurological problems, after a cell phone tower was put up 800 feet from their home.
- Michele Hertz, who experienced severe memory loss, inability to concentrate and other significant debilitating symptoms after a wireless "smart" meter was installed on her house.

The conventional medical establishment has yet to acknowledge electrohypersensitivity as a "real" health issue, but the number of people experiencing severe symptoms that clear up when exposure to EMFs is eliminated, makes it impossible to ignore.
Further, with the work of Magda Havas, PhD, of the Environmental & Resources Studies Department at Trent University, Canada and others, acceptance is slowly growing and the real health effects of EMF are becoming harder to deny.
For instance, research from Dr. Havas revealed that a cordless phone base station placed about two feet from your head and plugged in for three minutes at a time can significantly disrupt your heart rhythm, leading to increases in heart rate, arrhythmias and other disturbances in heart rate variability.

This is among the most solid proof that the effects of EMF radiation are real, as are the symptoms that some people readily experience when they're around such microwave-emitting devices. The biological effects on the heart in the Havas study were found at .3% of the FCC exposure limits.
Researchers have, in fact, found that there are a number of factors that influence the degree to which you may be affected by EMFs. For example, according to research by Dr. Dietrich Klinghardt, your physical body, such as your body weight, body-mass index, bone density, and water and electrolyte levels can alter the conductivity and biological reactivity to EMFs. Children are also particularly vulnerable.

While some of the health effects of the wireless revolution are immediately apparent to sensitive populations, most people seemingly feel fine when using the technology. However, this should not be taken as guarantee of safety, as some health conditions take years, or even decades, of exposure to develop.

The perfect example? Cancer.

On May 21, 2011, the International Agency for Research on Cancer (IARC), a committee of 27 scientists from 14 different countries working on behalf of the World Health Organization (WHO), also concluded that exposure to cell phone radiation is a "possible carcinogen" and classified it into the 2B category. This is the same category as the pesticide DDT, lead, gasoline engine exhaust, burning coal and dry cleaning chemicals, just to name a few.

The group did not perform any new research; rather the decision is based on a review of the previously published evidence, including the Interphone study results published so far (about 50% have still not been released). This is the same evidence that the National Cancer Institute (NCI) and the American Cancer Society (ACS), among others, have previously waved aside, calling it "reassuring," and claiming it showed "no evidence" of harm. The IARC decision came only days after the Council of Europe, elders from 47 European countries, called for a dramatic reduction in EMF exposure to humans from call phones and wireless technologies.

Some nations have already adopted the precautionary principle, and have previously issued precautionary advice to mobile phone users. Now that cell phone radiation has been classified as a "possible carcinogen," these messages can be strengthened in a meaningful way to reach more people, across the world.

Dr. Martin Blank, PhD, of Columbia University and one of the most experienced researchers of the cellular and molecular effects of electromagnetic fields in the U.S., gave an informative speech at the November 18, 2010 Commonwealth Club of California program, "The Health Effects of Electromagnetic Fields," co-sponsored by ElectromagneticHealth.org.

Dr. Blank spoke with deep experience and commanding authority on the impact of electromagnetic fields on cells and DNA, and explained why your DNA, with its 'coil of coils' structure, is especially vulnerable to electromagnetic fields of all kinds. As described in the International Journal of Radiation Biology, April 2011, DNA possesses the two structural characteristics of fractal antennas, electronic conduction and self-symmetry.

These properties contribute to greater reactivity of DNA to electromagnetic fields than other tissues, making the long-term consequences of repeated microwave exposures to our genetic material of great concern.

Dr. Blank is adamant when he says that there IS evidence of harm, and that the harm can be significant. He also points out that the science showing harmful effects has been peer-reviewed, published, and that the results have been replicated, evaluated and "judged by scientists capable of judging it."

Even barring all the scientific evidence, it simply makes sense that cell phones and wireless technology can impact the human body once you understand that your body is bioelectric. Your body contains electrons which keep an electrical current flowing, and inside every cell are mitochondria, the 'power plants' of the cell that respond to the body's natural electromagnetic fields.

As Dr. Maret explains in his interview with ElectromagneticHealth.org, your body is a complex communication system where cells, tissues, organs, and organisms "talk" -- it's a veritable "electronic symphony in your body." This communication includes finely tuned bio-electrical transmitters and receivers, which are tuned like tuning into a radio station.

And when you expose a radio antenna to a significant amount of external noise, you get static, and that is what is happening to your body in today's EMF-saturated environment.

We're still in the infancy of EMF science as it relates to understanding the mechanism of the human health effects, but there is enough solid evidence to show that there are very real risks apparent. It is time to exercise the precautionary principle, but keep in mind that completely eliminating exposure is close to impossible. Even if you don't use a cell phone and your home is wireless-free, you can be exposed to microwave radiation from your neighbor's wireless devices or while visiting "hot spots" or traveling near cell phone towers. That said, there's still plenty you can do to minimize your exposure and help safeguard your children's health:

- Children Should Never Use Cell Phones: Barring a life-threatening emergency, children should not use a cell phone, or a wireless device of any type. Children are far more vulnerable to cell phone radiation than adults, because of their thinner skull bones, and still developing immune and neurological systems.
- Reduce Your Cell Phone Use: Turn your cell phone off more often. Reserve it for emergencies or important matters. As long as your cell phone is on, it emits radiation intermittently, even when you are not actually making a call.
- Leave an outgoing message on your phone stating your cell phone policy so others know not to call you on it except in emergencies.
- Use a Land Line at Home and at Work: Although more and more people are switching to using cell phones as their exclusive phone contact, it is a dangerous trend and you can choose to opt out of the madness.
- Reduce or Eliminate Your Use of Other Wireless Devices: You would be wise to cut down your use of these devices. Just as with cell phones, it is important to ask yourself whether or not you really need to use them every single time.
- If you must use a portable home phone, use the older kind that operates at 900 MHz. They are no safer during calls, but at least some of them do not broadcast constantly even when no call is being made. Note the only way to truly be sure if there is an exposure from your cordless phone is to measure with an electrosmog meter, and it must be one that goes up to the frequency of your portable phone (so old meters won't help much). As many portable phones are 5.8 Gigahertz, we recommend you look for RF meters that go up to 8 Gigahertz, the highest range now available in a meter suitable for consumers.
- Alternatively you can be very careful with the base station placement as that causes the bulk of the problem since it transmits signals 24/7, even when you aren't talking. So if you can keep the base station at least three rooms away from where you spend most of your time, and especially your bedroom, it may not be as damaging to your health.
- Ideally it would be helpful to turn off or disconnect your base station every night before you go to bed. Levels of microwave radiation from portable phones can be extraordinarily high.
- Your portable phone is a problem if the technology is labeled DECT, or digitally enhanced cordless technology.
- Limit Your Cell Phone Use to Where Reception is Good: The weaker the reception, the more power your phone must use to transmit, and the more power it uses, the more radiation it emits, and the deeper the dangerous radio waves penetrate into your body. Ideally, you should only use your phone with full bars and good reception.
- Also seek to avoid carrying your phone on your body as that merely maximizes any potential exposure. Ideally put it in your purse or carrying bag. Placing a cell phone in a shirt pocket over

the heart is asking for trouble, as is placing it in a man's pocket if he seeks to preserve his fertility.

- Don't Assume One Cell Phone is Safer than Another. There's no such thing as a "safe" cell phone, and do not rely on the SAR value to evaluate the safety of your phone. Always seek CDMA carriers over GSM as they have far lower radiation in their signaling technology. And remember, eliminating cell phone use, or greatly lowering cell phone use from phones of all kinds, is where true prevention begins.
- Keep Your Cell Phone Away From Your Body When it is On: The most dangerous place to be, in terms of radiation exposure, is within about six inches of the emitting antenna. You do not want any part of your body within that area.
- Respect Others Who are More Sensitive: Some people who have become sensitive can feel the effects of others' cell phones in the same room, even when it is on but not being used. If you are in a meeting, on public transportation, in a courtroom or other public places, such as a doctor's office, keep your cell phone turned off out of consideration for the 'second hand radiation' effects. Children are also more vulnerable, so please avoid using your cell phone near children.
- Use Safer Headset Technology: Wired headsets will certainly allow you to keep the cell phone farther away from your body. However, if a wired headset is not well-shielded the wire itself acts as an antenna attracting ambient information carrying radio waves and transmitting radiation directly to your brain. Make sure that the wire used to transmit the signal to your ear is shielded.

The best kind of headset to use is a combination shielded wire and air-tube headset. These operate like a stethoscope, transmitting the information to your head as an actual sound wave; although there are wires that still must be shielded, there is no wire that goes all the way up to your head.

Are You Electrically Sensitive?

To further avoid EMF exposure, or for those who are especially sensitive, it's especially to stay protected during the night when your body is trying to repair and rebuild:

- Turn off all the fuses at night that supply your bedroom. You can install a 'demand switch' at your bedside to make this very convenient.
- Shield your bed with a special metalized fabric canopy to protect yourself from harmful frequencies that can disrupt cellular communication.
- If you are constructing a new home or renovating one and the walls are being rebuilt you can install radiant barrier, which is a tough type of aluminum foil that will also very effectively screen out the EMF. This is what I did for my own bedroom.
- At minimum, move your bed so that your head is at least 3-6 feet from all electrical outlets. If you are constructing the walls you can put the wires inside pipes, which will virtually eliminate the fields that are generated in the room when the current runs through the wire.
- Turn off and unplug everything electrical in your sleeping area, including your computer, WI-FI, cell and portable phones.
- Sleep on a non-metal bed and mattress.

- Be aware that cell phones and WI-FI are not the only EMF sources you need to be cautious of. Essentially, most all electronics will generate EMFs, including the wiring in your home, electric alarm clocks, electric blankets, computers and lamps, just to mention a few.
- For best results, avoid using electric blankets and electric heating pads, and unplug all electrical appliances when not in use. Even better, at night, turn off the fuses directly.
- Protect yourself from cordless phones. If you want to avoid the radiation you should switch back to a wired landline and ditch your cordless phone entirely.
- If you must use a conventional cordless phone, be sure to keep the base station at least three rooms away from where everyone sleeps and where you spend the most time during the day. Or simply keep it off except in the limited circumstances when you feel you need to use it.
- The base station of a DECT phone always transmits at full power, so this is not a device you want sitting on your nightstand next to your bed, on your kitchen counter or even on at all if it is not necessary.

http://articles.mercola.com/sites/articles/archive/2011/12/20/radiation-from-cell-phones-and-Wi-Fi-are-making-people-sick--are-you-at-risk.aspx

Radiation From Cell Phones and Wi-Fi Are Making People Sick — Are We All at Risk?

We are now exposed to electromagnetic radio frequencies 24 hours a day. Welcome to the largest human experiment ever.

December 2, 2011

Consider this story: It's January 1990, during the pioneer build-out of mobile phone service. A cell tower goes up 800 feet from the house of Alison Rall, in Mansfield, Ohio, where she and her husband run a 160-acre dairy farm. The first thing the Rall family notices is that the ducks on their land lay eggs that don't hatch. That spring there are no ducklings.

By the fall of 1990, the cattle herd that pastures near the tower is sick. The animals are thin, their ribs are showing, their coats growing rough, and their behavior is weird -- they're agitated, nervous. Soon the cows are miscarrying, and so are the goats. Many of the animals that gestate are born deformed. There are goats with webbed necks, goats with front legs shorter than their rear legs. One calf in the womb has a tumor the size of a basketball, another carries a tumor three feet in diameter, big enough that he won't pass through the birth canal. Rall and the local veterinarian finally cut open the mother to get the creature out alive. The vet records the nightmare in her log: "I've never seen anything like this in my entire practice... All of [this] I feel was a result of the cellular tower."

Within six months, Rall's three young children begin suffering bizarre skin rashes, raised red "hot spots." The kids are hit with waves of hyperactivity; the youngest child sometimes spins in circles, whirling madly. The girls lose hair. Rall is soon pregnant with a fourth child, but she can't gain weight. Her son is born with birth defects -- brittle bones, neurological problems -- that fit no specific syndrome. Her other children, conceived prior to the arrival of the tower, had been born healthy.

Desperate to understand what is happening to her family and her farm, Rall contacts the Environmental Protection Agency. She ends up talking to an EPA scientist named Carl Blackman, an expert on the biological effects of radiation from electromagnetic fields (EMFs) -- the kind of radiofrequency EMFs (RF-EMFs) by which all wireless technology operates, including not just cell towers and cell phones but Wi-Fi hubs and Wi-Fi-capable computers, "smart" utility meters, and even cordless home phones. "With my government cap on, I'm supposed to tell you you're perfectly safe," Blackman tells her. "With my civilian cap on, I have to tell you to consider leaving."

Blackman's warning casts a pall on the family. When Rall contacts the cell phone company operating the tower, they tell her there is "no possibility whatsoever" that the tower is the source of her ills. "You're probably in the safest place in America," the company representative tells her.

The Ralls abandoned the farm on Christmas Day of 1992 and never re-sold it, unwilling to subject others to the horrors they had experienced. Within weeks of fleeing to land they owned in Michigan, the children recovered their health, and so did the herd.

Not a single one of the half-dozen scientists I spoke to could explain what had happened on the Rall farm. Why the sickened animals? Why the skin rashes, the hyperactivity? Why the birth defects? If the radiofrequency radiation from the cell tower was the cause, then what was the mechanism? And why today, with millions of cell towers dotting the planet and billions of cell phones placed next to billions of heads every day, aren't we all getting sick?

In fact, the great majority of us appear to be just fine. We all live in range of cell towers now, and we are all wireless operators. More than wireless operators, we're nuts about the technology. Who doesn't keep at their side at all times the electro-plastic appendage for the suckling of information?

The mobile phone as a technology was developed in the 1970s, commercialized in the mid-80s, miniaturized in the '90s. When the first mobile phone companies launched in the United Kingdom in 1985, the expectation was that perhaps 10,000 phones would sell. Worldwide shipments of mobile phones topped the one billion mark in 2006. As of October 2010 there were 5.2 billion cell phones operating on the planet. "Penetration," in the marketing-speak of the companies, often tops 100 percent in many countries, meaning there is more than one connection per person. The mobile phone in its various manifestations -- the iPhone, the Android, the Blackberry -- has been called the "most prolific consumer device" ever proffered.

I don't have an Internet connection at my home in Brooklyn, and, like a dinosaur, I still keep a landline. But if I stand on my roof, I see a hundred feet away, attached to the bricks of the neighboring parking garage, a panel of cell phone antennae -- pointed straight at me. They produce wonderful reception on my cell phone. My neighbors in the apartment below have a wireless fidelity connection -- better known as Wi-Fi -- which I tap into when I have to argue with magazine editors. This is very convenient. I use it. I abuse it.

Yet even though I have, in a fashion, opted out, here I am, on a rooftop in Brooklyn, standing bathed in the radiation from the cell phone panels on the parking garage next door. I am also bathed in the radiation from the neighbors' Wi-Fi downstairs. The waves are everywhere, from public libraries to Amtrak trains to restaurants and bars and even public squares like Zuccotti Park in downtown Manhattan, where the Wall Street occupiers relentlessly tweet.

We now live in a wireless-saturated normality that has never existed in the history of the human race.

It is unprecedented because of the complexity of the modulated frequencies that carry the increasingly complex information we transmit on our cell phones, smart phones and Wi-Fi systems. These EMFs are largely untested in their effects on human beings. Swedish neuroscientist Olle Johansson, who teaches at the world-renowned Karolinska Institute in Stockholm, tells me the mass saturation in electromagnetic fields raises terrible questions. Humanity, he says, has embarked on the equivalent of "the largest full-scale experiment ever. What happens when, 24 hours around the clock, we allow ourselves and our children to be whole-body-irradiated by new, man-made electromagnetic fields for the entirety of our lives?"

We have a few answers. Last May, the International Agency for Research on Cancer (IARC, a branch of the World Health Organization), in Lyon, France, issued a statement that the electromagnetic frequencies from cell phones would henceforth be classified as "possibly carcinogenic to humans." The determination was based in part on data from a 13-country study, called Interphone, which reported in 2008 that after a decade of cell phone use, the risk of getting a brain tumor -- specifically on the side of the head where the phone is placed -- goes up as much as 40 percent for adults. Israeli researchers, using study methods similar to the Interphone investigation, have found that heavy cell phone users were more likely to suffer malignant tumors of the salivary gland in the cheek, while an independent study by scientists in Sweden concluded that people who started using a cell phone before the age of 20 were five times as likely to develop a brain tumor. According to a study published in the International

Journal of Cancer Prevention, people living for more than a decade within 350 meters of a cell phone tower experience a four-fold increase in cancer rates.

The IARC decision followed in the wake of multiple warnings, mostly from European regulators, about the possible health risks of RF-EMFs. In September 2007, Europe's top environmental watchdog, the EU's European Environment Agency, suggested that the mass unregulated exposure of human beings to widespread radiofrequency radiation "could lead to a health crisis similar to those caused by asbestos, smoking and lead in petrol." That same year, Germany's environmental ministry singled out the dangers of RF-EMFs used in Wi-Fi systems, noting that people should keep Wi-Fi exposure "as low as possible" and instead choose "conventional wired connections." In 2008, France issued a generalized national cell phone health warning against excessive cell phone use, and then, a year later, announced a ban on cell phone advertising for children under the age of 12.

In 2009, following a meeting in the Brazilian city of Porto Alegre, more than 50 concerned scientists from 16 countries -- public health officials, biologists, neuroscientists, medical doctors -- signed what became known as the Porto Alegre Resolution. The signatories described it as an "urgent call" for more research based on "the body of evidence that indicates that exposure to electromagnetic fields interferes with basic human biology."

That evidence is mounting. "Radiofrequency radiation has a number of biological effects which can be reproducibly found in animals and cellular systems," says David O. Carpenter, director of the Institute for Health and the Environment at the State University of New York (SUNY). "We really cannot say for certain what the adverse effects are in humans," Carpenter tells me. "But the indications are that there may be -- and I use the words 'may be' -- very serious effects in humans." He notes that in exposure tests with animal and human cells, RF-EMF radiation causes genes to be activated. "We also know that RF-EMF causes generation of free radicals, increases production of things called heat shock proteins, and alters calcium ion regulation. These are all common mechanisms behind many kinds of tissue damage."

Double-strand breaks in DNA -- one of the undisputed causes of cancer -- have been reported in similar tests with animal cells. Swedish neuro-oncologist Leif Salford, chairman of the Department of Neurosurgery at Lund University, has found that cell phone radiation damages neurons in rats, particularly those cells associated with memory and learning. The damage occurred after an exposure of just two hours. Salford also found that cell phone EMFs cause holes to appear in the barrier between the circulatory system and the brain in rats. Punching holes in the blood-brain-barrier is not a good thing. It allows toxic molecules from the blood to leach into the ultra-stable environment of the brain. One of the potential outcomes, Salford notes, is dementia.

Other effects from cell phone radiofrequencies have been reported using human subjects. At Loughborough University in England, sleep specialists in 2008 found that after 30 minutes of cell phone use, their subjects required twice the time to fall asleep as they did when the phone was avoided before bedtime. EEGs (electroencephalograms) showed a disturbance of the brain waves that regulate sleep. Neuroscientists at Swinburne University of Technology in Australia discovered in 2009 a "power boost" in brain waves when volunteers were exposed to cell phone radiofrequencies. Researchers strapped Nokia phones to their subjects' heads, then turned the phones on and off. On: brain went into defense mode. Off: brain settled. The brain, one of the lead researchers speculated, was "concentrating to overcome the electrical interference."

Yet for all this, there is no scientific consensus on the risks of RF-EMFs to human beings.

The major public-health watchdogs, in the US and worldwide, have dismissed concerns about it. "Current evidence," the World Health Organization (WHO) says, "does not confirm the existence of any health consequences from exposure to low level electromagnetic fields." (The WHO thus contradicts the findings of one of its own research units.) The US Federal Communications Commission has made similar statements. TheAmerican Cancer Society reports that "most studies published so far have not found a link between cell phone use and the development of tumors." The cell phone industry's lobbying organization, CTIA-The Wireless Association, assures the public that cell phone radiation is safe, citing studies -- many of them funded by the telecom industry -- that show no risk.

Published meta-reviews of hundreds of such studies suggest that industry funding tends to skew results. According to a survey by Henry Lai, a research professor at University of Washington, only 28 percent of studies funded by the wireless industry showed some type of biological effect from cell phone radiation. Meanwhile, independently funded studies produce an altogether different set of data: 67 percent of those studies showed a bioeffect. The Safe Wireless Initiative, a research group in Washington, DC that has since closed down, unpacked the data in hundreds of studies on wireless health risks, arraying them in terms of funding source. "Our data show that mobile phone industry funded/influenced work is six times more likely to find 'no problem' than independently funded work," the group noted. "The industry thus has significantly contaminated the scientific evidence pool."

The evidence about the long-term public health risks of exposure to RF-EMFs may be contradictory. Yet it is clear that some people are getting sick when heavily exposed to the new radiofrequencies. And we are not listening to their complaints.

Take the story of Michele Hertz. When a local utility company installed a wireless digital meter -- better known as a "smart" meter -- on her house in upstate New York in the summer of 2009, Hertz thought little of it. Then she began to feel odd. She was a practiced sculptor, but now she could not sculpt. "I couldn't concentrate, I couldn't sleep, I couldn't even finish sentences," she told me. Hertz experienced "incredible memory loss," and, at the age of 51, feared she had come down with Alzheimer's.

One night during a snowstorm in 2010 her house lost power, and when it came back on her head exploded with a ringing sound -- "a terrible piercing." A buzzing in her head persisted. She took to sleeping on the floor of her kitchen that winter, where the refrigerator drowned out the keening. There were other symptoms: headaches and nausea and dizziness, persistent and always worsening. "Sometimes I'd wake up with my heart pounding uncontrollably," she told me. "I thought I would have a heart attack. I had nightmares that people were killing me."

Roughly one year after the installation of the wireless meters, with the help of an electrician, Hertz thought she had figured out the source of the trouble: It had to be something electrical in the house. On a hunch, she told the utility company, Con Edison of New York, to remove the wireless meter. She told them: "I will die if you do not install an analog meter." Within days, the worst symptoms disappeared. "People look at me like I'm crazy when I talk about this," Hertz says.

Her exposure to the meters has super-sensitized Hertz to all kinds of other EMF sources. "The smart meters threw me over the electronic edge," she says. A cell phone switched on in the same room now gives her a headache. Stepping into a house with Wi-Fi is intolerable. Passing a cell tower on the street

hurts. "Sometimes if the radiation is very strong my fingers curl up," she says. "I can now hear cell phones ringing on silent. Life," she says, "has dramatically changed."

Hertz soon discovered there were other people like her: "Electrosensitives," they call themselves. To be sure, they comprise a tortured minority, often misunderstood and isolated. They share their stories at online forums like Stopsmartmeters.org, the EMF Safety Network, and the Electrosensitive Society. "Some are getting sick from cell phones, some from smart meters, some from cell towers," Hertz tells me. "Some can no longer work and have had to flee their homes. Some are losing their eyesight, some can't stop shaking, most cannot sleep."

In recent years, I've gotten to know dozens of electrosensitives. In Santa Fe, New Mexico, I met a woman who had taken to wearing an aluminum foil hat. (This works -- wrap a cell phone in foil and it will kill the signal.) I met a former world record-holding marathoner, a 54-year-old woman who had lived out of her car for eight years before settling down at a house ringed by mountains that she said protected the place from cell frequencies. I met people who said they no longer wanted to live because of their condition. Many of the people I talked to were accomplished professionals -- writers, television producers, entrepreneurs. I met a scientist from Los Alamos National Laboratories named Bill Bruno whose employer had tried to fire him after he asked for protection from EMFs at the lab. I met a local librarian named Rebekah Azen who quit her job after being sickened by a newly installed Wi-Fi system at the library. I met a brilliant activist named Arthur Firstenberg, who had for several years published a newsletter, "No Place to Hide," but who was now homeless, living out of the back of his car, sleeping in wilderness outside the city where he could escape the signals.

In New York City, I got to know a longtime member of the Institute of Electrical and Electronics Engineers (IEEE) who said he was electrosensitive. I'll call him Jake, because he is embarrassed by his condition and he doesn't want to jeopardize his job or his membership in the IEEE (which happens to have for its purpose the promulgation of electrical technology, including cell phones). Jake told me how one day, a few years ago, he started to get sick whenever he went into the bedroom of his apartment to sleep. He had headaches, suffered fatigue and nausea, nightsweats and heart palpitations, had blurred vision and difficulty breathing and was blasted by a ringing in the ears -- the typical symptoms of the electrosensitive. He discovered that his neighbor in the apartment building kept a Wi-Fi transmitter next door, on the other side of the wall to his bedroom. When Jake asked the neighbor to shut it down, his symptoms disappeared.

The government of Sweden reports that the disorder known as electromagnetic hypersensitivity, or EHS, afflicts an estimated 3 percent of the population. A study by the California Department of Health found that, based on self-reports, as many as 770,000 Californians, or 3 percent of the state's population, would ascribe some form of illness to EMFs. A study in Switzerland recently found a 5 percent prevalence of electrosensitivity. In Germany, there is reportedly a 6 percent prevalence. Even the former prime minister of Norway, Dr. Gro Harlem Brundtland, until 2003 the director general of the World Health Organization, has admitted that she suffers headaches and "strong discomfort" when exposed to cell phones. "My hypersensitivity," she told a Norwegian newspaper in 2002, "has gone so far that I react to mobile phones closer to me than about four meters." She added in the same interview: "People have been in my office with their mobile hidden in their pocket or bag. Without knowing if it was on or off, we have tested my reactions. I have always reacted when the phone has been on -- never when it's off."

Yet the World Health Organization -- the same agency that Brundtland once headed -- reports "there is no scientific basis to link EHS symptoms to EMF exposure." WHO's findings are corroborated by a 2008 study at the University of Bern in Switzerland which found "no evidence that EHS individuals could detect [the] presence or absence" of frequencies that allegedly make them sick. A study conducted in 2006 at the Mobile Phone Research Unit at King's College in London came to a similar conclusion. "No evidence was found to indicate that people with self-reported sensitivity to mobile phone signals are able to detect such signals or that they react to them with increased symptom severity," the report said. "As sham exposure was sufficient to trigger severe symptoms in some participants, psychological factors may have an important role in causing this condition." The King's College researchers in 2010 concluded it was a "medically unexplained illness."

"The scientific data so far just doesn't help the electrosensitives," says Louis Slesin, editor and publisher of *Microwave News*, a newsletter and website that covers the potential impacts of RF-EMFs. "The design of some of these studies, however, is questionable." He adds: "Frankly, I'd be surprised if the condition did not exist. We're electromagnetic beings. You wouldn't have a thought in your head without electromagnetic signals. There is electrical signaling going on in your body all the time, and the idea that external electromagnetic fields can't affect us just doesn't make sense. We're biological and chemical beings too, and we know that we can develop allergies to certain biological and chemical compounds. Why wouldn't we also find there are allergies to EM fields? Shouldn't every chemical be tested for its effects on human beings? Well, the same could be said for each frequency of RF radiation."

Dr. David Carpenter of SUNY, who has also looked into electrosensitivity, tells me he's "not totally convinced that electrosensitivity is real." Still, he says, "there are just too many people with reports of illness when chronically near to EMF devices, with their symptoms being relieved when they are away from them. Like multiple chemical sensitivity and Gulf War Syndrome, there is something here, but we just don't understand it all yet."

Science reporter B. Blake Levitt, author of *Electromagnetic Fields: A Consumer's Guide to the Issues*, says the studies she has reviewed on EHS are "contradictory and nowhere near definitive." Flaws in test design stand out, she says. Many with EHS may be simply "too sensitized," she believes, to endure research exposure protocols, possibly skewing results from the start by inadvertently studying a less sensitive group. Levitt recently compiled some of the most damning studies of the health effects from cell towers in a report for the International Commission on Electromagnetic Safety in Italy. "Some populations are reacting poorly when living or working within 1,500 feet of a cell tower," Levitt tells me. Several studies she cited found an increase in headaches, rashes, tremors, sleep disturbances, dizziness, concentration problems, and memory changes.

"EHS may be one of those problems that can never be well defined -- we may just have to believe what people report," Levitt says. "And people are reporting these symptoms all over the globe now when new technologies are introduced or infrastructure like cell towers go into neighborhoods. It's not likely a transcultural mass hallucination. The immune system is an exquisite warning mechanism. These are our canaries in the coal mine."

Swedish neuroscientist Olle Johansson was one of the first researchers to take the claims of electrosensitivity seriously. He found, for example, that persons with EHS had changes in skin mast cells -- markers of allergic reaction -- when exposed to specific EM fields. Other studies have found that radiofrequency EMFs can increase serum histamine levels -- the hallmark of an allergic reaction.

Johansson has hypothesized that electrosensitivity arises exactly as any common allergy would arise -- due to excessive exposure, as the immune system fails. And just as only some people develop allergies to cats or pollen or dust, only some of us fall prey to EM fields. Johansson admits that his hypothesis has yet to be proven in laboratory study.

One afternoon not long ago, a nurse named Maria Gonzalez, who lives in Queens, New York, took me to see the cell phone masts that irradiate her daughter's school. The masts were the usual flat-paneled, alien-looking things nested together, festooned with wires, high on a rooftop across from Public School 122 in Astoria. They emitted a fine signal -- five bars on my phone. The operator of the masts, Sprint-Nextel, had built a wall of fake brick to hide them from view, but Maria was unimpressed with the subterfuge. She was terrified of the masts. When, in 2005, the panels went up, soon to be turned on, she was working at the intensive care unit at St. Vincent's Hospital. She'd heard bizarre stories about cell phones from her cancer-ward colleagues. Some of the doctors at St. Vincent's told her they had doubts about the safety of their own cellphones and pagers. This was disturbing enough. She went online, culling studies. When she read a report published in 2002 about children in Spain who developed leukemia shortly after a cell phone tower was erected next to their school, she went into a quiet panic.

Sprint-Nextel was unsympathetic when she telephoned the company in the summer of 2005 to express her concerns. The company granted her a single meeting that autumn, with a Sprint-Nextel technician, an attorney, and a self-described "radiation expert" under contract with the company. "They kept saying, 'we're one hundred percent sure the antennas are safe,'" Maria told me as we stared at the masts. "'One hundred percent sure! These are children! We would never hurt children.'" She called the office of Hillary Clinton and pestered the senator once a week for six months -- but got nowhere. A year later, Gonzalez sued the US government, charging that the Federal Communications Commission had failed to fully evaluate the risks from cell phone frequencies. The suit was thrown out. The judge concluded that if regulators for the government said the radiation was safe, then it was safe. The message, as Gonzalez puts it, was that she was "crazy ... and making a big to-do about nothing."

I'd venture, rather, that she was applying a commonsense principle in environmental science: the precautionary principle, which states that when an action or policy -- or technology -- cannot be proven with certainty to be safe, then it should be assumed to be harmful. In a society thrilled with the magic of digital wireless, we have junked this principle. And we try to dismiss as fools those who uphold it -- people like Gonzalez. We have accepted without question that we will have Wi-Fi hotspots in our homes, and at libraries, and in cafes and bookstores; that we will have wireless alarm systems and wireless baby monitors and wireless utility meters and wireless video games that children play; that we will carry on our persons wireless iPads and iPods and smart phones. We are mesmerized by the efficiency and convenience of the infotainment appendage, the words and sounds and pictures it carries. We are, in other words, thoughtless in our embrace of the technology.

http://www.alternet.org/story/153299/radiation_from_cell_phones_and_Wi-Fi_are_making_people_sick_--_are_we_all_at_risk

Are Cell Phones and Wi-Fi Hazardous to Your Health?

"You may not be able to see electropollution, but your body responds to it as though it were a cloud of toxic chemicals." —Ann Louse Gittleman, author of Zapped: Why Your Cell Phone Shouldn't Be Your Alarm Clock and 1,268 Ways to Outsmart the Hazards of Electronic Pollution

The latest form of environmental pollution — and one that industry, government and wireless consumers don't like to acknowledge — may be the most devastating threat to health yet: electromagnetic fields (EMFs). A few years ago, I was so concerned that I took a certification course in the detection and harmful effects of EMFs. What it taught me, above all, was how much the scientific community is learning daily, and how little we in the medical profession knew. This area was both frightening and daunting in its scope. I'm grateful that following Devra Davis's *Disconnect: The Truth About Cell Phone Radiation* we now have *Zapped* to educate the public on this serious issue.

The UK's BioInitiative Report of July 2007 (updated in 2009) describes hundreds of studies that link EMF exposure to Alzheimer's disease, ALS (Lou Gehrig's disease), brain fog, cardiovascular disease, miscarriage, infertility, insomnia, learning impairment, as well as anxiety and depression. Wireless technologies — like cell and cordless phones — produce microwaves that increase the permeability of the blood-brain barrier, leading to changes in brain chemistry. Even low-level EMFs can cause brain cells to leak.

That's not all: Although actual tissue heating does not occur, EMFs also cause breaks in DNA, speed up cell division, disrupting the orderly process of chromosome matching and detaching, and activate stress protein or heat shock proteins. And as Anne Louise Gittleman writes in *Zapped*:

Most disturbing of all, the Swedish National Institute for Working Life found that people using cell phones for 2,000 hours — a total most of us could easily rack up over the years — had a 240 percent increased risk for malignant brain tumors on the side of the head where they usually held their phone.

So, what do we do to avoid these dangers? I'm relieved that Gittleman, my friend and colleague and author of over 30 bestselling books, has tackled this topic. We'll learn that most of us don't need to give up all the digital and electronic gadgets that make life so much easier. To protect ourselves, we first need to recognize the risks and then make smart choices in how we use all the available technological wonders.

Why Are EMFs So Dangerous?

What most people don't realize is the human body is naturally electrified. From the organic computer that is your brain, which sends out sensory messages like hunger and pain, to the energy that pumps your heart and makes your muscles contract, electricity powers your body. This innate electromagnetism within you is so critical to your daily functioning that modern medicine uses it in diagnostic testing (including electrocardiograms and MRIs) and, increasingly, to heal.

The "body electric" is an exquisitely tuned and sensitive creation, but unfortunately, human beings (and animals) respond favorably to only a very small range of electromagnetic frequencies. And there's a big difference between the body's natural electricity and the man-made electromagnetic frequencies that surround us 24/7 today. According to *New York Times* reporter B. Blake Levitt in *Public Health SOS*:

Most living things are fantastically sensitive to vanishingly small EMF exposures. Living cells interpret such exposures as part of our normal cellular activities (think heartbeats, brainwaves, cell division itself, etc.) The problem is, man-made electromagnetic exposures aren't "normal." They are artifacts, with unusual intensities, signaling characteristics, pulsing patterns, and wave forms. And they can misdirect cells in myriad ways.

Some of this radiation — extremely low frequency (ELF) radiation in power lines, the radio frequency (RF)/microwave range where all things wireless live, intermediate frequencies ("dirty electricity" or freaky frequencies linked to sick building syndrome), and the highest frequencies (gamma and X-rays) — is more damaging than natural frequencies to which humans (and animals) have adapted over millennia. Today, most Americans are constantly exposed to artificial frequencies, given the rapidly escalating pace of microwave and wireless expansion.

The bottom line is that electropollution — from cell towers, computers, cordless and mobile phones, PDAs, Wi-Fi, even the electrical appliances and wiring in our homes, offices and public buildings — continuously disturbs the sympathetic nervous system. This, in turn, elevates the body's fight-and-flight response, raising levels of the stress hormone cortisol. Fluctuations in cortisol lead to a wide range of health concerns ranging from belly fat and thinning skin to accelerated aging, blood sugar imbalance, cardiovascular problems, erratic sleep patterns and mood disturbances. Dr. Stephen Sinatra elaborates on this issue in his new book, *Earthing.*

Your body responds to EMFs as though they were public enemy number-one, triggering what two-time Nobel Prize nominee Robert Becker, M.D., in his 1998 book *The Body Electric*, called "subliminal stress." While intellectually you don't recognize this kind of stealth stress the way you would overwork or being stuck in traffic when you're late for an important appointment, your body's internal antennae pick up on it in several ways, according the late scientist, Dr. W. R. Adey, from Loma Linda University:

- The flow of blood and oxygen shuts down to all except major organs like the brain and heart.
- Any systems — including digestion and immunity — that aren't necessary for fight or flight response are put on hold.
- Blood pressure and heart rate as well as blood sugar levels increase to prepare your body for danger.

Recent research by Magda Havas, Ph.D., associate professor of Environmental and Resource Studies at Trent University in Canada, shows that dirty electricity — EMFs in electrical wiring — can raise blood sugar levels in diabetics and people at risk for diabetes. "Exposure to electromagnetic pollution in its various forms may account for higher plasma glucose levels and contribute to the misdiagnosis of diabetes," she writes. Dr. Havas' website is a goldmine of information on the entire topic of EMF pollution, as is Dr. Mercola's EMF site!

Electromagnetic Hypersensitivity

There are "canaries in the coal mine" — hypersensitive individuals who are severely weakened by EMFs, and find themselves marginalized by the medical profession and society in general. Some must live in areas far from cell towers, Wi-Fi and the like. On a cellular level, these individuals have measurable damage to the mitochondria, the energy factories in each cell, and require reparative nutrients, for

starters. I recently heard from a concerned family member of a man who had been exposed over time to a cell tower beaming through his office window. Quite ill, he was nonetheless unwilling to move his office location as I suggested, and I didn't hear from them again. Ignoring the messenger, however, doesn't solve the problem.

Zap-Proof Your Children

Today, an estimated 31 million kids are on their cell phones close to four hours a day. Mobile phone companies are even marketing phones to preschoolers. Gittleman writes:

The trouble is, kids absorb 50 percent more electropollution than adults. One study finds that a cell phone call lasting only two minutes can cause brain hyperactivity that lasts up to an hour in children. Because their skulls are smaller and thinner than adults, EMFs penetrate much deeper into children's brains. Kids' brains are also more conductive due to their higher water and ion concentration.

The Toronto Board of Health recommends that children under eight use cell phone only for emergencies and that teens limit calls to under 10 minutes. If your kids have cell phones, encourage them to use the same smart tips you do.

Smart Use of Technology

The good news is most of us don't have to give up our smartphones if we use them wisely. Here are some of the many tips Gittleman highlights in *Zapped:*

- Text, don't talk, whenever possible.
- Use speaker mode to keep your phone as far away from your head as possible.
- Go offline — turn off your cell phone when you're not using it and shut off your wireless router at night. (You'll be amazed how much more soundly you'll sleep.)
- Get your phone out of your pocket; men who carry their mobile there have lower sperm counts than those who don't carry a cell phone.
- Avoid tight spaces (buses, elevators, trains, and subways) where your phone has to work harder to get a signal out through metal.
- Buy low, choosing a phone with a low SAR (specific absorption rate) number.
- Replace your cordless phones with corded landline phones.
- Don't cradle your laptop—putting it on your lap exposes your reproductive organs to EMFs.
- *Most important of all, restrict cell and cordless phone use during pregnancy. Heavy phone use then has been linked to increased risk of miscarriage and birth defects. And a 2008 survey of more than 13,000 children found that those whose mothers used a cell phone during pregnancy were more likely to have behavior problems like hyperactivity and trouble controlling their emotions.*

Don't rely on the many stick-on devices available for your cell phone or computer that claim to protect you. Most are sold via network marketing, and I have yet to see the level of scientific proof that could convince me. You'll likely see comments to this blog, advertising them. *Caveat emptor*!

Even if you go back to wired technologies at home, Wi-Fi is expanding rapidly into schools and other public buildings. If the telecommunications industry has its way, we will all be bathed in a sea of artificial radiation from nonstop EMF exposure.

Due to their lobbying efforts, Section 704 of the Telecommunications Act of 1996 makes state and local governments powerless to prohibit cell towers and wireless antennas based on "environmental (i.e., human) health concerns." Write your congressmen and senators to change this legislation and to require the FCC to reduce exposure guidelines for EMFs.

Don't wait for the government to protect you, though.

http://www.huffingtonpost.com/hyla-cass-md/cell-phone-and-Wi-Fi-dange_b_758167.html

Canadian Tech Leader Warns of Wi-Fi, Smartphone, Cell Tower Radiation

The former president of Microsoft Canada is among those warning about the dangers of Wi-Fi and electromagnetic radiation exposure, and he's heading up initiatives to find safe alternatives to current wireless uses.

Frank Clegg, a leader on the Canadian technology scene for many years, says he supports those parents and concerned individuals who object to wireless Internet in schools.

"This is a real hazard and we shouldn't wait for the government to catch up to the technology," said Clegg, who was head of Microsoft Canada for nearly 15 years and now leads a national organization called Citizens 4 Safe Technology (C4ST). "We should exercise caution, especially with children."

Still generating heated arguments on both sides, exposure to electromagnetic radiation (generated by cellphones, smartphones, tablets and other wireless gadgets, as well as the towers, routers and meters that are part of the wireless Internet infrastructure) is seen by some as too low level, too short duration, too far a distance, to be of any significant medical concern.

Others maintain that causal links can be found between electro-magnetic radiation exposure and ill health, and treatment is now available at some hospitals for EMS, electro-magnetic hyper-sensitivity, an umbrella term used for medical issues related to cell phone use, wireless radiation and other related concepts.

Even a slight suspicion of such a connection should warrant a slower, more cautious approach to the use of wireless devices, groups like C4ST maintain, and especially any new installations of wireless transmitters in public spaces like schools or hospitals.

Clegg's run as president of Microsoft Canada ended in late 2005, a successful term in which the company grew from less than 100 hundred employees to over 700, while increasing revenue from about $50 million to more than $1 billion in sales.

His engagement with the tech community did not end, however, and following successful charges at both real estate and investment, he began dedicating much of his time to issues of tech safety and security: he worked with the Canadian charity KINSA, the Kids' Internet Safety Alliance, fighting against the online exploitation of children.

Now, with C4ST, he's working with a volunteer-based group of concerned citizens and researchers who want to work with industry and government to raise awareness about EMR and more closely integrate such information with public policy.

One way to raise awareness about wireless transmissions is to measure them.

That's the take at the Microwave Vision Group, a tech manufacturer that is showing its personal EMF monitoring device, the EME Spy 140, at various industry events and trade shows.
"This is a real hazard and we shouldn't wait for the government to catch up to the technology," said Clegg, who was head of Microsoft Canada for nearly 15 years and now leads a national organization called Citizens 4 Safe Technology (C4ST). "We should exercise caution, especially with children."

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http://whatsyourtech.ca/2013/05/29/canadian-tech-leader-warns-of-wi-fi-smartphone-cell-tower-radiation/

Do Cell Phone and Wi-Fi Fields Harm Our Bodies?

Studies suggest common forms of household radiation deserve more attention

Life requires energy. This isn't something mystical, it's biology. Electric impulses flow through our nerves, cells, and muscles—basically every cell and system in the human body carries a charge. This energy helps our bodies move and function.

But our energy environment isn't what it used to be. Over the last few decades, more energy fields have pervaded our world. Some come from power lines; others are emitted from cellphone towers in the form of 2G, 3G, and 4G networks. Still others emanate from Wi-Fi hotspots and the high-frequency WiMAX.

These energy fields are generated for operating our devices and technology, but in combination they may be affecting our bodies in a negative way. Some research suggests that the fields collectively known as electromagnetic radiation (EMR) or electromagnetic fields (EMF) interfere with our body's natural processes—even damaging our DNA.

In 2007 (and again in 2012), a group of scientists and public health experts released a report suggesting people reconsider our relationship with these energy fields. Known as the BioInitiative Report, its aim is to assess scientific evidence on how EMFs impact our health.

The conclusion is that we need to drastically reduce our EMF exposure.

"Not everything is known yet about this subject; but what is clear is that the existing public safety standards limiting these radiation levels in nearly every country of the world look to be thousands of times too lenient," states the report. "Changes are needed."

Meanwhile, other scientists insist that these energy fields cause no harm to humans. The BioInitiative Report is widely criticized by industries around the world because it only considers science that supports its own position and doesn't acknowledge research that suggests that EMFs are safe.

The World Health Organization (WHO) has been investigating the research on both sides. In 2011, the WHO's International Association for Research on Cancer (IARC) classified EMF radiation above the radio frequency range (RF-EMF) as a Class 2B carcinogen, which means it may cause cancer, but further research is necessary. This is due to evidence that links long-term wireless exposure to brain cancer.

However, recent research prompted some IARC panelists to take a stronger stance.

"RF-EMF should be regarded as a human carcinogen requiring urgent revision of current exposure guidelines," stated IARC scientist and Swedish oncologist Dr. Lennart Hardell in a 2014 edition of the International Journal of Environmental Research and Public Health.

Despite growing evidence of harm caused by EMFs, U.S. public health officials have been skittish about using language that might suggest EMFs pose health risks. In 2014, the Centers for Disease Control issued a public statement urging caution with cell phone use, but retracted the statement just a few weeks later.

However, in the U.K., Belgium, Russia, France, Israel, India, and elsewhere, regulators are taking EMF exposure, particularly wireless technology, much more seriously. In these countries, warnings are made clear and young children are discouraged from using this technology.

One of the contributing authors to the BioInitiative Report is Dr. Martin Blank, a scientist, lecturer, and retired professor from the Columbia University College of Physicians and Surgeons. He has investigated the cellular and biological effects of EMFs. The New York-born Blank now lives in Victoria, Canada, and has doctorates in both physical chemistry and colloid science.

Epoch Times spoke with Blank about why there is so much controversy among scientists over the safety of EMFs, and why children are most at risk.

Epoch Times: There are many frequencies in our environment today: cellular technology and Wi-Fi, on top of the energy that comes into our house through power lines. I'm tempted to call all of it electromagnetic radiation. Is that correct?

Dr. Martin Blank: Technically, no. To get radiation, you really have to get the electric and magnetic fields acting together so that the electric field will cause the electrons to move, which will generate a magnetic field. They get intertwined. And it's only when this is happening so fast up at the radiofrequency range that you can get the true blending.

The differences get smoothed out when you get to the radiofrequency range and higher. For example, the new 5G that's coming out, that's in the radiofrequency range. The 4G is radiofrequency. The 2G is electromagnetic.

Epoch Times: Some scientists insist that these energy fields are at too low a frequency to affect our bodies in any negative way. What do you think?

Dr. Blank: I've had this discussion many, many years ago with physicists who say this can't do anything if it's below thermal level. The answer is no. These effects occur at very low levels. They occur down at the ELF range (60 hertz).

Some of the things I studied were the basic enzymatic actions that cause ion movement in cells.

A very basic enzyme has a threshold level of 3 milligauss or 4 milligauss (a unit to measure magnetic fields). When people talk about radiofrequency stuff, this is thousands of times higher energy. There's no question that even very minute forces can have an effect on a biological system.

Epoch Times: What does the science say in terms of the impact these frequencies have on our health?

Dr. Blank: This is a complex thing, but we studied a few enzymes and they are all affected. If you're a lone electron sitting in the middle of nowhere and there's a field nearby, you're going to respond to those fields at relatively low levels.

For a system, you need a slightly stronger force to be able to cause a change in it. But we get changes in the functioning of cells with relatively small fields. That's been shown.

When you go higher than the normal range you can get damage. In 1995, Henry Lai published a paper showing that if you took DNA and subjected it to radiation, 60-hertz stuff, you got fragments coming off. You were breaking off parts of the molecule. There was a lot of controversy about this, and forces against this finding.

This is damage that is not repairable. When you break a piece of DNA, you've broken the code. It's not like when you get a cut and the skin heals. If you damage the DNA, that's called a mutation, and you affect the function of a cell. So depending on where the damage has occurred, you can cause a lot of problems.

Epoch Times: How is this bad? What purpose does DNA serve in our body?

Dr. Blank: When I learned about DNA in high school, I was taught that this was hereditary stuff.

But when I learned biology at the university level, they taught that DNA does everything all the time. It has the whole code in it. You need the DNA to keep the system going. It's telling the body which proteins to make and which systems to turn on. It's upgrading all the time, and if you cause damage in that thing, you're causing a lot of problems in the cell.

Often cells can't survive this DNA damage, but the body has a lot of resilience. You can cause damage to DNA, and some other part will take over and get it to function. This is why our species survives.

Epoch Times: Are these fields more harmful to children?

Dr. Blank: There is no question in my mind that children are far more vulnerable. This is accepted by people who understand how this radiation works, and understand the difference between children and adults.

Biologically, when we compare an adult and a child, the child has a thinner cranium bone and the nerves in their brain are not as fully myelinated. This means the child will get more penetration as a result of the same kind of exposure. And of course a child is still growing, so whatever damage is done is going to propagate.

Epoch Times: I've read that other countries are taking this more seriously.

Dr. Blank: Yes. France, for example. They made it a big thing when the National Library in Paris rejected the use of the Wi-Fi system.

Epoch Times: Are there any precautions that you personally take to limit your own exposure?

Dr. Blank: I do own a cellphone, but I only use it when I go to the States, and I only use it if I have to. I don't have Wi-Fi. You need a certain amount of this technology in order to do certain things, but I try to live without it.

Some of these things you can opt out of, but I think it's going to become harder and harder to avoid this kind of thing as they put up more and more of these antennas around neighborhoods.

As a civilization, we believe that progress is good and that we should buy into it. But sometimes new things aren't always to our benefit.

http://www.theepochtimes.com/n3/2155494-do-cell-phones-and-wi-fi-fields-harm-our-body/

Cell Phones & Wi-Fi – Are Children, Fetuses and Fertility at Risk?

Dedication to Ronald Herberman, MD

The program June 28, 2013 was dedicated to the late Ronald B. Herberman, Founding Director of the University of Pittsburgh Cancer Institute, Vice Chancellor of Cancer Research at University of Pittsburgh and the first head of an NCI funded cancer center to speak out on the risks from cell phones. He issued a warning of these risks to his 3,000 employees, addressed Congress, and, regarding inaccurate media reporting on cell phone radiation health risks in the *Economist*, Dr. Herberman said:

A disservice has been done in inaccurately depicting the body of science, which actually indicates that there ARE biological effects from the radiation emitted by wireless devices, including damage to DNA, and evidence for increased risk of cancer and other substantial health consequences…The public the world over has been misled by this reporting."

May we all find within us the courage Dr. Herberman repeatedly exhibited during his life, and share the knowledge found herein about risks to fertility, children and fetuses. Children have the most to lose from society's egregious irresponsibility in this matter.

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Conference Highlights: Discussion of Key Evidence that EMFs Negatively Impact Children, Fetuses and Fertility

The panel presented a wide range of scientific evidence that electromagnetic radiation of the kind emitted by portable phones, Wi-Fi routers, baby monitors, Bluetooth earpieces, towers, antennas, smart boards, smart meters, Google glass, and other wireless devices, is adversely affecting people across the globe, and especially children. This radiation may be 'non-thermal', but has clear and indisputable biological and health effects. Based on the DNA effects alone, there should be no delay in acting to protect the human species.

DNA is being damaged, and natural repair processes impaired, in this unnatural 24/7 bath of radiation. Children are especially vulnerable to DNA effects due to rapid growth and development of cells, as well as a longer lifetime of exposure. All frequencies react similarly with DNA, whether higher frequency or lower frequency. Some effects occur faster, some occur slower, but the effects are happening all the same. Cancer is believed to result from changes in DNA. DNA's coil of coil structure makes it exquisitely sensitive to EMF, more than other tissue in the body. The long-term impact for our species is of great concern as there is no evidence our bodies can adapt to these unnatural frequencies.

An increasing number of people listen, learn and think better in electromagnetically clean environments. The audience was asked to turn off their cell phones and wireless devices for this reason.

Cell phones, tablets and other wireless devices also have batteries that emit *lower frequency forms* of

radiation—and these, too, along with RF and microwaves, have consequences, such as increased risk for childhood asthma and obesity when exposed in utero, and increased risk of miscarriage.
Impacts of electromagnetic fields on children*:

→ Research shows radiation emitted by cell phones and Wi-Fi impacts children's development *in utero*, their cognitive function, attention, memory, perception, learning capacity, energy, emotions and social skills.

→ There is also diminished reaction time, decreased motor function, increased distraction, hyperactivity, and inability to focus on complex and long-term tasks.

→ Cellular devices can lead to a heightened sense of anxiety in children, to isolation, and feelings of psychological and physical dependency.

→ There are now 9 types of cancer linked to cell phone use:

1. Glioma (Brain Cancer)
2. Acoustic Neuroma (tumor on acoustic nerve)
3. Meningioma (tumor of the meninges)
4. Salivary Gland cancer (parotid gland in cheek)
5. Eye Cancer
6. Testicular Cancer
7. Leukemia
8. Thyroid Cancer
9. Breast Cancer

→ There is a direct relationship between duration of cell phone use and sperm count decline. Sperm count is reduced by half in men who carry cell phones in their pants pockets for four hours per day. The motility of the sperm is also impaired. The testicular barrier, that protects sperm, is the most sensitive of tissues in the body, and is 100x more absorbent. Besides sperm count and function, the mitochondrial DNA of sperm are damaged 3x more if exposed to cell phone radiation.

→ DNA mutations have been linked more to damage on the male side, in research from Iceland, the assumption being that male sperm is more vulnerable than female eggs, which are more protected, being deeper in the body.

Mutations increase with the age of the father, and more autism and schizophrenia increase with the age of the father.

→ Wi-Fi in homes depletes melatonin and leads to poor sleep quality and difficulty falling asleep.

→ Use of wireless devices after lights out has been associated with children's mental health risks and suicide.

→ Some of the most profound effects in children from *in utero* EMF exposure are emotional and behavioral.

→ Online time, particularly multi-tasking in young children, has been linked with a chronically distracted view of the world preventing learning critical social, emotional and relational skills.

→ There is imbalanced development of the right and left hemispheres of the brain, resulting in children having impaired ability to remember basic things, to use handwriting or to feel empathy. There is a physiological as well as psychological addiction that is taking place.

"Think about what it would be like to have an entire generation that has not developed the capacity for empathy."

—Devra Lee Davis, PhD MPH, Environmental Health Trust

Click to Watch Video:
Devra Davis, PhD,
Environmental Health Trust

→ Children are beginning to show signs of dementia, where they cannot remember basic things, a global phenomenon now being called "Digital Dementia", believed to potentially be irreversible. There are hundreds of digital detox camps in China and S. Korea; the first U.S. camp opened in Northern California this year.

→ Dr. Taylor summarized his recent study at Yale University: A standard cell phone with a SAR rating of 1.6W/kg was placed atop the cages of pregnant mice for the duration of their pregnancy. Their offspring showed hyperactivity, diminished memory, apathy, impulsiveness, and other behaviors, compared to unexposed controls, mirroring children with ADHD. The severity of the effect depended on the length of exposure.

Click to Watch Video:
Hugh Taylor, MD,
Yale University

→ Dr. Taylor said the incidence of ADHD in the U.S. is on the rise (3-5% of school aged children or 2mm children have ADHD) and the growth parallels the increased use of cell phones.

→ Besides observing behaviors in the mice, the Yale researchers also measured electrical activity in the brain of the exposed and unexposed mice. They found the mice that had been exposed briefly in utero had changes to the electrical signaling processes in the brain as adults. Note, the mice had only been exposed during pregnancy, not subsequently, but the brain function was "permanently altered".

There appears to have been a dose-response relationship, where the longer the mice had been exposed per day during the study the greater the changes in brain function. Continuous exposure throughout pregnancy was much more dangerous than briefer exposures.

→ Dr. Taylor reminded the audience that while we don't think of ourselves as being on the cell phone 24 hours a day, the cell phone is still emitting radiation 24/7 and impacting us if it is turned on and near us, day or night. "It's not talking on the phone that matters, it's any time the phone is turned on", he said. Every 900 milliseconds, whether you are using the phone or not, your cell phone has a spike in radiation because it is looking for a signal from the tower, according to Dr. Davis.

→ Researchers at UCLA found that children of mothers who used cell phones most frequently during pregnancy showed nearly a two-fold increase in behavioral and emotional problems and hyperactivity by the time they reached school age. Dr. Hugh Taylor stated:

When you combine data like this—studies that show there is in fact an association in humans, with our studies in animals—it is clearly cause and effect."

→ Wi-Fi in schools is an 'enormous problem'. Some schools install massive, industrial strength routers right next to where children sit. Symptoms reported by children who sit near Wi-Fi routers include nausea, headaches, blurred vision, and poor sleep. The Israeli Health Ministry issued a report recommending against Wi-Fi in schools because there is simply no information about the long-term effects of this type of chronic exposure.

→ Russians caused the same EHS symptoms in the U.S. Embassy in cold war. Symptoms of electrohypersensitivity in Wi-Fi environments—of fatigue, irritability, concentration difficulty—are the same symptoms experienced by US Embassy personnel in Moscow in the cold war, that came to be known as microwave syndrome (or radiowave sickness).

→ There are reports of children dropping dead in Canada, or needing to wear pacemakers, after Wi-Fi installation in their schools.

→ Dr. Blank presented a simple study done by Danish high school girls wanting to study biological effects of Wi-Fi. They took cress cells and exposed half to Wi-Fi for 12 days. At left are the unexposed and exposed cress cells. The effects of Wi-Fi on this plant were made clear.

→ Turkish scientists recently discovered that mice exposed to cell phone radiation produced offspring with smaller brains, and more brain, liver, and eye damage. The Turkish government is launching a major campaign to raise awareness about cell phone radiation safety specifically geared towards pregnant women and young men interested in fathering healthy children.

→ Prenatal exposure results in fewer cells in the hippocampus of the brain, the area we need for thinking, reasoning, judgment and significantly impairs the development of neurons in the brain.

→ There is also irreversible DNA damage occurring from these devices, which effects the functioning of the child's body, and the quality of the genes they then pass on to future generations. Human cells, like all matter, are made up of charged particles, and these particles respond to EMFs. DNA has many different lengths and responds differently to various radiation frequencies—like different length antennas—and many effects are irreversible. DNA damage and mutations can cause cancer and other illnesses, but it can take years to detect symptoms.

"The range of frequencies used today can cause damage to DNA, at levels that are currently being used."

—Martin Blank, PhD, Special Lecturer and Retired Associate Professor of Physiology and Cellular Biophysics, Columbia University

→ Fetal effects from cellphone and wireless include faster heart rates, genetic changes, altered brain development, and increased behavioral and emotional problems after birth.

→ The strongest evidence for EMF effects are the science showing the connection between cell phone

use and brain cancer (Hardell 2008, Kundi 2008), according to Dr. Carpenter. The latency period between cell phone use and brain cancer is thought to be 20 to 30 years. Brain cancer rates are double for people who've been using cell phones for 10 years or more, appearing on the side of the head where they hold their phones, and risks are 5x greater for children using cell phones under the age of 20 than those over the age of 50.

→ Because children's nervous systems are still developing, synapses and myelin are being laid down continuously. For the body to create proteins, it must have correct DNA coding. EMFs break DNA apart, resulting in bad coding and mutations that result in poor brain function. Teenagers and children using cell phones before the myelination process is completed in the 20s are unknowingly causing a "whopping impact" on their brains.

→ There is some evidence that DNA mutations resulting from radiofrequency signals are part of what's driving today's increased autism and schizophrenia rates. The evidence was summarized in December in the landmark BioInitiative Report 2012 by Harvard Professor, Dr. Martha Herbert, MD who runs the Transcend Research Lab at Mass General.

 Dr. Herbert stated:

 *EMF/RFR from Wi-Fi and cell towers can exert a disorganizing effect on the ability to learn and remember, and can also be destabilizing to immune and metabolic function. This will make it harder for some children to learn, particularly those who are already having problems in the first place."*

"Powerful industrial entities have a vested interest in leading the public to believe that EMF/RFR, which we cannot see, taste or touch, is harmless, but this is not true."

→ Radio towers, not just cell towers, are also a factor. Based on 50 years of data, the closer a child lives to a radio tower, the higher his or her risk for developing cancer. The standard for "safe" power density remains 1,000 times too high. A 6x risk of cancer is still considered 'safe', according to Dr. Martin Blank. Politics of EMF Science


Click to Watch Video:
Martin Blank, PhD,
Columbia University

No more research is needed in order to say with certainly that these effects are real, and there is sufficient cause to take action now to protect adults and children. While more research

will always be desirable to better understand certain connections, and to continue looking at the long-term trends with epidemiology, all members of the panel agreed there is sufficient scientific evidence today on which to take precautionary steps to minimize this radiation in our lives.

Click to Watch Video: Frank Clegg, Canadians 4 Safe Technology

Regulatory bodies have allowed a trillion dollar wireless industry to emerge without pre-market health testing or post-market health surveillance.

A whole generation of people has been unaware of the risks of wireless radiation, and have not been taking precautions. This is why public health officials are so concerned. There is already evidence that exposure to radiofrequency radiation in excess leads to disease. And exposures have grown dramatically in the last few years.

Our grandchildren and children are "being used as lab rats in an experiment with no controls….that's what we are doing with cell phone and wireless radiation with our children today."—Devra Davis, PhD, MPH. Environmental Health Trust

Scientists who expose the truth about the risks from electromagnetic fields are often intimidated and attacked, and their careers jeopardized. Industry-associated science is also designed to underestimate risks, thereby refuting the independent science and 'Manufacturing Doubt'. Esteemed scientists who publish widely sometimes find it hard to publish on this topic.

Just as Bill Moyers recently described was the case with suppression of evidence about lead("The Toxic Politics of Science") the wireless industry behaves as if risks from cell phones and wireless devices and infrastructure is 'a PR problem, not a public health problem'.

The FCC has inadequate exposure guidelines. US standards for radiofrequency/microwave exposure are based on an outdated, erroneous assumption that EMFs have no biological effects unless they cause tissue heating, like a high powered microwave oven heating your potato. *Science has disproven this myth*. The exposure guidelines fail to protect about 97 percent of the population, most especially children.

> *The cell phone standards we use today for the 6.5 billion cell phones in the world were set 17 years ago and have never been updated, despite the fact that the users and uses of cell phones are very different now. And they've never been tested for their safety around children…We're in the midst of a huge experiment on ourselves and on our children"*

—Devra Lee Davis, PhD, MPH, cancer epidemiologist and toxicologist, President of Environmental Health Trust, and author of Disconnect: The Truth About Cell Phone Radiation, What the Industry Is Doing to Hide It, and How to Protect Your Family

Lower power towers and devices are possible, though power levels are being continually increased. Cell phones and cell towers can be made safer, by using far less power. Also, many towers emit far more radiation than they claim.

Many countries are issuing advisories: Australia advises limiting children's exposure to cell phones; Belgium has banned sales of cell phones for use by children under age 7; Turkey has banned ads targeting sales to children. The French National Assembly has banned Wi-Fi in schools. Italy had a Supreme Court ruling in favor of a man who claimed his tumor was from cell phone use. A region of India, Rajasthan, has banned cell towers near schools, and won a court battle to defeat industries opposition. Standards in the Eastern block are 1,000 times stricter.

"It may take some sort of catastrophe to get people's attention."—Frank Clegg, former president of Microsoft Canada and founder of Canadians 4 Safe Technology, a member of the audience who later joined the panel to share his perspective.

Several panel members compared the current situation where the health risks of cell phone and wireless radiation are being downplayed, and the science suppressed or manipulated, to other well-known public health scandals driven by commercial interests, such as tobacco, lead, asbestos, DDT, Bisphenyl A, silica, vinyl chloride, PCBs, GMOs, pesticides in food, fracking, the neionicotinoid chemicals impacting bees.

Safety Recommendations

- Extreme caution was advised for pregnant women or women hoping to conceive due to the profound long-term impact known historically to occur from environmental factors. *"A lot of who we are right now has to do with what our mothers did when they were pregnant and what type of exposures they had."*—Hugh Taylor, MD, Chairman of Obstetrics and Gynecology and Reproductive Sciences, Yale University. As with DES and many other toxic substances, he said, the effects from exposure to the fetus may not appear for a generation.

- Children should not be playing with radiating cell phones. Young children should not be using cell phones, except in an emergency. If your child wants to play with the device, disconnect it from Wi-Fi and Internet, and put it in "airplane mode."

- Limit or eliminate Wi-Fi exposures. If you have Wi-Fi, get rid of it if you can. If you can't, make sure your router is not in a high use area. Keep it turned it off as much as possible, or put it on a timer. Make sure Wi-Fi is turned off at night. If your neighbors have Wi-Fi that reaches your home, shield your premises. Never use RF emitting devices in shielded premised.

- Schools should not have Wi-Fi. Panelists strongly opposed the installation of Wi-Fi in schools. Cabled/wired connections do not have the same risks. Push for no Wi-Fi in classrooms and No Wi-Fi zones for studying, and for at least one 100% No-Wi-Fi public school in your area.

- Resume using landline phones whenever possible. Get rid of your portable phone and use a landline instead. If you have a portable phone, don't sleep with the handset or base in your bedroom. Caution regarding 'Trimline' and other flat style phones, where the electronics for the speaker may be closer to your ear.

- Keep your cell phone away from your body. If you have a cell phone, keep it away from your body, as opposed to in your pocket or on your belt. If you're pregnant, keep it away from your belly. Keep your cell at the other end of the room, or on the seat of the car. Use texting more than talking to keep the device away from your skull. Special cell phone cases are available that filter out a significant portion of the radiation with a mechanical means, but not all. Many popular metal cases can actually magnify radiation. Fully shielded cases will be available through Electromagnetichealth.org. Please email info@ electromagnetichealth.org to receive announcement.

- Use a wired (non-bluetooth) earpiece with cell phones and portable phones.

- Caution about using cell phones in cars. Signals bounce around inside your vehicle—and your head is the antenna.

- Opt-out of new utility meters called 'smart meters'. When possible, prevent smart meters from being installed in your home. Reflect radiation away from your home with shielding paints and materials found at www.EMFSafetyStore.com

- Never use wireless baby monitors. Avoid the use of wireless baby monitors as they all operate on microwave frequency. Find the old analog models.

- Know your exposures. For about $500, you or your community can purchase an Electrosmog meter with which to measure the EMF in any particular area—homes, schools, churches, etc. Don't guess or assume—measure.

- EMF free zones are needed for pregnant women and children. "Wi-Fi free" or "low Wi-Fi" zones in public spaces should be designated for pregnant women and children and others who are sensitive to EMFs. The same applies in schools.

- We need to be tracking biological effects*. "We need to seriously begin tracking the biological effects of EMFs…We need to be monitoring our children's health routinely. We have to train people how to do the research, and we have to invest in the research that's not being done."*— Devra Lee Davis, PhD MPH

- Discuss the need to monitor health, mental health and DNA impacts of the widespread radiation with your representatives in Congress. Tell them research by telcom industry affiliated persons should be disallowed due to the importance of this subject.

- We must take precaution. "The precautionary principle is in order here—certain precautions should be taken as a result of the risk that's been identified. That's the reason we have seat belts in cars… not because every car is going to crash, but because we want to minimize the damage when they do."—Martin Blank, PhD

- A one-dollar fee has been proposed on the sale of all cell phones as a means of generating revenue for research and education. Over several years, such a levy would generate billions of dollars to finalize any unanswered questions about risks. Discuss such a levy with your representatives in Congress.

- Industry must become engaged. Strategies must be introduced to get industry involved, such as providing incentives or rewards for safer technology, or even amnesty. If all else fails, lawsuits, some of which are in the works, will get their attention.

- FCC safety guidelines must be updated. Outdated, unrealistic safety guidelines must be replaced with new ones that reflect modern biological science, such as those suggested in the BioInitiative Report 2012. In fact, the current guidelines are based on a false premise that non-heating waves do no harm, and this must be acknowledged to stop perpetuating this myth at our expense.

- Support labeling laws requiring cell phone manufacturers to list radiation levels in an obvious place on the packaging and at the retailer.

- Educated parents need to become involved, especially to protect our children. Contact www.ElectromagneticHealth.org or www.EnvironmentalHealthTrust.org to learn how your can become involved in raising awareness on this important children's health issue, or by funding research, media communications and support for education and remediation in local communities. Keep abreast on this subject going forward as it related to children, fetuses and schools at Facebook's Campaign for Radiation Free Schools.

http://electromagnetichealth.org/electromagnetic-health-blog/summary-and-audio/

New report: Wireless technology causes brain damage

In April 2014, the BioInitiative Working Group – consisting of 29 experts from ten countries, ten holding medical degrees, 21 PhDs, and three MsC, MA or MPHs – said there is growing evidence that wireless technology causes brain damage, cancer tumors plus a host of chronic health conditions.

Based on a review of the science released in 2012 and 2013, Lennart Hardell, MD, PhD at Orebro University, Sweden says, ""there is a consistent pattern of increased risk for glioma (a malignant brain tumor) and acoustic neuroma with use of mobile and cordless phones".

"We know that microwaves can cause genetic damage." – Barry Trower, a retired British military intelligence scientist and expert in microwave technology.

"Our grandchildren and children are being used as lab rats…" This quote is taken directly from Devra Davis, PhD, MPH, president of Environmental Health Trust. Dr. Davis is seriously concerned about the future of humanity. Our children are being exposed to a level of 'unnatural' microwave radiation which damages DNA and inhibits cellular repair – which leads to cancer. This is truly an unproven, mad experiment on humans with dire health consequences.

Here are some quick facts about the dangers of wireless technology:
1. In 2007, the BioInitiative Working Group released a 650-page document with over 2000 studies linking RF and EMF exposure to cancer, Alzheimer's disease, DNA damage, immune system dysfunction, cellular damage and tissue reduction.
2. In May 2011, the World Health Organization's International Agency for Research on Cancer categorized "radiofrequency electromagnetic fields as possibly carcinogenic to humans based on an increased risk for glioma, a malignant type of brain cancer, associated with wireless cellphone use."
3. In April 2012, the American Academy of Environmental Medicine (AAEM) – a national organization of medical and osteopathic physicians – concluded that, "genetic damage, reproductive defects, cancer, neurological degeneration and nervous system dysfunction, immune system dysfunction, cognitive effects, protein and peptide damage, kidney damage, and developmental effects have all been reported in the peer-reviewed scientific literature."

http://www.naturalhealth365.com/wireless-technology-microwave-radiation-brain-damage-1243.html

Children's Health Expert Panel: Cell Phones & Wi-Fi—Are Children, Fetuses and Fertility at Risk?

"It may take some sort of catastrophe to get people's attention," said Frank Clegg, former president of Microsoft Canada and founder of Canadians 4 Safe Technology, referring to the increasing saturation of Wi-Fi technologies on the public at large, and especially, children.

Leading experts from top universities recently convened at a program organized by ElectromagneticHealth.org in Connecticut to discuss the reality that such a catastrophe is already brewing and, as the panel warned, is now already negatively impacting children, fetuses and fertility. But the majority of parents are not connecting the dots by linking symptoms in their children to the radiation.

During the discussion "Cell Phones & Wi-Fi – Are Children, Fetuses and Fertility at Risk?," a wide range of scientific evidence was presented that RF/MW electromagnetic radiation has indisputable biological and health effects, including at non-thermal levels, with chronic exposures generally associated with greater harm. This is the kind of radiation emitted not only by cell phones but also by:

- Wi-Fi routers
- Baby monitors
- Bluetooth earpieces
- Towers
- Antennas
- Smart boards
- Smart meters
- Cordless phones
- Other wireless devices

'Our Grandchildren and Children Are Being Used as Lab Rats…' This quote, from Devra Davis, PhD, MPH, president of Environmental Health Trust, sums up perhaps the most alarming EMF issue to date. The fact is, we know that exposure to this 'unnatural bath of radiation' damages DNA and impairs natural cellular repair processes, a phenomenon that may lead to cancer. Yet we are proceeding with this large-scale, uncontrolled experiment anyway.

Because children are still developing, they have rapid cellular replication and growth rates that make them especially vulnerable to DNA damage. They also have a longer lifetime exposure to this new pervasive radiation than any previous generation.

As the expert panel stated, research shows that radiation from cell phones and Wi-Fi has already been shown to cause diminished reaction time in children, decreased motor function, increased distraction, hyperactivity and inability to focus on complex and long-term tasks.

In one controlled study, researchers from Yale University positioned a cell phone above a cage of pregnant mice. The phone was transmitting an uninterrupted active call for the entire 17 days of gestation.

When the exposed offspring were later tested, they showed signs of ADHD, and reduced transmissions in the prefrontal cortex of the brain. It's widely known that children, due to their thinner skulls, smaller brains, softer brain tissue and far more rapidly dividing cells, are far more susceptible to damage from cell phone use than adults. This study clearly showed brain patterns are altered, with lifelong repercussions from brief prenatal exposures to microwave radiation.

Dr. Taylor indicated that there was a dose-response relationship found, and that disruption to the electrical signaling between neurons resulted in permanent changes in the way the brain is patterned that will carry forward into adulthood. The electrical signaling plays a major role in how the brain develops, which determines a lot of who we are as adults, he said, including "how we think and how we behave."

"This is the first experimental evidence that fetal exposure to radiofrequency radiation from cellular telephones does in fact affect adult behavior…" said Hugh Taylor, Professor and Chairman, Department of Obstetrics, Gynecology and Reproductive Sciences, Yale University.

Camilla Rees, MBA of ElectromagneticHealth.org,2 said Dr. Taylor encouraged the audience to appreciate that while we don't think of ourselves as being on the cell phone 24 hours a day, the cell phone is still emitting radiation 24/7 and impacting us if it is turned on and near us, day or night.

"It's not talking on the phone that matters, it's any time the phone is turned on," he said. Every 900 milliseconds, whether you are using the phone or not, your cell phone has a spike in radiation because it is looking for a signal from the tower…"

She summarized key impacts on children from cell phone and Wi-Fi radiation drawn from the BioInitiative Report, the Mobilewise (UK) report on cell phone effects on children, Russian research overseen by the Chairman of the Russian National Committee on Non-Ionizing Radiation Protection, and the Yale report, "Cell Phones: Technology, Exposures, Health Effects."

Reference to the latest BioInitiative Report's (2012) section on possible EMF links to autism written by Harvard Professor Dr. Martha Herbert, who runs the Transcend Research Lab at Mass General, was also made. Dr. Herbert has said,

"EMF/RFR from Wi-Fi and cell towers can exert a disorganizing effect on the ability to learn and remember, and can also be destabilizing to immune and metabolic function. This will make it harder for some children to learn, particularly those who are already having problems in the first place."

"Powerful industrial entities have a vested interest in leading the public to believe that EMF/RFR, which we cannot see, taste or touch, is harmless, but this is not true."

Several panelists mentioned the new condition "Digital Dementia," increasingly being reported globally, where children are exhibiting signs of deterioration in cognitive abilities from overuse of internet technologies, thought to result from imbalanced development of the brain. The lesser cognitive function

will also result from the RF/MW exposures, but researchers who are focused on 'overuse' have not been as aware of this factor.

More research is necessary here to ferret out how much of the behavioral and brain effects of technology overuse are coming from the RF/MW, or brain changing aspects use of the technology itself, and the resulting lesser human interaction and lower quality relationships.

An excellent new book by Raffi Cavoukian, renowned singer, children's champion and supporter of a commercial-free childhood, "#LightWebDarkWeb," takes a deep philisophical look at society's unquestioning embrace of these technologies for children. It covers the health, privacy, safety, security, social, societal, mental health and addiction issues from children's use of social media and modern communications technologies. Raffi says we need to "act quickly to subdue the perils of InfoTech's shadow," and "to move the risk-benefit ratio in favor of the LightWeb."

In light of the growing evidence for harm to children and fetuses, Dr. Davis explained:3

"The cell phone standards we use today for the 6.5 billion cell phones in the world were set 17 years ago and have never been updated, despite the fact that the users and uses of cell phones are very different now. And they've never been tested for their safety around children… We're in the midst of a huge experiment on ourselves and on our children…

A whole generation of people has been unaware of the risks of wireless radiation, and have not been taking precautions. This is why public health officials are so concerned. There is already evidence that exposure to radiofrequency radiation in excess leads to disease. And exposures have grown dramatically in the last few years. Our grandchildren and children are "being used as lab rats in an experiment with no controls… that's what we are doing with cell phone and wireless radiation with our children today."

Frank Clegg, formerly CEO of Microsoft Canada, also commented on the adequacy of safety guidelines: Clegg said he is disappointed with industry, and regrets the lack of responsibility demonstrated by the technology sector in turning a blind eye to the biological realities of this radiation.

Nine Types of Cancer are Linked to Cell Phone Use

It was back in 2011 that the International Agency for Research on Cancer (IARC), a committee of 27 scientists from 14 different countries working on behalf of the World Health Organization (WHO), concluded that exposure to cell phone radiation is a "possible carcinogen" and classified it into the 2B category -- the same category as the pesticide DDT, lead, gasoline engine exhaust, burning coal and dry cleaning chemicals, just to name a few. The children's health expert panel explained that, as of 2013, there are nine types of cancer linked to cell phone use, including:

- Glioma (brain cancer)
- Acoustic Neuroma (tumor on acoustic nerve)
- Meningioma (tumor of the meninges)
- Salivary Gland Cancer (parotid gland in cheek)
- Eye Cancer

- Testicular Cancer
- Leukemia
- Thyroid Cancer
- Breast Cancer

The science connecting cell phone and Wi-Fi radiation is among the strongest there is, and children, again, are slated to bear the brunt of what could become a new epidemic of cell-phone and Wi-Fi-induced cancers. The panel reported:

"The latency period between cell phone use and brain cancer is thought to be 20 to 30 years. Brain cancer rates are double for people who've been using cell phones for 10 years or more, appearing on the side of the head where they hold their phones, and risks are 5x greater for children using cell phones under the age of 20 than those over the age of 50."

Fertility and Sperm Count May Be at Risk

Infertility rates have been on the rise in the US, and today's children may be even worse off than their parents if current trends continue. Several of the panel members focused on this issue, including studies that have found cell phone radiation can affect men's sperm count and the quality and motility of their sperm. One such study, published in PLoS One,4 found:

"RF-EMR [radiofrequency electromagnetic radiation] in both the power density and frequency range of mobile phones enhances mitochondrial reactive oxygen species generation by human spermatozoa, decreasing the motility and vitality of these cells while stimulating DNA base adduct formation and, ultimately DNA fragmentation. These findings have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and wellbeing of their offspring."

The panel further reported:

"There is a direct relationship between duration of cell phone use and sperm count decline. Sperm count is reduced by half in men who carry cell phones in their pants pockets for four hours per day. The motility of the sperm is also impaired. The testicular barrier, that protects sperm, is the most sensitive of tissues in the body, and is 100x more absorbent. Besides sperm count and function, the mitochondrial DNA of sperm are damaged 3x more if exposed to cell phone radiation.

…DNA mutations have been linked more to damage on the male side in research from Iceland, the assumption being that male sperm is more vulnerable than female eggs, which are more protected. Mutations increase with the age of the father, and more autism and schizophrenia increase with the age of the father."

EMF-Free Zones Should Be Available for Pregnant Women and Children

The weight of the evidence clearly supports the need for Wi-Fi-free or low-Wi-Fi areas where pregnant women or those hoping to conceive, children and others sensitive to EMFs, can be protected, according to the panel.

The European Council has already taken the exemplary step of recommending that mobile phones and wireless networks get banned in classrooms and schools, according to Dr. Davis, and the Turkish government is launching a campaign to educate pregnant women and young men of reproductive age about the safety risks of cell phone radiation. Rajasthan India has banned cell towers on or near schools. The Israeli Health Ministry has issued a report recommending against Wi-Fi in schools, on the basis that not enough is known about its chronic exposure. It has been shown, however, that increasing numbers of people think and learn better in locations that are free of cell phones, wireless devices and other forms of EMFs.

The Israeli Supreme Court in July ordered the Israeli government to investigate how many Israeli students are suffering from electrosensitivity in response to a brief claiming that it is unreasonable to expose children to WI-FI when it is proven to cause sickness. The Government must submit the result of its investigation, supported with a sworn affidavit, to the court by November 16, 2013. Israel Minister of Health Rabi Yaakov Litzman wrote to the Minister of Education saying:

"I do fear that there will come a day that we will all cry because the irreversible damage that we, in our own hands cause the future generation."

The panel noted that 'extreme caution' is advised for pregnant women and women hoping to conceive:6

"Prenatal exposure results in fewer cells in the hippocampus of the brain, the area we need for thinking, reasoning, judgment and significantly impairs the development of neurons in the brain… Some of the most profound effects in children from in utero EMF exposure are emotional and behavioral."

Around the world, many countries are already adopting the Precautionary Principle regarding cell phone use, and this is also what the panel recommended. Russian officials have issued the recommendation that all children under the age of 18 should avoid using cell phones entirely. The UK, Israel, Belgium, Germany, India, France and Finland also urge citizens to err on the side of caution with respect to their children's use of cell phones. Panel member Martin Blank, PhD said:

"The precautionary principle is in order here – certain precautions should be taken as a result of the risk that's been identified. That's the reason we have seat belts in cars… not because every car is going to crash, but because we want to minimize the damage when they do."

Safety Recommendations for Cell Phone and Wi-Fi Use

The cell phone industry is one of the fastest growing and strongest global industries in the world today and is even stronger than the pharmaceutical industry. As a multi-trillion dollar industry that funds media around the world they are capable of making sizable political donations and persistent lobbying efforts that dictate government policies, and that also influence science carried out at universities and prominent cancer institutes.

So while cell phone dangers will one day likely be as well known as tobacco dangers, there's going to be a window when people are extremely vulnerable. And that window is right now. Children are especially

vulnerable to damage from cell phone radiation, and should not use them at all (or only for very limited amounts). Men and women who want to have healthy children need to take special precautions to protect their reproductive organs and should not keep phones in their front pockets or close to their abdomens.

In the US, public warnings are not yet commonplace, but it's still important to protect yourself – and your children. There is plenty of science showing harm to warrant taking action now

The panel advised:
◦Children should not play with radiating cell phones. Young children should not use cell phones except in an emergency. While you can put the phone in 'airplane mode,' which disconnects it from Wi-Fi and the Internet, the cell phone still emits magnetic fields from the battery, which have also been shown to have equally important biological consequences. In no cases should children sleep with cell phones. Extreme caution was advised for pregnant women or women hoping to conceive due to the profound long-term impact of environmental factors.
◦Limit or eliminate Wi-Fi exposures. If you have a WI-Fi router make sure your router is a low power version, not in a high-use area and keep it turned off as much as possible. Consider putting it on a timer so it is only available during certain hours, and never during sleeping hours.
◦Schools should not have Wi-Fi. Cabled/wired connections do not pose the same risks. If there is Wi-Fi, again, it should be limited to the time when the Wi-Fi is specifically needed and not be operating at other times. Ideally, classrooms and school libraries and gyms should be Wi-Fi-free.
◦ Resume using landline phones whenever possible. Get rid of your portable phone and use your landline. At the very least, don't keep your cell phone in your bedroom while you sleep. Be aware even landline phones emit magnetic fields from the speaker, and sensitive people can sometimes feel them, especially on long calls and particularly when using trim phones. Old-fashioned desk phone earpieces offer a greater distance between the speaker and your ear that can make a meaningful difference.
◦ Keep your cell phone away from your body. Avoid keeping it in your pocket or on your belt. If you're pregnant, keep your cell phone away from your belly. Keep your phone at the other end of the room or on the seat of the car. Use texting more than talking. A cell phone case for the iPhone is available that filters out a significant portion of radiation (but by no means all the power and frequencies and other biologically disruptive signal characteristics also remain). There are several options for shielded cell phone cases and holsters at www.EMFSafetyStore.com.
◦ Use a wired earpiece or headphones with cell phones. Like with landline phones, some people are impacted by the magnetic fields from the speaker in the ear buds, so choose a model with the greatest distance from your ear, or use air tube technology with no electronics near your ear.
◦ Use caution using your cell phone in your car. Signals bounce around inside your vehicle, and your head is the antenna.
◦ Opt-out of new utility meters called 'smart meters.' Prevent smart meters from being installed in your home whenever possible.
◦ Avoid using wireless baby monitors, as they all operate on microwave frequency. Look for the old wired monitors.
◦ Know your exposures.
◦ Support labeling laws that require cell phone manufacturers to list radiation levels in an obvious place on the packaging and at the retailer.

http://articles.mercola.com/sites/articles/archive/2013/09/21/cell-phone-Wi-Fi-radiation.aspx

Wi-Fi & Cell Phones Pose a Much Greater Danger Than Most People Realize

I've posted a few articles in prior years (links at the bottom) on the dangers of cell phone usage and the damaging health effects from microwave energy fields, but the two videos seen below add powerful evidence that holding a cell phone against your ear while talking is the dumbest thing you could possible do.

The damage to children, especially very young children, is exponentially greater than that of adults. If you care about your kids living a normal life span, do NOT give them a cell phone – ever.

Other microwave electronic devices such as Smart Meters and Wi-Fi computer components, are adding a tremendous burden of toxic, microwave EMF pollution to the body that is having a cumulative–and disastrous–effect.

Using a high quality, German microwave frequency analyzer last October to test the intensity of ambient microwave fields in my neighborhood, I was dumbfounded to discover that Wi-Fi routers used for internet access in many homes put out an ENORMOUS amount of microwave energy (600-1000 microwatts) that is being absorbed by the people living in that house 24/7.

It was shocking enough to see that our newly installed Smart Meters were putting out 1-2 WATTS every two minutes, but to see the added burden of Wi-Fi router radiation was stupefying. The safe level for human microwave exposure, according to Swiss and German environmental safety groups, is ONE MICRO watt per cubic meter. One watt is the equivalent of ONE MILLION micro watts.

While not mentioned in these videos, I've received information recently from a very sensitive medical intuitive who is discovering that many people are beginning to experience CALCIFICATION of organ and muscular tissue cell walls due to excessive exposure to high intensity microwave energy fields, such as those found in a home with a Wi-Fi router, Wi-Fi printer, Bluetooth mouse, smart meters, near cell phone towers, etc. It appears that the depositing of calcium into cell walls, normally composed of lipid (fat) cells, is the body's attempt to shield against the penetration of microwave energy fields into the nucleus of the cell, where our DNA strands reside in the chromosomes.

I met a young Japanese guy (32) recently who told me that he's had lower back pain and kidney pain for the past 3 years and doesn't know why since his doctor couldn't find anything wrong .I asked my medical intuitive friend to check, and sure enough, he's calcifying like a rock. If he doesn't take corrective action to pull that calcium out, he's going to be in big trouble within a few years. Obviously, stopping all exposure to microwave energy fields needs to be at the top of his priorities.

It is next to impossible to undo the damage from excessive microwave exposure to the brain once acquired, so it's imperative to AVOID the exposure in the first place. This is critically important when it comes to children.

https://wakeup-world.com/2012/09/13/find-out-the-facts-Wi-Fi-cell-phones-pose-a-much-greater-danger-than-most-people-realize/

Is Your Cordless Phone Harming Your Health?

The more I learn about wireless devices, the less I want them in my home. This includes cordless phones. The standard DECT (Digitally Enhanced Cordless Technology) phone utilizes a technology that utilizes a digital signal that is both powerful and clear.

It's what you'll readily find on store shelves. Look for 2.4 or 5.8 GHz when trying to identify a DECT phone. Manufacturers include Panasonic, GE, Motorola, AT&T, and V-Tech.

If you have concerns about WI-FI, you will want to have equal concern for DECT as they both operate with frequencies in the microwave and radio spectrum. In 2011 the World Health Organization (WHO) classified electromagnetic radiation as a possible 2B carcinogen. (The same category as lead, DDT, and styrene.)

Other wireless devices commonly found in the home include:

- Remote controls for opening gates
- Wireless security systems
- Wireless video cameras
- Wireless baby monitors
- Smart meters

DECT cordless phones continuously emit microwave radiation at full power as long as the base station is plugged into an electrical outlet. That means radiation is emitted 24 hours a day whether the phone is being used or sitting idle in its cradle.

Dr. Magda Havas is one of the premier researchers on the adverse impact of DECT phones. In a petition calling on the Canadian government to ban DECT phones, Dr. Havas points to the growing evidence linking DECT phones with ill health. By superimposing her studies with others, Dr. Havas created the following graphic to show that, even from a distance of 3 meters, EEG brain waves are altered.

Health effects of DECT phones, according to Dr. Havas,

"At 2.8 meters motor function, memory and attention of children are affected. At 1.7 meters, sleep is disturbed. How many people have DECT phones near their bed? At 30 cm memory is impaired and at closer distances the immune system is affected, REM sleep is reduced, insulin levels drop, and there are pathological changes in the blood brain barrier. Studies also show that there is 100% increase in adult leukemia between 45 and 130 cm from the phone and a similar increase in childhood leukemia between 35 and 260 cm."

Thankfully, it's easy to replace your DECT phone. Corded phones are readily available at electronics stores and online. If a portable home phone is your only option, consider the non-DECT 900 MHz analog phone that only emits radiation when in use.

Why not err on the side of caution and return to the old-fashioned corded phones. You may notice improvements in your sleep, concentration, and overall health!

http://it-takes-time.com/2015/06/01/health-effects-of-cordless-phones/

Wireless pollution 'out of control' as corporate race for 5G gears up

With the UK's Digital Economy Bill set to be finalized today, new 5G microwave spectra are about to be released across the planet without adequate safety testing, writes Lynne Wycherley. Global neglect of the Precautionary Principle is opening the way to corporate profit but placing humans and ecosystems at risk, and delaying a paradigm shift towards safer connectivity.

In *Drowning in a Sea of Microwaves*, the late geneticist Dr Mae-Wan Ho - a visionary voice who opposed GMOs - identified pollution from wireless technologies as a pressing issue of our times.

Noting evidence for *"DNA damage ... cancers, microwave sickness, [and], impairment of fertility"*, she concluded: *"Evidence is emerging that the health hazards associated with wireless microwaves are at least comparable to, if not worse than, those associated with cigarette smoking."*

Since the advent of radar, followed by mobile phones and dense Wi-Fi networks, such anthropogenic radiation has sky-rocketed. Although it is non-ionising, and does not destabilise molecules directly, evidence of other harm has been growing since 1950s studies on radar workers.

According to the updated *Bio-initiative Report* (2012+) by 29 precautionary scientists, effects on biology feature in several thousand, peer-reviewed papers. Yet troubling new findings rarely filter into the media. Or global Green discourse.

Though many studies have reported 'no significant effect', research by University of Washington biology professor Henry Lai, and others, reveals that wireless-industry funding is far more likely to yield such findings.

"Toujours ils créent doubte" ('they are forever creating doubt'), explains former Luxembourg Green MP Jean Huss, whose research on the wireless industry inspired the Council of Europe to call for many precautions (2011), including protection of warning scientists, and wired internet in schools.

But wireless-product marketing has a loud voice. Few of us realise that genetic effects and free radical damage - both disease risks over time - are the most common, cautionary findings. Device-crowded spaces, such as our peak commuter trains or all-wireless classrooms, may be creating a subtly toxic environment.

Wide-ranging, oxidative harm to animals has been found from Wi-Fi sources. And linked pre-diabetic and pre-cancerous changes. Ground-breaking work by biochemistry professor Martin Pall, Washington State University - winner of eight international awards - reveals a viable mechanism for such harm. But as with other 'inconvenient truths', it is going unheard.

Life's exquisite electro-physiology is still being discovered. Researchers at Bristol University reported in May that bees' hairs are highly sensitive to flowers' delicate EMFs. In controlled trials in Switzerland, bees reacted to mobile-phone signals with high-pitched 'piping': a cue to desert a hive.

Other studies show that mitochondria, the tiny power houses in our cells, are at risk from our new EMFs. And that even DNA, in its delicate antenna-like structure, may be frequency-sensitive.

The long-term, ecological implications of our new, anthropogenic radiation are not known. But peer-reviewed studies revealing harm to birds, tadpoles, trees, other plants, insects, rodents and livestock, offer clues.

Biology professor Lukas Margaritis, at Athens University, for example, uncovered harm to fruit flies from just a few minutes' exposure to our everyday wireless devices, including cordless phones, Bluetooth, and even digital baby monitors. Reviewing research, India's Ministry of Environment and Forests warned that sensitive habitats may need some protection.

The UK's Digital Economy Bill, about to receive its final seal, has sensible proposals for increasing country-wide access to fibre broadband: a technology that does not, in itself, stoke microwave pollution, though wireless add-ons do so. But probe beyond the bill to Ofcom's 5G consultations, and new EMF exposures emerge: part of global trend.

The worldwide rush towards 5G or 'fifth generation' wireless rollouts is set to raise our pulsing pollution to new levels. Untested, high microwave frequencies are being lined up to increase bandwidth, automation, and usage - at great profit to the industry.

These millimetre and centimetre waves, though too weak to heat us, may pose possible risks to our skin, and deeper surface tissue, including that of plants. High-density transmitters are envisaged. A troubling prospect for the many hundreds of patients seen by professor Dominique Belpomme's clinic in Paris: patients whose disabling symptoms from wireless technologies are supported by new brain scans and blood tests.

A delegation of scientists have petitioned for such electrosensitivity to be recognised as an environmentally-induced illness, with an International Disease Code (2015).

Pushing for fast rollouts, the wireless industry is also in conflict with the Internatonal EMF Scientists' Appeal to the United Nations. Signed by 223 scientists from 41 nations, it calls for remedial action - such as new safety limits, wave-free zones, and education of doctors - to protect our DNA, fertility, and nervous systems, plus children and pregnant women, from growing wireless exposure. And from rising, mains-electricity fields.

Signs that such caution may be needed are growing. The pulsed, polarized, microwaves used by wireless technologies pose more biological risks than smooth or natural waves. Weak millimetre waves have a known potential to increase antibiotic resistance: what ecological effects might they risk, perhaps, if used universally?

Studies also reveal a risk to skin pain receptors. Published associations between radio-masts and skin cancers, though at lower frequencies, plus mobile-phone masts and EMF-sensitive cancers (Adilza Dode, Minas Gerais University 2013), raise further questions.

In his summer press conference, Tom Wheeler - former head of the CTIA, the vast telecoms lobby-group, and controversial chair of the Federal Communications Commission - proposed unbridled *"massive deployment"* of commercial 5G transmitters, taking off in 2020.

Anticipating *"tens of billions of dollars"* of economic growth, with US telecoms *"first out of the gate"*, he warned *"Stay out of the way of technological development! Turning innovation loose is far preferable to expecting ... regulators to define the future".*

With no mention of health-testing, carbon costs, or corporate responsibility, the FCC voted unaminously to go ahead by releasing swathes of untested high frequencies for private sector exploitation - so setting a trend. To questionable ends: added to other issues, how will our communities

be affected by addiction to 5G multi-stream videos? How will it impact our spiritual communion with Nature?

Many American health activists, and cautioning scientists, are aghast. Dr Joel Moskowitz, director of community health studies at the University of California, warns *"precaution is warranted before 5G is unleashed on the world"*.

Former government physicist Dr Ron Powell points out the plans *"would irradiate everyone, including the most vulnerable to harm from radiofrequency radiation: pregnant women, unborn children, young children...the elderly, the disabled, and the chronically ill... It would set a goal of irradiating all environments".*

This drive to mine the electromagnetic spectrum come-what-may has echoes of fracking, and other headlong trends. In *Captured Agency*, the Harvard ethics report on the FCC, and the wider wireless industry, Norm Alster exposes ruthless *"hardball tactics"*, supported by *"armies of lawyers"*, at expense to our health.

Microwaves, Science and Lies (2014), filmed by Jean Hêches across Europe, exposes similar patterns that are driving our pulsed radiation to risky levels. Western "safety limits", based only on high levels that heat tissue, far exceed those of Russia, China, and some other nations.

Professor Yuri Grigoriev, long-serving chair of Russia's non-ionising radiation protection body (RNCNIRP), warned the UK's Radiation Research Trust *"ionising radiation is monitored...[but] levels of non-ionising radiation are constantly increasing and ubiquitous: it is out of control ... Urgent action is needed"*.

Stealthy pollution-raisers, such as the 5G Internet of Things - with 30 billion tiny transmitters forecast for 2020 - and also, sadly, wireless smart-meters [1, 2*], vetoed by the American Academy of Environmental Medicine, may run counter to a cherished Green goal: that of nurturing healthy environments.

Can we manage our energy, perhaps, in more bio-sensitive ways? Court claims for wireless-meter health harm, supported by medical testimonies - including by neurology professor Andrew Marino (Louisiana) - are sweeping America. Professor Pall explains such meters' *"high intensity"* microwave pulses may be more toxic than we realise: *"We know from the nanosecond studies these can be very damaging".*

Data obtained by a judge revealed all-hour, house-piercing pulses every few seconds. New data-over-wiring innovations (if free of "dirty electricity") may offer inspiring, alternative ways forward.

To create - in Wheeler's phrase - a global '5G ecosystem' of wireless super-saturated environments, at insidious risk, over time, to *living* ecosystems, not least our own bodies, is dysfunctional. And spiritually disturbing. It suggests a mindset deeply at odds with the orchid-like beauty of the Earth.

But cleaner innovations, such as LiFi, 'eco-dect-plus' phones, and the latest fibre-optics, suggest a wiser course. A new paradigm - safer connectivity, plus more balanced use - is emerging. And reminds of other step-changes in awareness. From pesticides to organic, from smoke-filled to smoke-free.

We can accede, if we wish, to our rising, planetary smog. To safety limits as high as the moon, in many scientists' eyes. And to wireless rollouts' growing carbon costs. Or taking pause, we may begin to call the industry to account - plus governments lulled by it.

We may air helpful new findings, such as risks from tablet-like exposures (Alexander Lerchl, Jacob Bremens University, 2015). And stark risks from passive exposure, bared by Leif Salford, medical professor at Lund University. We may defend DNA, if we wish, from ionizing and published non-ionizing risks, just as we defend our planet.

http://www.theecologist.org/News/news_analysis/2988266/wireless_pollution_out_of_control_as_corporate_race_for_5g_gears_up.html

A 5G Wireless Future

It would greatly extend FCC's current policy of the mandatory irradiation of the public without adequate prior study of the potential health impact and assurance of safety. It would irradiate everyone, including the most vulnerable to harm from radiofrequency radiation: pregnant women, unborn children, young children, teenagers, men of reproductive age, the elderly, the disabled, and the chronically ill."

—Ronald Powell, PhD, Letter to FCC on 5G expansion

The use of mobile wireless technologies continues to increase worldwide. A new faster 5th generation (5G) telecommunication system has recently been approved by the Federal Communications Commission(FCC) with new antennas already being installed and tested in Palo Alto and Mountain View. While it may give us uber automation and instantaneous "immersive entertainment" a lot of questions remain with regards to public health and safety of wireless devices. Will the adoption of this new 5G technology harm directly or indirectly the consumers and businesses it hopes to attract?

5G is the new promised land for wireless technology. It could connect us in our homes, workplaces and city streets to over a trillion objects around the world. (96) The Internet of Things (IoT) is primed to give us self-driving cars, appliances that can order their own laundry soap, automation hubs that pay your bills, not to mention fast movie downloads and virtual reality streaming from anywhere when you are on the go. Companies are already asking local cities and counties to move forward to create "Smart Cities" which have comprehensive digital connectivity by installing a massive wireless sensor network of almost invisible small cell antennae on light posts, utility poles, homes and businesses throughout neighborhoods and towns in order to integrate IoT with IT. They state it will improve services, the economy and quality of life. This communication network will form an expanded electromagnetic microwave blanket above each city and county, permeating the airspace and providing seamless connectivity where people and things will exchange data. Former Federal Communications Commission (FCC) chair Tom Wheeler called this a "National Priority" and thus ushered in approval for the addition of this new pervasive network of high frequency short wave millimeter broadband for commercial use first planned in urban areas.

Engineers and physicists are busy working out the details of carrier frequencies and the architecture of the new network. Manufacturing industries are already developing commonly used products that feature wireless integration that will connect to the densely clustered antennas. Marketing companies are now pushing ads for "smart" devices for "smart" people in "smart" cities. Even the healthcare industry is anticipating using some of these wearable devices for patients with cardiac conditions or to do remote surgery in other parts of the world. Opening up 5G Spectrum access hopes to drive an explosion of new products. The economic opportunities are obvious and business will be booming in the tech industry.

Concerns continue to rise however about the basic safety of our current use of wireless technologies not to mention adding layers of newer microwave frequencies that have not been tested for short term or long term safety. Important questions have not been addressed while industry and government policy have already moved forward.

- Why is the FCC streamlining permitting of 5G high frequency when they have not completed their investigation on health effects nor updated safety limits for low-intensity radio frequency radiation?

- Is the widespread "deployment" of this pervasive higher frequency small cell distributed antennae system in our cities and on our homes safe for humans and the environment?
- Will it add to the burden of chronic disease that costs our nation over a trillion dollars annually? (105) Are we already digitally over connected, outsourcing our grey matter and becoming a dysfunctional addicted nation because of it?
- How will this affect our privacy, cyber security and the security of medical records?
- Will we as physicians be able to recognize the emerging adverse health effects of new millimeter technology and wearable technology let alone that of current wireless devices?

Letters to the FCC in 2016 responding to the 5G roll out with the addition of new high frequencies were mixed. Industry generally applauded the FCC for its efforts and discussed the growing demand for this technology along with a need for flexible regulation to implement it. Some expressed concerns about interference with other satellite systems. Some felt there should be maximum spectrum usage opening up even higher frequencies that are only experimental now in order to help "the underserved". Others argued about opening this up to licensed versus unlicensed uses. Industry did not mention any potential public or environmental health hazards regarding the use of these new frequencies.

Private citizens and Phd's, however did raise a red flag at the FCC, recommending a halt to infrastructure plans and more testing for health and environmental reasons. They questioned the current FCC standards which are outdated and not protective of human health. They asked "How will it affect children, pregnant women and the elderly who are the most vulnerable in our population?" While scientists gave ample evidence that precaution should prevail, I found the most compelling letters were from those who describe their fear as electro-sensitive people in an already dangerously high electromagnetic environment for them.

Linda K., a Michigan resident, explained how she became increasingly sensitive to EMF after a cell tower was placed within 1000 feet of her house. She experienced insomnia at first and did not know there was a cell tower until several years later when she then associated the timing of its placement with her symptoms. After smart meters were installed in her area (but not on her house) she became sensitive to her laptop on wireless and her cell phone. Comcast then placed a Wi-Fi hotspot within 400 feet of her house and she stated her symptoms increased to the point that if she was outside in her yard more than 20 minutes she developed increasing fatigue, headaches, heart palpitations and high pitched ringing in her ears. These are all reported effects in those sensitive to EMF from wireless devices. She wrote about her concerns and that the new frequencies may add to her symptoms and inability to leave her house.

In another letter Veronica Z. noted "This is a notice of survival. What many of us deal with currently is trying to survive in an environment that is hostile to us biologically. We have lost all of our rights, our finances, our homes, our ability to earn a living due to this ubiquitous exposure. We are being tortured every second of every day and have been reduced to simply trying to survive the moments we are alive. Others have been unable to do so and have opted to not stay living on this planet of torture...There is no escape for people with severe sensitivities to this deadly radiation."

Are these people telling the truth? Is this just psychological? You may wonder, however, more and more people from all ages, professions and walks of life are relating similar symptoms in the presence of wireless devices. Some children reported these symptoms when their school adopted WiFi. Dr. Scott

Eberle, a well respected Petaluma hospice physician, eloquently described his development of electro-sensitivity in the November 2016 issue of the SCCMA Bulletin. He goes to great lengths to continue his profession, interact with his collegues and maintain a healthy existence. (67) We are exposed to increasing levels of microwave EMF in our daily lives. More scientific evidence links biologic effects with increased reports of health related effects including electrosensitivity. In 1971 Russian scientists Gordon and Sadchikova from the Institute of Labor Hygiene and Occupational Diseases described a comprehensive series of symptoms which they called 'microwave sickness" and presented this at an international WHO meeting. (109) In a 1981 NASA report, "Electromagnetic Field Interactions: Observed Effects and Theories" microwave sickness was also described. The symptoms recorded were headaches, eyestrain, fatigue, dizziness, disturbed sleep at night, sleepiness in daytime, moodiness, irritability, unsociability, hypochondriac reactions, feelings of fear, nervous tension, mental depression, memory impairment, pulling sensation in the scalp and brow, loss of hair, pain in muscles and heart region, breathing difficulties, increased perspiration of extremities.

Belpomme, in 2015, completed the most comprehensive study of electrosensitivity, investigating 1216 people: 71.6% with EHS, 7.2% with CS, and 21.2% with both. They found an elevation in several reliable disease biomarkers—each occurring within a range of 23% to 40% of all cases— which prompted their conclusion that these sensitivities can be objectively characterized and diagnosed and "appear to involve inflammation-related hyper-histaminemia, oxidative stress, autoimmune response, capsulothalamic hypoperfusion and pathologic leakage of the blood-brain barrier, and a deficit in melatonin metabolic availability"

The scientific literature abounds with evidence of non-thermal cellular damage from non-ionizing wireless radiation for several decades. There are likely several mechanisms both direct and indirect. Oxidative damage is one that has been well studied. Effects have been demonstrated on cell membranes causing a shift in the voltage gated calcium channels. Sperm studies have consistently found genotoxic, morphologic and motility abnormalities in the presence of cell phone radiation. DNA damage, blood brain barrier effects, melatonin reduction, nerve cell damage, mitochondrial disruption and memory disturbances have been revealed. The Bioinitiative Report (139) has chronicled these effects and a growing wave of PEER reviewed studies is building on that base daily. In 2011, the International Agency for Research on Cancer classified radiofrequency as 2B carcinogen and "possibly carcinogenic to humans", the same category as DDT, lead and other pesticides.

The most recent and compelling evidence has come from the 2016 National Institutes of Health, National Toxicology Program. Called the NTP Toxicology and Carcinogenicity Cell Phone Radiation Study, the 10 year $25 million research revealed conclusively that there was a harmful effect from cell phone microwave radiation. (124,125) The frequencies are similar to other wireless devices we commonly use. The studies were robust, collaborative, well controlled and with double the number of rats required to reveal a significant effect, if present. The preliminary results of the study showed that RFR caused a statistically significant increase in two types of brain tumors, gliomas and schwannomas. These were the same two types of tumors shown to increase in human epidemiological studies on long term use of cell phones. Dr. Lennart Hardell and others have demonstrated a consistent pattern of increased incidence of ipsilateral (same side) acoustic neuromas (vestibular schwannomas) and gliomas with each 100 hours of cell phone use. (112-118) Another telling finding was that the control rats had much lower than expected cancer rates. It is believed due to the fact the control rats were in a controlled faraday cage and not exposed to normal ambient EMF that could contribute to cancer.

Ron Melnik, PhD, Senior Toxicologist and Director of Special Programs in the Environmental Toxicology Program at the National Institute of Environmental Health Sciences (NIEHS) and designer of the study states, “The NTP tested the hypothesis that cell phone radiation could not cause health effects and that hypothesis has now been disproved. The experiment has been done and, after extensive reviews, the consensus is that there was a carcinogenic effect.”

The term "millimeter waves" (MMW) refers to extremely highfrequency (30-300 GHz) electromagnetic radiation. Millimeter Waves (MMW) used in the next-generation of high-speed wireless technologies have shallow penetration thus effect the skin surface, the surface of the eye or on bacteria, plants and small life forms. Surface effects, however, can be quite substantial on an organism as stimulation of skin receptors can affect nerve signaling causing a whole body response with physiological effects on heart rate, heart rhythm, and the immune system. In a 1998 review article, Pakhomov (123) looked at the bio-effects of millimeter waves. He reviewed dozens of studies and cites research demonstrating profound effects of MMW on all biological systems including cells, bacteria, yeast, animals and humans. Some effects were clearly thermal as millimeter microwaves are rapidly absorbed by water which is abundant in living organisms. When microwaves are absorbed the energy can cause tissue heating. Many of the millimeter frequency studies however showed effects without heating of tissues and at low intensities. Research was variable and showed both regenerative effects and also adverse effects depending on frequency, power and exposure time.

Chernyakov induced heart rate changes in anesthetized frogs by microwave irradiation of remote skin areas. Complete denervation of the heart did not prevent the reaction. This suggested a reflex mechanism of the MMW action involving certain peripheral receptors.

Potekhina found certain frequencies from 53-78 GHz band (CW) changed the natural heart rate variability in anesthetized rats. He showed that some frequencies had no effect (61 or 75 GHz) while other frequencies (55 and 73 GHz) caused pronounced arrhythmia. There was no change in skin or whole body temperature.

One study of MMW teratogenic effects was performed in Drosophila flies by Belyaev. Embryos were exposed to 3 different GHz frequencies for 4-4.5 hours at 0.1 mW/cm^2. He found that irradiation at 46.35 GHz, but not at 46.42 or 46.50 GHz, caused marked effects including an increase in morphological abnormalities and decreased survival. It was felt the MMW disturbed DNA-protein interactions at that particular frequency.

Bulgakova in over 1,000 studies with 14 different antibiotics showed how MMW exposure of S. aureus affects its sensitivity to antibiotics with different mechanisms of action. The MMW increased or decreased antibiotic sensitivity depending on the antibiotic concentration. (134) Pakhomov warns, “Regardless of the primary mechanism, the possibility of significant bio-effects of a short-term MMW irradiation at intensities at or below current safety standards deserves consideration and further study. The possibility of induction of adverse health effects by a local, low-intensity MMW irradiation is of potential significance for setting health and safety standards and requires special attention.” He called for replication of studies especially long term effects of MMW.

Prost in 1994 studied millimeter microwave radiation on the eye. He noted that microwaves of different wave-lengths can induce the development of cataracts. (13) His research found that low power

millimeter waves produced lens opacity in rats exposed to 10mW/cm^2, a predisposing indicator of cataracts.

Kolomytseva, in 2002, looked at the dynamics of leukocyte number and functional activity of peripheral blood neutrophils under whole-body exposure of healthy mice to low-intensity extremely-high-frequency electromagnetic radiation (EHF EMR, 42.0 GHz, 0.15 mW/cm^2, 20 min daily). The study showed that the phagocytic activity of peripheral blood neutrophils was suppressed by about 50% in 2-3 h after a single exposure to EHF EMR.

Gapeve in 2003 showed for the first time that low-intensity extremely high-frequency MMH electromagnetic radiation in vivo causes effects on spatial organization of chromatin in cells of lymphoid organs. Chromatin is a complex of DNA and proteins that forms chromosomes within the nucleus of eukaryotic cells. He exposed mice to a single whole-body exposure for 20 min at 42.0 GHz and 0.15 mW/cm^2.

Habauzit in 2013 looked at gene expression in keratinocytes with 60GHz exposure at upper limit of current guidelines and concluded “In our experimental design, the high number of modified genes (665) shows that the ICNIRP current limit is probably too permissive to prevent biological response.

Commercial production often precedes research on consumer protection and health effects. We have too many toxins that have escaped premarket safety protocols for too long—lead, asbestos, smoking and our modern unregulated nanoparticles to mention just a few. These affect our long term and short term health in ways we do not even know. If we become ill, we do not question or identify the daily or weekly chemical exposures that could have contributed to that cancer or arthritis or lung disease or Alzheimer’s. We have too many toxins to sort it all out. Research shows that wireless microwave radiation adds yet another dose of toxic exposure to our daily lives. We cannot hear it or smell it or feel it. Yet it affects our biology and our wellbeing with perhaps subtle affects. If we are electro-sensitive then we are more likely to avoid exposure. Trees are even susceptible to EMF harm and they cannot move away. (128) What about birds and bees and us?

If we are concerned about putting a cell phone to our ears for long periods of time after reading about the NTP study then why aren’t we concerned about other wearable devices? While very cool to use Google Glass and Virtual Reality may have dangerous consequences to our eyes, brain function or immune systems with long term use, especially to children. What are the frequencies in these devices? 3G, 4G, 5G or a combination of zapping frequencies giving us immersive connection and entertainment but at a potentially steep price.

Safety testing for 5G is the same as other wireless devices. It is based on heat. This is an obsolete standard and not considering current science showing cellular and organism harm from non-thermal effects. There is a large gap in safety data for 5G biological effects that has been demonstrated in older studies including military.

https://wirelessaction.files.wordpress.com/2016/09/5g-wireless-future-sccma-bulletin_feb-2017.pdf

Medical Director of Switzerland's Paracelsus Clinic Takes Stand on Hazards of Electromagnetic Pollution 'Electromagnetic Load' a Hidden Factor in Many Illnesses

Dr. Thomas Rau, Medical Director of the world renowned Paracelsus Clinic in Lustmühle, Switzerland says he is convinced 'electromagnetic loads' lead to cancer, concentration problems, ADD, tinnitus, migraines, insomnia, arrhythmia, Parkinson's and even back pain. At Paracelsus (www.paracelsus.ch), cancer patients are now routinely educated in electromagnetic field remediation strategies and inspectors from the Geopathological Institute of Switzerland are sent to patients' homes to assess electromagnetic field exposures.

Of note, Dr. Rau says a strategy to consider for those experiencing 'electrical sensitivity' symptoms is to remove the electromagnetic 'hot spot' in the head created by the presence of metal fillings. Concern is thus not only for the 'neurotoxic' aspect of mercury in fillings, an increasingly understood hazard, but because fillings themselves act as antennas in the presence of electromagnetic fields from cell phones and cell towers, wi-fi networks, portable phones, and other sources of radiofrequency radiation.

Rau says the removal of dental fillings can be an important early step in reducing electrical sensitivity, allowing some people to live in homes they otherwise could not tolerate.

Cultures have shown beneficial bacteria grows more slowly in the presence of electromagnetic fields, says Rau, allowing pathological organisms to dominate. Thus, a strategy with electrically sensitive patients, or with those facing chronic conditions, is the aggressive supplementation with probiotics and other Biological Medicine approaches to balance intestinal flora. Many people with chronic infections likely linked to EMF exposures, such as Lyme Disease, are symptom- free after an aggressive microorganism rebalancing program.

Electrical sensitivity—originally known as radio wave sickness—is a sometimes debilitating experience created by these and other disregulating effects of electromagnetic fields. Linked to many acute and chronic illness conditions, electrical sensitivity is a serious emerging public health issue globally and a subject in which most doctors have no training.

A Petition to Congress, created by www.ElectromagneticHealth.org is now circulating on the internet, requesting Congress 1) mandate the FCC lower exposure guidelines to reflect the large body of science showing biological effects at exposures much lower than current standards, 2) repeal Section 704 of the Telecommunications Act of 1996, which rescinded state and local governments right to resist towers on health or environmental grounds, 3) stop the roll out of the Wi-Max network until Congress better understands the potential health consequences, and 4) accommodate citizens unable to function adequately in high EMF environments, including forbidding cell towers on school properties.

Rau says exposing children in schools to radiation, known to impair brain function and learning, is "criminal". He says, "It is unethical to expose children to electromagnetic load in this way. We know that power stations for electromagnetic waves like mobile phones are hurting the brains of children, so to put such stations into schools is really…very, very bad. Dr. Rau says, the question is, "Does the school, or does the society, really want to have intelligent, well-educated children, or not?" He says, "If you install mobile phone towers, which radiate to the children, their intelligence, their brain capacity, decreases.

You will have more ADD children, you will have less function of the brain, which in the long term reflects on the intelligence of the children, of the possibility to really teach children, and in the long term, the more this overcomes society, the more we will have dumb children."

The reality of the health consequences of electromagnetic radiation eventually will have to be faced, and this will only happen with active pressure on Congress. It is estimated that 3-8% of populations in developed countries experience serious electrohypersensitivity symptoms today, and 35% experience mild symptoms. With increasing electromagnetic field exposures, these numbers, along with the suffering involved for people who are impacted, and the health care costs involved, are bound to go up.
http://www.marioninstitute.org/electromagnetic-load-a-hidden-factor-in-many-illnesses/

How to identify and reduce electrosmog

1. What are the recommended levels for RF radiation?

Various radiofrequency (RF) radiation guideline recommendations (given as µW/m^2*):

10 000 000 µW/m^2 – FCC (USA) OET-65, recommendation
9 000 000 µW/m^2 – ICNIRP 1998; WHO, recommendation
100 000 µW/m^2 – Russia and Italy, recommendation **
1 000 µW/m^2 – the Bioinitiative Report 2007, recommendation
170 µW/m^2 – the Seletun Statement 2010, recommendation
3 µW/m^2 – the Bioinitiative Report 2012, revised recommendation *(Precautionary ceiling (top) level for 2013, may be revised at a later date)*
0.1 µW/m^2 – contribution from the sun at daytime during big solar storms

0.000 001 – 0.000 000 000 01 µW/m^2 – this is the natural background during normal cosmic activities; proposed by Olle Johansson, Karolinska Institute (1997), as a genuine hygienic safety value. Above this level we could say electrosmog pollution is present, unless in the midst of a large solar storm.

*microwatts per meter squared

** EMF World Standards Database World Map (World Health Organization)

Please note: The range 0.000001 – 0.00000000001 µW/m^2 is the true natural background level during normal cosmic activities, which is what we have evolved to tolerate, according to Dr. Olle Johansson. In developed nations, according to Dr. Johansson, these levels might only be seen in a cave or specially designed military installation. However, it is instructive to see the great distance between *what we evolved to tolerate* and the suggested guidelines above. In the USA, the FCC guidelines make it currently legal to allow RF radiation levels at 10 000 000 µW/m^2, which is 10,000,000,000,000 (ten trillion) times higher than the *upper* natural background levels we evolved to tolerate! Is it any wonder that bioeffects and health impacts would be observed under these alarming conditions?

When 1/88 children in the USA are born autistic, and RF radiation does impact the brain and neurological systems, particularly at risk are the fetus, embryo, young child and developing children through age of 20, according to scientists, it is no wonder that the BioInitiative Report 2012 (on RF radiation and bioeffects) has an entire section on Autism. It is a proven fact that we are destroying and mutating our DNA with RF radiation such as emitted from wireless toys, wireless utility meters, and cell antennas and towers. Known to inflame tissues, interfere with cellular function, and damage DNA and sperm, the exposures everyone is getting via the wireless craze is resulting in an increase in certain cancers, reproductive problems, and birth defects that may result in autism, learning disabilities, and ADHD, according to some scientists.

The FCC limit is 3,333,333 times higher than BioInitiative Limit of 3.0 µW/m^2, for sensitive populations that include children and pregnant women

An FCC Limits Primer (by StopSmartMeters.org)

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Some examples:

a. Example at a school in Encinitas CA, with 20 cellular antenna on the church property where the school leases classrooms (12 antenna in the steeple next to classrooms, and 8 in the parking lot):

The RF fields were found to vary from 200 to greater than 20,000 µW/m^2

3.0 µW/m^2 (divided by) 20,000 µW/m^2 = 6,666 times higher than the BioInitiative 2012 limit

b. Example of measurements from 3 types of smart meters using a Ten-Mars TM-195 3-Axis RF field meter.

Table 2: Hickory Creek Focus AXR mesh, frontal radiation

Distance		**Day 1**	**Day 2**
Ft	**m**	**mW/m^2**	**mW/m^2**
3	1	191	—
5	1.6	116	—
10	3.2	34	22
15	4.8	8	—
20	6.5	4	3
30	9.7	3	2
50	16.1	1	1
100	37.3	0.4	0.4

Ambient	0.6	0.02

All values are peak.

The measurements were taken in the early evening on both days and are consistent. The radiation levels reach the ambient levels at a distance of about 100 ft (32 meters) from the front of the meters.

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2. A sample of bioeffects and health impacts listed for various levels:

a. See the 2012 BioInitiative Report and the Color Charts [Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure (Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)] associated with the report for current references (December, 2012).

Examples from BioInitiative 2012 Color Charts: Note: Charts are in uW/cm^2 ; CEP has converted several to **uW/**m^2 (in parentheses) ; to convert rest of chart, multiply x 10,000 for **µW/**m^2, or *move decimal point **to right**, four places*.

0.003 – 0.02 uW/cm^2 **(30.0 – 200.0 µW/**m^2**)** In children and adolescents (8-17 yrs) short-term exposure caused headache, irritation, concentration difficulties in school. Heinrich, 2010

0.003 to 0.05 uW/cm^2 **(30.0 – 500.0 µW/**m^2**)** In children and adolescents (8-17 yrs) short-term exposure caused conduct problems in school (behavioral problems) Thomas, 2010

0.005 uW/cm^2 **(50.0 µW/**m^2**)** In adults (30-60 yrs) chronic exposure caused sleep disturbances, (but not significantly increased across the entire population) Mohler, 2010

0.005 – 0.04 uW/cm^2 **(50.0 – 400.0 µW/**m^2**)** Adults exposed to short-term cell phone radiation reported headaches, concentration difficulties (differences not significant, but elevated) Thomas, 2008

CEP NOTE: 0.01 uW/cm^2 **(100.0 µW/**m^2**) = 1/1000th of FCC guidelines**

0.006 – 0.01 uW/cm^2 **(60.0 – 100.0 µW/**m^2**)** Chronic exposure to base station RF (whole-body) in humans showed increased stress hormones; dopamine levels substantially decreased; higher levels of adrenaline and nor-adrenaline; dose-response seen; produced chronic physiological stress in cells even after 1.5 years. Buchner, 2012

CEP NOTE: 1000 uW/cm^2 **(10 000 000 µW/**m^2**)** – FCC (USA) OET-65, recommendation **- "FCC Guideline", 6-minute occupational exposure and 30 minute public exposure based on heating**

b. According to Firstenberg, presented (2007) in an amended table by M. Havas, PhD of scientific findings to include FCC guideline info : At 1/100th of FCC guidelines: sleep disorders, abnormal blood pressure, nervousness, weakness, fatigue, limb pain, joint pain, digestive problems, learning problems

(fewer schoolchildren promoted). **At 1/1000th of FCC guidelines:** altered EEG, disturbed carbohydrate metabolism, enlarged adrenals, altered adrenal hormone levels. structural changes in liver, spleen, testes, and brain, slowing of the heart, increase in melatonin, decreased cell growth, increased sterility, childhood leukemia, impaired motor function, reaction time, memory and attention of school children, and altered sex ratio of children (fewer boys); cardiac arrythmias and sometimes cardiac arrest (frogs); altered white blood cell activity in schoolchildren, headache, dizziness, irritability, fatigue, weakness, insomnia, chest pain, difficulty breathing, indigestion (humans – occupational exposure); **1% of FCC guideline**: damaged mitochondria, nucleus of cells in hippocampus of brain, impaired memory and visual reaction time, redistribution of metals in the lungs, brain, heart, liver, kidney, muscles, spleen, bones, skin, blood. (5)

Note: Firstenberg / Havas table below is in **µW/c**m^2 - multiply x 10,000 for **µW/**m^2 **(provided in parentheses)**, or move decimal point **to right** four places.

Power Density in µW/cm^2 **(µW/**m^2**) – Reported Biological Effects – References**
0.0000000000001 Altered genetic structure in E. Coli Belyaev 1996
0.0000000001 (.000001 µW/m^2**) Threshold of human sensitivity Kositsky 2001**
0.000000001 (.00001 µW/m^2**) Altered EEG in human subjects Bise 1978**
0.0000000027 Growth stimulation in Vicius fabus Brauer 1950
0.00000001 Effects on immune system in mice Bundyuk 1994
0.00000002 Stimulation of ovulation in chickens Kondra 1970
0.000005 Effect on cell growth in yeast Grundler 1992
0.00001 1/100 millionth of FCC guidelines
0.00001 Conditioned "avoidance" reflex in rats Kositsky 2001
0.000027 Premature aging of pine needles Selga 1996
0.002 (20.0 µW/m^2**) Sleep disorders, abnormal blood pressure, nervousness, weakness, fatigue, limb pain, joint pain, digestive problems, fewer schoolchildren promoted Altpeter 1995, 1997**
0.0027 Growth inhibition in Vicius fabus Brauer 1950
0.0027 to 0.065 Smaller tree growth rings Balodis 1996
0.01 1/1000th of FCC guidelines
0.01 (100 µW/m^2**) Human sensation Kolbun 1987**
0.06 Altered EEG, disturbed carbohydrate metabolism, enlarged adrenals, altered adrenal hormone levels, structural changes in liver, spleen, testes, and brain—in white rats and rabbits Dumanskij 1974
0.06 (600 µW/m^2**) Slowing of the heart, change in EEG in rabbits Serkyuk, Reported in McRee 1980**
0.1 Increase in melatonin in cows Stark 1997
0.1 to 1.8 Decreased life span, impaired reproduction, structural and developmental abnormalities in duckweed plants Magone 1996
0.13 Decreased cell growth (human epithelial amnion cells) Kwee 1997
0.168 **(1680.0 µW/**m^2**)** Irreversible sterility in mice Magras 1997
0.2 (2000.0 µW/m^2**) to 8.0 Childhood leukemia near transmitters Hocking 1996**
0.3 (3000.0 µW/m^2**) Impaired motor function, reaction time, memory and attention of schoolchildren, and altered sex ratio of children (fewer boys) Kolodynski 1996**
0.6 Change in calcium ion efflux from brain tissue Dutta 1986
0.6 **(6,000.0 µW/**m^2**)** Cardiac arrhythmias and sometimes cardiac arrest (frogs) Frey 1968

4 **(40,000.0 µW/**m^2**) Altered white blood cell activity in schoolchildren Chiang 1989**
1 (10,000.0 µW/m^2**) Headache, dizziness, irritability, fatigue, weakness, insomnia, chest pain, difficulty breathing, indigestion (humans—occupational exposure) Simonenko 1998**
1 Stimulation of white cells in guinea pigs Shandala 1978
1 Within 16 feet (5 meters) of a Wi-Fi node in San Francisco Maifeld 2007
2 "Microwave hearing"—clicking, buzzing, chirping, hissing, or high-pitched
tones Frey 1963, 1969, 1971, 1973, 1988, Justeson 1979, Olsen 1980, Wieske 1963, Lin 1978
2.5 (25,000.0 µW/m^2**)Breakdown of blood-brain barrier (used a digital cellular phone to provide the radiation) Salford 1997**
5 **(50,000.0 µW/**m^2**)**Leukemia, skin melanoma and bladder cancer near TV and FM transmitter Dolk 1997
5 **(50,000.0 µW/**m^2**)** Biochemical and histological changes in liver, heart, kidney, and brain tissue Belokrinitskiy l982
10 1% of FCC guideline
10 **(100,000.0 µW/**m^2**)**Damaged mitochondria, nucleus of cells in hippocampus of brain Belokrinitskiy 1982a
10 **(100,000.0 µW/**m^2**)** Impaired memory and visual reaction time in people living near transmitters Chiang 1989
10 **(100,000.0 µW/**m^2**)**Decreased size of litter, increased number of stillborns in mice Il'Chevich (reported in McRee
1980)
10 **(100,000.0 µW/**m^2**)**Redistribution of metals in the lungs, brain, heart, liver, kidney, muscles, spleen, bones, skin, blood
Shutenko 1981
1000 FCC Guideline, 6-minute occupational exposure and 30 minute public exposure based on heating

3. Practical suggestions to reduce electrosmog, based on current science cited in the BioInitiative Report 2012:

The following may seem difficult to achieve in today's world (2013) but we can assure you that it is possible to take control of your environment and greatly reduce your (and your loved ones') exposure to electrosmog by applying the following suggestions.

When you consider that only 1-2 decades ago, none of the wireless and RF-emitting technologies so popular today were in use, you can realize that these are not necessary for living, and in fact, are increasingly implicated in shorter lifespans (cancer, heart); debilitating illness (headaches, coronary problems, immune disorders, neurological problems and more); and suspected to cause birth defects. **It is worth it to reduce electrosmog pollution in your own personal environments!** Here's how:

CEP recommends that wireless devices be removed from homes and communities. wired internet, corded phones, no wireless or wired utility "smart" or PLC meters (opt-out if available, avoid installation or close proximity, if no opt-out). Be aware that second-hand RF radiation from others' cell phones, Wi-Fi, and smart meters does produce measurable levels that are of concern. Avoid if possible.

How to protect yourself against smart meters (article)

CEP recommends ridding the home, vehicle, school, and workplace of RF radiation sources such as smart meters, Wi-Fi, wireless baby monitors, wireless security systems, cell phones, DECT phones and others that are cordless, Bluetooth and other similar wireless technologies including headsets, wireless tv, wireless appliances, appliances with wireless built-in to communicate with the smart meters (HAN appliances, which can be distinguished by the FCC ID code on the equipment), wireless security systems, turn off the wireless feature on computers, laptops, notebooks, etc. in the Control panel, no wireless printers, wireless reading devices, and all wireless devices not on this list.

Cell phones should not be used in cars, or during public transportation, as the signal has a harder time getting out and the phone produces more RF radiation as it ramps up to find a signal.

Pregnant mothers should NOT use cell or cordless phones nor be in Wi-Fi environments. All of the above should be removed from the home and other occupied spaces during pregnancy.

Children should NOT be given cell phones of their own, nor adults' cell phones to entertain them. They should not be exposed to adult cell phone use in the home nor in vehicles. Children should not be given wireless laptops, tablets, notebooks, or reading devices to use on a regular basis. If some of these are to be used occasionally, they should be shielded and wired. Phones in the home should be wired.

Cellphones should not be carried in "on" position in pockets (this includes airplane mode). Laptop computers should not be used on laps. Scientists have confirmed that RF radiation from laptops and cell phones can damage sperm and reproductive systems may be interfered with, that the sperm, female reproductive system, developing embryo, and fetus are very sensitive to RF radiation and are at grave risk of damage that may lead to miscarriage and/or birth defects. Cell phones, if these must be used, should be used in speaker mode, at several feet from body, and only rarely. Studies have shown bioeffects at arm's length.

If laptops are used, place on a table, 2-3 feet from the body, with extended (additional) wired keyboard (low RF if possible) and extended, wired low RF mouse, and additionally, may wish to obtain shielding material for the base of the keyboard. Testing with a RF field meter to determine levels is recommended.

Avoid close proximity to cell towers and cellular antenna. www.antennasearch.com has locations of many (not all) cellular antenna/towers. **ALERT**: **find out if your child's school or your church has hidden or visible cellular antenna or cell towers on the property**, that can be sources of high levels of RF radiation. Sadly, many schools and churches are allowing telecom companies to lease space to install these cellular facilities, which are promoted as "safe' because they are legal and meet the very exceedingly obsolete FCC guidelines, based only on the heating of tissues in a large male.

When purchasing a vehicle, be aware that newer vehicles may have high RF exposures – wireless features built-in, as well as many computerized systems that may be a source of RF radiation. Hybrid and electric vehicles may have increased RF radiation exposures due to charged batteries in close proximity to driver and passengers.

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4. Measure and monitor your environments for RF radiation - before and after you implement the above suggestions

Please note: CEP does *not* sell any of these products. These are offered only as examples of items that may help you identify, reduce, and avoid RF radiation. They may be obtained through some of the websites links below, or obtained through eBay, Amazon, or other outlets. Stop Smart Meters offers the Cornet meters, including the latest version.

CEP recommends measuring the RF radiation in your vehicle, home, church [may have cell antenna in steeple or on property] school [may have cell antenna on property and/or Wi-Fi] and workplace [Wi-Fi, wireless security system] with a sensitive RF (radiation) field meter that measures in **either µW/**m^2 **or µW/c**m^2 **up to at least 6 GHz**, necessary for testing the new Wi-Fi frequencies, up to 5.6 GHz. **Simple to use, inexpensive but reliable rf field meters are the:**

Cornet ED 78S RF/LF Electrosmog Meter (used only)

Cornet ED88T Tri-Mode (RF/LF/ E-Field) Electrosmog Meter (new version)

These small-sized, convenient, less expensive meters measure in mW/m^2 and have a Peak/Max hold (so you can view how high the pulses get to). The BioInitiative Report 2012 recommends a precautionary level of 3.0 microwatts per meter squared (0.0003 microwatts per centimeter squared) which is equal to 0.003 milliwatts per meter squared. Of note, the Cornet meters above come with a scale of "safe-caution-danger" zones that do not correspond to the latest scientific data, and are generally higher than what is recommended by BioInitiative 2012. So comparing the measurements obtained with 0.003 milliwatts per meter squared is a better way to determine the level of risk if using the Cornet meters. On the Cornet meter used by this writer, a label has been placed, with 0.0003 mW/m^2 on the front, to compare readings to.

http://www.electrosmogprevention.org/smart-meter-resources-links/safety-guidelines-for-rf-exposure/

Another Inconvenient Truth

February 8th, 2017

On May 26 of last year cell phone use was directly linked to cancer. Our Government's National Toxicology Program (NTP), part of the National Institute of Health, released a preliminary report stating, "Two types of cancer were caused by heavy cell phone use, glioma brain tumors and heart schwanomas." They were surprised because this study, initiated by the Food and Drug Administration, was to show cell phone use did not cause cancer. The NTP came out with these findings so agencies that protect your health and safety could take appropriate measure to insure public safety.

This is new and important information because you can begin taking protective measures by monitoring all wireless products and their sources that your children are using. This includes (1) Wi-Fi which is usually on 24/7 at home and you can get radiation from your neighbor's wireless use, (2) smartmeters, electric, gas and water are radiating 24/7, (3) smart appliances radiate 24/7, (4) students have Wi-Fi in their classroom, radiating 6 hours a day 5 days a week, (5) students also have computers in their classrooms and for homework, radiating 4 to 6 hours per day, (6) gaming, social media, watching TV programs, movies and sporting events on their cellphones, tablets and computers - radiating them another 2 to 6 hours a day, (7) many neighborhoods have cell phone antenna towers radiating 24/7, within different zones: the deadly zone 150 meter (492') radius from the tower, the dark zone 500 meter (1640') radius, and there are some adverse effects as far out as 1000 meters, (8) many children have 4G phones which they usually carry next to their bodies and on night stands, radiating them continuously while it's in their possession, which is contrary to most manufacturer's safe usage guidelines, (9) printers, faxes, baby monitors and headsets, (10) remote controlled: toys, TV's, stereos, keys, lights, fans, switches, alarm systems, and (11) all the other wireless devices you have and are going to buy in the future.

Radiation exposure is accumulative, and when you add up all the exposure your child is getting it gets scary. Microwave radiation penetrates deeper within smaller bodies. The earlier children are exposed to heavy radiation the sooner the clock starts ticking for higher risk of getting cancer and other adverse health conditions from radiation. If you start exposing young children early they could be at high risk before they graduate from high school or college.

Studies by independent scientists have connected wireless radiation to cancer and a multitude of adverse health conditions. In 2011 the World Health Organization listed cell phone radiation a Possible Carcinogen. In 2012 an Italian Supreme court ruling said, "Brain cancer was connected to heavy cell phone use." On February 27, 2016 an Italian study linked cell phone radiation to cancer and now the above study linking cell phone use to cancer.

After the Federal Communications Commission (FCC) received information of the NTP's rodent study, Chairman Tom Wheeler, rolled out the 5G program as a national priority and bared any questions or comment on the NTP study. 5G increases ambient cell tower radiation; 5G operates at higher frequencies that have a short range and 5G can't penetrate solid objects very well so antennas will be on practically every telephone pole. The government is not going to protect you; the telecom industry has too much influence over their protective agencies. You need to take responsibility and create safe environments for your children.

Chairman Wheeler stated, “We wanted to be the first to have 5G,” even though South Korea is ahead of them -- which is a good thing. South Korea is one of the world’s most technologically advanced countries and they are experiencing repercussions that go with advancement without safety trials and precautions. They have a budding epidemic called “digital dementia,” with children more at risk than adults because their brains are still growing. “The situation is worsening”, Korean doctor’s report, “with the percentage of people between ages 10 and 19, who use their smartphones for more than seven hours a day, leaping from 7% to 18.4% in one year.” Doctors have warned that these deficits in brain development are irreversible.

Wireless radiation causes cancer and many adverse health conditions. Protect your children and yourselves by reducing your exposure, not buying wireless products before they’re proven safe, reduce use, and eliminate the ones that are not necessary. Please, practice prudence and precaution when something is affecting your children’s health.

http://hpr1.com/index.php/lifestyles/wellness/another-inconvenient-truth/

Controversy surrounding EMF exposure: Do wireless devices pose dangers?

We're living in the age of wireless everything -- and it's being debated whether devices, such as cell phones, Wi-Fi routers and even baby monitors could be harmful to us.

"I started to get headaches and tinnitus, my ears were ringing really bad, my hair stated to fall out, I was getting acid reflux and leg cramps, and my memory was going," said Paul Harding.

In 2011, Harding says it was those symptoms he began experiencing after the utility company put a smart meter on his home. After the installation, he says he'd wake up at 3:12 a.m. every morning with a racing heart beat.

"When they put the smart meter on, the power mode switch supply inside of it is creating dirty electricity and when it sends its information, the wiring in your home is acting like an antenna so RF travels on energized wiring, so it's actually pulsing the electric field that you're absorbing," explained Harding.

Harding talked with a few neighbors who had similar symptoms and after reading a few articles, he believed he was suffering from something called Electromagnetic Radiation Sickness. He says harmful RF or radio frequencies are produced in your home by things like Wi-Fi routers, cell phones and computers.

"Well there's all sorts of devices out there that use wireless technology and there are devices, such as dimmer switches, CFL light bulbs that are producing what is called dirty electricity, so absorbing those fields that they are producing, studies have shown to cause nerve blockage."

Harding is now making it his mission to help others to get rid of what he says is unnecessary exposure to RF, AC magnetic fields, and AC electric fields in their homes, like this woman who did not want to be identified:

"It feels like a live wire inside of my body, and I don't know what it's from, like power overload or something."

Harding uses equipment to measure for dirty electricity, electrosmog and power quality.

"This is a high frequency analyzer. It measures anywhere between 2.4 and 10 gigahertz. This is also a high frequency analyzer, but it goes from 27 megahertz to 2.4 gigahertz," he said.

In a situation like this, Harding recommends painting the walls with RF electric field deflecting paint, applying special tint on the windows and unplugging the Wi-Fi.

This woman did, and after the meter is measuring .04 and is nearly silent.

Harding also recommends electricity filters and fixing mistakes in your home's wiring.

"When they're running right next to each other, it will cancel out that magnetic field. When there is a wiring error, which we see quite often with mistakes that are made when the house was put together you see very large magnetic fields."

"To put it into perspective, the sun, if you're out in Phoenix midday in June, that's over one kilowatt per square meter, so all of these things are much lower than that," explained Peter Rez, a professor in Arizona State University's physics department.

There's been a lot of controversy surrounding this topic and how much EMF exposure is safe or if it's even harmful at all.

"All of these environmental sources are very, very low and the worst possible case is the cell phone transmitting to a tower a long way away and everything else is going to be less than that," added Rez, who says there's no reason for concern.

"EMF, the main effect is heating. When you have very high power EMF as in a microwave oven, the effect is obvious, you heat up your food. However the levels of EMF from the environment from radio transmissions, from cell phones, from local wireless area networks is very, very low, it's negligible."

Although there is controversy, Harding says he's seen results and believes in what he's doing.

"We don't want to know that our precious smart phones to be, you know, we don't want to know that they could possibly be hurting us, but if you were to look on the iPhone and go from general to legal RF exposure, it will tell you to keep that phone 10 millimeters to 5 millimeters away from your body at all times."

Harding says some people are more sensitive to EMF radiation than others. He suggests getting rid of wireless devices in your home, such as keyboards, a computer mouse, and baby monitors.

By the way, it can cost thousands of dollars to have a home mitigated of EMF and that does not include Harding's services.

http://www.fox10phoenix.com/news/arizona-news/95054197-story

Are my toys playing with my DNA?

Nov 27, 2015

Last week, I got my first wearable. Before using it, I wanted to read up on it, to learn if it was safe to have on my person, 24/7. My goal was a blog about how to safely use gadgets. But I ended up learning a lot more than I expected. Let me start at the beginning.

My new $12 Mi Band is a barebones wearable from Xiaomi without even a dial to tell the time. What it does have is a motion sensor that counts my steps and monitors my sleep patterns. It also has a vibration motor as well as notification lights to communicate. I can set it to vibrate when I get a call, or receive messages, or as an alarm. The notification lights do some notifying. But decoding flashing lights is a bit too nerdy for me. The invisible cellphone unlock function is fun, and I happily buckled on the band.

My wife however didn't share my excitement. She worries about the harm that gadgets may be doing to our bodies. She's not into technology, but she's aware her ear gets warm when she talks too long on her cellphone and it begins to hurt, and she intuitively knows that can't be good.

My curiosity was tickled and I began to wonder if her worry was justified. Cellphones have become popular only in the last 10–15 years, and it may be too early to understand their effect on our bodies. So I read up about them.

What I found was an almost fictional tale of invisible rays, DNA cracking, ruthless corporates, global media manipulation, a crusading scientist whose house gets mysteriously burnt down, and more. In short, all the ingredients for a riveting Hollywood thriller.

I was more worried about my brains being cooked than cooking up a thriller. So I have stuck to my goal of a blog about safely using gadgets, though I have touched upon these stories, and given links for more details. However the blog is a bit longer than I expected. Getting at the truth was not easy with so many exposes, coverups and unverified stories.

It took nearly 50 years for the dangers of smoking to become accepted. The fact that tobacco was a huge cash generating industry with a powerful lobby may have something to do with it. But tobacco was miniscule compared to the size of the global cellphone industry, so it may be a case of deja vu.

A cellular phone is basically a radio that sends signals on electromagnetic waves (microwaves) to its network's cellular tower. The waves' effect is like a microwave oven, but weaker. It's measured as SAR (specific absorption rate), and a cellphone's legal limit is 1.6 watts/kg. Cellphones with high SAR are more damaging. The harmful effects are increased by other factors like the cellphone's signal strength, distance from your body, and time on your body. However, heating may not be where the real danger is. I'll come back to this.

All of us have first-hand stories of the effects of cellphones. Mine is about a friend who used to drive around all day with his cellphone on the car seat between his thighs and up close to his unmentionables. He ended up visiting his doctor to complain about a pain in the unsaid part. The doctor advised him to keep his cellphone away from his body, and the pain vanished.

That's when I first began to wonder if I was being too complacent about my toys. The problem is technology is so deeply interwoven with my life that it's hard to avoid close contact with my gadgets. But if I can make some sense of the online info overload, maybe I can work out some guidelines for myself.

There is a lot of conflicting info on the internet about the danger of cellphone usage. So I tried to put two and two together. Like the fact that many insurance companies no longer cover health problems caused by cellphones radiation. Besides, 60% of insurance companies are refusing to cover cellphone makers and wireless carriers against future health damage suits, and forecasting brain tumor costs between 2020 and 2030.

The alarm bells began going off in my head.

In May 2015, 190 independent scientists from 39 countries, who between them have authored more than 2,000 papers on the topic, requested the UN, WHO, and national governments to put stricter controls on cellphone phone radiation. They point to new research that suggests even the low levels of radiation from cellphones could potentially cause cancer.

One of the issues is that the cellphone industry uses SAR as a measure of a cellphone's safety. SAR only measures the heating effects of cellphone radiation. But new studies suggest that exposure to cellphone radiation can cause dangerous biological effects without any heating.

Studies have shown that the unique pulsing nature of a cellphone's electromagnetic waves causes resonance in our cells, which can break DNA strands and cause DNA to lose its ability to repair itself.

In one word, cancer.

Also since nerve cells can no longer divide and proliferate, this damage could lead to degenerative diseases such as Parkinson's and Alzheimer's… You can read more about this here.

This one hour talk by Dr. Devra Davis back in 2012 is a bit heavy, but has a lot of information and disturbing facts. And this video about a breast cancer in the shape of a cellphone is quite an eye opener.

All living organisms generate electromagnetic fields called a biofield. Some of the waves emitted by a cellphone are similar to this human biofield. They confuse the body.

To give a rough analogy, it's like a pilot receiving instructions from the control tower as he prepares to land his plane. Imagine if a second voice comes on the same radio speaking in an unknown language. The crosstalk will confuse the pilot as he can't make out what the control tower is saying. He will abort the landing and wait till he can hear the control tower clearly. But what if the second voice keeps babbling away, drowning out the control tower's voice, and his fuel starts to run out...

Similarly when the body is constantly bombarded with electromagnetic waves, our cells get confused, stop their regular activities and go into a protective mode. This causes biological problems like damage to our DNA, intracellular free-radical buildup, leakage in the blood-brain barrier, disruption of intercellular communication, and an increased risk of tumors.

One reason may be that the effects of radiation may show up only after years, maybe even decades. Secondly, we may not be connecting the dots. Just like people once did not connect cancer with tobacco.

The truth is many studies have linked cellphone radiation to development of brain tumors, genetic damage, and other exposure-related conditions. But a well-funded cellphone industry media machine continues to mislead us. For instance, an industry-funded study in Denmark confidently proclaimed in 2011 that cellphone use is completely safe. Here are some insights into how the industry manipulates the media.

In 2009, a review of cellphone studies was conducted by Dr. Joel Moskowitz at the University of California, Berkeley. He found that industry-funded studies tended not to associate cellphone use with a heightened risk of tumors, while public-funded studies usually found the opposite result. "This is very much like studying tobacco back in the 1950s," he says. "The industry has co-opted many researchers."

When I began this article, I was only thinking about the effects of Bluetooth on my Mi band. But I soon realized Bluetooth's harmful effects paled in comparison to the potential damage by a cellphone's radiation.

Like many people, my cellphone is my favorite toy. It's by my side, 24/7. It wakes me up, brings me news, records runs, plays music, gives messages alerts, enables replies, assists me with my schedule, lets me shoot and share photos and videos, tracks finances, stores documents, helps me navigate the roads, and lets me play games. It's mostly in my pocket unless I'm working when it resides on my desktop within hand's reach.

Putting my cellphone away is going to hurt as bad as extracting a tooth. But I won't think twice if it's a rotten tooth. So why should this be different?

Remember the cozy feeling of your warm phone in your pocket? That's the feeling of your chromosomes being toasted! Soft tissues are more affected by radiation, and a cellphone in my pocket puts my internal organs at risk.

But what is a really safe distance? My cellphone's manual recommends at least an inch away from my body. According to the Pittsburgh Cancer Institute, moving your cell phone just 5 cm (2 inches) away from your head while talking on it, reduces the electromagnetic radiation that reaches my head by 75%. It goes down to less than 1% by keeping the cell phone over 18 cm (7 inches) away from any part of your body. That's clear enough.

When I have to put my cellphone in my pocket, I now push in my wallet between it and my body. If I'm working, my cellphone sits within hand's reach but not so far that I can't read the screen. If I'm driving, it will go into the car's side pockets. Jogging time use is still an issue.

A poor signal causes the cellphone to emit more radiation as it powers up to try to link to cellphone network towers. So now if my signal strength is bad, I keep my phone away from my body.

Dual SIM cards means more radiation. So if I don't need the second number to be working all the time, I just turn off the second SIM.

Traveling is another time when a cellphone emits a lot of radiation as it keeps losing connection with one cellphone tower, and trying to connect to the next. I now use my speakerphone or headsets while travelling.

Speaking of cellphone towers, they are an even more dangerous source of radiation. Distance is again the key. If you move 10 meters away from a tower, the radiation is less than 0.1% of what it is one meter from the tower.

The longer the cellphone is in contact with your body, the more harm it does. My headset is always connected so my default answer mode is via headset. If I don't have my earphones, I switch the phone from ear to ear to cut contact time. Some researchers point out that earphones may channel the waves directly to the ear but as the effect is diluted, it's a far lesser evil.

Kids have smaller, softer skulls. This means when kids hold cellphones to their ears, the rays penetrate much deeper and cover almost all of their brains. A study by Dr. Lennart Hardell in Sweden, found that kids who began using cell phones in their teens had four to five times more malignant tumors by their late 20s as those who did not use cell phones as teenagers. Other studies have found an increase in autism over a period that closely parallels the increase in cellphone use.

Ideally, children should not use the cellphone phone network at all. I usually ask my kid to use the landline where possible. If she must use my cellphone, the call must be short, and preferably on the speakerphone.

Are Wi-Fi, cordless phones, Bluetooth, GPS safe?

The short answer is no. Gadgets like cordless phones, Wi-Fi routers, Bluetooth devices all emit electromagnetic waves, and are usually turned on 24/7.

In cordless phones, both the handset and the base station of a cordless emits radiation equal or more than a cellphone, and they do this even when they are not being used.

A Class 1 Bluetooth device emits the same amount of radiation as a cellphone. Class 2 is less and Class 3 the least. Sadly, Bluetooth device makers rarely mention what Class it is. Secondly a Bluetooth headset gives you a double dose of radiation as your cellphone is usually close to you. Using Bluetooth speakers in a car is even worse as the effect is multiplied by the radiation reflecting off the car walls like a microwave oven. As for all those Bluetooth speakers, keyboards, trackpads, mice… I know, I know, I own so many myself that I am almost in tears.

The GPS radio in your cellphones periodically transmit data to update your location. The good thing is this lets you track a lost phone. The bad is it also means another radio in the phone emitting more radiation. GPS navigational devices in cars also emit radiation. In some cases, they were found to be so excessive that the companies were blacklisted.

As for Wi-Fi, many countries are now questioning its safety in schools. I found a website maintained by UK scientists that has a whole collection of studies on the effect of Wi-Fi radiation on children. These studies suggest that Wi-Fi radiation can be linked with impaired concentration, loss of short term memory, headaches, fatigue, sleep disorders, digestive problems, depression and anxiety. Another recent study in Denmark had Danish students taking 400 cress seeds (cress is a very fast growing herb) and splitting them between two rooms. Both sets of seeds received the same amount of care, except that in one room, the seeds were placed next to two Wi-Fi routers. 12 days later, the seeds that were in the room with the Wi-Fi signals had failed to sprout while the others sprouted in the normal fashion. It's surprising there is not more public debate on these studies.

I have also unplugged the cordless, and packed it away. My landline is upstairs but if need be, I can always get a wired extension.

I often see 'experts' interpreting the statistics on existing studies to prove cellphone radiation does not harm us.

To which, I give you my favorite quote on statistics: 'Do not put your faith in what statistics say, until you have carefully considered what they do not say.' ~William W. Watt

What would my reaction be if a car manufacturer asked me to prove their car is unsafe by driving it and crash testing it?

I would laugh and say, "Sorry, I will buy the car only if you prove it's safe."

The cellphone industry's own studies prove cellphone radiation is safe, but it's unreliable as it hasn't been verified by independent agencies. In effect, they are turning around and asking me to prove cellphones are dangerous.

So why am I still buying cellphones?

Because the industry knows I'm addicted to my toys, and won't give them up.

Why are the big guys like the Apples and Googles not funding such studies in a big way? Or maybe the right question is what are they doing about it?

Google doesn't build cellphone hardware. Did it conflict with their 'Do no evil' philosophy? There are several ongoing class action lawsuits against cellphone makers. If these succeed, Google won't be affected.

Apple however will be affected. Is that why they have more liquid funds than any other company? Apple is reported to be moving into the electric car industry. Is it their way forward in a possible post-cellphone era?

While reading up for this piece, I discovered an unseen but epic battle going on between research and truth. Take the story of Professor Henry Lai of the University of Washington who with a fellow researcher, 'N.P.' Singh, studied the effects of the supposedly safe cellphone type of radiation on the DNA of rats. They found the DNA in the brain cells of the rats being damaged or broken by exposure to this radiation.

The cellphone industry stood to lose billions in medical payouts, and basic changes in cellphone design. Not surprisingly, they went all out to discredit Lai's work, and came up with new studies to counter his findings. They even tried to get him fired and succeeded in stopping the funding for his research.

In 1993, the cellphone industry was finally pressured by Congress to invest $28 million to study cell phone safety. This was due to the massive publicity of a lawsuit filed by businessman against cellphone manufacturer NEC; his wife had died of a brain tumor which he blamed on her cellphones.

Based on this, Dr. Carlo PhD, JD, was hired by the Cellular Telephone Industry Association in 1993 to lead a 7-year research program to determine if cell phones were safe. When his work revealed preventable health hazards associated with cellphone use, the industry that hired him turned against him, and he

was asked to quit. Like Dr. Lai, his work was discredited, his character questioned, and even his house was mysteriously burnt down. You can google up Dr. Carlo to read the whole story.

My beloved cellphone has been banished to a safe distance of 7 inches.

The results of the many independent research studies convince me that cellphones affect our cell DNA and cause other health issues. After all, the researchers had nothing to gain but a lot to lose by sticking out their necks.

'If you can't convince them, confuse them' seems to be the philosophy of the cellphone industry. On one hand, they have successfully funded studies to contradict independent research. On the other, they've cut off funding and discredited all studies that highlight harmful effects of cellphone radiation.

The truth is the cellphone industry is conducting a global laboratory test on four billion guinea pigs to check the effects of electromagnetic waves.

I am not a guinea pig. Are you?

https://medium.com/indian-ink/are-my-toys-playing-with-my-dna-31f8c5809d6c

What Will Happen When They Know?

February 22, 2017

What happens when a false belief collides with reality? This is the question of our time. Do you shift course and change or double down or continue on as though nothing has happened? Does wealth and power allow you to change the laws of physics or biology? What happens when the majority of people have accepted a reality and you are now not only wrong, but in the minority? What happens when denial is no longer an option?

It's easy to point to politicians and business leaders who are challenged by reality. It's much harder when this situation appears in your own life. What happens when a reality undermines your identity in the world? Will you listen, even when the answer is something you don't want to hear? Will you be able to change your mind, even though you have invested your time and money? Will you take a stand to prevent others from being harmed? Will you resist change even when harm to yourself is inevitable? Or have you even lost the capacity to change at all?

There is a train wreck about to happen in Silicon Valley as two grand ideas collide with reality. Larry Page from Google and others are making plans to focus on health and how to extend human life. Facebook founder Mark Zuckerberg and his wife Dr. Priscilla Chan have asked the question, "Can we cure all diseases in our children's lifetime?" and have pledged $3 billion dollars toward that goal.

Another inspiring goal in Silicon Valley is to bring Internet access to everyone on the planet. The goals around health and Internet access both seem incredibly empowering at face value. The conflict between them only appears when you re-evaluate the false assumption that wireless technology is safe, and you read the mounting evidence of harm, the thousands of studies that have been amassed over decades by hundreds of researchers around the world.

A truly safe technology would not cause damage to DNA. It would not increase free radical damage or contribute to an increased risk of cancer. It would not negatively impact sleep or the nervous system. It would not open up the protective blood brain barrier. It would not increase inflammation, a factor in all chronic disease. Published studies have found all of these effects, and many more.

Finding this evidence and reading through it is hard. But what makes this truly challenging is seeing evidence that this harm has been known for decades by the US government, well before cellular technologies were licensed and sold to consumers . Some of the companies even tried to "wargame" and confuse the science, something that even tobacco companies did not attempt to do. A Harvard ethics paper has been written on this topic.

It is clear that some people have known about this harm for decades, but most people in Silicon Valley are completely unaware of it. So, what will happen the day that Larry Page gets this information from one of his health care researchers at Calico Labs? Or if he types in a Google or Google Scholar search and finds published research about the detrimental health effects of wireless? Will he realize that Google's plans to use wireless in the US and in balloons around the world is in direct conflict with his goal to extend human life?

What will happen the day when Dr. Priscilla Chan, a pediatrician, reads the American Academy of Pediatrics latest recommendations to reduce wireless exposure for children? What will she tell her husband Mark Zuckerberg, founder of Facebook, who is developing drones to provide wireless coverage to the most unreachable corners of the planet?

What will Elon Musk do when he discovers that one of the biggest challenges of getting to Mars (shielding astronauts from the health impacts of ionizing cosmic radiation) is not much different from protecting Solar City customers from the radiation emitted by smart meters, wireless solar monitors, and solar power inverters? Will he change his proposed rollout of SpaceX satellites to provide worldwide Wi-Fi coverage?

The hardest parts of this problem are not technical. They are the same patterns of attitudes and beliefs and ego that have plagued humans for as long we have existed.

I don't know what these individuals will do. I only know that accepting this was hard for me, and I hadn't made public commitments to billions of people or invested large amounts of money in this endeavor, as Page, Musk, and Zuckerberg have. I can only hope and pray, that they will make wise choices. That their high intentions for humanity will continue and they will muster the courage to face the hard reality that these exposures are harmful. That they will help make Internet access safer than it currently is and eventually completely safe. And in the end, that we will share information and empower each other without sacrificing our health or the health of our children.

http://www.clearlightventures.com/blog/2017/2/22/what-will-happen-when-they-know

If Wi-Fi and cell phone radiation are safe, why has Belgium's telecomm boss banned them from his offices?

99 percent of the population continues to use Wi-Fi and other wireless devices without a second thought, but a growing number of people are becoming increasingly concerned with the health issues surrounding the use of these technologies. Didier Bellens happens to be one of these people. What makes Mr. Bellens different is that he also runs Belgacom, the largest telecommunications company in Belgium. His concern is such that not only has he chosen to do without Wi-Fi on the 27th floor of Belgacom where his office is situated, he also chooses to do without a cell phone; only taking calls on the office's landline.

You would think as the president of Belgacom, Bellens might choose to be a little less vocal about his concerns surrounding the use of Wi-Fi and cell phones; however, he has no qualms about educating others about these issues, especially those of the younger generation. As Bellens explains, "during the day, it is better to use a headset because the GSM, it heats." He goes on to say. "The waves are dangerous. At night, it is better to shut it off."

Bellens' claims may not be as outlandish as they may first seem. In early 2011, the World Health Organization (WHO) classified radiation from devices like cell phones and Wi-Fi as a 'Possible Human Carcinogen' (Class 2B).

In 2007, the BioInitiative Working Group reviewed 30 years of scientific studies documenting bio-effects and adverse health effects from these electromagnetic field (EMF) exposures. It concluded that "the existing public safety limits are inadequate." The newly published 2012 BioInitiative report written by 29 independent scientists from around the world says the situation is much worse than thought in 2007.

There are many concerns surrounding the use of cells phones. One of the most worrying is the link to brain tumors. In addition to a myriad of other health complications, Professor Joel Moskowitz of the University of California, Berkeley found, through compiling the research findings of every study conducted on the link between brain tumors and cell phone usage, "consistent evidence that heavy cell phone use for a decade or longer increases brain tumor risk at least 30%."

And just how dangerous is the microwave radiation emitted by Wi-Fi?

The radiation levels emitted by Wi-Fi are admittedly low. But the problem is the nature of these EMFs. These pulsed and modulated frequencies are particularly biologically damaging, and the accumulation of all these sources and options that are a real concern.

The concerns with using Wi-Fi center around the discoveries Dr. Magda Havas, Ph.D., Associate Professor of Environmental & Resource Studies at Trent University, has made over the years through her research and visiting sites where Wi-Fi use is high, e.g., schools.

Dr. Havas found those exposed to Wi-Fi experience:
- Headaches
- Dizziness
- Feeling out of place
- Rapid heart rate
- Heart arrhythmia

• Clumped blood cells, which among other things, can lead to fatigue, numbness, and nausea

Research shows exposure to Wi-Fi can:
• Perpetuate cancer growth
• Cause permanent DNA damage
• Compromise the immune system
• Affect a male's sperm

There is even limited evidence of autism.

If more telecommunications company bosses followed Bellens' lead and told the truth about these radiation emitting consumer goods at least people could use these technologies in full knowledge of the potential risk to their health. Wishful thinking?

http://www.naturalnews.com/038702_cell_phone_radiation_dangers_Belgium.html

Next time you're on a cellphone looking up at those long lingering plumes spreading across the sky, you might decide to end that call

If you spot any cell towers, roof-mounted transmitters or high-voltage power lines within a mile of your location, you may wish to evacuate the area immediately.

And once home, you will want to permanently disconnect all wireless devices, including computer routers and "always-on" portable phone cradles.

Because what you see in the sky is what you breathe. And chances are you've been breathing barium for more than a decade.

Barium Conducts Electromagnetic Energy — Blame it on Capt. Kirk
Ever since Captain Kirk teleported to the surface of an alien planet and whipped out his portable communicator, everyone Earthside wanted one. And the telecos gave us flip-phones. Along with compulsive texting, streaming video, online gaming and banking, the worldwide web and more.

It took more than 20 years to connect the first billion subscribers. But only another 40 months to connect the second billion. The three billionth "user"• placed a cell phone call just 24 months after that.

Never before in human history have so many embraced such risky technology so fast. In Toronto alone, there are 7,500 cell towers. In the USA: over 190,000.

BioElectric Beings
Everyone fixated on Captain Kirk's hand-phaser. But his wireless communicator was the real ray gun that could not be dialed down.

Cell phones and "cellular networks" are aptly named. Every transmission disrupts your cells directly.

"Human beings are bioelectrical systems. Our hearts and brains are regulated by internal bioelectrical signals. Environmental exposures to artificial EMFs can interact with fundamental biological processes in the human body," states the landmark BioInitiative metastudy.

As former microwave warfare expert Barry Trower points out, an invisible ocean of electromagnetic waves from radio, radar and TV transmissions, cell towers, smart grids and overhead power cables traveling at the speed of light "can all be reflected and refracted" by metal appliances, rain, snow, glass and conductive materials deliberately sprayed into the air.

You Are an Antenna
A water-filled upright human is a sizeable antenna. And since all moving electrons generate electrical current, all those electromagnetic waves inundating our everyday lives pass into our bodies, where they each generate an electric current.

These induced electric currents change the charge on which our complex bioelectrical body/brain/heart network operates to maintain our health and vitality.

Microwaves at 1/10th British safety guidelines emit frequencies causing the biggest changes in cell calcium levels… as reported in the UK Daily Mail.

Wireless Headaches

Headaches can stem from microwave-induced leakage of harmful molecules through the blood-brain barrier. [Electronics Australia Magazine Feb/00]

At one-ten-thousanth of a watt, the blood-brain barrier opens, allowing blood proteins inside to disrupt brain signals and start killing brain cells. A cell phone typically transmits at 2 watts.

Just two minutes on a cell phone, or sitting near a wireless computer router or portable phone cradle, shorts-circuits the electrical ion activity powering the blood-brain barrier.

This allows proteins and other blood toxins to enter the brain and resume damaging neurons in thinking and memory centers.

Dr. Leif Salford is finding "astonishing number of dead neuron cells, actually suffering holes in their brains from the damage" caused by a single cell phone call.

No wonder wireless-altered brains lead to lack of concentration, memory loss, aggressive behavior, accelerated aging, impaired learning ability and dementia.

Fibrils of proteins clumping in electromagnetically-altered brains are an identifying characteristic of Alzheimer's, Early Onset Alzheimer's, Parkinson's, Fibromyalgia, Multiple Sclerosis and cancer patients.

"There is strong evidence that… microwaves are associated with accelerated aging (enhanced cell death and cancer) and moods, depression, suicide, anger, rage and violence, primarily through alteration of cellular calcium ions and the melatonin/serotonin balance," writes veteran EMF researcher Dr. Neil Cherry in New Zealand.

So Far, So Bad

While hundreds of millions of wireless addicts insist that nothing negative is happening, the effects of this invisible plague are worsening. In the United States, one in six children currently suffers neurological disability.

With the much heralded new 4G LTE networks and devices "producing a waveform that maximizes radiation absorption for 3-6 year olds,"• writes Simon Best, the accelerating trend is straight up.

The electrosmog blanketing cities worldwide would resemble the murky view from Shanghai's high-rise windows if it were visible.

Just add micro-particulate fallout from undisclosed aerosol spray programs and one in three people can expect to be diagnosed with asthma.

Low frequencies are directly linked with epidemic rates of dementia that threaten to bankrupt Canada, the USA and much of the world within a few decades — just as the challenges and costs of crop-killing climate-shifts, sea-level rises and increasingly costly oil will require all the smarts and cash we can muster.

"The scope of the looming medical-care disaster is beyond comparison with anything that has been faced during the entire history of humanity," declares dementia expert Dr. Barry Greenberg in Toronto.

"The medical-care system is going to be bankrupt by 2050 if we don't figure out a way to delay or treat Alzheimer's disease," echoes U.S. health and human services secretary, Kathleen Sebelius.

Brain cell membranes made leaky by electromagnetic radiation exposure create enough energy to excite neurons into hair-trigger mode, overloading hyperactive brains.

More than 1 in 10 children in the United States are currently diagnosed with Attention Deficit/ Hyperactivity Disorder.

A 6,000% increase in autism diagnosis in recent years has kept pace with the proliferation of wireless grids and gadgets.

As reported in the UK Telegraph, 1980 to 2000 saw an increase of nearly 50% in the estimated number of new cases of Malignant Brain/Central Nervous System tumors in the United States.

Anyone who starts using wireless devices at any age can expect a 500% risk of developing brain cancer within 10 years – even sooner for children. Using cell and cordless phones is even worse.

"For such a risk to show up in cellphone users within 10 years, given what we know about brain tumors, which is that they can have a latency of 40 years, is deeply, deeply disturbing," worries Dr. Devra Davis. [MSN June 7/04; Globe & Mail Sept 24/10]

Bye Bye Babies

Up to 16% of North American couples are already experiencing infertility – a near doubling since 1992. In cell tower-festooned Delhi, one in four couples cannot conceive after trying for two years or longer. Surviving sperm are increasingly found to be too damaged to achieve fertilisation. [TNN Aug 13/09]

At current rates, plummeting global sperm counts will hit 'zero' by 2048.

Embryos, fetuses, infants and children are especially vulnerable to pulsed wireless signals, which penetrate directly through their rapidly developing bodies and brains.
"Children who were exposed to cell phones before and/or after birth tended to have higher prevalence of emotional symptoms, behavioral problems, inattention, hyperactivity and problems with peers," says prominent EMF researcher Professor Kjell Mild in Sweden.
Children and teenagers are five-times more likely to develop brain cancer if they use cell phones.

Microwave Sickness is already of significant public concern in countries where wireless technologies were introduced some 10 years ahead of North America.

"Hot spots" include Sweden, Denmark, France, Germany, Italy, Switzerland, Austria, Greece and Israel.

Sweden leads the pack. Data collected by the Swedish government has found that the introduction of cellphone technology nationwide in 1997 coincided with an alarming increase in prostate cancer, brain tumors, melanomas and lung cancers.

So did deaths from Alzheimer's, traffic accident injuries, sick leave rates, and the numbers of infants born with heart problems.

With a quarter-million residents now on permanent paid disability for microwave illness, Sweden changes everything. [Pathophysiology June/09]

Widespread common complaints of Microwave Sickness include, but are not limited to:

- aching joints
- asthma attacks
- fierce headaches
- sudden dizziness
- rashes and sores
- gastro-intestinal discomfort
- persistent dry hacking cough
- inability to concentrate or remember simple things
- heart flutter, inflammation, stoppage

"Cell phones have enjoyed exceptional freedom from government oversight and control to protect against health and environmental hazards," comments Dr. John Wargo, professor of Environmental Risk and Policy at Yale University.

http://humansarefree.com/2016/04/wireless-chemtrails-and-you.html

The Kids Are Not All Right

How Wireless Tech Is Harming Our Youth and What Parents Can Do Right Now

"Children are not little adults and are disproportionately impacted by all environmental exposures, including cell phone radiation. Current FCC standards do not account for the unique vulnerability and use patterns specific to pregnant women and children." —American Academy of Pediatrics, 2013

Don't run with scissors. Don't talk to strangers. Don't play with matches. Don't drink and drive. Don't do drugs. Parents are eternally concerned about their children's safety. From infancy to adolescence, children are developing humans—physically, behaviorally and intellectually. To emerge as healthy, well-adjusted adults, kids need their parents' protection. And when it comes to children and wireless-tech safety, there's a lot parents need to know.

What is Wi-Fi, Really? We can't see Wi-Fi with the naked eye—but we're surrounded by it, 24/7. Wireless technology encompasses our cell phones, tablets, cell towers, smart meters, wireless-enabled laptops, baby monitors, gaming consoles, e-readers, virtual-reality toys and the emerging Internet of Everything. The term "Wi-Fi" sounds harmless enough, right? Its utterance like a baby's coo or cartoon slang. It alliteratively conjures "Sci-Fi" flying cars and time travel. But let's call wireless tech what it really is— radiofrequency radiation, also called microwave radiation. Technically speaking, "Wi-Fi deploys pulse modulated microwave radiation (within the larger radiofrequency spectrum) with a carrier frequency that is similar to that used by a microwave oven (about 2.45 gigahertz)."5 In 2011, the International Agency for Research on Cancer classified radiofrequency radiation as "possibly carcinogenic to humans." This is the same category as lead, DDT, and other pesticides.

Who's at Risk? Science shows that wireless radiation can cause a gamut of biological effects, from cancer and neurodegenerative diseases to birth defects and infertility. And yet, outdated world-wide safety regulations only consider short-term heating (i.e., thermal) and shock effects. They don't consider the chronic, non-thermal exposures of our wireless tech world.2 As a human population, we are all at risk from environmental exposures and toxins. But, the most vulnerable are children, the developing fetus and pregnant women. A child's brain, nervous system and immune system are in development at these critical periods. Despite this, "there is a growing, unchecked and unregulated availability of a range of transmitting equipment specifically aimed at parents of babies and young people."2 Yes, this includes that wireless baby monitor (2 inches from your baby's head), that working cell phone in your toddler's mouth, or that tablet broadcasting under your teen's pillow—all these seemingly innocuous devices can be hazardous to your child's health.

"Around the world we are paying the price now for having delayed actions on tobacco and asbestos after insisting on human harm before taking action. We cannot afford to wait for definitive proof of human risks from radiation emitted by wireless transmitting devices before taking steps to reduce exposures. The absence of evidence of hazard is not proof of safety"—says Dr. Devra Davis, president of the Environmental Health Trust and visiting professor at the Hebrew University Hadassah Medical School and Ondokuz Mayis University, Turkey.

Who is SAM? Standing for "Specific Anthropomorphic Mannequin," SAM is a plastic model of a head, which, in 1989, was made to represent the top 10 percent of U.S. military recruits. That's a 220-pound man with a pretty large head. SAR, another relevant acronym, stands for "Specific Absorption Rate"—a measure of tissue-radiation exposure.9 The cell phone industry currently uses SAM for compliance

testing against safety guidelines and to certify the SAR for mobile phone users. However, research shows that a smaller head than SAM will absorb significantly more radiofrequency radiation.12 Obviously, children's smaller heads have a shorter distance to the brain center. Also, children's skulls and ears are thinner, allowing radiation to penetrate farther. And children's brains contain more fluid, and thus absorb more radiation.4, 12 The SAR for a 10-year-old is up to 153 percent higher than the SAR for the SAM model,1 yet there is no pre-market certification testing for SAR on a childequivalent head (or an adult's head smaller than SAM). And "when electrical properties are considered, a child's head's absorption can be over two times greater, and absorption of the skull's bone marrow can be 10 times greater than adults."

What Does the Latest Science Say? In May 2016, the National Toxicology Program released partial findings of their $25 million study on cell phones and cancer. The results showed that exposure to wireless radiation significantly increases the prevalence of highly malignant heart and brain cancers in rodents. "The findings of brain tumors (gliomas) and malignant Schwann cell tumors of the heart in the NTP study, as well as DNA damage in brain cells of exposed animals, present a major public health concern because these tumors occurred in the same types of cells that had been reported to develop into tumors (gliomas and acoustic neuromas) in epidemiological studies of adult cell phone users," explains Ron Melnick, Ph.D., senior toxicologist and director of Special Programs in the Environmental Toxicology Program at the National Institute of Environmental Health Sciences, National Institutes of Health, now retired. In response to these results, the American Academy of Pediatrics issued new recommendations for reducing exposure to cell phones and wireless devices. In an AAP press release, Jennifer A. Lowry—M.D. and chair of the AAP Council on Environmental Health Executive Committee—said: "They're not toys. They have radiation that is emitted from them and the more we can keep it off the body and use (the phone) in other ways, it will be safer."

Microwave Tech in Schools

Computers and the Internet are vital learning tools. But the crux of the matter with wireless tech is safety. And this rampant technology has never been tested for the longterm, overlapping, cumulative exposures experienced in today's schools by the most vulnerable population: children. Students in schools are bombarded with wireless radiation from every conceivable angle: their own personal devices, the devices of all nearby users in surrounding classrooms, wireless devices in the school itself (routers, printers, smart boards, etc.), and transmitters (i.e., cell towers) in close proximity outside the school. Plus, to simultaneously handle the hundreds of devices needed to conduct its daily activities, schools typically install stronger Wi-Fi systems. Most residential homes now have Wi-Fi hubs and multiple devices per household member—meaning that when kids return home, they get no respite.

Consequently, in schools across the world, kids are getting sick from this unprecedented level of wireless exposure. Dafna Tachover, founder of We Are The Evidence—an advocacy group for those injured by wireless technology—is an attorney in both Israel and New York. She regularly works with children and parents who have developed electro-sensitivity to wireless tech. Symptoms commonly reported include: headaches, nausea, vomiting, cognitive problems, tingling, severe exhaustion, noise sensitivity, sinus pressure and nose bleeds. In a case submitted to the Israeli Supreme Court, Tachover presented 200 children, from six schools, who had become sick from wireless tech. In one particular school, 70 children from three classes started having symptoms after a second wireless router was installed. Tachover uncompromisingly states: "Our school systems are creating the most intense environment of radiation, and they're doing it to the most sensitive population. The harm has already been proven. There's an

epidemic of sickness in the schools." After significant efforts, in April 2016 the city of Haifa, in Israel, ordered all Wi-Fi to be disconnected in schools. In a press release, Haifa's mayor, Yona Yahav, is cited saying, "When there is a doubt, when it comes to our children, there is no doubt." This is a step in the right direction, but internationally there continue to exist countless groups of concerned parents and researchers urging school administrations to adopt best tech practices. Schools can get the same educational benefits from a wired (fiber-optic and Ethernet) network, and in doing so, they wouldn't be putting an entire generation of kids at risk.

There's No Wi-Fi in Narnia

Some schools are now rolling out virtual-reality curricula, like the Google Expeditions Pioneer Program. Sure, it sounds cool to take a trip to Mars without leaving the classroom. But, hold that virtual-reality visor up to a child's eyes, and what you've got is a cell phone encased in a cardboard box, beaming microwave radiation directly into a child's brain. Whether used in school or at home, virtual-reality toys have never been premarket tested for health consequences. Dr. Mary Redmayne, a researcher at Monash University in Australia, explains: "Children's brains are not fully myelinated and eyes absorb radiation readily due to their high water content. Placing a two-way microwave radiating device directly in front of young eyes is not a wise choice in my opinion."

Theodora Scarato—Environmental Health Trust's director of Public Affairs and Educational Resources—speaks to another angle regarding digital play. "The research shows that simpler is often better in terms of toys. When you have a bunch of building blocks, then a child can use their own creativity to imagine what these blocks are. But when it's already pre-scripted, the child is using less creativity, because the choice has already been taken away. You can only be as creative as the program application is. And that is stifling. When I listen to children tell me about what they imagine in their minds, I'm always blown away. A computer's drop down menu can't even come close."

Tech Addiction

"A representative survey of American tweens (8- to 12-year-olds) and teens (13- to 18-year-olds), documented that outside of school and homework, tweens spend almost six hours per day (5:55 hours) and teens spend almost nine hours per day (8:56 hours) using media."11 While "Tech Addiction" is not yet classified as a disorder in The Diagnostic and Statistical Manual of Mental Disorders, the phenomenon is nonetheless being investigated by a host of psychologists and researchers. Clinical psychologist Catherine Steiner Adair sheds light on the impact of the omnipresent glowing screen within the family dynamic: "Everything a baby needs from its environment between birth and 2 years comes from people, from relationships with people and interactions with the environment—physically exploring, playing, crawling, and interacting with others. When we triangulate our relationship with our babies and tech, we compromise that essential connection."10 Further, "the development of empathy is a critical step in early childhood and over a lifetime. Empathy is the caring glue that creates our humanity, our compassion."10 We learn empathy through direct human contact. This is thwarted when kids correlate personal identity with their Xbox avatar or their Facebook status. The blood in Halo isn't real; sad-face emojis aren't tears. When disconnected from real-life interaction, kids don't learn accountability for negative actions or mean words. What kind of society will emerge when our technology-obsessed youth is decoupled from the tangibility of human consequences?

Like a Kid in a Candy Store

An apt allegory might be Roald Dahl's Charlie and the Chocolate Factory. Faced with his tempting, addictive, untested, fantastical inventions, the story's overindulgent kids were squeezed, colorized, ballooned and miniaturized, while their parents stood idly by and watched—all for Mr. Wonka's industrial benefit and profit. Kids today should not literally be left to their own devices. The proliferation of wireless radiation is the biggest public health experiment ever conducted, and it's happening on an entire generation of children. Do you want to experiment on your kids?

https://alisonmain.files.wordpress.com/2017/01/2-17_pm_the-kids-are-not-alright.pdf

Autism may be Linked to Electromagnetic Radiation Levels In Mother's Bedroom During Pregnancy

Incidence of autistic babies has increased from 1 in 150 in 2002 to an estimated 1 in 50 babies today. Dr. Dietrich Klinghart, MD, PhD of the Institute of Neurobiology in Seattle recently conducted a pilot study to assess the potential role of electromagnetic frequencies in the dramatic rise in autism and other neurological impairments over the past decade. Various measurements of electromagnetic radiation exposure were assessed in the case of 10 children with neurological impairment, 8 categorized with Autism Spectrum Disorder. Data was obtained for:

1) Mothers' Body Voltage in the mothers' sleeping location during pregnancy;
2) Child's Body Voltage in current sleeping location;
3) Microwave Power Density in mothers' sleeping location during pregnancy (microwatt/square meter); and
4) Child's Microwave Exposure in current sleeping location.

Data for mothers with neurologically impaired children were contrasted with similar data for 5 healthy children and their mothers.

This pilot data strongly suggests that electromagnetic radiation in the sleeping environment of mothers during pregnancy, as well as electromagnetic radiation in the sleeping environment of children, may be key undiscovered contributing if not causative factors in neurological impairments in children, including autism. Given increasing levels of ambient electromagnetic radiation in modern environments from society's use of electronic equipment, wireless technologies, such as cell phones and wireless networks, high frequency transients on electric lines, and broadband over power lines (BPL), this association needs immediate further exploration.

http://electromagnetichealth.org/media-stories/#Autism

Autism and EMF? Plausibility of a pathophysiological link - Part I.

Abstract

Although autism spectrum conditions (ASCs) are defined behaviorally, they also involve multileveled disturbances of underlying biology that find striking parallels in the physiological impacts of electromagnetic frequency and radiofrequency exposures (EMF/RFR). Part I of this paper will review the critical contributions pathophysiology may make to the etiology, pathogenesis and ongoing generation of core features of ASCs. We will review pathophysiological damage to core cellular processes that are associated both with ASCs and with biological effects of EMF/RFR exposures that contribute to chronically disrupted homeostasis. Many studies of people with ASCs have identified oxidative stress and evidence of free radical damage, cellular stress proteins, and deficiencies of antioxidants such as glutathione. Elevated intracellular calcium in ASCs may be due to genetics or may be downstream of inflammation or environmental exposures. Cell membrane lipids may be peroxidized, mitochondria may be dysfunctional, and various kinds of immune system disturbances are common. Brain oxidative stress and inflammation as well as measures consistent with blood-brain barrier and brain perfusion compromise have been documented. Part II of this paper will review how behaviors in ASCs may emerge from alterations of electrophysiological oscillatory synchronization, how EMF/RFR could contribute to these by de-tuning the organism, and policy implications of these vulnerabilities. Changes in brain and autonomic nervous system electrophysiological function and sensory processing predominate, seizures are common, and sleep disruption is close to universal. All of these phenomena also occur with EMF/RFR exposure that can add to system overload ('allostatic load') in ASCs by increasing risk, and worsening challenging biological problems and symptoms; conversely, reducing exposure might ameliorate symptoms of ASCs by reducing obstruction of physiological repair. Various vital but vulnerable mechanisms such as calcium channels may be disrupted by environmental agents, various genes associated with autism or the interaction of both. With dramatic increases in reported ASCs that are coincident in time with the deployment of wireless technologies, we need aggressive investigation of potential ASC - EMF/RFR links. The evidence is sufficient to warrant new public exposure standards benchmarked to low-intensity (non-thermal) exposure levels now known to be biologically disruptive, and strong, interim precautionary practices are advocated.

https://www.ncbi.nlm.nih.gov/pubmed/24095003

Study Uncovers How Electromagnetic Fields Amplify Pain in Amputees

For years, retired Maj. David Underwood has noticed that whenever he drove under power lines and around other electromagnetic fields, he would feel a buzz in what remained of his arm. When traveling by car through Texas' open spaces, the buzz often became more powerful.

"When roaming on a cellphone in the car kicked in, the pain almost felt like having my arm blown off again," said Underwood, an Iraq War veteran who was injured by an improvised explosive device (IED). His injuries have resulted in 35 surgeries and the amputation of his left arm. Shrapnel from the IED also tore part of his leg and left him with more than 100 smaller wounds. "I didn't notice the power lines, cellphones on roam or other electromagnetic fields until I first felt them in my arm."

Until a recent study led by researchers at The University of Texas at Dallas was published online last month in PLOS ONE, there was no scientific evidence to back up the anecdotal stories of people, such as Underwood, who reported aberrant sensations and neuropathic pain around cellphone towers and other technology that produce radio-frequency electromagnetic fields.

"Our study provides evidence, for the first time, that subjects exposed to cellphone towers at low, regular levels can actually perceive pain," said Dr. Mario Romero-Ortega, senior author of the study and an associate professor of bioengineering in the University's Erik Jonsson School of Engineering and Computer Science. "Our study also points to a specific nerve pathway that may contribute to our main finding."

Most of the research into the possible effects of cellphone towers on humans has been conducted on individuals with no diagnosed, pre-existing conditions. This is one of the first studies to look at the effects of electromagnetic fields (EMFs) in a nerve-injury model, said Romero-Ortega, who researches nerve regeneration and builds neural interfaces — technology that connects bionic or robotic devices to the peripheral nerve. There are nearly 2 million amputees in the United States, according to the Centers for Disease Control and Prevention, and many suffer from chronic pain.

After interacting with Underwood, Romero-Ortega decided to study the phenomena that Underwood described.

The team hypothesized that the formation of neuromas — inflamed peripheral nerve bundles that often form due to injury — created an environment that may be sensitive to EMF-tissue interactions. To test this, the team randomly assigned 20 rats into two groups — one receiving a nerve injury that simulated amputation, and the other group receiving a sham treatment. Researchers then exposed the subjects to a radiofrequency electromagnetic antenna for 10 minutes, once per week for eight weeks. The antenna delivered a power density equal to that measured at 39 meters from a local cellphone tower — a power density that a person might encounter outside of occupational settings.

Researchers found that by the fourth week, 88 percent of subjects in the nerve-injured group demonstrated a behavioral pain response, while only one subject in the sham group exhibited pain at a single time point, and that was during the first week. After growth of neuroma and resection — the typical treatment in humans with neuromas who are experiencing pain — the pain responses persisted.

"Many believe that a neuroma has to be present in order to evoke pain. Our model found that electromagnetic fields evoked pain that is perceived before neuroma formation; subjects felt pain almost immediately," Romero-Ortega said. "My hope is that this study will highlight the importance of developing clinical options to prevent neuromas, instead of the current partially effective surgery alternatives for neuroma resection to treat pain."

Researchers also performed experiments at the cellular level to explain the behavioral response. That led researchers to explore the protein TRPV4, which is known to be a factor in heat sensitivity and the development of allodynia, which some subjects displayed.

"It is highly likely that TRPV4 is a mediator in the pain response for these subjects," Romero-Ortega said. "Our calcium imaging experiments were a good indicator that TRPV4 is worth further exploration."

Romero-Ortega said since the research produced pain responses similar to those in anecdotal reports and a specific human case, the results "are very likely" generalizable to humans.

"There are commercially available products to block radio frequency electromagnetic energy. There are people who live in caves because they report to be hypersensitive to radiomagnetism, yet the rest of the world uses cellphones and does not have a problem. The polarization may allow people to disregard the complaints of the few as psychosomatic," he said. "In our study, the subjects with nerve injury were not capable of complex psychosomatic behavior. Their pain was a direct response to man-made radiofrequency electromagnetic energy."

At one point in the study, members of the research group showed Underwood video of subjects in the experiment and their response to radiofrequency electromagnetic fields.

"It was exactly the same type of movements I would have around cellphones on roam, power lines and other electromagnetic fields," said Underwood, who has served on congressional medical committees and been exposed to some of the best doctors in the world. "It is pretty amazing that a few short conversations with this team led to validation of what I, and many others, experience."

Researchers said that the next step is to develop devices that block neuropathic pain from radiofrequency electromagnetic energy.

Dr. Bryan Black, a research associate in the Department of Bioengineering in the Jonsson School; Dr. Rafael Granja-Vazquez, a postdoctoral fellow at UT Dallas; Dr. Benjamin Johnston of Brown University; and Dr. Erick Jones Sr., a professor of industrial, manufacturing and systems engineering at UT Arlington, also contributed to the work.

http://www.utdallas.edu/news/2016/2/3-31891_Study-Uncovers-How-Electromagnetic-Fields-Amplify-_story-wide.html

Krakow's bold step to curb electromagnetic pollution reflects growing evidence of harm

12th January 2017

As Kraków, Poland's second city, takes steps to protect its citizens from rising electromagnetic 'smog' from mobile phones, Wi-Fi, Bluetooth, smart meters and other devices, Lynne Wycherley summarizes 2016's news highlights on the emerging bio-risks of rising exposure to non-ionizing radiation. For how much longer can governments continue to ignore the growing evidence of harm?

The first mayor of Kraków to be elected by popular ballot, law professor Jacek Majchrowski is tackling an environmental issue most governors avoid: the electromagnetic pollution in his city.

Following work on air pollution, and in response to growing demand, he is initiating forums for citizens to discuss the growing 'smog' of electro-magnetic fields (EMFs).

In a world first he is also initiating the provision of meters to detect radio-frequency (RF) / extremely low frequency (ELF) EMFs so people can collect objective data on their exposure.

In December, Majchrowski hosted an international conference on EMF pollution and citizens' 'right to information' - an echo of the new Right to Know law in Berkeley, California (cell-phone sellers must supply safety information).

Speakers included Sławomir Mazurek, a pro-reform Polish minister for the Environment. Majchrowski and his team are now re-zoning mobile-phone masts (cell towers) to reduce EMF exposure levels.

With similar boldness, Argentina's Lower National Congress proposed a new health law last year to regulate electromagnetic pollution.

Supported by trade unions and NGOs, its radical draft measures included hard-wired networks in schools (also hospitals) - recalling the recent Green-led French law on *"electromagnetic sobriety"* (2015) and recommendations of the American Pediatrics Society and British Doctors' Initiative.

Across the planet, 2016 had seen a paradoxical trend: anthropogenic radiation from mobile and wireless trends continued to rise rapidly, alongside striking, under-reported findings on its possible bio-risks.

Cell-phone use was still climbing. India alone reached over 1 billion verified subscriptions. But like Wilde's picture of Dorian Gray, the small screens endlessly sold to us harboured a troubling reality. In May, researchers in the USA's $25 million National Toxicology Programme released early warnings (later stated in detail). Cell-phone radiation had shown clear tumor-promoting effects in the hearts and brains of the rats under study.

In Britain, meanwhile, neuroscientist Dr. Sarah Starkey published a key peer-reviewed paper (October 2016) that exposed shocking bias in the 2012 report by AGNIR, the Advisory Group on Non-ionising Radiation - a report behind many governments' take-no-action health policies, including the UK's. And one which (as she demonstrates) blatantly excludes the peer-reviewed precautionary science.

Long buried by Germany's government, a report offering a rare window on 878 Russian-language science papers (1960-1997) was finally translated, with updates, into English. Long-term studies on Soviet workers repeatedly charted chronic debilitation from weak EMFs - including pulsed microwaves that have been commercially 'repackaged' for today's telecoms.

Though research protocols differed from those current today, raising potential questions, the author, medical Professor Karl Hecht, persuasively condemns his government - and the West as a whole - for its reliance on short-term studies.

But escalating trends were in train. In July, the USA's Federal Communications Commission approved unbridled commercial development of 5G, (July), despite serious question-marks about the new electromagnetic radiation being lined up for use, and the spiraling public exposure it would bring.

A parallel trend for hidden transmitters saw more antennae disguised as birdboxes - and now as cables (January 2017) - the polar opposite of 'right to know'.

Whilst BT ran adverts for *"the most powerful Wi-Fi in the world"* (UK), newly published papers continued to show DNA or organ damage to Wi-Fi-exposed animals - raising questions about our habitual close exposure to routers / boosters.

And while the ITU (International Telecoms Union) told the United Nations that 95% of the world's population had mobile phone-mast coverage (July), with added 4G/LTE supplying 53%, a landmark study in Germany (September) revealed progressive harm to trees from the growing microwave radiation. Strongly irradiated trees, even two miles from antennae, died back, often to the point that they were felled.

Similarly troubling, a Greek study of pollinating insects found that many species decreased in step with phone-mast radiation (Lázaro et al). Underground-nesting species fared much better - an imbalance, the authors noted, that could have wide eco-impacts, or affect crops.

Other 2016 peer-reviewed studies on phone-masts (cell towers) found genetic effects in nearby residents. *(See also Gandhi 2015) plus lab-demonstrated amputee pain from the pulsing output.)*

A study on Antarctic krill (March) found that navigation was disrupted by an exceptionally weak radiofrequency field. Research showing insect cell-death from 6 minutes' weak wireless exposure added to previous, similar findings (a, b, c) on Bluetooth etc. Both hint at a need to monitor our fast-rising, non-ionizing radiation.

In Los Angeles, a young director began filming *Generation Zapped*, a courageous documentary on smartphone / wireless risks. Now in its late stages of production, it attracted wide support.

Psychiatry professor Nicholas Kardaras, an expert in addiction, published his gripping book *Glow Kids: how screen addiction is hijacking our kids* (USA). Drawing on his clinical experience of over 1,000 teenagers, he adopted the term *"digital heroin"* for interactive small screens.

Sharing evidence for addiction-hallmark brain changes, however, he neglected plausible links with the wireless radiation itself (published RF risks to the prefrontal brain / opioid receptors).

A survey suggested US smartphone ownership began, on average, at age 10. Around the world, research showing children's cell-phone radiation absorption was higher than adults' - especially in the brain and bone marrow - continued to be overlooked. As did Russia's 4-year study on multi-tested cognitive decline in 7 to 12 year-olds using cell phones (2011), a contrast to milder, short-term findings elsewhere.

Cell-phone risks to the blood-brain barrier which shields the brain from toxins - long highlighted by Professor Salford - found support in a new study. Professor Hardell (who called for pulsed RF to be upgraded to a Class 1 carcinogen in 2014) co-published on whether cell-phones might be a possible, hidden factor in the rise of thyroid cancer.

And a review of 21 studies showing RF/cell-phone risks to male fertility (Houston 2016) concluded that free radical damage played a key role.

Outside Sweden, human rights continued to be denied to the rising numbers of adults and children testifying to EHS (severe 'electrosensitive' symptoms).

Reviewing up to date biological evidence, the European Academy for Environmental Medicine recommended low pulsed-microwave exposure limits (0.006 V/m) for those affected - far lower than from today's wireless transmitters - including in schools, hospitals, public transport, and libraries.

In July, the Spanish Court of Madrid pronounced a former telecoms engineer permanently disabled by EHS. Meanwhile an appeal judge (UK) awarded Employment and Support Allowance to a claimant, using surrogate terms due to the lack of legal recognition of EHS.

ICNIRP, the controversial regulatory body with newly documented conflicts of interest, now held 5 of the 6 seats in the WHO's core group on EMFs (2016). As early as 2000, in a 189-page report, environmental professor Neil Cherry concluded ICNIRP neglected evidence *"that would have had a chemical declared carcinogenic, neuropathogenic, cardiogenic and teratogenic for humans many years ago."*

Though views would vary widely, by October 2016, 223 EMF scientists from 41 nations had signed the ongoing appeal to the WHO and UN for new safety standards.

The UK's microwave smart-meter rollout lumbered forward, despite spiraling costs, overseas court claims for health damage, and scientists' call for worldwide, non-toxic alternatives. TV adverts obscured the meters' microwave spikes (downplayed by manufacturers) and research on emerging health risks. *(See note.)*

Installation began to take off in London's tenanted accommodation. Mel Kelly, reprinted in *The Ecologist*, had already pointed out that many poorer households (tenants) would face involuntary metering and exposure.

The interaction of toxic chemicals and electromagnetic fields continued to be neglected. The discovery of EMF-sensitive magnetite in the brain from chemical air pollution (September) did not bode well. Nor did the earlier discovery that weak wireless exposure speeded up rodent body tumors triggered by a chemical carcinogen (Lerchl 2015).

Apple launched its wireless 'earbuds', which expose the brain to Bluetooth, just as Professor Pall (winner of eight international awards) published a new paper on wireless risks to our nervous systems and brains (September).

This followed his ground-breaking work on a 'master mechanism' of harm: 26 peer-reviewed papers revealed over-stimulation of electrical gates (VGCCs) in our cell walls. This process boosts production of

peroxynitrite *(see note)* - one of the most toxic compounds in the body - an emerging disease risk factor which triggers free radical damage to cells, tissues, mitochondria, and DNA.

Noting 93 papers showing free radical damage from low-level wireless radiation, Yakymenko, et al 2016 concluded it has *"a high pathogenic potential"*. Associate Professor Havas (November 2016) drew a similar, insightful parallel with weakly ionizing radiation such as X-rays or low energy gamma rays of nuclear origin.

Overall, 2016's precautionary findings, added to the accumulating data suggesting bio-risks, raise sensitive questions. Are we placing a covert stress, perhaps, on our exposed trees and pollinators? Could we be failing to safeguard children, teenagers, and those in frail health? What is the growing carbon cost of global, ever-on transmitters?

And as time passes, might profit-driven trends for microwave 'smart homes', crammed with devices plus micro-transmitters (IoT), risk a subtle 'sick building syndrome', to everyone's hidden cost? Our care for humanity, and the delicate legacy of DNA, invites us to reflect on such questions.

Can we take inspiration from Krakow, and the French Green law on EMFs? As 2017 unfolds, it seems clean ways forward deserve new thought, alongside creative steps for low-addiction living - a vital complement to going low carbon.

http://www.theecologist.org/News/news_analysis/2988521/krakows_bold_step_to_curb_electromagnetic_pollution_reflects_growing_evidence_of_harm.html

The effects of radiofrequency electromagnetic radiation on sperm function

Abstract

Mobile phone usage has become an integral part of our lives. However, the effects of the radiofrequency electromagnetic radiation (RF-EMR) emitted by these devices on biological systems and specifically the reproductive systems are currently under active debate. A fundamental hindrance to the current debate is that there is no clear mechanism of how such non-ionising radiation influences biological systems. Therefore, we explored the documented impacts of RF-EMR on the male reproductive system and considered any common observations that could provide insights on a potential mechanism. Among a total of 27 studies investigating the effects of RF-EMR on the male reproductive system, negative consequences of exposure were reported in 21. Within these 21 studies, 11 of the 15 that investigated sperm motility reported significant declines, 7 of 7 that measured the production of reactive oxygen species documented elevated levels and 4 of 5 studies that probed for DNA damage highlighted increased damage, due to RF-EMR exposure. Associated with this, RF-EMR treatment reduced antioxidant levels in 6 of 6 studies that studied this phenomenon, while consequences of RF-EMR were successfully ameliorated with the supplementation of antioxidants in all 3 studies that carried out these experiments. In light of this, we envisage a two-step mechanism whereby RF-EMR is able to induce mitochondrial dysfunction leading to elevated ROS production. A continued focus on research which aims to shed light on the biological effects of RF-EMR will allow us to test and assess this proposed mechanism in a variety of cell types.

http://www.reproduction-online.org/content/early/2016/09/06/REP-16-0126

Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression

Abstract

Non-thermal microwave/lower frequency electromagnetic fields (EMFs) act via voltage-gated calcium channel (VGCC) activation. Calcium channel blockers block EMF effects and several types of additional evidence confirm this mechanism. Low intensity microwave EMFs have been proposed to produce neuropsychiatric effects, sometimes called microwave syndrome, and the focus of this review is whether these are indeed well documented and consistent with the known mechanism(s) of action of such EMFs. VGCCs occur in very high densities throughout the nervous system and have near universal roles in release of neurotransmitters and neuroendocrine hormones. Soviet and Western literature shows that much of the impact of non-thermal microwave exposures in experimental animals occurs in the brain and peripheral nervous system, such that nervous system histology and function show diverse and substantial changes. These may be generated through roles of VGCC activation, producing excessive neurotransmitter/neuroendocrine release as well as oxidative/nitrosative stress and other responses. Excessive VGCC activity has been shown from genetic polymorphism studies to have roles in producing neuropsychiatric changes in humans. Two U.S. government reports from the 1970s to 1980s provide evidence for many neuropsychiatric effects of non-thermal microwave EMFs, based on occupational exposure studies. 18 more recent epidemiological studies, provide substantial evidence that microwave EMFs from cell/mobile phone base stations, excessive cell/mobile phone usage and from wireless smart meters can each produce similar patterns of neuropsychiatric effects, with several of these studies showing clear dose–response relationships. Lesser evidence from 6 additional studies suggests that short wave, radio station, occupational and digital TV antenna exposures may produce similar neuropsychiatric effects. Among the more commonly reported changes are sleep disturbance/insomnia, headache, depression/depressive symptoms, fatigue/tiredness, dysesthesia, concentration/attention dysfunction, memory changes, dizziness, irritability, loss of appetite/body weight, restlessness/anxiety, nausea, skin burning/tingling/dermographism and EEG changes. In summary, then, the mechanism of action of microwave EMFs, the role of the VGCCs in the brain, the impact of non-thermal EMFs on the brain, extensive epidemiological studies performed over the past 50 years, and five criteria testing for causality, all collectively show that various non-thermal microwave EMF exposures produce diverse neuropsychiatric effects.

http://www.sciencedirect.com/science/article/pii/S0891061815000599

The alteration of spontaneous low frequency oscillations caused by acute electromagnetic fields exposure

Abstract

OBJECTIVE:
The motivation of this study is to evaluate the possible alteration of regional resting state brain activity induced by the acute radiofrequency electromagnetic field (RF-EMF) exposure (30min) of Long Term Evolution (LTE) signal.

METHODS:
We designed a controllable near-field LTE RF-EMF exposure environment. Eighteen subjects participated in a double-blind, crossover, randomized and counterbalanced experiment including two sessions (real and sham exposure). The radiation source was close to the right ear. Then the resting state fMRI signals of human brain were collected before and after the exposure in both sessions. We measured the amplitude of low frequency fluctuation (ALFF) and fractional ALFF (fALFF) to characterize the spontaneous brain activity.

RESULTS:
We found the decreased ALFF value around in left superior temporal gyrus, left middle temporal gyrus, right superior temporal gyrus, right medial frontal gyrus and right paracentral lobule after the real exposure. And the decreased fALFF value was also detected in right medial frontal gyrus and right paracentral lobule.

CONCLUSIONS:
The study provided the evidences that 30min LTE RF-EMF exposure modulated the spontaneous low frequency fluctuations in some brain regions.

SIGNIFICANCE:
With resting state fMRI, we found the alteration of spontaneous low frequency fluctuations induced by the acute LTE RF-EMF exposure.

https://www.ncbi.nlm.nih.gov/pubmed/24012322

Additive Effects of Millimeter Waves and 2-Deoxyglucose Co-Exposure on the Human Keratinocyte Transcriptome

Abstract

Millimeter Waves (MMW) will be used in the next-generation of high-speed wireless technologies, especially in future Ultra-Broadband small cells in 5G cellular networks. Therefore, their biocompatibilities must be evaluated prior to their massive deployment. Using a microarray-based approach, we analyzed modifications to the whole genome of a human keratinocyte model that was exposed at 60.4 GHz-MMW at an incident power density (IPD) of 20 mW/cm^2 for 3 hours in athermic conditions. No keratinocyte transcriptome modifications were observed. We tested the effects of MMWs on cell metabolism by co-treating MMW-exposed cells with a glycolysis inhibitor, 2-deoxyglucose (2dG, 20 mM for 3 hours), and whole genome expression was evaluated along with the ATP content. We found that the 2dG treatment decreased the cellular ATP content and induced a high modification in the transcriptome (632 coding genes). The affected genes were associated with transcriptional repression, cellular communication and endoplasmic reticulum homeostasis. The MMW/2dG co-treatment did not alter the keratinocyte ATP content, but it did slightly alter the transcriptome, which reflected the capacity of MMW to interfere with the bioenergetic stress response. The RT-PCR-based validation confirmed 6 MMW-sensitive genes (SOCS3, SPRY2, TRIB1, FAM46A, CSRNP1 and PPP1R15A) during the 2dG treatment. These 6 genes encoded transcription factors or inhibitors of cytokine pathways, which raised questions regarding the potential impact of long-term or chronic MMW exposure on metabolically stressed cells.

https://www.ncbi.nlm.nih.gov/pubmed/27529420

Transcriptome Analysis Reveals the Contribution of Thermal and the Specific Effects in Cellular Response to Millimeter Wave Exposure

Abstract

Radiofrequency radiations constitute a new form of environmental pollution. Among them, millimeter waves (MMW) will be widely used in the near future for high speed communication systems. This study aimed therefore to evaluate the biocompatibility of MMW at 60 GHz. For this purpose, we used a whole gene expression approach to assess the effect of acute 60 GHz exposure on primary cultures of human keratinocytes. Controls were performed to dissociate the electromagnetic from the thermal effect of MMW. Microarray data were validated by RT-PCR, in order to ensure the reproducibility of the results. MMW exposure at 20 mW/cm^2, corresponding to the maximum incident power density authorized for public use (local exposure averaged over 1 cm^2), led to an increase of temperature and to a strong modification of keratinocyte gene expression (665 genes differentially expressed). Nevertheless, when temperature is artificially maintained constant, no modification in gene expression was observed after MMW exposure. However, a heat shock control did not mimic exactly the MMW effect, suggesting a slight but specific electromagnetic effect under hyperthermia conditions (34 genes differentially expressed). By RT-PCR, we analyzed the time course of the transcriptomic response and 7 genes have been validated as differentially expressed: ADAMTS6, NOG, IL7R, FADD, JUNB, SNAI2 and HIST1H1A. Our data evidenced a specific electromagnetic effect of MMW, which is associated to the cellular response to hyperthermia. This study raises the question of co-exposures associating radiofrequencies and other environmental sources of cellular stress.

Results

Comparison between Sham and MMW exposed cells

The global gene expression change between the 60-GHz exposed cells at 20 mW/cm^2 (Expo) and unexposed cells (Sham) evidenced 789 differentially expressed probes with a fold change above 2 (Table 1 and Table S2 in File S1). This probe list included 665 annotated coding genes and 51 long intergenic non-coding RNAs (lincRNA). Among the coding genes, 366 (55%) were down-regulated (Expo <Sham) and 299 (45%) were up-regulated (Expo> Sham). It should be noted that when the microarray analysis is done with an absolute fold change filtered at 1.5, then 1172 probes were found to be differentially expressed (Table 1). Functional enrichments were performed using the DAVID software (David version 6.7; http://david.abcc.ncifcrf.gov/). Biological categories were considered enriched for a corrected p-value below 0.05. The main biological categories associated with these differentially expressed genes were chaperone and heat shock (Figure 2), which is consistent with the heat shock effect of MMW exposure in our conditions. Indeed, under this IPD exposure, the temperature in the cell medium is increased by 6.7°C (Figure 1). In fact, this differentially expressed gene list evidenced two main impacts of the MMW exposure on the cell (Figure 2). The first one is the response to unfolded protein that is a well-known consequence of the temperature increase. The second effect is the negative regulation of the gene expression that is illustrated by an increase in the expression of genes implicated in the negative regulation, and by the down regulation of most differentially expressed genes.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4193780/

Thermal mechanisms of millimeter wave stimulation of excitable cells

Abstract

Interactions between millimeter waves (MMWs) and biological systems have received increasing attention due to the growing use of MMW radiation in technologies ranging from experimental medical devices to telecommunications and airport security. Studies have shown that MMW exposure alters cellular function, especially in neurons and muscles. However, the biophysical mechanisms underlying such effects are still poorly understood. Due to the high aqueous absorbance of MMW, thermal mechanisms are likely. However, nonthermal mechanisms based on resonance effects have also been postulated. We studied MMW stimulation in a simplified preparation comprising Xenopus laevis oocytes expressing proteins that underlie membrane excitability. Using electrophysiological recordings simultaneously with 60 GHz stimulation, we observed changes in the kinetics and activity levels of voltage-gated potassium and sodium channels and a sodium-potassium pump that are consistent with a thermal mechanism. Furthermore, we showed that MMW stimulation significantly increased the action potential firing rate in oocytes coexpressing voltage-gated sodium and potassium channels, as predicted by thermal terms in the Hodgkin-Huxley model of neurons. Our results suggest that MMW stimulation produces significant thermally mediated effects on excitable cells via basic thermodynamic mechanisms that must be taken into account in the study and use of MMW radiation in biological systems.

https://www.ncbi.nlm.nih.gov/pubmed/23790370

Low power radio-frequency and microwave effects on human electroencephalogram and behavior

Abstract

In a pilot study of ten human subjects, temporary changes in brain waves and behavior were seen on exposure to power densities lower than 10(-12) W/cm^2, which is substantially below typical urban levels. Frequencies included .1 to 960 MHz continuous and 8.5 to 9.6 GHz pulse-modulated waves. Since the relaxation frequency of protein-bound water is considered to fall between 100 and 1,000 MHz, absorptions and quantum effects may be the mechanistic basis for the electroencephalogram changes observed in most of the subjects produced by 10(-15) W/cm^2 cw radio-frequency energy of between 130 and 960 MHz. Constructive and destructive interference patterns from standing waves within the skull possibly interact with the bioelectric generators in the brain, since electroencephalogram wave amplitudes and frequencies increased or decreased respectively at different radio wavelengths.

https://www.ncbi.nlm.nih.gov/pubmed/751078

Millimeter wave absorption in the nonhuman primate eye at 35 GHz and 94 GHz

Abstract

The purpose of this study was to evaluate anterior segment bioeffects of pulsed 35 GHz and 94 GHz microwave exposure in the nonhuman primate eye. Five juvenile rhesus monkeys (Macaca mulatta) underwent baseline anterior segment ocular assessment consisting of slit lamp examination, corneal topography, specular microscopy, and pachymetry. These studies were repeated after exposure of one eye to pulsed 35 GHz or 94 GHz microwaves at varied fluences, with the other eye serving as a control. The mean fluence required to produce a threshold corneal lesion (faint epithelial edema and fluorescein staining) was 7.5 J cm(-2) at 35 GHz and 5 J cm(-2) at 94 GHz. Transient changes in corneal topography and pachymetry were noted at these fluences. Endothelial cell counts remained unchanged. Threshold corneal injury from 35 GHz and 94 GHz microwave exposure is produced at fluences below those previously reported for CO2 laser radiation. These data may help elucidate the mechanism of thermal injury to the cornea, and resolve discrepancies between IEEE C95.1 (1999), NCRP (1986), and ICNIRP (1998) safety standards for exposure to non-ionizing radiation at millimeter wavelengths.

https://www.ncbi.nlm.nih.gov/pubmed/12075687

Increased sensitivity of the non-human primate eye to microwave radiation following ophthalmic drug pretreatment

Abstract

Previous studies in our laboratory have established that pulsed microwaves at 2.45 GHz and 10 mW/cm^2 are associated with production of corneal endothelial lesions and with disruption of the blood-aqueous barrier in the non-human primate eye. In the study reported here we examined ocular damage in monkeys (M. mulatta and M. fascicularis) following topical treatment with one of two ophthalmic drugs (timolol maleate and pilocarpine) that preceded exposure to pulsed microwaves. Anesthetized monkeys were sham exposed or exposed to pulsed, 2.45 GHz microwaves (10 microseconds, 100 pps) at average power densities of 0.2, 1, 5, 10, or 15 mW/cm^2 4 h a day for 3 consecutive days (respective SARs were 0.052, 0.26, 1.3, 2.6, and 3.9 W/kg). Immediately before microwave exposure, one or both eyes were treated topically with one drop of 0.5% timolol maleate or of 2% pilocarpine. Following administration of a drug, we observed a significant reduction in the power-density threshold (from 10 to 1 mW/cm^2) for induction of corneal endothelial lesions and for increased vascular permeability of the iris. Diagnostic procedures (in vivo specular microscopy and fluorescein iris angiography) were performed following each exposure protocol. In addition, increased vascular permeability was confirmed with horseradish peroxidase tracer techniques. Although we did not measure intraocular temperatures in experimental animals, the results suggest that a mechanism other than significant heating of the eye is involved. Our data indicate that pulsed microwaves at an average SAR of 0.26 W/kg, if administered after pretreatment with ophthalmic drugs, can produce significant ocular effects in the anesthetized primate.

https://www.ncbi.nlm.nih.gov/pubmed/1445419

Effects of low-intensity extremely high frequency electromagnetic radiation on chromatin structure of lymphoid cells in vivo and in vitro

Abstract

Using a comet assay technique, it was shown for the first time that low-intensity extremely high-frequency electromagnetic radiation (EHF EMR) in vivo causes oppositely directed effects on spatial organization of chromatin in cells of lymphoid organs. In 3 hrs after single whole-body exposure of NMRI mice for 20 min at 42.0 GHz and 0.15 mW/cm^2, an increase by 16% ($p < 0.03$ as compared with control) and a decrease by 16% ($p < 0.001$) in fluorescence intensity of nucleoids stained with ethidium bromide were found in thymocytes and splenocytes, respectively. The fluorescence intensity of stained nucleoids in peripheral blood leukocytes was not changed after the exposure. The exposure of cells of Raji hunan lymphoid line and peripheral blood leukocytes to the EHF EMR in vitro induced a decrease in fluorescence intensity by 23% ($p < 0.001$) and 18% ($p < 0.05$), respectively. These effects can be determined by changes in a number of physiological alkali-labile sites in DNA of exposed cells. We suggested that the effects of low-intensity EHF EMR on the immune system cells are realized with the participation of neuroendocrine and central nervous systems.

https://www.ncbi.nlm.nih.gov/pubmed/12677665

Suppression of nonspecific resistance of the body under the effect of extremely high frequency electromagnetic radiation of low intensity

Abstract

The dynamics of leukocyte number and functional activity of peripheral blood neutrophils under whole-body exposure of healthy mice to low-intensity extremely-high-frequency electromagnetic radiation (EHF EMR, 42.0 GHz, 0.15 mW/cm^2, 20 min daily) was studied. It was shown that the phagocytic activity of peripheral blood neutrophils was suppressed by about 50% ($p < 0.01$ as compared with the sham-exposed control) in 2-3 h after the single exposure to EHF EMR. The effect persisted for 1 day after the exposure, and then the phagocytic activity of neutrophils returned to the norm within 3 days. A significant modification of the leukocyte blood profile in mice exposed to EHF EMR for 5 days was observed after the cessation of exposures: the number of leukocytes increased by 44% ($p < 0.05$ as compared with sham-exposed animals), mostly due to an increase in the lymphocyte content. The supposition was made that EHF EMR effects can be mediated via the metabolic systems of arachidonic acid and the stimulation of adenylate cyclase activity, with subsequent increase in the intracellular cAMP level. The results indicated that the whole-body exposure of healthy mice to low-intensity EHF EMR has a profound effect on the indices of nonspecific immunity.

https://www.ncbi.nlm.nih.gov/pubmed/11855293

Effects of millimeter wave on gene expression in human keratinocytes

Abstract

OBJECTIVE:
To explore the effect of millimeter wave exposure at low power density on gene expression in human keratinocytes (HaCaT).

METHODS:
HaCaT keratinocytes were exposed to 30.16 GHz millimeter wave with power densities of 1.0 or 3.5 mW/cm^2 for 30 min per day. Gene expression profiles were obtained using the Affymetrix human genome U95A GeneChip. Reverse-transcription polymerase chain reaction (RT-PCR) was performed to confirm the differential expression of genes obtained from Genechip analysis.

RESULT:
PAR-2 and ERGIC-53 genes in HaCaT cells were up-regulated by 3.5 mW/cm^2 millimeter wave exposure for 4 times. ERGIC-53 gene was also up-regulated by 1.0 mW/cm^2 millimeter wave exposure for 4 times. However, no significant change for PAR-2 expression was found after the same exposure.

CONCLUSION:
Millimeter wave exposure could affect gene expression in human keratinocytes, which might be related to the intensity and the times of exposure.

https://www.ncbi.nlm.nih.gov/pubmed/18275115

Low power radio-frequency and microwave effects on human electroencephalogram and behavior

Abstract

In a pilot study of ten human subjects, temporary changes in brain waves and behavior were seen on exposure to power densities lower than 10(-12) W/cm^2, which is substantially below typical urban levels. Frequencies included .1 to 960 MHz continuous and 8.5 to 9.6 GHz pulse-modulated waves. Since the relaxation frequency of protein-bound water is considered to fall between 100 and 1,000 MHz, absorptions and quantum effects may be the mechanistic basis for the electroencephalogram changes observed in most of the subjects produced by 10(-15) W/cm^2 cw radio-frequency energy of between 130 and 960 MHz. Constructive and destructive interference patterns from standing waves within the skull possibly interact with the bioelectric generators in the brain, since electroencephalogram wave amplitudes and frequencies increased or decreased respectively at different radio wavelengths.

https://www.ncbi.nlm.nih.gov/pubmed/751078

Impact of 60-GHz millimeter waves and corresponding heat effect on endoplasmic reticulum stress sensor gene expression

Abstract

Emerging high data rate wireless communication systems, currently under development, will operate at millimeter waves (MMW) and specifically in the 60 GHz band for broadband short-range communications. The aim of this study was to investigate potential effects of MMW radiation on the cellular endoplasmic reticulum (ER) stress. Human skin cell lines were exposed at 60.4 GHz, with incident power densities (IPD) ranging between 1 and 20 mW/cm(2) . The upper IPD limits correspond to the ICNIRP local exposure limit for the general public. The expression of ER-stress sensors, namely BIP and ORP150, was then examined by real-time RT-PCR. Our experimental data demonstrated that MMW radiations do not change BIP or ORP150 mRNA basal levels, whatever the cell line, the exposure duration or the IPD level. Co-exposure to the well-known ER-stress inducer thapsigargin (TG) and MMW were then assessed. Our results show that MMW exposure at 20 mW/cm(2) inhibits TG-induced BIP and ORP150 over expression. Experimental controls showed that this inhibition is linked to the thermal effect resulting from the MMW exposure.

https://www.ncbi.nlm.nih.gov/pubmed/25099539

Experimental studies on the influence of millimeter radiation on light transmission through the lens

Abstract

The influence of microwave radiation in millimeter range on the eye has not been investigated so far. However, it is known that microwaves of different wave-length can induce the development of the cataract. Therefore the purpose of the study was to investigate light transmission through the lens after exposure to microwave radiation in millimeter range. The studies were carried out on 22 rats exposed to microwave radiation of 5.6 mm length and power per unit area 10 mW/cm^2 or 1 mW/cm^2 during 58 days. Light transmission through the isolated lenses was measured spectrophotometrically. Transmission through the lenses was significantly decreased (about 33%) in the rats exposed to microwave radiation of 10 mW/cm^2. The results of the study indicate that also microwave radiation in millimeter range can induce changes in the lens, predisposing to cataract development.

https://www.ncbi.nlm.nih.gov/pubmed/7897988

Changes in gap junctional intercellular communication in rabbits lens epithelial cells induced by low power density microwave radiation

Abstract

OBJECTIVE:
To demonstrate the changes in gap junctional intercellular communication (GJIC) mediated by low power density microwave radiation in rabbits lens epithelial cells (LECs) and its mechanisms.

METHODS:
Rabbits' eyes were exposed to 5 mW/cm(2) and 10 mW/cm(2) power densities of microwave radiation for 3 hours. The fluorescence-recovery-after-photobleaching (FRAP) method was used to determine the GJIC. The localization and function of connexin 43 in LECs was detected by laser scanning confocal microscopy.

RESULTS:
The GJIC of rabbits LECs was inhibited by microwave radiation especially in the 10 mW/cm(2) irradiated samples. A decrease in connexin 43-positive staining was seen in 5 mW/cm(2) x 3 h treated LECs. Intracellular space accumulation and cytoplasmic internalization were clearly demonstrated in 10 mW/cm(2) group.

CONCLUSIONS:
Low power densities microwave radiation (5 mW/cm(2) and 10 mW/cm(2)) induces damage to connexin 43 and inhibits the GJIC of rabbits LECs. These changes result in an osmotic imbalance within the lens and induce early cataract. 5 mW/cm(2) or 10 mW/cm(2) microwave radiation is cataractogenic.

https://www.ncbi.nlm.nih.gov/pubmed/12622942

The Neuroinflammatory Etiopathology of Myalgic Encephalomyelitis/Chronic Fatigue Syndrome (ME/CFS)

Myalgic Encephalomyelitis/Chronic Fatigue Syndrome (ME/CFS) is a debilitating multi-systemic chronic illness of unknown etiology, classified as a neurological disorder by the World Health Organization (WHO). The symptomatology of the condition appears to emanate from a variety of sources of chronic neurological disturbance and associated distortions, and chronicity, in noxious sensory signaling and neuroimmune activation. This article incorporates a summary review and discussion of biomedical research considered relevant to this essential conception perspective. It is intended to provide stakeholders with a concise, integrated outline disease model in order to help demystify this major public health problem. The primary etiopathological factors presented are: (A) Postural/biomechanical pain signaling, affecting adverse neuroexcitation, in the context of compression, constriction, strain, or damage of vertebral-regional bone and neuromuscular tissues; (B) Immune mediated inflammatory sequelae, in the context of prolonged immunotropic neurotrophic infection—with lymphotropic/gliotropic/glio-toxic varieties implicated in particular; (C) A combination of factors A and B. Sustained glial activation under such conditions is associated with oxidative and nitrosative stress, neuroinflammation, and neural sensitivity. These processes collectively enhance the potential for multi-systemic disarray involving endocrine pathway aberration, immune and mitochondrial dysfunction, and neurodegeneration, and tend toward still more intractable synergistic neuro-glial dysfunction (gliopathy), autoimmunity, and central neuronal sensitization.

Nociceptive afferent input excites post-synaptic neurons and may also be read by glia, triggering cellular responses e.g., via the stimulated neuronal release of chemical mediators that bind to glial receptors (Ren and Dubner, 2008). Calcium ion (Ca(2+)) influx into astrocytes following stimulation causes central terminals of the nociceptor to release a host of neuroactive signal molecules. These include the primary neuroexcitatory neurotransmitter, glutamate, nitric oxide (NO), and pro-inflammatory cytokines: Tumor necrosis factor alpha (TNF-α) and interleukin-1 beta (IL-1β) (Ricci et al., 2009).

Activated microglia behave similarly in responding to immune challenge/inflammation (Renno et al., 1995), also inducing superoxide production. Superoxide and NO are free radical substrates of the potent, toxic oxidant peroxynitrite (ONOO–), and hence sources of oxidative and nitrosative (O+NS) damage, both individually and, particularly, when combined (Barger et al., 2007). Along with the abovementioned stimuli, glia may also be primed to respond more harshly by exposure to toxins and electromagnetic fields (EMF), including non-ionizing, radio frequency (RFR) electromagnetic radiation (EMR) (Hao et al., 2010), autoimmune processes (Colton, 2009), and the effects of aging (Norden and Godbout, 2012).

http://journal.frontiersin.org/article/10.3389/fphys.2017.00088/full

EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses

Abstract

Chronic diseases and illnesses associated with non-specific symptoms are on the rise. In addition to chronic stress in social and work environments, physical and chemical exposures at home, at work, and during leisure activities are causal or contributing environmental stressors that deserve attention by the general practitioner as well as by all other members of the health care community. It seems necessary now to take “new exposures” like electromagnetic fields (EMF) into account. Physicians are increasingly confronted with health problems from unidentified causes. Studies, empirical observations, and patient reports clearly indicate interactions between EMF exposure and health problems. Individual susceptibility and environmental factors are frequently neglected. New wireless technologies and applications have been introduced without any certainty about their health effects, raising new challenges for medicine and society. For instance, the issue of so-called non-thermal effects and potential long-term effects of low-dose exposure were scarcely investigated prior to the introduction of these technologies. Common electromagnetic field or EMF sources: Radio-frequency radiation (RF) (3 MHz to 300 GHz) is emitted from radio and TV broadcast antennas, Wi-Fi access points, routers, and clients (e.g. smartphones, tablets), cordless and mobile phones including their base stations, and Bluetooth devices. Extremely low frequency electric (ELF EF) and magnetic fields (ELF MF) (3 Hz to 3 kHz) are emitted from electrical wiring, lamps, and appliances. Very low frequency electric (VLF EF) and magnetic fields (VLF MF) (3 kHz to 3 MHz) are emitted, due to harmonic voltage and current distortions, from electrical wiring, lamps (e.g. compact fluorescent lamps), and electronic devices. On the one hand, there is strong evidence that long-term exposure to certain EMFs is a risk factor for diseases such as certain cancers, Alzheimer’s disease, and male infertility. On the other hand, the emerging electromagnetic hypersensitivity (EHS) is more and more recognized by health authorities, disability administrators and case workers, politicians, as well as courts of law. We recommend treating EHS clinically as part of the group of chronic multisystem illnesses (CMI), but still recognizing that the underlying cause remains the environment. In the beginning, EHS symptoms occur only occasionally, but over time they may increase in frequency and severity. Common EHS symptoms include headaches, concentration difficulties, sleep problems, depression, a lack of energy, fatigue, and flu-like symptoms. A comprehensive medical history, which should include all symptoms and their occurrences in spatial and temporal terms and in the context of EMF exposures, is the key to making the diagnosis. The EMF exposure is usually assessed by EMF measurements at home and at work. Certain types of EMF exposure can be assessed by asking about common EMF sources. It is very important to take the individual susceptibility into account. The primary method of treatment should mainly focus on the prevention or reduction of EMF exposure, that is, reducing or eliminating all sources of high EMF exposure at home and at the workplace. The reduction of EMF exposure should also be extended to public spaces such as schools, hospitals, public transport, and libraries to enable persons with EHS an unhindered use (accessibility measure). If a detrimental EMF exposure is reduced sufficiently, the body has a chance to recover and EHS symptoms will be reduced or even disappear. Many examples have shown that such measures can prove effective. To increase the effectiveness of the treatment, the broad range of other environmental factors that contribute to the total body burden should also be addressed. Anything that supports homeostasis will increase a person’s resilience against disease and thus against the adverse effects of EMF exposure. There is increasing evidence that EMF exposure has a major impact on the oxidative and nitrosative regulation capacity in affected individuals. This concept

also may explain why the level of susceptibility to EMF can change and why the range of symptoms reported in the context of EMF exposures is so large. Based on our current understanding, a treatment approach that minimizes the adverse effects of peroxynitrite – as has been increasingly used in the treatment of multisystem illnesses – works best. This EMF Guideline gives an overview of the current knowledge regarding EMF-related health risks and provides recommendations for the diagnosis, treatment and accessibility measures of EHS to improve and restore individual health outcomes as well as for the development of strategies for prevention.

https://www.degruyter.com/view/j/reveh.ahead-of-print/reveh-2016-0011/reveh-2016-0011.xml

Dirty Electricity and the Link to Cancer

The Health Hazards of EMFs

History has shown that the western world with its vested interests is slow to inform citizens about toxic agents and help protect them. The "dirty electricity" pandemic is no stranger to inaction, as were the asbestos, lead, acid rain, DDT, PCB and tobacco-smoking public health issues before it. The contention that artificially created electromagnetic fields (EMFs) which emanate from electricity generation can cause cancer has medical and legal experts commenting that EMFs will dwarf the tobacco-smoking issue and the asbestos crisis combined.

This health issue has a history replete with destroyed careers and tarnished reputations involving scientists who have sought to help the people, and with so-called experts who have colluded with the forces going against the precautionary principle of public health: first, *do no harm.*

In his assessment for the journal of the Royal Institute of Public Health in the UK, Dr Stephen J. Genuis reported that vested interests have been effective in delaying restrictive EMF legislation. He also noted that claims of environmental harm have been challenged by researchers who fail to disclose covert ties to industry, that economic interests exert undue influence on medical journals, and that some editors and journal staff have suppressed publication of scientific results that are adverse to the interests of industry.[1]

Professor Mark Ellwood, who was installed by the Australian federal government in the most elevated position in the nation as Director of the National Cancer Control Initiative to provide advice and make recommendations to the government and other key groups regarding cancer control, submitted expert witness reports for the power companies (and telecommunications companies) for court cases. Professor Andrew Wood, installed by the federal government in another position that serves to protect us—ARPANSA, the Australian Radiation Protection and Nuclear Safety Administration—also submits expert witness reports for the power industry for court cases. Professor Wood is currently chair of the ELF (extremely low frequency) Standard Working Group for the ARPANSA Radiation Health Committee.

It was not until 1979 that the western world took notice that these silent, invisible EMFs may be hazardous. Epidemiologist Dr Nancy Wertheimer and electrical engineer Ed Leeper conducted a study in Denver, Colorado, USA, and reported that children who were twice or three times as likely to have leukaemia tended to live in homes close to power lines and transformers. Their results, published in a scientific paper, showed an increased incidence of leukaemia, lymphomas and nervous system tumours in children.[2]

Their hotly debated research had an immediate effect: in response to public opposition to the construction of new high-voltage power lines, the electricity industry convened an expert panel of eminent and conservative medical scientists.

Included in this panel was Professor David Carpenter, from the Department of Public Health at New York University, and Dr David Savitz, one of America's most respected epidemiologists. Professor Carpenter's original scepticism was overturned when the Wertheimer and Leeper study, originally heavily criticised as flawed, was extended and improved. It confirmed a significantly increased risk of leukaemia.[3]

The reason why childhood leukaemia is studied is because the strongest evidence for a cancer is that the same cancer is significantly elevated in children.

In 2001, leading occupational medical epidemiologist Dr Sam Milham, MPH, and E. M. Ossiander, of the Washington State Department of Health, Olympia, researched the rise of electrification in the UK and USA and concluded that the childhood leukaemia peak of common acute lymphoblastic leukaemia was attributable to residential electrification: 75 per cent of all childhood acute lymphoplastic leukaemia and 60 per cent of all childhood leukaemia could be preventable.[4] In 2007, Professor Michael Kundi reported that up to 80 per cent of all cases of childhood leukaemia may be caused by exposure to these fields.[5]

It was reported as early as the 1960s (Court-Brown and Doll) that a new leukaemia-causing agent entered the UK and USA in the 1920s-1930s.6 Today it is quite widely accepted that these EMFs can cause childhood leukaemia.

There is some evidence that other childhood cancers may be related to EMF exposure, but not enough studies have been done.[7]

Wertheimer and Leeper were the first to see a magnetic field-breast cancer connection in their 1982 study of residential magnetic field exposures of adults.8 Even though this study looked at overall cancer risk in adults and found an increase in excess cancers of the nervous system, uterus and lymphoid tumours, "they discovered a nearly threefold increase among women younger than 55 who lived near power lines, indicating that magnetic field exposure had accelerated, development and growth of breast cancer".[9]

Breast tissue (along with foetal tissue) is the most sensitive tissue in the body and also the most sensitive to artificial (man-made) radiation, which is why any study into breast cancer has significant ramifications for all of us.

Breast cancer is a very-high-risk disease for women today. The contention that EMFs are a risk factor, let alone a *causative* factor, in female breast cancer has been heavily resisted. When individual cases of breast cancer or breast cancer clusters in women occur, various reproductive factors are also taken into account which can mask the role that EMFs play.

When, in 2001, three men in one small office developed breast cancer, Dr Sam Milham testified for the men in their 2003 court case, arguing that their cancers were caused, in part at least, by EMFs emanating from an electrical vault next to a basement office where the men worked.[10] In 1997, Dr Thomas Erren, MPH, had noted that an association between ELF EMFs and breast cancer is supported in men.[11]

In 2002, even the Washington, DC, legal counsel for electricity utilities worldwide conceded in a privileged attorney-client communication that the stance of the power industry had to change.[12] Studies are normally conducted on exposed and unexposed subjects, but with these EMFs we are all exposed, making a definitive cause hard to prove.

Also, it would be unethical to expose people to high measurements of these EMFs to prove the case. People don't welcome having to change convenient lifestyles, and, when doubt and confusion are introduced, the public is often quick to disregard the importance of data that makes changing ingrained habits a requirement.

There have been thousands of studies of EMFs, more so than with any other health issue. In 1997, Dr Erren commented that there are more epidemiological studies that link cancer to these fields than to environmental tobacco smoke.[13] We are all concerned about the infiltration of chemicals into our wider and more personal environments, yet an analysis of 65 studies reported that the combined effects of toxic agents together with EMFs enhance the damage as compared to the toxic exposure alone.[14]

In 2007, the World Health Organization (WHO) stated that it is "reasonable and warranted" to lessen exposure to these ELF EMFs, "(provided that the health, social and economic benefits of electric power are not compromised"[15]—information that will take decades to be acted upon around the globe.

EMFs and Cancer Clusters

Fifty-three people in a small post office in Capalaba, Brisbane, Australia, with an old electricity substation next door, were diagnosed with serious and fatal diseases by 2000, although staff had started to take notice of the disease patterns in the early 1990s. Investigation of the electrical environment was incomplete, and there is still no resolution to this situation today.

When research is conducted into these disease clusters, often it's the case that measurements are taken after hours when the electrical environment has changed or that investigations are conducted after extensive remedial electrical work has been completed. Often the cancers are put down to "random chance" or "coincidence".

However, in the case of the breast cancer cluster involving 17 women working in a small area within the Australian Broadcasting Corporation (ABC) TV studios in Toowong, Brisbane, the cancers, which were diagnosed between 1995 and 2006, were thought to be workplace-related but no cause could be found. In early 2005, the women pinpointed the area which they thought was in question.

A private firm, EMC Technologies, took radio-frequency electromagnetic radiation measurements in April 2005 and concluded that all the work areas surveyed complied with the ARPANSA RPS3 standard,[16] but it wasn't until 18 December 2006 that ARPANSA investigated the premises for ELF EMFs. Within three days, the ABC staff were no longer working on the premises.

The specific measurements of ELF EMFs in the area pinpointed by the staff were not mentioned in the ARPANSA report.[17] Complete and precise measurements of ELF EMFs as well as transient EMFs should have been taken in the area.

Professor Bruce Armstrong led the ABC's own investigation into the cancer cluster in 2006, looking at other breast cancer risk factors such as reproductive, lifestyle and age factors.

When questioned on national television in August 2007 on this breast cancer cluster and the frustration of some of the women who felt that the proper investigations were not carried out before all the equipment was taken out, he stated: "It is very important to do the investigations properly, and indeed we did have a problem with the ABC with the fairly quick decision to remove people from the site.

It did mean that some of the measurements we wanted to do were not complete, and I do understand how the women feel in that respect; they don't feel that it's been done satisfactorily..."[18]

This breast cancer cluster came close to showing the world that EMFs can cause breast cancer. Even though further analysis was not conducted on male staff in this workplace, the possibility does exist that prostate and/or testicular cancers may have been present or may develop in the future.

If complete measurements of all aspects of the electrical environment had been taken, this could have been a win-win situation for all citizens of the world: the women could have known what caused their breast cancer and (along with every other woman and man) would have been able to ensure that their next working environment was safe; ABC TV would have been the perfect medium to spread the much-awaited information across the globe; and the ABC itself would have been commended on its groundbreaking achievement in helping millions of people (and scientists) throughout the world understand EMFs more fully. It also could have enabled the process of workplace reform to be instigated.

These cancer clusters serve to show us what is happening silently on a daily basis in everyone's lives. The adults and children of today have already been affected by these EMFs. Miscarriage, stillbirth, pre-term delivery, altered gender ratio and congenital abnormalities have been linked to maternal exposure.[19] Testicular abnormalities, atypical sperm, chromosomal aberrations and offspring congenital defects have all been linked to paternal exposure.[20] Fathers employed in industries with higher than average EMF exposure have also been noted to have offspring with higher rates of brain and spinal cord tumours.[21]

The Perils of Dirty Electricity

Any harmful EMFs can be classed as "dirty"—to put into common idiom the scientific and technical language that accompanies this public health issue— yet there is another facet of electricity, termed "dirty electricity", that is now seen as even more of a threat to our health than the electromagnetic fields mentioned above. It is not only the fields from power lines and substations that can be a concern; dirty electricity is running through virtually every building on the planet. An even more prevalent and insidious agent, this secretive and subtle underlying menace is in all probability one cause of the dramatic increase in many illnesses and cancers.

Dr Sam Milham stated in 2008: "Very recently, new research is suggesting that nearly all the human plagues which emerged in the twentieth century, like common acute lymphoblastic leukemia in children, female breast cancer, malignant melanoma and asthma, can be tied to some facet of our use of electricity.

There is an urgent need for governments and individuals to take steps to minimize community and personal EMF exposures."[22]

In 1994, the B Armstrong et al. study relating to dirty electricity was published.[23] However, it was not until 2005, when Dr Sam Milham and electrical engineer Lloyd Morgan came out of retirement due to their concern over a cancer cluster, that information worthy of creating a paradigm shift finally began to emerge, with the results having serious implications for all of us.

(These brave researchers had honourable intentions and impressive credentials.[24] Dr Sam Milham in 1982 was the first to link workers exposed to EMFs with higher rates of leukaemia. Lloyd Morgan, a brain tumour survivor and a director of the Central Brain Tumor Registry of the United States (CBTRUS), introduced the Benign Brain Tumor Registries Amendment Act into US Congress that became law in

2002. Along with breast cancer, leukaemia and diseases of the central nervous system, brain tumours are among the diseases that are more prominent in this health issue.)

The researchers were responding to alarm over a cluster of 18 cancers reported in 2003 among the 137 teachers at a middle school in California. Even though the school district administration had refused a number of requests for these men to assist in the evaluation of this cluster, which involved nearly three times more cancers than the average, one teacher invited these researchers to visit the school after hours to take measurements of the electrical environment, which they did at their own expense. When the researchers reported their findings to the Superintendent of Schools, Dr Milham was threatened with prosecution for "unlawful...trespass" and the teacher who had invited them into the school received a letter of reprimand. The teachers then filed a California OSHA (Occupational Safety Health Administration) complaint, which ultimately led to the progressive California Department of Health Services (CDHS) becoming involved. The CDHS measured the different facets of the electrical environment and provided Milham and Morgan with the data, which showed that dirty electricity—"transients", which are radio-frequencies riding along electrical wiring—was involved. Finally, this was a study that was conducted with the highest integrity, able to break through the red tape and politics that usually accompany the problem of harmful electrical environments. Of immense importance, Milham and Morgan commented that transients may be a universal carcinogen similar to ionising radiation,[25] an already established cause of cancer.

The only two published studies relating to dirty electricity—Armstrong *et al.* 1994 study and the Milham-Morgan study—both show very positive increases in cancer risk with increasing *cumulative* exposure to transients.

What is of critical importance is that the cancer risks at the school in California were comparable to the smoking-lung cancer risk. Of no surprise, breast cancer cases were reported in this cluster along with several other cancers including colon cancers, uterine cancers and malignant melanomas. Artificially created EM radiation (EMR) is a determinant in the development of malignant melanoma, an increasingly prevalent cancer that was uncommon until around 50 years ago.[26]

In fact, research on EMFs has been conducted for over 50 years in Russia,[27] and the newer research on dirty electricity has been carried out by Russian experts in conjunction with scientists and electrical engineers from the United States, Canada, Kazakhstan and the Ukraine.[28] Kazakhstan has already swiftly mandated protection against dirty electricity in industrial situations,[29] a model which should be implemented in all countries across the globe.

Ongoing Risk Assessment

We are in the midst of an invisible and silent plague of pandemic proportions that has been woven into our everyday lives. Dirty electricity, is in virtually every building, whether it be our homes, schools, workplaces or hospitals. Energy-efficient appliances and equipment are amongst the culprits that create dirty electricity. Dr Magda Havas, Associate Professor of Environmental and Resource Studies at Trent University, Ganada, reports that many houses with solar panels have very high levels of dirty electricity.[30] Wind turbines can also generate dirty electricity, which is then transferred along the grid.

If these EMFs released a visible substance on us, we would comprehend very quickly the attack on our body and that dirty electricity :is creating havoc with our immune systems. Even though we cannot see it and most of u .cannot feel it, dirty electricity is affecting all of us. Removing dirty electricity has seen

cases of multiple sclerosis improve dramatically and even go into remission, and has also resulted in asthmatics using inhalers less often.[31] Some diabetics are discovering that their insulin levels are being artificially raised in dirty electrical environments. In 2004, Dave Stetzer, president of Stetzer Electric, and Dr Havas presented to the WHO their research showing the difference between the blood sugar level in a dirty electrical environment (a measurement of 36) and one that was filtered (a measurement of nine).[32]

Autism is now seen as the fastest-growing developmental disability. Dr Havas reported that a recent pilot research study has shown higher rates of babies born with- autism where the mothers' sleeping locations had high levels of radio-frequency EMR.[33]

Children who have leukaemia or are in recovery have poorer survival rates if exposure to extremely low frequency EMF levels is high.[34] It follows that all ill and recovering patients should be aware of their exposure to these fields.

Lichtenstein el al. concluded from their study of identical twins that environmental factors are the initiating event in the majority of cancers.[35] On studying cancer trends in the 20th century, Hallberg and Johansson reported that there is a common environmental stress that accelerates several forms of cancer—colon cancer, lung cancer, breast cancer, bladder cancer and melanoma.[36] From when electricity was first generated to the introduction of AM radio (1920s), radar (1940s), FM radio and TV (1950s), computers (1970s), mobile phones (1980s), and wireless technologies and compact fluorescent lighting (2000s), artificially created EMR is the most likely environmental stress.

Artificially created EMR may also be the underlying menace in the tobacco smoking and asbestos crises. Hallberg and Johansson reported that exposure to radiowaves (artificially created EMR) appears to be *as big a factor in causing lung cancer as cigarette smoking*, and that deaths due to asbestosis were not known until after the 1960s despite the fact that asbestos had been used as a building material since the end of the 19th century.[37]

We cannot afford to be unsuspecting recipients of this artificial electromagnetic radiation which has been newly introduced in such a short period of our history. Associate Professor Olle Johansson, of the Department of Neuroscience at the Karolinska Institute in Sweden, commented that today no one would consider having a radioactive wristwatch with glowing digits (as you could in the 1950s), having your children's shoes fitted in a strong X-ray machine (as you could in the 1940s), keeping radium in open trays on your desk (as scientists did in the 1930s) or X-raying each other at garden parties (as physicians did in the 1920s).[38]

These examples relate to *ionising* radiation; apart from nuclear fallout, we have a choice whether to expose ourselves to it or not.

Many different types of artificially created radiation have been woven into our daily lives. It is awareness that will bring understanding of the different types of radiation so we can make our own informed choices on what we are willing to be exposed to and what we must avoid. School teachers and principals alike must be educated on this most important health issue so that measures can be put into place to ensure that they and our children are not at risk in a dirty electrical environment, for dirty electricity has been found to be especially prevalent in environments with concentrated fluorescent lights and computers. Employers and employees alike must understand that their workplace must also be

protected. People in their own homes must also protect themselves from modern equipment that also generates dirty electricity.

Finally, Dr Cedric Garland, the epidemiologist currently investigating the breast cancer cluster on the campus of the University of California, San Diego, is focusing on the possible role of EMFs, especially transients.[39] Dr Garland advised that the female employees should be informed about tamoxifen research—that ELF EMFs have been found to partially block this drug's action in preventing breast cancer spreading or a recurrence of breast cancer—and recommended that those taking the drug should be transferred to a lower-current area if they so desired.

Transients cause cancer. Just as we filter our water to remove contaminants so we have cleaner water, now we must filter our electricity to remove this contaminant so we have cleaner electricity.

http://www.whale.to/a/fisher_donna.html

Wireless Wake-Up Call: A New Paradigm in EMF Science

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I began to question the trajectory of our culture five years ago when a bank of wireless smart meters was installed below my bedroom in San Francisco. Within a week, my wife and I were experiencing headaches, insomnia, tinnitus, heart palpitations, and fatigue. We had never experienced these symptoms before and when we left our house, they diminished. After some research, I found the same thing was happening to thousands of people throughout California and other states and countries where wireless smart meters were installed.1 This set me on a journey to learn as much as possible about how electromagnetic fields (EMF) affect biology. I now have a website on this subject and recently gave a TED talk at TEDxBerkeley on the University of California, Berkeley, campus. This is called Wireless Wake-Up Call and can easily be found through an internet search. I encourage you to watch the TED talk before reading further as the talk is a good introduction to this subject. In this article, I provide more technical analysis than a fifteen-minute talk for a general audience can allow. I will cover the basic problem with the recent exponential rise in EMF pollution, the evolution of EMF science, and possible solutions. I also describe steps you can take today to create a much healthier home from this perspective.

Before we move on, I want to acknowledge that I realize this subject may be controversial for you. It was for me five years ago. The predominant view in our society is that electromagnetic fields are completely safe if they do not heat or shock you. Much of our economy is based upon this assumption, so one would conclude that it must be true. My intention is not to be confrontational. It is to begin a discussion and to encourage some of the brightest minds in the United States to realize that we are not seeing the whole picture on the safety of wireless technology. As you will see in this article and in your own research, there is now enough evidence that weak electromagnetic fields affect biology. This could have serious consequences for the future of our civilization; it is an issue we must begin to acknowledge so solutions can be created. I welcome your feedback and to furthering this discussion.

Our electromagnetic environment has changed immensely over the past ten years, and wireless technology is set to expand even faster in the next five. Before the invention of the iPhone eight years ago, the electromagnetic exposure for most people was quite low unless they were early adopters of wireless technology or lived next to a cell phone tower. However, today we have nearly ubiquitous Wi-Fi, even in schools, and additional cell towers to provide the data to everyone's smart phone. We also have smart watches, smart utility meters, smart thermostats, smart homes, and new vehicles with Bluetooth and Wi-Fi. This increase in microwave radiation is unprecedented, but it is only the beginning.

The next phase is the "Internet of Things," which will connect everything we purchase to the internet with its own IP address and wireless transmitter. The "connected home" of the future may have up to one million bursts of microwave radiation pulsing through it each day. To make all of this work and to circumvent the community review process for cell tower siting, wireless companies are now joining with local governments to put powerful cell antennas on utility poles, often just 10 to 20 feet from homes. This is called the Distributed Antenna System (DAS) and is currently being rolled out in cities such as San Francisco, where new antennas are being placed on most city blocks.2 Many cities in the United States will have this system in coming years. To add to this, Google and Facebook are competing to provide their own internet service. Through projects such as Google's "Project Loon," which will put up balloons with Wi-Fi antennas at 60,000 feet3 and Facebook's proposed 60 GHz Terragraph Wi-Fi system,4 we

have entered a new era of electromagnetic exposures. However, this is all being done on the assumption from a previous era that pulsed microwave radiation is completely safe.

Our society's EMF safety guidelines are based on thermal standards. The idea is that if non-ionizing electromagnetic fields do not heat you, then they cannot possibly hurt you. Even though there is plenty of evidence that non-thermal EMF exposures cause biological damage, this evidence is repeatedly dismissed by the private bodies and government agencies that set safety standards. The reason for this is quite practical. In the 1950s, after the development of radar in WWII, the military and industrial applications of microwave technology were seen as a higher priority than any potential ill effects on health. They reasoned the Cold War and economic growth were more important than the possibility of illness or cancer for a segment of the population 20 to 30 years in the future. However, the people making those decisions in the 1950s and 1960s could have never imagined that 60 years later, our society would be experiencing the tremendous boom in consumer wireless technology that has occurred. Nor could they have imagined the predicament that future political and industrial leaders would find themselves in. Today we have a situation where the growth in consumer wireless technology has created some of the biggest and most profitable companies in the world. This technology has quickly become an integral part of our economy and, lately, one of the few reliable growth sectors. Wireless is also an incredibly popular technology that much of the population loves and is addicted to.5 This is primarily because of the convenience and the fact that people simply enjoy communicating. Plus, it provides immense tax revenue and surveillance capabilities to the government through data collection. For all of these reasons, there is no politician or industry leader who will be able to admit the safety standards do not protect the public because they are not designed for the exposures we experience today.

The study of the biological effects of electromagnetic fields is a very complicated arena. It takes researchers who understand complex biological processes as well as the physics and engineering of electromagnetic fields. When studies find biological effects, they must then be replicated, but if just one parameter is changed slightly, the biological effect can be lost. Parameters include frequency, pulsation patterns,6 power, polarization7 , and whether windows exist where effects can be more significant at lower power levels. Additionally, the funding to repeat studies is often not available, especially when almost all funding for this type of research comes from industry sources that may not want results that could hurt their profits.8 One of the first persons to discover the biological effects of non-thermal microwave radiation was Dr. Allan Frey. In 1975, he found that microwave radiation opened the blood brain barrier of rats, which is very similar to that of humans.9 This experimental result has been repeated in subsequent studies10, 11 and is of great concern because the blood brain barrier plays a vitally important role in the protection of the brain from pathogens, toxins, and heavy metals. Many other biological effects of non-thermal EMFs have been found over time.12 They include sperm damage, nervous system disruption, cardiac/ECG changes, endocrine system malfunction, increased brain glucose levels, behavioral changes, and acute symptoms such as headaches, insomnia, tinnitus, difficulty concentrating, and fatigue. In all, over 100 non-thermal biological effects have been documented in thousands of studies on this subject.13 As might be expected, there are also many thousands of studies that show no biological effects from electromagnetic fields.14 One of the most disconcerting effects of non-thermal microwave radiation is DNA damage. The reason is obvious: DNA damage can lead to cancer and this critical outcome would require authorities to take action. The European Union funded REFLEX-Study looked at this exact issue. The 2004 study was coordinated by Dr. Franz Adlkofer in Vienna

and the published results were very concerning for the cell phone industry and the public.15 The data showed that cell phone radiation caused DNA damage.16 This was obviously quite a surprise as it had been previously thought that non-ionizing radiation could not cause DNA damage because it was not strong enough to knock an electron off a molecule. Not surprisingly, the study was quickly attacked and a leading industry-friendly scientist, Dr. Alexander Lerchl, stated that the data must have been faked. The resulting media storm and pressure on the researchers and their universities diminished the impact of Dr. Adlkofer's study and prevented the use of European Union funds to further the research. However, after a full review and investigation, the research results stand and in 2015 the Hamburg District Court in Germany forced Dr. Lerchl to recant his allegations and convicted him of defamation and libel.17

Lerchl made the news earlier in 2015 for another reason. He was the head of a study that was a replica of a 2010 research project18 that found weak 3G cell phone signals promoted tumor growth in mice.19 The positive results of his study were another blow to the cell phone industry. They confirmed that when mice are exposed to a known cancer agent, ENU, in the womb, and then also exposed to 3G cell phone radiation, there was a significant increase in tumor production over the mice that had been exposed only to ENU.20 In a press release from Jacobs University in Bremen, Germany, Dr. Lerchl stated: "Our results show that electromagnetic fields obviously enhance the growth of tumors."21 This is a significant change for a leading scientist who has spent the past couple of decades publicly stating there is no good science showing non-thermal biological effects from electromagnetic fields. However, if research increasingly shows DNA damage and cancer promotion from non-ionizing microwave radiation, what is the biological mechanism? For, without a mechanism, it will be difficult for scientists to fully accept this new paradigm.

In 2013, Dr. Martin Pall, professor emeritus from Washington State University, made a key discovery that helps us to understand this paradigm.22 Through a review of the scientific literature and his own meta-study, he found that one of the primary non-thermal effects of electromagnetic fields is the activation of voltage-gated calcium channels (VGCCs) in the plasma membrane of cells. When electromagnetic fields activate these channels, large amounts of intracellular calcium (Ca2+) are produced. This excess calcium in the cells produces a chain of chemical reactions leading to the production of free radicals and oxidative stress. The free radicals then culminate in DNA damage.23 The diagram, above, shows the basic outline of this mechanism. In short, the excess calcium directly increases nitric oxide (NO) within cells. The increase of nitric oxide can result in therapeutic effects, which is one reason why non-thermal electromagnetic fields are increasingly used in medical therapies. However, nitric oxide can also interact with superoxide (OO-) to create peroxynitrite (ONOO-). It has been found that when peroxynitrite breaks down, it creates reactive free radicals and oxidative stress within cells.24 It is these free radicals and oxidative stress from peroxynitrite that are thought to be the main culprits in causing disease and DNA damage. I encourage you to read Dr. Pall's research papers showing how this knowledge could be used to create technologies that reduce the activation of VGCCs25 and also to watch his presentation at the University of Oslo in Norway.26 In addition, the IEEE Power Electronics Magazine recently published an article on a similar mechanism for biological effects from weak electromagnetic fields.27

We are now at the point where it is no longer tenable for regulatory bodies to claim that non-thermal electromagnetic fields are safe. This is happening simultaneously with the expansion of wireless technology at an unprecedented rate. Unless something is done, within five years much of our

civilization will be filled with levels of microwave radiation that are known to cause disease. In the United States, the one regulatory body that could change the course we are on is the Federal Communications Commission (FCC). This body sets the legal exposure limits. However, its primary objective is actually to increase and monitor the advancement of wireless technology. The health of the public is not its primary concern, nor even its job. This is likely why the FCC only protects the public from thermal exposures. To further complicate this matter, the FCC is believed to be heavily influenced by the wireless industry. In 2015, the Harvard School of Ethics and journalist Norm Alster published a report on this called "Captured Agency."28 Mr. Alster details how the revolving door between the agency and the industry it supposedly regulates is endangering the public. You have to look no further than the head of the FCC, Thomas Wheeler, who was once the top wireless lobbyist in the country. Former FCC commissioners also lead prominent wireless lobbying organizations. It should be noted that Norm Alster wrote about the Dot Com crash and the 2008 Financial Crisis before they occurred. That he would now turn his considerable journalistic abilities toward this issue is very telling. One of the most striking aspects about the FCC is that the agency does not have the expertise to determine the safety of electromagnetic fields. It is legally tasked with one of the most important public safety issues, but essentially takes no responsibility. Instead, it counts on private and semi-private scientific organizations to inform it. These include IEEE, The American National Standards Institute (ANSI), the National Council on Radiation Protection and Measurements (NCRP), and a German chartered NGO called the International Commission on Non-Ionizing Radiation Protection (ICNIRP).29

One of the primary organizations that western governments, including the United States, use to set microwave radiation safety guidelines is ICNIRP.30 However, there is a problem with using private bodies for something as important as public safety. Small, private clubs can be easily manipulated by lobbying and by pressure from industry and military interests. Private organizations can also self-select members who have a certain bias toward EMF science without comment or input from the public. This is a highly undemocratic way to choose the people who are responsible for determining if the technology our children and grandchildren use on a daily basis is actually safe. Prof. Dariusz Leszczynski of Finland is an accomplished RF scientist who has written about the dangers of this situation. He was on the thirty-one member WHO International Agency for Research on Cancer committee that in 2011 determined non-thermal microwave radiation is possibly carcinogenic (Class 2b Carcinogen).31 In a recent article, he noted that the current ICNIRP members and new members coming in for the 2016-20 term are known to have identical opinions on EMF safety:32 •RF-EMF does not cause any health effects. •Human sensitivity to RF-EMF does not exist. •The only biological mechanism for RF-EMF is thermal. •Non-thermal biological effects do not exist. If our safety standards are set by an unaccountable private body made up of members who already have a bias against the considerable science showing detrimental non-thermal EMF biological effects, then it is likely we are setting up for a major health crisis.

What I have shared thus far could be considered the bad news. The good news is that solutions do exist. On a personal level, there are many things you can do to make your home, office, and children's schools safe from an electromagnetic perspective. In the two sidebars accompanying this article, the basic steps you can follow are clearly laid out. By taking these steps, you can begin to minimize exposure levels for you and your family until political will arises to create solutions on a broad scale. Solutions also exist on a societal level and this is where engineers can be of immense value. One of the primary solutions is to wire our society with optical fiber. Using light to transmit data creates no electromagnetic fields, except at the switches. Fiber optics is also "future proof" because it provides nearly unlimited bandwidth. This

will allow technology industries to prosper as bandwidth is no longer a limiting factor. Finding inexpensive ways to bring fiber optics to and within every home will be a boon. Companies are already doing this 33,34,35 and one in Germany and Austria has developed a technology that turns existing copper wiring into fiber optics by extracting the copper and blowing in optical fiber. For now, one of the most important things we can do is to limit the rollout of wireless technology to only necessary applications and in ways that do not directly overexpose humans, especially children. Our carefree expansion of wireless technology must come to an end. A more intelligent way forward is needed if we are to have a technological society that is also safe for humans. I believe that acknowledging the importance of this issue will move our society forward. It will also birth entire industries devoted to creating safer technology. Billion dollar companies can be created in this new frontier. You may already have an idea that will serve the parents who are now demanding safer technology for their children. As engineers, creating a healthy society with incredible technology would be a true paradigm shift and one of our greatest achievements. I hope you will join me in this grand endeavor.

https://www.tbp.org/pubs/Features/Su16Johnson.pdf

EMF Superhero

EMF (Electromagnetic Field) pollution can be very scary. It is somewhat invisible, a bit daunting and may seem more complicated than college calculus.

No wonder most people prefer to keep their heads in the sand. Do not fear though.

As you master each step, you will reduce one of the most potent sources of pollution on the planet. Few people realize it yet, but man-made EMF pollution may be one of the health and environmental crises of the 21st century. It is and will continue to affect nearly every family and community on the planet. The effects are just now starting to appear.

Let's get started….

EMF Superhero Training – Phase 1 (Easy and Effective – Basic Training for EMF Superheroes)

1. **Get Wired: EMF Superhero Rule #1 – Cables are Cool and Wireless is Kryptonite!** We all love the convenience of wireless and Apple likes to make us think cables are out of style. However, here is the deal – an overwhelming majority of the independent science points to the dangers of wireless technology. So, replace cordless phones and wireless baby monitors with wired versions. "DECT" cordless phones and headsets are one of the biggest sources of microwave radiation in a home or office. The same is true for your Wi-Fi router. Turn off your Wi-Fi and run an Ethernet cable from your router to your computer (more on toxic Wi-Fi in Phase 2 of your training). We can have, and will continue to have amazing technological advances – but they will be wired.
2. **Get Smart:** If you have a wireless "smart" meter attached to your home, replace it with a wiser, safer analog meter. Thousands of people in the United States, Canada and Australia have been injured by wireless "smart" meters. Further, "smart" meters are not "green" or environmentally sustainable – no matter how many times the advertising people say it. They constantly emit microwave radiation, which harms all life. How can this be sustainable? They also put "dirty electricity" onto the wiring of our homes (see Phase 2 for more on this).
3. **Get Real:** Cell phones are Kryptonite too! Now, most people love these amazing little devices. They seemingly give us incredible superpowers. However, allow me to let you in on a little secret that every EMF Superhero knows….. cell phones are the cigarettes and asbestos of our time. The Supreme Court knows this. This former wireless industry engineer even knows it. After 10 years of use, the incidence of brain cancer skyrockets – especially if you start using a cell phone as a child or teenager. So, if you must have one, use it rarely and wisely. Here are some important tips:

    - Use speakerphone or an "airtube" headset. Please don't put a cell phone to your head.
    - Primarily use a cell phone for texting and emergency calls. Save voice calls for your wired land line phone or Skype at home.
    - Keep your phone on "airplane mode" most of the time. That way it is not radiating your private parts when in your pocket. EMF Superheroes realize that "smart" phones radiate every few seconds and lessen the chance of our being able to produce little Superheroes.

- Never put an operating cell phone next to your head or reproductive organs. If you would like to train your friends and family to use a cell phone wisely, download this brilliant app to their phones (it even has a parental lock).
- Save high-data activities (videos, music, internet browsing and email) for a wired computer at home. This will greatly reduce the radiation you are exposed to. This also means the little girl living next to the cell phone tower down the road may receive a little less radiation (All EMF Superheroes care about people living next to the cell phone towers. EMF Superheroes also know that cancer clusters are appearing around the world next to cell phone towers).
- Never use a cell phone in your car. The radiation is magnified as the phone searches for the next mast and is reflected by the metal that makes up the vehicle.
- EMF Superheroes know that sacred geometry stickers and pendants, while supposedly providing superpowers, do not protect our brain cells. Don't develop a false sense of security because of them. Distance and shielding are the only known ways to reduce EMF pollution.

EMF Superhero Training – Phase 2 (Bootcamp for EMF Superheroes continues….)

1. Practice Safe PC: Computers are heavy emitters of EMF pollution. No wonder people around the world are starting to get headaches and other health effects when using them. In order to stay healthy when using a computer, EMF Superheroes always do the following:

    - Use an external keyboard and mouse (wired, not wireless). This way your hands and body are farther from the EMF pollution coming from the computer. Here is a guide that I created for this.
    - Place a Defender Pad laptop shield over the main body of the laptop in order to block some of the EMF pollution.
    - Use an older laptop – they emit less EMF pollution than newer models. PC's emit less EMF pollution than Apple computers.
    - Primarily use a laptop on battery power (not plugged-in and charging). This will decrease the EMF pollution that your body receives. You may also want to ground your computer (contact us for more info on this).
    - Use a shield in order to reduce the EMF pollution coming from the computer screen.
    - Never use a tablet (iPad) computer to surf the internet. Tablets only use Wi-Fi (EMF Superheroes know that Wi-Fi is toxic as it messes with our superhero abilities. After all, Wi-Fi is air pollution). Tablet computers constantly emit high amounts of microwave radiation (which damages our cells in ways that won't be seen for years or decades). If anyone you know has a tablet computer, make sure the "airport" or Wi-Fi functions are turned off. If your child's school wants every student to use a tablet computer – be an EMF Superhero and explain to them how dumb and shortsighted this idea is!
    - Use a wired external keyboard and mouse.
    - Use your computer strategically. Most people love Facebook, but it keeps us glued to the computer. Limit your computer use. Take frequent breaks. Go for long, slow

walks. Your nervous and immune systems will thank you. Your Superhero abilities will increase.

- If you are a writer or spend a lot of time writing, do most of your typing on an AlphaSmart 3000. These electronic keyboards emit almost zero EMF pollution, so you can type all day without headaches and then transfer the file to your primary computer.
- Connect to the internet with an Ethernet cable, not dangerous Wi-Fi. When you use Wi-Fi to connect to the internet, you are subjecting your brain and body to microwave radiation.

2. **Just Say No To Wi-Fi:** EMF Superheroes know that Wi-Fi is so 2013. Wired solutions are the future. If you really want to be high-tech, go completely wired in your home by turning off your Wi-Fi. You can run Ethernet cables to your computers. There are even technologies, such as D-Lan in Europe, where every electrical outlet in your home is wired to the internet. Important note for EMF Superheroes: If someone in your household is addicted to their beloved Wi-Fi and is not quite ready to quit cold turkey, then at least turn it off at night and when not in use. A timer is good for this (like the one used for Christmas lights). You can also put a microwave radiation reducing silver scarf over the router.
3. **Sleep Sound:** Superheroes need their beauty rest and they know that EMF Pollution affects melatonin production at night. One of best ways to sleep deeper is to have your bedroom completely free of EMF pollution. In addition to turning off all wireless devices in your home, remove and unplug all electrical devices from your bedroom. A battery-powered alarm clock is all you need (preferably not an iPhone, but if you must, be sure to keep it on "airplane" mode all night). One of the best things you can do is turn off the circuit breaker to your sleeping area. This will cut off the flow of (dirty) electricity through your bedroom walls at night. Try it – you might have the best sleep in years!
4. **Clean House:** Electricity today is now extremely "dirty". Thanks to the "smart" grid, wireless "smart" meters and all the digital devices we plug into our electrical wiring, basic electricity now produces radio-frequency radiation throughout our homes. It radiates from every wire within the walls of your home, which can cause headaches, insomnia and a myriad of health problems. EMF Superheroes know this is a huge issue and some use filters as a temporary solution. Some of the best "dirty" electricity filters can be found here. These filters are also excellent. Note that filters do not always help some electro-sensitive individuals, so test them for yourself before buying dozens. Ultimately, we will have to force the utility companies to clean up their act!
5. **See the Invisible:** You may want to hire an EMF professional to come over and measure things (highly recommended – contact us for a list of qualified professionals). However, EMF Superheroes also take matters into their own hands. Seeing and hearing is truly believing, so you must get a measurement device.

EMF Superhero Training – Phase 3 (This is where you truly become an EMF Superhero. If you have children, an electro-sensitive person in your life or care about your community and the planet, then these are the steps for you).

1. **Find the EMF Villains Near You:** No, we are not talking about your local Public Utility Commission (although they are high on the list thanks to their love of "smart" meters). We are

talking about cell phone towers! They are the toxic smokestacks of our time – spewing microwave radiation 24/7. This website shows the cell towers near you and is usually quite accurate. However, it cannot keep up with the myriad of new transmitters being installed every day by cell phone and utility companies (thanks to the infrastructure needed for millions of wireless "smart" meters). Unfortunately, any telephone pole on your street could host a wireless transmitter, which could be right outside your bedroom window. Walk around your neighborhood with your measurement device to get a truly accurate picture.

2. **Bed Canopies for EMF Superheroes:** Every EMF Superhero needs a protection at night. If you live near a wireless transmitter or cell phone tower, we highly recommend that you sleep under a bed canopy that acts as a protection shield and blocks out most of the microwave radiation (this is especially important for children and electro-sensitive individuals). Here are the best bed canopies available. Unfortunately, some people have no choice but to move away from cell phone towers because the wireless industry lobbyists snuck a rider into the 1996 Telecommunications Act that made it illegal to sue a wireless company because they destroyed your health. EMF Superheroes know this law is unconstitutional and must be overturned! Watch this video to learn more:
3. **Shields and EMF Superhero Capes:** If you are unable to fly away like other Superheroes or simply do not want to move, you can shield your home with EMF blocking paint, window shielding and other fabrics . It is vital for your long-term health that your sleeping rooms have low EMF pollution. Dr. Dietrich Klinghardt found that women who sleep in a high EMF environment either are not able to conceive or have a high risk of having an autistic child. The combination of bed canopies, shielding materials and turning off the electricity to your bedroom at night will greatly reduce the EMF pollution you are subjected to while you sleep (this is the critical time each day when your body heals itself).
4. **Strike Back:** If you got this far, you are a true EMF Superhero! It is time for you to take your new superpowers and go help the world. Find a way to raise awareness about EMF pollution. Share this page on Facebook and Twitter. Organize parents to demand that your children not be subjected to Wi-Fi all day, every day, at school. Get all your neighbors to turn off their Wi-Fi at night and opt-out of the "smart" meter program. Organize a protest around a local cell phone tower. Go make some news! Show your new EMF measurement device to family and friends. Some will even pay you to measure their home. Once people see EMF pollution with their own eyes, they will be your supporter. You will be their EMF Superhero!

You can be an EMF Superhero too. The world needs you!

https://www.emfanalysis.com/emf-superhero/

Case Study: Actual Measurements, Interpretation, and Comparison of RF Radiation Exposures

Radiofrequency Levels: *Units in* mW/m^2

No Concern: less than 0.0001	Slight Concern: 0.0001 – 0.0100	Severe Concern: 0.0100 – 1.0000	Extreme Concern: Over 1.0000

Biological effects have been observed down to very low exposure levels!

**1 mW/m² = 0.1 μW/cm²*

Power Density (mW/m^2)*	Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure (All At Exposure Levels the FCC tells us are "safe")
0.000000000001	Super-low intensity RFR effects at MW resonant frequencies resulted in changes in genes; problems with chromatin conformation (DNA)
0.00000000005	Changed growth rates in yeast cells
0.0034	Chronic exposure to mobile phone pulsed RF significantly reduced sperm count
0.005	RFR decreased cell proliferation at 960 MHz GSM 217 Hz for 30-min exposure
0.006 - 0.128	Fatigue, depressive tendency, sleeping disorders, concentration difficulties, and cardiovascular problems reported with exposure to GSM 900/1800 MHz cell phone signal at base station level exposures.
0.03 - 0.2	In children and adolescents (8-17 yrs.) short-term exposure caused headache, irritation, concentration difficulties in school.
0.03 to 0.5	In children and adolescents (8-17 yrs.) short-term exposure caused conduct problems in school (behavioral problems)
0.05	In adults (30-60 yrs.) chronic exposure caused sleep disturbances, (but not significantly increased across the entire population)
0.05 - 0.4	Adults exposed to short-term cell phone radiation reported headaches, concentration difficulties (differences not significant, but elevated)
0.06 - 0.1	Chronic exposure to base station RF (whole-body) in humans showed increased stress hormones; dopamine levels substantially decreased; higher levels of adrenaline and nor-adrenaline; dose response seen; produced chronic physiological stress in cells even after 1.5 years.
0.1 - 1.1	RFR from cell towers caused fatigue, headaches, sleeping problems
0.1 - 0.5	Adults (18-91 yrs.) with short-term exposure to GSM cell phone radiation reported headache, neurological problems, and sleep and concentration problems.
0.05 - 0.4	Adults exposed to short-term cell phone radiation reported headaches, concentration difficulties (differences not significant, but elevated)
0.15 – 2.1	Adults exposed to short-term GSM 900 radiation reported changes in mental state (e.g., calmness) but limitations of study on language descriptors prevented refined word choices (stupefied, zoned-out)
0.5 - 1	RFR linked to adverse neurological, cardio symptoms and cancer risk
0.5 - 1	RFR related to headache, concentration and sleeping problems, fatigue
0.7 - 1	Sperm head abnormalities in mice exposed for 6-months to base station level RF/MW. Sperm head abnormalities occurred in 39% to 46% exposed mice (only 2% in controls) abnormalities was also found to be dose dependent. The implications of the pin-head and banana-shaped sperm head. The occurrence of sperm head observed increase occurrence of sperm head abnormalities on the reproductive health of humans living in close proximity to GSM base stations

	were discussed."
1	EEG brain waves are altered when exposed to cell phone signal
1.3	RFR from 3G cell towers decreased cognition, well-being
1.6	Motor function, memory and attention of school children affected (Latvia)
3.8	RFR affected calcium metabolism in heart cells
1.68 - 10.53	Irreversible infertility in mice after 5 generations of exposure to RFR from an 'antenna park'
2 - 80	RFR caused a two-fold increase in leukemia in children
2 - 80	RFR decreased survival in children with leukemia
2.1 - 12.8	Adolescents and adults exposed only 45 min to UMTS cell phone radiation reported increases In headaches.
5	Significant degeneration of seminiferous epithelium in mice at 2.45 GHz, 30-40 min.
5 - 10	Wi-Fi level laptop exposure for 4-hr resulted in decrease in sperm viability, DNA fragmentation with sperm samples placed in petri dishes under a laptop connected via WI-FI to the network.
8 - 100	RFR caused emotional behavior changes, free-radical damage by super-weak MWs
10	RFR induced pathological leakage of the blood-brain barrier
10	RFR caused significant effect on immune function in mice
10	RFR affected function of the immune system
10	Short-term (50 min) exposure in electrosensitive patients, caused loss of well-being after GSM and especially UMTS cell phone radiation exposure
12.5	RFR exposure affected kidney development in rats (in-utero exposure)
13 - 57	RFR associated with a doubling of leukemia in adults
15	RFR reduced memory function in rats
20	RFR induced double-strand DNA damage in rat brain cells
20 - 40	Direct effect of RFR on ion channels in cells/opening of acetylcholine channels
20 - 40	Altered cell membranes; acetylcholine-induced ion channel disruption
24	Interference with medical devices at least up to 1000 MHz
25	RFR affected calcium concentrations in heart muscle cells
40	RFR caused changes in hippocampus (brain memory and learning)
40 - 100	Visual reaction time in children is slowed/lower memory function in tests
40 - 150	Memory impairment, slowed motor skills and retarded learning in children
50	RFR caused drop in NK lymphocytes (immune function decreased)
52.5	20 minutes of RFR at cell tower frequencies induced cell stress response
50 - 100	RFR caused impaired nervous system activity
60	RFR induced DNA damage in cells
87.5	RFR at 900 MHz for 2-12 hours caused DNA breaks in leukemia cells
100	Significant differences in visual reaction time and reduced memory function
100	Changes in behavior (avoidance) after 0.5 hour exposure to pulsed RFR
100 - 250	Changes in the hippocampus of the brain
100 - 1000	Increased risk in radar operators of cancer; very short latency period; dose response to exposure level of RFR reported.
125	RFR caused calcium efflux in cells - can affect many critical cell functions
135	RFR affected human lymphocytes - induced stress response in cells

200	Increase in serum cortisol (a stress hormone)
282	RFR increased free radical production in rat cells
375	Immune system effects - elevation of PFC count (antibody producing cells)
450	Pulsed RFR affected serum testosterone levels in mice
500	Cell phone RFR caused a pathological leakage of the blood-brain barrier in 1 hour
500	An 18% reduction in REM sleep (important to memory and learning functions)
600	RFR caused structural changes in cells of mouse embryos
600	Pulsed RFR affected immune function in white blood cells
600	Cortex of the brain was activated by 15 minutes of 902 MHz cell phone
650	RFR affected genes related to cancer
925	RFR caused genetic changes in human white blood cells
1000	Changes in immune function
1000	A 26% drop in insulin
1000	A 24.3% drop in testosterone after 6 hours of CW RFR exposure
1200	A pathological leakage in the blood-brain barrier with 915 MHz cell RF
5000	Intestinal epithelial cells exposed to 2.45 GHz pulsed at 16 Hz showed changes in intercellular calcium.
5000	A 24.6% drop in testosterone and 23.2% drop in insulin after 12 hrs. of pulsed RFR exposure.

Government regulations do not protect us!

Power Density (mW/m^2)	Standard/Regulation
5300 - 6000	Limit for uncontrolled public exposure to 800-900 MHz (ANSI, IEEE, FCC)
10000	PCS STANDARD for public exposure (as of September 1,1997)
50000	PCS STANDARD for occupational exposure (as of September 1, 1997)

The BioInitiative Report [(2012)] recommends exposure no higher than $1mW/m^2$ – 10,000 times lower than current US FCC standards ($10,000\ mW/m^2$)

Ambient background levels of RF radiation

0.03	Background RF levels in US cities and suburbs in the 1990s
0.5	Median ambient power density in cities in Sweden (30-2000 MHz)
1 - 100	Ambient power density within 100-200' of cell site in US (data from 2000)

How Much Radiation Are You Being Exposed To?

**The Cornet ED88T meter used is only capable of measuring exposure levels up to 1827 mW/m^2 – therefore, readings of 1827 indicate that the meter was maxed out and actual RF levels were likely much higher.*

Because computers connected via Ethernet cable (most desktops PCs), corded landline telephones, and incandescent light-bulbs do not emit any microwave radiation, they were not measured. Devices in Airplane Mode also generally do not emit any microwave radiation. Notice how much radiation levels decrease as distance increases.

		Max Power Density (mW/m^2)		
	Distance from Emissions:	~ .1"	~ 1'	~ 6'
GE Microwave Oven (heating one cup of water)		1827*	1827*	178.6
Apple iPad Air	Wi-Fi – streaming video	258.1	9.81	1.555
	Wi-Fi, Bluetooth – streaming video	325	10.27	1.629
	Wi-Fi, Bluetooth	270.3	5.034	1.451
	Wi-Fi	240.9	4.384	1.207
	Bluetooth	57.8	2.05	1.294
NETGEAR Nighthawk Wireless Router		874	364.7	98.1
NETGEAR AC Series SMART Wi-Fi Router		428.5	33.26	5.78
AT&T DECT Cordless Phone Base Station		1827*	63.3	26.42
AT&T DECT Cordless Phone	Standby	0.24	0.0727	0.4092
	Connecting (Dialing)	1827*	53.94	1.827
	Connected	1827*	83.5	3.564
AT&T Digital Life Wireless Security System Base Unit (3G)		191.4	21.97	2.098
CFL Light-Bulb		0.2642	0.1555	0.1127

LED Light-Bulb		0.1386	0.1153	0.0981
CISCO Wireless Access Point	E006	409.2	24.09	0.3999
	E008	240.9	23.01	0.633
	E010	123.5	6.94	0.141
	E102	178.6	6.33	0.2409
	F120	178.6	2.831	0.5271
Apple TV	Wi-Fi	19.14	0.1153	0.258
	Wi-Fi, Bluetooth	619	10.04	1.264
	Wi-Fi, Bluetooth, Air-Play	1451	2.581	1.745
iPhone 5	Wi-Fi	33.26	0.916	0.2301
	Bluetooth	27.66	20.98	0.1355
	Wi-Fi, Bluetooth	53.94	20.5	0.1051
	Wi-Fi, making call	1153	4.092	8.54
	Bluetooth, making call	1827*	6.94	0.1324
	Wi-Fi, Bluetooth, making call	1827*	6.94	0.1324
Samsung Galaxy Note 5	Wi-Fi	20.04	2.004	0.325
	Bluetooth	874	12.64	0.0895
	Wi-Fi, Bluetooth	428.5	1.386	0.1355
	Wi-Fi (playing video)	13.24	2.301	0.4486
	Wi-Fi, Bluetooth (playing video)	17.45	2.581	0.578
	Wi-Fi, making call	409.2	3.564	0.3176
	Bluetooth, making call	515.1	7.61	2.831
	Wi-Fi, Bluetooth, making call	539.4	4.285	0.619
iMac	Wi-Fi	11.27	0.4285	0.0779
	Bluetooth	2.197	0.874	0.1264
	Wi-Fi, Bluetooth	20.5	1.745	0.2642
	Wi-Fi (playing video)	16.67	0.578	0.0527
	Wi-Fi, Bluetooth (playing video)	10.76	0.727	0.1264
Apple Bluetooth Keyboard	Passive	3.483	0.2766	0.0874
	Active Use	6.63	0.23	0.0527
Apple Bluetooth Mouse	Passive	3.483	0.2642	0.0779
	Active Use	7.97	0.2831	0.1355

MacBook	Wi-Fi	79.7	5.78	2.897
	Bluetooth	0.895	0.0711	0.039
	Wi-Fi, Bluetooth	42.85	0.779	0.1235
	Wi-Fi (playing video)	3.819	0.0491	0.0258
	Wi-Fi, Bluetooth (playing video)	3.483	0.2409	0.1101
Chromebook	Wi-Fi	2.197	0.4807	0.1127
	Bluetooth	1.418	0.0694	0.0459
	Wi-Fi, Bluetooth	2.248	0.1294	0.2301
	Wi-Fi (playing video)	17.45	0.399	0.0874
	Wi-Fi, Bluetooth (playing video)	10.51	0.194	0.0428

Severe Concern *Extreme Concern (>1)*

**This guide is not a replacement for medical advice. If you think you may be electrohypersensitive, see a doctor or professional immediately. Radiation was not measured in a 100% stable environment. You should hire a professional EMF expert for more accurate recordings. Radiation was measured using a Cornet ED88T Electrosmog meter, which can be purchased at www.stopsmartmeters.org/store/*

Comparing Wireless Device Emissions to Scientific Research

Radiation Levels (mW/m^2)		Researcher	Year
10000	**FCC Exposure Guidelines, 30 min. public exposure, based solely on thermal effects**	**FCC**	**1996**
500	**2 feet from a microwave oven**		
90	**iPads and Wi-Fi enabled laptops – direct body contact**		
60	DNA damage in cells	Phillips	1998
52.5	Induced stress response	Kwee	2001
50	**2 feet from a DECT cordless phone base station, Wi-Fi router, or Wi-Fi enabled iPad**		
50	Impaired nervous system activity	Dumansky	1974
50	Drop in NK lymphocytes (immune function decreased)	Boscolo	2001
40	Slowed memory and altered immune function in children	Chiang	1969
40	Changes in hippocampus (part of brain that controls memory, learning)	Tattersall	2001
30	Irreversible infertility in mice (3 generations)	Magras	1997
22	**2 feet from a Wi-Fi enabled laptop**		
20	Double-strand DNA damage	Kesari	2008
13	Twice the rate of leukemia in adults	Dolk	1997
12.5	Affected kidney development	Pyrpasopoulou	2004
10	Headaches, dizziness, irritability, fatigue, weakness, insomnia, chest pain, difficulty breathing, indigestion	Simonenko	1996
10	Affected functions of immune system	Novoselova	1999
8	Emotional behavior changes (free-radicals)	Akoev	2002
6	Change in calcium ion efflux from brain tissue	Dutta	1986
5	**10 feet from a smart-meter**		
5	Decreased sperm motility and increased DNA fragmentation	Advendano	2010
3.8	Affected calcium metabolism in heart cells	Schwartz	1990
3.5	Pathological leakage in blood-brain barrier	Salford	2003
3	Affected neurological system, brain function	Vorobyov	2010
2.2	Reduced density and number of young in bird populations	Balmori	2009
2	Decreased survival in children with leukemia	Hocking	2000
2	Twice the rate of leukemia in children	Hocking	1996
1.7	Irreversible infertility in mice (5 generations)	Magras	1997
1.6	Negatively affected memory, attention, motor function of schoolchildren	Kolodynski	1996
1.5	Reduced memory function	Nittby	2007
1.3	Decreased cognition, well-being	Zwamborn	2003
1	**10 feet from a DECT cordless phone base station or Wi-Fi router**		
0.7	Sperm head abnormalities in mice	Otitoloju	2010
0.638	Decreased cognitive function	Papageorgiou	2011
0.6	Slowing of heart, change in EEG	Serkyuk	1980

0.5	400 yards from a cell tower		
0.5	Adverse neurological, cardiovascular symptoms and cancer risk	Khurana	2010
0.5	10x increased risk of cancer in women, with short latency	Wolf	2004
0.4	10 feet from a Wi-Fi enabled laptop		
0.3	Headaches, memory changes, depressive symptoms, sleeping problems	Rassoul et al.	2000
0.1	Behavioral disruption	Navakatikan	1994
0.1	Significant increase in breast cancer and brain tumors	Oberfeld	2008
0.1	Fatigue, headaches, sleeping problems	Navarro	2003
0.05	Headaches, fatigue, cardiovascular issues	Kundi	2009
0.05	In adults 30-60 yrs., chronic exposure caused sleep disturbances	Mohler	2010
0.03	In children and adolescents 8-17 yrs., behavioral problems in school	Thomas	2010
0.03	In children and adolescents 8-17 yrs., headaches, irritation, concentration difficulties in school	Heinrich	2010
0.02	Sleep disorders, abnormal blood pressure, nervousness, fatigue, joint pain, digestive disorders, fewer schoolchildren promoted	Altpeter	1995
0.006	Fatigue, depressive tendency, sleeping disorders, concentration difficulties, cardiovascular problems	Oberfeld	2004
0.005	Decreased cell proliferation	Velizarov	1999
0.003	Significantly reduced sperm count	Behari	2006
0.000001	Natural Environment – Low Radiation		

https://wirelessaction.files.wordpress.com/2016/09/wa_rf-radiation-guide1.pdf

Digital Utility Meters ("Smart" Meters)

Smart meters and cell damage from pulsed EM radiation - our health at risk?

11th April 2017

'Smart meters' looked like a great idea, writes Lynne Wycherley, giving us more control over our energy use. The downside? They emit as many as 14,000 short bursts of intense microwave radiation a day, disrupting cellular electrochemistry and causing health symptoms from migraine to tinnitus, insomnia, dizziness, anxiety, chest pain, palpitations and memory loss. Now a growing number of 'electro-sensitives' have had enough!

"Smart meters' should be abolished because they use short high-intensity pulses of microwave radiation. We know from the nanosecond studies these can be very damaging with calcium channel activation continuing long after the pulse has ceased."

As early as 2012, environmental health Professor David Carpenter, founder of Albany School of Public Health, and author of 370 peer-reviewed publications, issued a public letter on the plausible toxic risks of intensive, pulsed-microwave smart metering.

His letter Smart-meters: Correcting the Gross Misinformation was rapidly signed by 50 international health experts.

"We, the undersigned ... have co-authored hundreds of peer-reviewed studies on the health effects of electromagnetic fields (EMFs) ... Mass deployment of smart grids could expose large chunks of the general population to alarming risk scenarios ...

"More than a thousand studies done on low intensity, high frequency, non-ionizing radiation going back at least fifty years, show ... biochemical changes which ... may lead to diseases."

Noting, among other risks, the free-radical / cellular / genetic harm recorded in many recent papers on wireless exposure - and the relative potency of smart-meters' pulses - he adds: "Prolonged exposure ... may eventually lead to cellular malfunction ... With both cell towers and smart meters, the entire body is immersed by microwaves."

Though his letter needs updating (see Belpomme, for example, below) he and his signatories are correct in signaling that all of us in the Green movement - activists, politicians, energy suppliers, families - have been given a sanitized version of long-term EMF health risks, including from high-density smart metering. At worst, equivalent to Big Tobacco's "smoke it baby! there are no risks!"

The International Appeal to the United Nations

Though there is no world consensus on the degree of risk arising from pulsed-microwave pollution (RF-EMFs), it is salutary that most independent EMF scientists are voicing caution. And their numbers are rising rapidly.

In an unprecedented step, 190 precautionary scientists launched an appeal to the United Nations (2015, ongoing) to seek progressive, healthy alternatives to high-SARS phones / tablets and the piercing pulsed microwaves from smart meters, plus similar rollouts.

"Now is the time to ask serious questions about this emerging environmental health crisis", their video warns, before offering some strong medicine:

"We have created something that is harming us and it is getting out of control! ... Wireless utility meters, and cell towers, are blanketing our neighborhoods with radiation... BIOLOGICAL facts are being ignored ... International standard setting bodies are not acting to protect the public's health." [Emphasis as per the published transcript]

In its call for cleaner, safer, ways forward, the International EMF Scientist Appeal is undeniably 'Green'. Yet how many of us are fully aware of its call? Today, it carries 224 signatories from 41 nations; all have peer-reviewed research in the field, and none - to their credit - have been cowed or co-opted by the multi-billion dollar Big Telecoms industry: a colossus whose turnover has begun to rival that of fossil fuels.

Standard-setting bodies with documented conflicts of interests, meanwhile, continue to stifle reform - not least in the UK: see the shocking exposé of AGNIR, for example, by UK neuroscientist Dr. Sarah Starkey. Plus French documentary *Microwaves, Science & Lies*, and the recent letter of no confidence in the EMF wing of the World Health Organization.

People testifying to harm

Within months of PG&E's (Pacific Gas & Electric) Californian smart-meter rollout, over 2,000 health complaints were filed. Harsh headaches, dizziness, tachycardia, insomnia, tinnitus; in desperation, some householders fled their homes, while others slept in their cars.

Let's not forget that PG&E is the energy giant first exposed by Erin Brockovich for dumping hexavalent chromium.

As wave after wave of people have attested to similar problems from US and Canadian rollouts - many testifying to no prior inkling of smart-meter problems (as here /here) - court cases have arisen. Biophysics professor Andrew Marino, an authority on physiological reactions to 'weak' EMFs, gave lengthy evidence in defence of impacted residents.

Eviscerating outdated exposure standards, he concluded "coercing the complainants to endure... such exposure ... amount[s] to involuntary human experimentation." In addition health risks from "the type of electromagnetic energy emitted from smart meters ... are heightened in the very young, the very old, and in those with pre-existing diseases and disorders."

Case histories, echoing others around the world, include, for example, 84-year old Dr. Georgetta Livingstone (Michigan). When her meter was fitted, she was hit by unexpected sharp pains in her body, headaches, violent head-to-toe rashes, insomnia, intense itching, depression and anxiety. With no remission, it seems, until her meter was finally removed. (Notice Professor O Johansson: skin reactions to EMFs). Such testimonies, however contested, may offer us helpful clues.

IT professionals are among those testifying to impacts. Silicon Valley consultant Jeromy Johnson (see his TED talk) and his wife, a GP, were axed by headaches, insomnia, and palpitations.

In Smart meters, the opposite of green, hosted by Green editor Rob Sidon, Johnson notes that if we connect everything wirelessly to smart meters we risk "filling our homes, our children, and ourselves" with RF microwaves emerging as subtly bioactive. (See, e.g., harm to insects from all 'weak' sources tested: Margaritis et al 2013). "How can a technology be considered sustainable if its byproduct harms not only humans but plants, insects and animals?"

Problems have also emerged in Australia, and beyond. In her peer-reviewed paper, Dr. Federica Lamech, GP (Victoria), shares 92 in-depth patient case histories. Smart meters, it seems, were 'the last straw' in wireless exposure, tipping them into full-blown electrosensitivity - a syndrome now hallmarked, it seems, by toxic and inflammatory biomarkers, and impaired brain blood-flow (Belpomme 2015-2016: nearly 700 lab-verified cases, Paris).

Lamech herself was stricken "with palpitations, chest pain, insomnia, dizziness, inability to concentrate, memory loss and fainting spells. I [later] found out it was [when] the smart meters were remotely turned on."

Professor Dariusz Leszczynski, biochemist, notes it is normal to have a bell-curve of responses to environmental toxins, and pulsed RF, his field, is no exception. If so, how can we, as Greens, find ways to support the human rights of adults / children at the 'unlucky' end of the spectrum?

Dr. Isaac Jamieson, who advises the EU on bio-sustainability, analysed (1, 2,) how Big Energy smart-metering can infringe the Universal Declaration of Human Rights, especially birthright to health.

Eyes on stalks: the corporate hijack of smart-metering

According to multi-award-winning health documentary Take Back Your Power, Big Energy may have hidden drivers for smart-metering. Filmed in Canada and the USA, this deeply humanitarian film, best seen in full [here], reveals how Green aims can sadly become co-opted and perverted. In a race "to monetize the data", a focus on the bottom line is sweeping injured families aside.

Director Josh del Sol told me, based on his long research, "with more than 5,000 technology patents muffled by the USPTA ... new, decentralized, clean energy technologies are in fact being artificially-blocked from market proliferation." TNCs "are hijacking the good intentions of environmentalists everywhere ... with a profit potential (for them) in the trillions."

Notice, for example, this big-client marketing by Onzo (2017): "We take data from smart meters... and build a highly personalized profile for each and every utility customer. We then tag this profile with key behavioral, attitudinal and lifestyle characteristics ... We even tag appliances that we see being used in the home. .. giving [you] the ability to monetize [your] customer data by providing a direct link to appropriate third party organizations."

Hidden risks to our cells

Dr. Dietrich Klinghardt and team (New Jersey) found striking increases in toxic, inflammatory markers in patients' blood samples - and their asymptomatic spouses - after smart-meter installation. Naturally, this needs wider testing, controlling for any confounding factors, but might there be wider risks, however subtle, at a cellular level?

Professor Martin Pall, a biochemist with 8 international awards, clearly thinks so. In 2013, he won a Global Medical Discovery listing for his landmark paper on a master mechanism of harm from wireless pulsed microwaves: watch his gripping, short talk. Supported by many peer-reviewed papers, it helps to explain the damage (nitrosative / oxidative) to organs and DNA seen in many new studies on Wi-Fi and similar sources.

It's striking that Pall singles out smart metering. *"'Smart meters' should be abolished because they use short high-intensity pulses of microwave radiation. We know from the nanosecond studies these can be*

very damaging and act via VGCC [calcium channel] activation [his research] with activation continuing long after the pulse has ceased ... It has been known for over 30 years that short microwave pulses can cause massive cellular damage." See also his review of pulsed-microwave neurological risks, including from wireless smart meters (2015).

Disturbing toxic 'window effects' have been found at low wireless intensities: co-tumor promotion, for example, from levels comparable to tablets' (Professor Lerchl 2015). While peer-reviewed findings at far lower levels - a clue to life's sensitivity - raise growing questions about microwave-dense 'smart homes' and corporate IoT.

A 2011 study, 'Electromagnetic hypersensitivity: evidence for a novel neurological syndrome' described by DE McCarty et al in the *International Journal of Neurosciences* concluded that *"EMF hypersensitivity can occur as a bona fide environmentally inducible neurological syndrome."*

The single subject was a self-diagnosed EMF sensitive exposed to a 60Hz field of 300V/m in a *"double-blinded EMF provocation procedure specifically designed to minimize unintentional sensory cues"* who *"developed temporal pain, headache, muscle twitching, and skipped heartbeats within 100 s after initiation of EMF exposure ($p < .05$)."*

The authors continue: *"The symptoms were caused primarily by field transitions (off-on, on-off) rather than the presence of the field, as assessed by comparing the frequency and severity of the effects of pulsed and continuous fields in relation to sham exposure. The subject had no conscious perception of the field as judged by her inability to report its presence more often than in the sham control.*

"The subject demonstrated statistically reliable somatic reactions in response to exposure to subliminal EMFs under conditions that reasonably excluded a causative role for psychological processes."

Downplayed pollution; ripples in the UK

When governments or smart-meter manufacturers cite 'compliance', they are referring to widely challenged 'safety standards' based on high microwave levels that cook tissue; all risks from lower exposures - growing annually in peer-reviewed literature - are air-brushed away.

Output is often time-averaged, disguising the microwave pulse-intensity, allowing some misleading comparisons with cell-phones: see industry whistle-blower Diana Ostermann and Dr. Karl Maret. Sporadic uploads to masts (WAN) can be cited without mentioning the all-hour house-piercing 'spikes' [here] - every two seconds, in the case of tested British Gas meters.

Dr. Andrew Tresidder, GP, perceives medical risks (ditto Dr. Liz Evans GP): *"some have 14,000 very high intensity spikes per day. Biologically, 14,000 screams are not silence!"* Data obtained by a Californian court revealed, for example, 9,600 spikes per day, rising up to 190,000.

Dr. Andrew Goldsworthy, a senior EMF biologist, advised Parliament that permanent exposure *"without the fully informed consent of the people affected is in contravention of the Nuremberg code".* Contrast this to Big Energy's all-soothing, all-cosy smart meter adverts, and questions of ethics hit home.

As Greens, we may have missed these aspects. Governments, in Rachel Carson's words, have fed us *"little tranquilliser pills of half truth".* Can we catch up with the rapidly growing precautionary science? In all conscience, how many households may be struggling with hidden impacts?

With no clue that the meters (though not a full-blown mesh network, UK) may be a plausible risk factor, particularly if by children's bedrooms or banked in flats? *(See **Notes** for emerging case histories)*.

Kilohertz voltage-spikes from smart meter's switched-mode power (lay measurements here) can add to EMFs in homes, and raise other potential health questions (see Dr. David Carpenter), even - unfortunately - in wired smart-meters.

Under revised EU energy rules, meanwhile, some countries have waived smart-metering as cost-ineffective. Overseas, fires have prompted some large recalls.

A potential creeping stress on trees?
In last year's peer-reviewed research paper revealing phone-mast microwave damage to trees - even, in cases, at two miles - the authors noted *"this constitutes a danger to trees worldwide".* Might wireless smart grids exacerbate this? Notice Professor C Georgiou's work on EMF free-radical risks to plants, and Haggerty 2010 on aspen seedlings sickened by background RF.

Civilian researchers in Monterey (California) recorded unusual bark splits in oaks and pines following the microwave 'smart' grid and Wi-Fi grid switch-on: could this be a theme for eco-research? According (again) to Dr. Andrew Goldsworthy, Imperial College, in *Why Our Urban Trees Are Dying*, our rocketing RF pollution could be a factor in tree disease:

"Trees are now dying mysteriously from a variety of diseases in urban areas all over Europe and are also showing abnormal photoperiodic responses. In addition, many have cancer-like growths under the bark (phloem nodules) and the bark may also split so that the underlying tissues become infected. All of these can be explained as being a result of ... radio-frequency radiation."

Wings for a wiser world
As Greens, we have not always penetrated the emerging risks of dense, pulsed-microwave smart-metering and grids. Nor have we questioned, as fully as we might, other electrosmog raisers, such as LTE, IoT and corporate-proposed 5G. [NEW: see the Environmental Health Trust on 5G and the skin-burning properties of weak millimeter waves.]

Nor have we challenged the deep, pervasive big-industry influences on EMF research, regulation, and 'spin', as exposed in a remarkable new book (just published), *Corporate Ties That Bind: An Examination of Corporate Manipulation and Vested Interests in Public Health.*

But as we catch up with the latest cautioning science, we can begin to expose these dark trends, and the risks and pollution levels they feed. While laying bare the outworn paradigm (denial of all non-heating effects) to which TNCs and governments so scandalously cling.

And on balance, we could begin to initiate healing changes. For though it is challenging to discover that pulsed RF is emerging, by degrees, as subtly bioactive, our Green ethics, our courage, surely enables us to adapt.

Potential solutions, for social and technical visionaries, are legion. From the new, responsive data-over-grid technology, for example, that can manage energy without microwave smart meters. To cleaning up kilohertz EMFs (dirty electricity, also from solar inverters) including, perhaps, the subtly neuro-active frequencies.

To the deep carbon savings of simple energy bill comparison with neighbors, a growing trend. To lending families plug-in energy monitors, perhaps, an alternative to permanent pollution. To conserving wired resources while cleaner technologies evolve. To the inspiring possibilities of data-rich infrared and VLC (Li-Fi / visual light communication) - now found to have useful reflectivity - combined with fiber-optics ... And so on.

Globally, the more we can integrate EMF precautionary science into our daily lives, low carbon strategies, and environmental health awareness, then the more bio-sensitive, and inspiringly fit for the future, we become. So hatching an overdue paradigm - Wings for a wiser world.

http://www.theecologist.org/campaigning/2988831/smart_meters_and_cell_damage_from_pulsed_em_radiation_our_health_at_risk.html

Getting Smarter About the Smart Grid

Abstract

In recent years, the notion of the "smart grid" has emerged—first using information technology as a means of improving electricity reliability—then more recently to improve efficiency, reduce pollution, and to incorporate more renewable generation. But the public face of this smart grid has too often become the deployment of vast networks of remotely readable electric meters by utilities, often with large government subsidies. In the name of the smart grid, billions of taxpayer and ratepayer dollars are being spent on these so-called "smart meters." But now the utilities and their smart meters are experiencing increasing public pushback. In reality, these meters and their dedicated networks are primarily for the benefit of utilities, reducing their operating costs and increasing profits by firing meter readers—ironically with federal stimulus funds—while doing essentially nothing to advance what should be the real goal of the smart grid: balancing supply and demand and integrating more renewable sources. Instead, the meter networks squander vast sums of money, create enormous risks to privacy and security, introduce known and still unknown possible risks to public health, and sour the public on the true promise of the smart grid. This paper examines the technical shortcomings of the smart meter strategy along with its related economic, privacy, security, and potential health risks—explaining why this approach cannot lead to energy sustainability. It analyzes the failures of both federal grid policy and state regulation. It further explores and explains the technical challenges and economic potential of a true smart grid. Finally, it proposes a roadmap for a transformation to a renewable, sustainable electricity economy that could lead the way to a clean energy future.

It is obvious from decades of research on a wide range of frequencies within the radiofrequency (RF) spectrum that EMFs have biological effects, and associated health effects are likely. But the nature and extent of such effects (including cumulative effects) and any associated risk is not clear. Such effects have not been well researched for all frequencies and power densities, including those relevant to smart meters. For example, mobile phone radiation has long been a matter of concern and some scientific controversy. The World Health Organization (WHO) had conducted a study of cancer risk in cellphone users, known as the Interphone Study, begun in the late 1990s and sponsored by thirteen nations, various cellphone manufacturers, and other industry groups (Interphone, 2012).45 WHO has reportedly been assuring consumers that no adverse health effects had been established (Dellorto, 2011). However, in May of 2011, a review of the research by WHO's International Agency for Research on Cancer (IARC) found evidence that mobile phone users display significantly increased incidence of glioma and acoustic neuroma brain cancer (Dellorto, 2011). After reviewing the WHO Interphone Study and other evidence, IARC classified radiofrequency radiation as a Class 2B "possible carcinogen"—thus listing cell phone use, and other RF emitting devices and equipment, in the same "carcinogenic hazard" category as lead, engine exhaust, and chloroform.46

Other criticisms of the Interphone Study have also emerged, including that the evidence for risk may have been understated due to design flaws by as much as 25% (Morgan, 2010).

Then in October, 2011, a large government-funded study by Danish researchers found no increased risk of brain cancer associated with mobile device use, although the study was criticized because "brain tumors can take a long time to develop" (Cheng, 2011), and because of serious design flaws in this ongoing study that would serve to underestimate risk 48 (BMJ, 2012; ElectromagneticHealth.org, 2011; 2011a).

Although both involve microwave frequency radiation, it is difficult to draw a comparison between cellular telephones and smart meters. Cellphones are used intermittently and held close to the head, while (mesh network) meters operate continuously, and the radiation generated may or may not be in close proximity to residents. Moreover, propagation characteristics vary widely. An added complication with cellphone measurements is that newer cellphones employ adaptive power control techniques. This means that actual transmitted maximum power levels can vary over orders of magnitude depending on conditions. Nevertheless, many utility customers in several states have reported a variety of harmful effects including sleep disorders, headaches, nausea, neurological diseases, heart irregularities, cognitive impairment, fetal risks, etc.

Critics of this report responded that it "minimized" some risks and failed to provide modeling or actual measurements of smart meters (Maret, 2011, p. 1), and that "…rather than being an independent science-based study, the CSST [report] largely cuts and pastes estimates from a brochure by the Electric Power Research Institute (EPRI), an industry group, issued some weeks earlier" (Hirsch, 2011, p. 1). Hirsch, a nuclear policy analyst at the University of California, also challenged the report's failure to consider the relative duty cycles of smart meters, cellphones, and microwave ovens, and he contended that the cumulative whole body exposure from meters could actually, under some circumstances, be 100 times higher when appropriate corrections are made.

Other critics of the CSST Report challenge the third and fourth findings (above), i.e., that there is a lack of evidence of non-thermal health effects from RF radiation. The presently accepted measure of EMF dose is the thermally-based specific absorption rate (SAR)—the rate at which electromagnetic energy is absorbed by tissue. Columbia University cellular biologists Blank and Goodman (2012) propose that the SAR value used to set the safety standard for EMF "…fails as a standard for predicting cancer risk…because cancers are believed to arise from mutations in DNA…" They argue that such DNA changes can be induced at electromagnetic radiation levels that are orders of magnitude lower than those observed SAR thermal effects. They propose that changes in DNA induced by interaction with EMF could be a better measure of the biologically effective dose…" They also propose a specific mechanism of non-thermal energy absorption based on the properties of DNA acting as a "fractal antenna" structure with an extremely wide frequency range (Blank and Goodman, 2011).49

Another contrast between cellphones and meters is that cellphone use is optional and under control of those being exposed, whereas smart meters are not.

Olle Johansson, PhD, Associate Professor, Department of Neuroscience, Karolinska Institute in Sweden, and Professor, Royal Institute of Technology, argues that an array of health effects and disorders have been demonstrated to result from non-thermal levels of EMF and that utility meters and other emitting appliances should be hard-wired (Johansson, 2012). 50

Karl Maret, MD, a physician specializing in electrical and biomedical engineering, has similarly argued that EMF health effects are likely and should be mitigated by shifting to hard-wiring meters (Maret, 2012). 51 In recent testimony to the Senate Finance Committee in the Vermont State Legislature, Dr. Maret emphasized the need to hard-wired meters, saying, "With the wired meters our health long-term would be more assured. There would be no radiation whatsoever, and I think that's the core issue here." (Caruso, 2012)

The American Academy of Environmental Medicine (AAEM) adopted a resolution in January 2012 calling for a halt to wireless smart meters based on a review of the scientific and medical literature. The resolution stated, "Chronic exposure to wireless radiofrequency radiation is a preventable environmental hazard that is sufficiently well documented to warrant immediate preventative public health action" (AAEM, 2012, p 1). The resolution affirmed that the FCC guidelines consider only thermal exposures and so are inadequate for application to public health standards.

http://gettingsmarteraboutthesmartgrid.org/pdf/SmartGrid_Report_PDF-2012-11-26-Final.pdf

Electric Smart Meters: Not a Smart Solution for Your Health?

Electric smart meter… Going on just the name, this sounds like something really cool, right?

But just how "cool" are smart meters? Not cool at all actually. While the government and utility companies echo each other on how safe smart meters for electricity are – a growing number of some people are vehemently opposed to a smart meter being installed on their property.

Nomi Davis is one of these people. She resides in Salt Spring Island, Vancouver, Canada, and took out a class action lawsuit against the British Columbia Hydro and Power Authority to demand freedom of choice for all of BC Hydro's customers.

Jennifer Stahl and Malia "Kim" Bendis, two mothers living in Naperville were arrested for trying to stop utility workers and local police from trespassing on their private property in order to install smart meters.

Not just individual homeowners, but entire communities up and down the country and across the globe are up in arms because the electric smart meter roll-out is practically global.

So what's all the fuss about?

What is a Smart Meter?
It's quite simply a type of meter that can be used to measure your electric, gas, or water usage. That all? Not quite. Smart meters have earned the sobriquet "smart" because they send back information on your power consumption to the utility company. The utility companies argue that smart meters enable them to embrace the convenience of technology and the meter man no longer needs to come round to check your water, gas, or electricity consumption.

The truth though is that smart meters may help utility companies save money… but it is at the expense of our health. There are many reasons people are opposed to smart meters:

- they overcharge the consumer
- they broadcast your personal info and detailed energy use habits
- they are a fire risk
- they emit electromagnetic fields (EMFs)

The emission of EMFs is probably the most important issue.

Why Are Smart Meter Dangerous?
Typically, smart meters utilize a form of EMF called radio frequency (RF) radiation to send consumption data back to their main system. This RF radiation, or microwave radiation, is of a similar frequency to that used in cordless phones, cell phones, Wi-Fi routers, and other wireless devices. Even though the smart meter is installed outside your house, this RF radiation can easily penetrate walls and your body too.

Many smart meters emit radiation constantly. The utility company PG&E's own documents reveal that their meters pulse 10,000 times a day. As a result, your body is constantly exposed to this radiation. On a daily basis, your cells go through a natural process of degeneration, production as well as division.

When new cells are produced with damaged DNA molecules and continue to be replicated, health issues such as cancer and long-term gene mutation can occur.

Other health issues that have been conncected with smart meters are:

- learning and memory problems
- difficulty sleeping
- fatigue
- tinnitus
- headaches
- anxiety and depression
- arthritis
- skin reaction
- hyperactivity in children
- neuropathy
- and many more

Electric Smart Meters Create Dirty Electricity

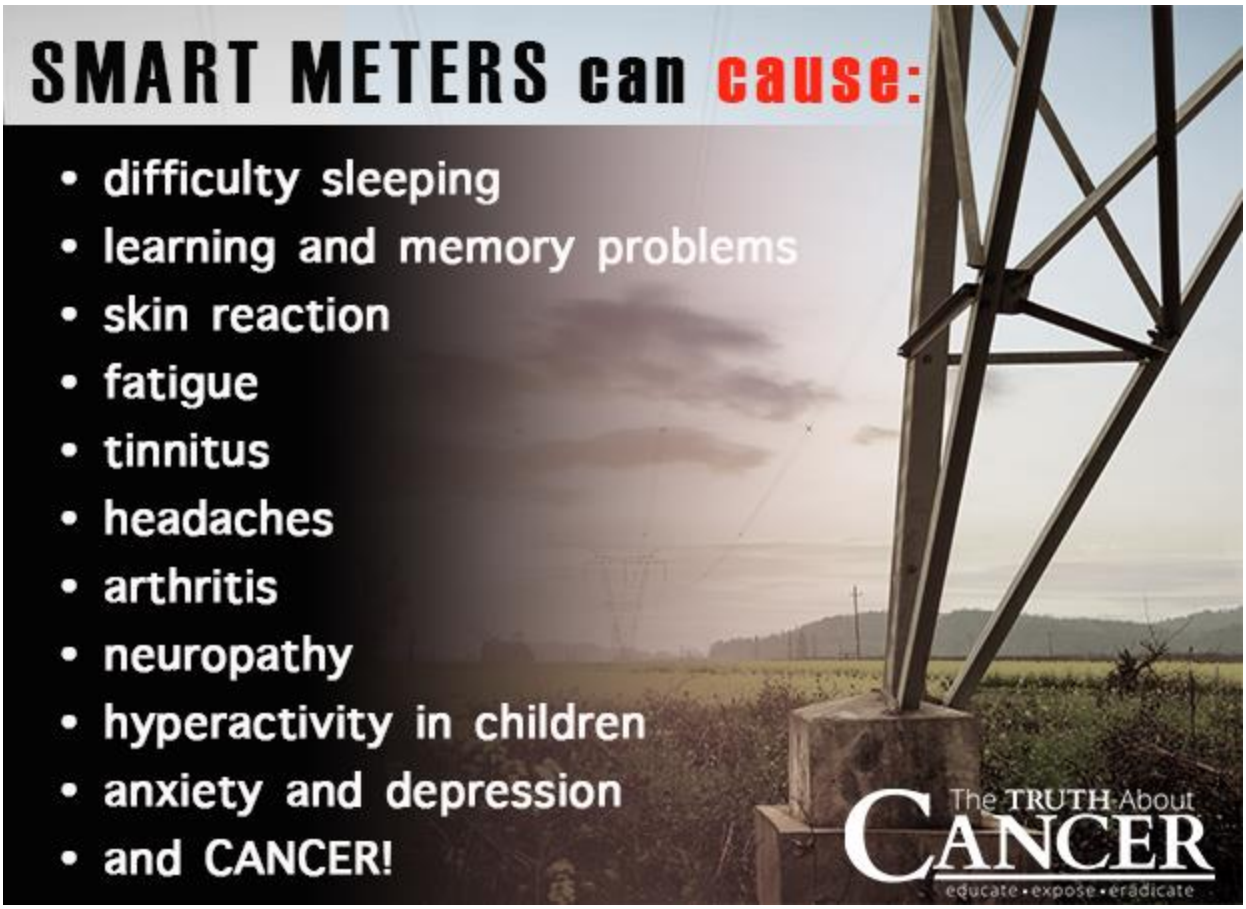
Not all smart meters utilize wireless means to send information back to the utility company. Some use powerline networking. This means that data is sent back on the same wiring line, instead of wirelessly. This creates dirty electricity, a form of electromagnetic pollution which is linked to a long list of diseases.

Even if your smart meter does not use powerline networking it's still very likely that you are being subjected to dirty electricity. This is because most smart meters use switched mode power supply technology in them, which creates dirty electricity.

Smart meters Cause 160 Times More Radiation Exposure Than Cell Phones

Daniel Hirsch, a lecturer and expert in nuclear policy at University of California, Santa Cruz, has studied smart meters. He found that given that smart meters operate 24/7, they emit 160 times more cumulative whole-body exposure than a cell phone.

He states that: *"the cumulative whole body exposure from a Smart Meter at 3 feet appears to be approximately two orders of magnitude higher than that of a cell phone."*



Precautionary Actions to Take

- Call up your utility company to check if your meter has been changed to a smart meter. If that ends up fruitless, physically inspect your meter. If it has a digital display, it is most likely a smart meter. If there are dials, then you probably still have an analog meter.
- If in doubt take readings with a radio frequency (RF) meter. Or call in a building biologist or other qualified EMF consultant to take readings.
- If you discover you have a smart meter, contact your utility to opt-out. And contact a local electrician to install an analog meter. You can buy an analog meter on the Internet for under $40. But you may have to pay a monthly opt-out fee.
- The other option is to shield. If you can't have your smart meter removed then several smart meter shielding options exist − some are more effective than others. My advice is to always test before and after with an RF meter to ensure that the shielding has been effective.

Make sure that any correspondence with your utility company is done via registered mail. This way you will have a paper trail to fall back on should you need to.

Making a Bigger Impact in Protecting Against EMFs

Now that you've protected yourself, you can move on to making a bigger impact on this matter. File complaints regarding the smart meter to bodies such as the Consumer Product Safety Commission, Consumer Reports, Special Litigation Section of the U.S. Department of Justice, EMR Policy Institute or

to the FDA. Insert evidence you have collected previously to make a stronger case and urge many more in your local area to lodge complaints too. The larger the number, the louder the voice!

If you would like to do more on a national scale, you can participate in movements like *Take Back Your Power* and *Stop Smart Meters* (just Google them to learn more). These offer a platform to get your voice heard alongside like-minded people who are opposed to smart meter installation. It is also for citizens to join together to have the freedom to choose whether they'd like a smart meter installed on their property or not.

Take Responsibility For Your Own Health

According to consulting engineer Rob States, the objectives of the Smart Grid Program can be achieved without using smart meters. Furthermore, many people claim higher utility bills since they've had a smart meter installed.

More importantly, the long-term effects of smart meter radiation are a cause for concern. It's up to you as an individual to take responsibility for your own health, as many people are finding out… living in proximity to a smart meter is not conducive with healthy living.

Live your life without the threat of cancer. Go here to be notified each week about new, cutting-edge information that impacts your health.

https://thetruthaboutcancer.com/electric-smart-meters/

Smart Meter Radiation 100 Times Greater Than Cell Phones—And Exposure Is Constant, Doctors Warn

Smart meters appeared on the power grid scene as a way for electric companies to take readings of customers' usage without an actual person having to visit every building.

These little devices were presented as a way to save time, money, and the gasoline required to drive around all day.

Some even to so far as to say that this technology would be more eco-friendly. However, experts have now voiced their concerns over smart meter radiation.
Using radio frequency microwave transmissions (RF) pulsing continuously through your home, meters measure energy usage and send the information to the energy provider.

Transmissions are relayed at intervals via power lines, the internet, or cellular modes—internet and cell (wireless) being the most common.

The American Cancer Society's warns:

"Smart meters give off RF radiation. RF radiation is low-energy radiation. RF radiation doesn't have enough energy to remove charged particles such as electrons (ionize), and so is called non-ionizing radiation. Non-ionizing radiation has enough energy to move atoms in a molecule around or cause them to vibrate, which can lead to heat but it can't damage DNA directly."

"RF radiation is classified by the International Agency for Research on Cancer (IARC), as 'possibly carcinogenic to humans.' This is based on the finding of a possible link in at least one study between cell phone use and a specific type of brain tumor. Because RF radiation is a possible carcinogen, and smart meters give off RF radiation, it is possible that smart meters could increase cancer risk…Smart meters have not been studied to see if they cause health problems."

The American Academy of Environmental Medicine issued a letter to the state of California to oppose the use of Smart Meters: "based on a scientific assessment of the current medical literature…Chronic exposure to wireless radiofrequency radiation is a preventable environmental hazard that is sufficiently well documented to warrant immediate preventative public health action." (2)

Dr. David Carpenter is a vocal opponent of Smart Meters. With very impressive medical credentials, he warns of the ill effects to the central nervous and reproductive systems. In addition, he highlights the documented evidence that RF causes cancer.

La Maison Saine et Écologie published an open letter from Dr. Carpenter that was endorsed by over fifty international experts. In it, he delineates the dangers that the RF microwave radiation from Smart Meters pose (3).

Links to cell phone use and brain tumors have been established by several independent studies (4). In fact, it's estimated that Smart Meters emit 160 times more radiation than cell phones do (5, 6).

A class-action tort lawsuit was filed against Southern California Edison in 2013 for health damage caused by the use of Smart Meters (7). More specifically, lawsuits have reported symptoms of insomnia, dizziness, nausea, heart palpitations, interference with pacemakers, tinnitus, seizures, and chronic headaches.

https://dailyhealthpost.com/smart-meter-radiation/

Toxic radiation: So-called 'SMART METERS' are anything but smart

An estimated 65 million American homes already have one. They have been touted as being part of the "*green energy revolution*," a way to reduce energy consumption nationwide and of benefit to the consumer overall. But, countless accounts of sickness and even death are telling an entirely different story – when it comes to so-called 'smart meters.'

In reality, smart meters are not smart, they're actually emitting toxic radiation and are quite dangerous – on so many levels. Repeated exposure can lead to migraines and neurological conditions as well as brain, breast and other kinds of cancer.

Smart metering signifies the digitalization of individual energy use into one central "grid." Smart meters are individual two-way communication systems that are part of this larger grid. Within them, energy usage over a certain period of time is calculated and that information is sent to the energy company in that region via a Wi-Fi network.

Smart meters are also part of a larger network called the Advanced Metering Infrastructure (AMI). AMI began with the American Recovery and Investment Act of 2009. According to an in-depth Westin-Price report conducted in 2015, the Obama Administration has poured an estimated 11 billion dollars into AMI – mostly for incentive programs to encourage utility companies to participate.

AMI connects all electrical service across the entire nation into one networked system. According to the Westin-Price report, the Department of Energy (DOE) and the U.S. Department of Agriculture (USDA), as well as major universities and corporations, including "General Electric, IBM, Hewlett Packard, Siemens, Toshiba, Microsoft, Cisco, Verizon, Google, Itron and Tantalus," are making huge profits off of the creation and maintenance of AMI.

And that may be just the tip of the iceberg. According to a letter written by Virginia Farver, whose son Rich was part of the "Brain Cancer Cluster" (half a dozen students who developed fatal brain cancers between 2008-2010 on the campus of San Diego State University), also part of the SMART Grid network is a world-wide network of communications systems which includes academic-based regional computer networks such as San Diego's High Performance Wireless Research and Education Network (HPWREN), Lambda Rail (Grid), the Tera Grid and the PRAGAMA Grid.

All of the college students who died during those years spent significant time in a first-floor room located directly below a HPWREN cell tower, which was also part of the UCSD Supercomputer Center in San Diego as well as a source for the Ground Wave Emergency Network (GWEN). According to Farver, GWEN's emissions in particular have been known to "hug the ground."

Farver and the Brain Cancer Cluster story were featured in the 2013 film, Take Back Your Power.

The Brain Cancer Cluster group at SDSU ultimately perished of cancers such as brain lymphoma and glioblastoma. Their symptoms began, however, with headaches, nausea, heart palpitations, sinus problems, insomnia and nose bleeds – classic symptoms of what is known as "Electro-Sensitivity." Their bodies were inundated with microwave radiation without end.

And this is exactly what happens to vulnerable residents of a household that has a smart meter installed on their home.

Residential smart meters can be programmed to gather information as often as every 15 seconds and emit pulsed non-ionizing microwaves (similar to a cell phone) to the tune of 10,000 to 200,000 pulses per meter per day. With that much EMFs, the body simply never has time to recover. Keep in mind, the World Health Organization has classified non-ionizing radiation as a Class 2B Carcinogen, on par with lead and propylene oxide – both known carcinogens.

To date there has been no "official" study as to the health effects of smart meters on humans. Medical professionals and concerned citizens are conducting their own experiments, however. In the film, *Take Back Your Power*, independent researcher Dr. Frank Springbob studied samples of patient's blood under black-field microscopy after about a minute of exposure one foot away from a smart meter. The results were shocking and included corrugated blood cells as well as red blood cell clumping to what were healthy cells before exposure. These are all signs of free-radical damage.

The situation has become so dire that the American Academy of Environmental Medicine (AAEM) has proposed that a moratorium be placed on smart meter technology until the health effects can be adequately studied.

http://www.naturalhealth365.com/toxic-radiation-brain-cancer-1994.html

EMF damages chitin – the missing link to bee deaths and monarch butterfly declines?

Steep recent declines in bee and butterfly populations have alarmed biologists and the public. Parasites have caused recent devastating impacts to bees.

Why is chitin important?

Chitin, the second most important natural polymer in the world,…

Chitin, the second most abundant natural polymer in the world, functions as a natural structural polysaccharide [A major component of the carapaces, crusts and shells of crustaceans such as shrimps, crabs and lobsters, it is also an ingredient of cell walls in fungi and yeast..

Chitin is isolated from the exoskeletons of crustaceans, molluscs, insects and certain fungi. [i]

Bees' and other insects' bodies are covered by an exoskeleton of small, movable plates of chitin. The 'veins' in insect wings are chitin. Chitin is part of the cell walls. .[ii] This is a critically important material.

…many "critters" on the low end of the food chain rely upon "chitin" a particularly amazing organic chain molecule with structural, optical properties, and even the ability to as a sensory device for various electro-magnetic energies.

But what is most interesting to me, is that chitin is a particularly effective bio-concentrator for man made radiation and heavy metals.

Chitin is particularly strong with its chemical bonds, most acids cannot destroy chitin. But radiation is also particularly good at destroying the chitin bonds, thus destroying the chitin.

So radiation is destroying the basis of the ocean food chain.

Curiously enough, bees and butterflies also use chitin in their structures and functional features. Damage to chitin exoskeleton makes it easier for parasites to get in, and that is a main cause of bee deaths…[iii]

If you damage or destroy the chitin, these insects and sea creatures are defenseless or dead. Reproduction will stop. Extinction is probable.

The article from Nuke Professional below[iv] outlines the impact to chitin from ionizing radiation. Radioactive contamination of air and ocean especially from Fukushima, as well as from nuclear plants' regular emissions, and nuclear waste worldwide, is having devastating impacts. This includes the effects to ocean creatures which have chitin.

Can the EMF from cell phones, cell towers, Wi-Fi, Smart Meters and wireless devices also damage chitin?

This research was published recently, posted by Dr. Joel Moskowitz of UC Berkeley.[v]

On a Possible Mechanism of the Effect of Microwave Radiation on Biological Macromolecules[vi]

Nikiforov VN, Ivanov AV, Ivanova EK, Tamarov KP, Oksengendler BL. [On a Possible Mechanism of the Effect of Microwave Radiation on Biological Macromolecules].Â Biofizika. 2016 Mar-Apr;61(2):255-8. [Article in Russian]

Abstract

A model describing the process of dissociation of hydrogen bonding in water clusters when irradiated by electromagnetic field in the microwave range is suggested. The model is also applicable for the case of rupture of the covalent bond of the water molecule cluster. If the energy absorption occurs at the interface of water and polymer clusters (e.g., DNA, chitosan), degradation of the polymer chain is possible.

From the beginning of Smart Meter deployments, people have witnessed odd bee behavior, bee disappearance, and bee deaths. Impacts to bees from EMF and RF were the subject of "Bees, Birds and Mankind: Destroying Nature by Electrosmog" translated to English in 2007 http://www.hese-project.org/hese-uk/en/papers/warnke_bbm.pdf

FCC proposes 5G with even higher frequencies which are closer to ionizing radiation and have more power to break chemical bonds. Space-based Wi-Fi plans such as Project Loon will completely blanket the earth in these frequencies.

Humans can't survive without bees and other pollinators.

Some experts warn that the ongoing Fukushima disaster will cause an extinction level event (ELE).

Will the Internet of Things and 5G cause a double ELE?

https://smartmeterharm.org/2016/08/08/emf-damages-chitin-the-missing-link-to-bee-deaths-and-monarch-butterfly-declines-will-the-smart-grid-5g-and-project-loon-finish-the-bees/

Biological Effects from RF Radiation at Low Intensity Exposure, based on the BioInitiative 2012 Report, and the Implications for Smart Meters and Smart Appliances

Introduction and Conclusions

The Biological Effects Chart, at the end of this document, has been produced using data from a massive new review of the medical research literature on the biological effects of electromagnetic fields. That review is called the BioInitiative 2012 Report.2 The purpose of the Biological Effects Chart is to show the radiofrequency (RF) exposure levels at which biological effects were found in 67 studies from the RF Color Charts of the BioInitiative 2012 Report, and then to compare those exposure levels to the following:

(1) Current FCC Maximum Permitted Exposure (MPE) limits that govern Smart Meters and Smart Appliances in the United States
(2) New biologically based RF exposure limits proposed in the BioInitiative 2012 Report
(3) Calculated RF exposure levels produced by a single Smart Meter at various distances
(4) Calculated RF exposure levels produced by a single Smart Appliance at various distances

This comparison is based on RF exposure levels expressed as the RF power density (RF power per unit area). This comparison does not address other potentially important factors such as carrier continuity (continuous versus pulsed radiation) and modulation technique (the method used to impress information on the carrier), among others. The purpose is to identify what biological effects arise from exposure to RF power density levels like those produced by Smart Meters and Smart Appliances.

This comparison indicates the following:

(1) The current FCC Maximum Permitted Exposure (MPE) limits are so high that they provide no protection for the public from the biological effects found in any of the 67 studies.
(2) New biologically based RF exposure limits proposed in the BioInitiative 2012 Report are 1 million times lower than current FCC limits and would protect against the biological effects found in nearly all of the 67 studies.
(3) A single Smart Meter on a home can produce RF exposure levels that caused the biological effects found in either most or many of the 67 studies, depending on the distance from the Smart Meter.
(4) A single Smart Appliance in the home can produce RF exposure levels that caused the biological effects found in nearly half or fewer of the 67 studies, depending on the distance from the Smart Appliance. Multiple Smart Appliances in a home multiply the total exposure.
(5) A single Smart Meter on a nearest neighbor's home can produce RF exposure levels that caused the biological effects found in many of the 67 studies. A given home may have one to eight nearest neighbors, each with a Smart Meter, multiplying the total exposure in the given home.

Conclusions and Observations

Current FCC Maximum Permitted Exposure (MPE) Limits Are Too High to Protect the Public

Because the FCC Maximum Permitted Exposure (MPE) limits are at power densities higher than the power densities addressed in all of the 67 studies, those limits provide no protection against the biological effects found in any of the 67 studies, no matter what the source of the RF radiation.

Further, the FCC Maximum Permitted Exposure limits apply to each source of radiation, individually, not to the combined exposure from all sources. But a person will generally be exposed to radiation from a combination of sources. So the FCC Maximum Permitted Exposure limits not only are too high to protect a person from a single source of radiation, but also do not consider the actual exposure received by a person from multiple sources of radiation.

New Biologically Based RF Exposure Limits, Proposed in the BioInitiative 2012 Report, are 1 Million Times Lower than the FCC Limits, to Protect the Public

The new RF exposure limits proposed in the BioInitiative 2012 Report are about 1 million times lower (stricter) than the current FCC Maximum Permitted Exposure Limits in the frequency ranges at which Smart Meters, Collector Smart Meters, and Smart Appliances operate.

A Single Smart Meter Can Produce RF Power Density Levels Shown to Cause Biological Effects

The Biological Effects Chart enables a comparison between the RF power densities produced by a Smart Meter, at various distances from that Smart Meter, and the RF power densities that triggered biological effects in the 67 studies.

The power density at 1 meter (3 feet) from a Smart Meter is higher than the power density that triggered biological effects in 50 of the 67 studies.

The power density at 5 meters (16 feet) from a Smart Meter is higher than the power density that triggered biological effects in 26 of the 67 studies.

The power density at 20 meters (66 feet) from a Smart Meter is higher than the power density that triggered biological effects in 14 of the 67 studies.

This distance of 20 meters is likely as far from a Smart Meter as a person can get and still be inside the typical home. So living and sleeping on the side of a home that is farthest from the Smart Meter is helpful but still may not reduce the received power densities to biological insignificance. Further, one or more of the neighbors' Smart Meters may be closer and may thus be the stronger source.

The power density at 100 meters (328 feet) from a Smart Meter is higher than the power density that triggered biological effects in 6 of the 67 studies.

So, even at the distance of a football field from the Smart Meter, the power density received may still be biologically significant

A Single Smart Appliance inside a Home Can Produce RF Power Density Levels Shown to Cause Biological Effects

Unfortunately, the problem of excess exposure to RF radiation will get worse as Smart Appliances are adopted. They contain their own internal RF transmitters and receivers. Those Smart Appliances are designed to communicate with Smart Meters and to report through the Smart Meters to the electric power company. The data the Smart Appliances report will be sufficient for the electric power company to identify which appliances you own, when you use them, and how much power they consume, throughout the day and the night. The electric power company may even be able to turn the Smart Appliances off by sending a wireless signal to the Smart Meter that is then transferred to the Smart Appliances, but that is less certain at this time.

A Single Smart Meter on a Neighbor's Home Can Produce RF Power Density Levels Shown to Cause Biological Effects

For some locations in a given home, the distance to a neighbor's Smart Meter may be less than the distance to the resident's own Smart Meter. Thus, a neighbor's Smart Meter may be the principal source of radiation for some locations in the given home. The Biological Effects Chart shows that a single Smart Meter can produce RF power densities found to cause biological effects even at distances greater than 20 meters, and certainly up to 100 meters. And the number of neighbors within that range can be large. A given single family home in a residential community may have one to eight nearest neighbors, and even more next nearest neighbors, all within 100 meters (328 feet) of a given home, and each with a Smart Meter

The problem of exposure from the neighbors' Smart Meters becomes more serious as the distances between adjacent homes, and thus the distances between adjacent Smart Meters, get smaller. So, generally speaking, residents of townhouses will receive more radiation from their neighbors' Smart Meters than residents of single family homes. And residents of apartments will receive even more radiation from their neighbors' Smart Meters, depending on the location of the Smart Meters in the apartment buildings.

So Smart Meters are a community concern, not just an individual concern. To resolve the problems of RF exposure for a given home, it will be necessary to address all of the Smart Meters near that home. Smart Appliances, too, contribute to this concern. While, individually, they have a lower RF power output than a Smart Meter, the Smart Appliances of neighbors can also increase the RF exposure in the given home.

RF Radiation May Affect Unborn and Very Young Children More Severely than Adults

The BioInitiative 2012 Report presents evidence that unborn and very young children may be more greatly affected by RF radiation than adults because unborn and very young children are in "critical phases of growth and development".39

Concern for unborn and very young children is shared by the American Academy of Pediatrics (AAP) which wrote to the U.S. Congress in support of a bill before the U.S. House of Representatives (H.R. 6358).40 This bill would fund development of better founded RF exposure limits to protect against cell phones and other wireless sources of RF radiation. The AAP made the following statement:

The AAP strongly supports H.R. 6358's emphasis on examining the effects of radiofrequency (RF) energy on vulnerable populations, including children and pregnant women. In addition, we are pleased that the bill would require the consideration of those effects when developing maximum exposure standards. Children are disproportionately affected by environmental exposures, including cell phone radiation. The differences in bone density and the amount of fluid in a child's brain compared to an adult's brain could allow children to absorb greater quantities of RF energy deeper into their brains than adults. It is essential that any new standards for cell phones or other wireless devices be based on protecting the youngest and most vulnerable populations to ensure they are safeguarded through their lifetimes.

Smart Meters and Smart Appliances operate in the same frequency ranges as cell phones. Further, Smart Meters have twice the RF power output of the typical cell phone, as shown in the table below, and will be transmitting day and night. Emerging Smart Appliances will likely have about oneZfifth the RF power output of the typical cell phone. But a given home may have several Smart Appliances; and they, too, will be transmitting day and night.

http://emfsafetynetwork.org/wp-content/uploads/2013/08/Biological-Effects-From-RF-Radiation-and-Implications-for-Smart-Meters-June-5-2013-2.pdf

Cell Phones & Cell Towers

Cell Phone Use in Children and Teens Translates To 5 Times Greater Increase in Brain Cancer

If today's young people don't reduce their use of wireless mobile devices, they may suffer an "epidemic" of the disease in later life. Research indicates children and teenagers are five times more likely to get brain cancer if they use mobile phones.

At least nine out of ten 16-year-olds have their own handset, as do more than 40 percent of primary schoolchildren.

Many scientists have claimed that the wave of mobile communications made popular in the last two decades will result in long-term health implications worldwide. An unprecedented level and frequency of tumor growth inside the human brain may be inevitable.

Yet investigating dangers to the young were been omitted from a massive investigation of the risks of cancer from using mobile phones, even though the official Mobile Telecommunications and Health Research (MTHR) Programme — which is conducting it — admits that the issue is of the "highest priority".

Mobile phone owners were urged to limit their use after the World Health Organization admitted they may cause cancer.

Despite recommendations of an official report that the use of mobiles by children should be "minimized", the Government has done almost nothing to discourage it.

Minister across Europe have been encouraged to bring in stricter limits for exposure to radiation from mobile and cordless phones, Wi-fi and other devices, partly because children are especially vulnerable to them. They are more at risk because their brains and nervous systems are still developing and because — since their heads are smaller and their skulls are thinner — the radiation penetrates deeper into their brains.

Neurosurgeon and researcher Dr. Leif Salford has conducted many studies on radio frequency radiation and its effects on the brain. Dr. Salford called the potential implications of some of his research "terrifying." Some of the most concerning conclusions result from the fact that the weakest exposure levels to wireless radiation caused the greatest effect in causing the blood brain barrier to leak.

Since he began his line of research in 1988, Dr. Leif Salford and his colleagues at Lund University Hospital in Sweden has exposed over 1,600 experimental animals to low-level radiation. Their results were consistent and worrisome: radiation, including that from cell phones, caused the blood-brain barrier–the brain's first line of defense against infections and toxic chemicals–to leak.

Swedish research reported at the first international conference on mobile phones and health stemmed from .further analysis of data from one of the biggest studies carried out into the risk that the radiation causes cancer, headed by Professor Lennart Hardell of the University Hospital in Orebro, Sweden. Professor Hardell told the conference — held at the Royal Society by the Radiation Research Trust — that "people who started mobile phone use before the age of 20" had more than five-fold increase in glioma", a cancer of the glial cells that support the central nervous system. The extra risk to young people of contracting the disease from using the cordless phone found in many homes was almost as great, at more than four times higher.

Those who started using mobiles young, he added, were also five times more likely to get acoustic neuromas, benign but often disabling tumors of the auditory nerve, which usually cause deafness.

By contrast, people who were in their twenties before using handsets were only 50 percent more likely to contract gliomas and just twice as likely to get acoustic neuromas.

Professor Hardell told the IoS: "This is a warning sign. It is very worrying. We should be taking precautions." He believes that children under 12 should not use mobiles except in emergencies and that teenagers should use hands-free devices or headsets and concentrate on texting. At 20 the danger diminishes because then the brain is fully developed. Indeed, he admits, the hazard to children and teenagers may be greater even than his results suggest, because the results of his study do not show the effects of their using the phones for many years. Most cancers take decades to develop, longer than mobile phones have been on the market.

The research has shown that adults who have used the handsets for more than 10 years are much more likely to get gliomas and acoustic neuromas, but he said that there was not enough data to show how such relatively long-term use would increase the risk for those who had started young.

He wants more research to be done, but the risks to children will not be studied in the MTHR study, which will follow 90,000 people in Britain. Professor David Coggon, the chairman of the programmes management committee, said they had not been included because other research was being done on young people by a study at Sweden's Kariolinska Institute.

He said: "It looks frightening to see a five-fold increase in cancer among people who started use in childhood," but he said he "would be extremely surprised" if the risk was shown to be so high once all the evidence was in.

But David Carpenter, dean of the School of Public Health at the State University of NewYork — who also attended the conference — said: "Children are spending significant time on mobile phones. We may be facing a public health crisis in an epidemic of brain cancers as a result of mobile phone use."

A scholarly article on cell phone safety published online in the journalElectromagnetic Biology and Medicine reported the finding that cell phones used in the shirt or pants pocket exceed the U.S. Federal Communications Commission (FCC) exposure guidelines and that children absorb twice as much microwave radiation from phones as do adults.

The paper notes that the industry-designed process for evaluating microwave radiation from phones results in children absorbing twice the cellphone radiation to their heads, up to triple in their brain's hippocampus and hypothalamus, greater absorption in their eyes, and as much as 10 times more in their bone marrow when compared to adults.

Earlier research on pregnant mothers who use mobile phones has shown they are likely to give birth to kids with behavioral problems, especially if those children start using mobile phones early themselves.

Researchers from the National Institutes of Health have found that less than an hour of cellphone use can speed up brain activity in the area closest to the phone antenna, raising new questions about the health effects of low levels of radiation emitted from cellphones.

The study published in The Journal of the American Medical Association, is among the first and largest to document that the weak radio-frequency signals from cellphones have the potential to alter brain activity.

"The study is important because it documents that the human brain is sensitive to the electromagnetic radiation that is emitted by cellphones," Dr. Volkow said. "It also highlights the importance of doing studies to address the question of whether there are — or are not — long-lasting consequences of repeated stimulation, of getting exposed over five, 10 or 15 years."

https://www.rfsafe.com/cell-phone-use-children-teens-translates-5-times-greater-increase-brain-cancer/

New study reveals 300% Increased brain cancer risk for long-term users of cell phones and cordless phones

A Swedish study on the use of wireless phones, including cell phones and cordless phones, has uncovered a link between electromagnetic radiation exposures and the risk of malignant and non-malignant brain tumors.

Cell phones and cordless phones emit a form of non-ionizing electromagnetic radiation, radiation which can be absorbed by tissues and cells that come into close contact with the phone, e.g., the head and neck. The most conclusive evidence as to the dangers of cell phone and similar radiation exposures come from studies on long-term exposure (ten years or more) like this Swedish study.

300% increased risk for long term users

This new study reveals that people who used cell phones and cordless phones for more than a year were at a 70% greater risk of brain cancer compared to those who used cell phones and cordless phones for a year or less. Those who used cell phones and cordless phones for more than 25 years were found to have a 300% greater risk of brain cancer than those who used cell phones and cordless phones for a year or less.

The total number of hours of cell phone and cordless phone use was found to be as important as the number of years of use. A quarter of the study's subjects were found to have lifetime cell phone or cordless phone use of 2,376 or more hours, which corresponds to about 40 minutes a day over ten years. Heavier users were found to have a 250% greater risk of brain tumors compared to those who'd never used cell phones or cordless phones or used them for less than 39 hours in their lifetime.

Brain cancer risk highest on side of head used to phone

This new study echoes the previous study findings of the decade long 13-nation Interphone study, which found a 180% greater risk of brain cancer among those who used cell phones for 1,640 or more hours in their lifetime. But it also goes further.

In this latest study, for all types of cell phone and cordless phone use, brain cancer risk was found to be greater in the part of the brain where the exposure to cell phone and cordless phone radiation was highest, on the side of the head where people predominantly used their phones.

Wireless safety standards inadequate

Given the consistent results from these studies, public health bodies from around the world are asking that the current wireless safety standards be reviewed.

The World Health Organization (WHO) recently classified radio frequency electromagnetic fields as a Group 2B possible carcinogen. Doctors groups are also sounding the alarm. The American Academy of Environmental Medicine, the International Society of Doctors for the Environment (ISDE) and the Irish Doctors Environmental Association (IDEA) are all calling for improved standards.

In the absence of sufficiently protective standards and legislation, individuals need to act now. This means:

- Limiting calls to those that are absolutely necessary on wireless devices
- Using a speaker phone or air tube headset whenever possible
- Keeping cell phones away from the body
- Turning your cell phone off when not in use
- Texting instead of talking
- Alternating from one side of the head to the other when phoning
- Avoiding using a cell phone when reception is poor
- Using a corded land line whenever possible
- Removing cordless phones from bedrooms

Minimizing the effects of these wireless exposures now instead of later is timely and crucial.

https://www.rfsafe.com/new-study-reveals-300-increased-brain-cancer-risk-long-term-users-cell-phones-cordless-phones/

Brain Cancer Top Killer in Kids: Are Cellphones a Factor?

Brain cancer is now the leading cause of cancer deaths in children, according to a new study. Researchers say a chief reason is that new treatments for leukemia — long the No. 1 killer of kids — have knocked it from the top spot in recent years.

But some studies and experts suggest brain cancer rates in kids may be, in part, tied to the increasing use of cellphones by children and teens, and the rates of brain cancer may increase — perhaps drastically — when they become adults.

"I think that there will be a significant, if not enormous increase in primary brain tumors among young people, but perhaps not until they reach the age of late twenties or even thirties," neurosurgeon Dr. Russell Blaylock tells Newsmax Health.

Children are especially vulnerable to the damage caused by cellphones since their thinner skulls absorb twice the radiation. "This is common sense," says Blaylock, author of The Blaylock Wellness Report newsletter.

"Young people are constantly on cellphones, and young, immature cells are being exposed to radiation 24/7. It's going to affect nervous system function and the reproduction of cells."

Past studies on kids' cellphone use and cancer have been mixed, with most saying there is no danger, but some suggesting a potential risk that requires further study.

Among several widely publicized studies in adults that found no danger from using cellphones, Blaylock notes that some were funded by organizations with financial interests in the cellphone industry, and were conducted for too short a time for changes to be noted.

In addition, he warns that the actual numbers of gliomas — a type of cancerous brain tumor — caused by cellphones may be much higher that reports indicate, especially in adults, because due to problems with reporting, many cases slip through the cracks and are never taken into account.

Blaylock is also concerned about neurological damage.

"Of equal concern is the neurological damage done by the microwave radiation that results in a number of other neurological conditions, such as dementia syndromes, Parkinson's disease, language difficulties, reading problems, vertigo, hearing problems, seizures and progressive neurodegenerative disorders," says Blaylock.

"These may be much more common than brain tumors."

Blaylock warns that we may see a dramatic rise in brain tumors in the next 10 years, fueled by years of heavy usage by youngsters.

"The microwaves emitted by cellphones have been shown to cause DNA damage and induce inflammation — chronic inflammation in tissues eventually leads to cancer in some users," Blaylock said.

"There's growing evidence that cellphones cause cancerous brain tumors in adults.

"I would bet that the microwaves activate microglia in the brain and this triggers immunoexcitotoxicity — one of the main mechanisms of glioma development," he said.

Even though some studies have indicated cellphones are safe, others are troubling:

• In July, a study conducted by the National Toxicology Program (NTP), a branch of the National Institutes of Health, concluded that cellphones were a likely cause of cancer.

The study exposed more than 2,500 rats for two years to the type of radiation people are exposed to when they use cellphones, and found an increase in two types of deadly tumors — gliomas and malignant schwannomas, an extremely rare tumor of the heart.

• Research printed in Electromagnetic Biology & Medicine found that 93 of 100 previous studies concluded that the low-intensity radiofrequency radiation (RFR) cellphones emit can damage DNA and cause cancer.

They determined that using a cellphone for 20 minutes each day for five years increased the risk of one type of brain tumor by 300 percent, and talking on a cellphone for an hour a day for four years increased the risk of some tumors up to 500 percent.

• An animal study from Yale University linked the radiation from cellphones to changes in brain development that could cause hyperactivity.

We have shown that behavioral problems in mice that resemble ADHD are caused by cellphone exposure in the womb," said senior researcher Dr. Hugh S. Taylor, a reproductive specialist.

"The rise in behavioral disorders in human children may be in part due to fetal cellular telephone irradiation exposure," Taylor said.

In addition, a British study found that children who used cellphones risked memory loss, sleeping disorders, and headaches.

"I think we are going to see a tremendous effect from cellphones years from now," Blaylock said.

"Millions of people are susceptible to cancer, degenerative brain disorders like Alzheimer's disease, and other brain diseases from the radiation produced by cellphones," says Blaylock, "and the more the phones are used, the higher the risk.

"The effects on some people will be minimal, but millions of others, especially those who have DNA repair defects, are going to have a significantly higher risk. If you are a part of that 10 or 15 percent of the population who have these defects, your risk is going to be extremely high, and you won't even know it.

"It would be ludicrous to say that cellphone radiation is harmless and has no negative effects. That's nonsense."

http://www.newsmax.com/Health/Headline/brain-cancer-killer-cellphones/2016/09/18/id/748870/

Why You Need to Stop Carrying Your Mobile Phone in Your Pocket or Bra

If you're a man and you carry your mobile phone in your pants pocket, or a woman who tucks her phone into her bra or bra strap… chances are you aren't aware of the damage this practice may be causing. You're not going to hear about it from the cell phone companies who are resisting mounting evidence about the dangers of mobile phone radiation.

Another recent study has demonstrated that cell phones are no friends of testes, the male reproductive organs in which sperm is made. It was shown that when cell phones were in talk mode and located in close proximity to the testes, sperm cells were damaged. The study is alarming because of two key problems…

First, damaged sperm can lead to birth defects and higher incidences of various disabilities, as is the case in a greater than average number of children of older fathers. Second, the scenario tested in the study is a common one. Males who chat using hands free headsets often leave their mobile phones resting in their pockets − in perfect range to cause the testes harm.

Ashok Agarwal, who led the study and is the Director of the Center for Reproductive Medicine at the Cleveland Clinic, states, "We believe that these devices are used because we consider them very safe, but it could cause harmful effects due to the proximity of the phones and the exposure that they are causing to the gonads."

The study consisted of semen samples taken from 32 men who exhibited similar sperm health. The samples were kept at constant temperature and other similar conditions, while being split into a control group and a test group. The test group was placed for an hour within 2.5 cm of a cell phone in talk mode, at 850 MHz, which is perhaps the most common frequency.

The transmissions led to an apparent increase in oxidative stress, with free radicals and oxidants being created at a higher than normal rate and antioxidants being broken down. Agarwal says this stress equates to damaged sperm. Other factors which can cause it include environmental pollutants or infections in the urinary genital tract, he adds.

Do cellphones cause cancer? This is perhaps the greatest area of concern when it comes to cell phone use. Mobile phone radiation *has* been linked to various forms of cancer. Evidence is mounting that prolonged exposure to radiation from cell phones carried on the body can lead to breast and other cancers − at earlier ages than ever.

The World Health Organization has classified mobile phones, and any wireless devices that use microwaves to communicate, as a group 2B risk − which means that they are "possibly carcinogenic to humans." Many believe that the evidence is already strong enough to classify mobile phones as definite cancer causers. They point to the increased incidence of cancer in areas of the body closest to where cell phones are carried and used. For example, testicular cancer in men occurring more frequently in the testes closest to where cell phones are carried.

A pile of research has confirmed that non-ionizing communications radiation in the radio-frequency (RF) microwave spectrum has the same effect on human health as ionizing gamma wave radiation from nuclear reactions. It has been known for about 15 years that microwaves from cell phones and tower transmitters cause damage in human blood cells which results in nuclei splintering off into micronuclei fragments.

An industry study showed that human blood exposure to cell phone radiation had a 300% increase in genetic damage in the form of micronuclei. This suggests a health threat much greater than that of smoking or asbestos exposure. The development of micronuclei is a pre-cancerous condition that can quickly develop into full blown cancer.

Research studies have also reported that adults who have used mobile phones for at least ten years experience an increase in brain cancer, salivary gland cancer, and even rare eye cancers on the side of the head where the cell phone was predominantly held.

A recent study completed at Breastlink in California has revealed a strong connection between cell phones placed in the bra and the development of breast cancer in young women. The research team noted that, in the absence of family history or genetic predisposition, breast cancer occurring in women under the age of 40 is uncommon.

The researchers examined the cases of four women, with ages from 21 to 39, who developed multi-focal invasive breast cancer. They focussed on the possible association of these cases with the radiation from electromagnetic field exposures from cellular phones. Each of the women regularly carried her smart phone directly against her breasts tucked into her brassiere for up to ten hours a day, and had been doing so for several years.

Each woman developed tumors in the areas of the breasts immediately underlying the phones. Notably, the women had no family history of breast cancer, tested negative for the BRCA1 and BRACA 2 genes associated with breast cancer development, and had no other known breast cancer risks.

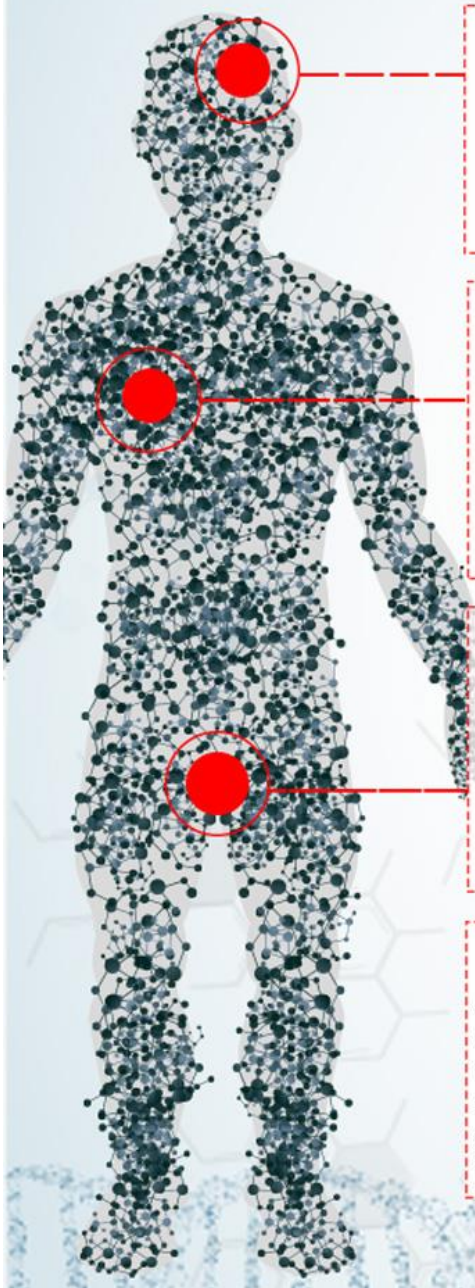
A review of their breast images showed clustering of multiple tumor foci in the breast directly under the area of phone contact. The pathology reports of all four women revealed striking similarity:

- All tumors were hormone-positive
- All tumors were low-intermediate grade
- All tumors showed an extensive intraductal component
- All tumors revealed almost identical form and structure, and specific structural features

Breast surgeon Dr. John West told TV station KTVU that *"young breasts in the early evolution are more sensitive to changes that might lead to cancer."* Dr. West and others have also pointed out that men too are getting breast cancer by carrying cell phones in their shirt pockets.

Dangers of Cell Phones

Despite fierce industry resistance, evidence continues to mount about the dangers of cell phones. Following are some of the major areas of health concerns.



Salivary Gland, Brain and Eye Cancer

Research studies report that adults who have used mobile phones for at least 10 years experience an increase in brain cancer, salivary gland cancer, and even rare eye cancers on the side of the head where the cell phone was predominantly held.

Breast Cancer

A recent study has revealed a strong connection between cell phones placed in the bra and the development of breast cancer in young women. Dr. John West and others have pointed out that men too are getting breast cancer by carrying mobile phones in their shirt pockets.

Infertility/Decreased Sperm Counts

A recent study has shown that when cell phones are in talk mode and located in close proximity to the testes (the male reproductive organs in which sperm is made), sperm cells were damaged. Damaged sperm can lead to birth defects and higher incidences of various disabilities.

Other Health Risks

A cell phone is a two-way microwave-radiating device whose long-term use has been associated with glioma, acoustic neuroma, meningioma, salivary gland tumors, eye cancer, testicular cancer and leukemia, along with a wide range of other biological effects.

The TRUTH About CANCER

educate • expose • eradicate

The wireless phone industry has vigorously disputed every study indicating a link between mobile phones and health problems. They have even provided their own studies which purportedly show that cell phones are safe and present no health hazards. Of course, whenever there are huge profits and liabilities at stake, industries typically try to counter harmful evidence. One example is when industry labored for years to keep asbestos and fiberglass off the carcinogens list.

Another example is the tobacco industry disputing and denying for years that smoking caused cancer or other health problems. Stan Glantz, professor of medicine at the University of California at San Francisco and director of the Center for Tobacco Research and Education, compared the cell phone situation right now to the cigarette situation in the 1950s.

"There was enough evidence to be concerned [about cigarettes in the 1950s], but the details were not really nailed," Glantz said. "Cell phone companies have learned from cigarette companies how to contest science, and they're doing it."

Then there is the Word Health Organization (WHO) that sponsored the Interphone Study. First the study was delayed for four years. Then a news embargo was placed on study participants. And finally, instead of reporting proof of cell phone dangers (as had been documented all the way up until just days before the study was finally released), the study instead reported that it found no evidence of cell phone dangers. The findings contradicted the study's evidence as well as the opinions of some study scientists!

In actuality, the Interphone Study did discover that long-term mobile phone usage increased the chance of glioma by 40%, but dismissed the risk because of possible biases and errors. Six of eight Interphone studies found increased risks of glioma, the most common brain tumor, with one study finding a 39% increase.

An Israeli study found heavy users were about 50% more likely to suffer tumors of the parotid salivary gland. Two studies into acoustic neuroma, a tumor of a nerve between the ear and brain, reported a higher risk after using mobiles for ten years. A Swedish report reported the risk as being 3.9 times higher.

Contradicting the study's conclusions, Dr. Elisabeth Cardis of the Centre for Research in Environmental Epidemiology in Barcelona (who led the stud) said: "Overall, my opinion is that the results show a real effect." Bruce Armstrong, another Interphone researcher from the University of Sydney, said: "There is evidence that there may be a risk; Interphone has made that a little stronger."

Why did the study reverse itself at the end? Many observers believe that the study's independence was compromised because the mobile phone manufacturers helped fund the project to the tune of around 5.5 million Euros.

In 2015, a landmark cellphone "Right to Know" law was passed with a unanimous 9-0 vote by the city council of Berkeley, California, home of the world renowned University of California Berkeley and arguably one of the most erudite cities in the world. This was the first safety ordinance of its kind in the United States and requires cell phone makers to include a city-prepared notice letting people know the minimum separation a cell phone must be held from the body to limit radiation exposure.

https://thetruthaboutcancer.com/mobile-phone-radiation/

Why Cell Phone Radiation Danger is Serious – Science Tells the Story

May 5, 2014

Despite what the telecom industry may want us to believe, if we do the research, we find there is now an overwhelming abundance of independent, peer-reviewed studies telling us that cell phone radiation is dangerous for our health. The research links cell phone radiation with many different disorders and diseases.

Cell Phones & Cancer

Researchers of the 2012 BioInitiative Report agree that approximately ten years of cell phone use may lead to tumors. In particular, there are significant studies that directly correlate RF radiation from cell phones with brain tumors.

Studies report that:

- The chance of developing a brain tumor goes up as much as 40% after a decade of cell phone use.
- People are 5 times more likely to develop a brain tumor if they began using a cell phone before the age of 20.
- People have twice the risk of developing the cancer known as "Glioma", if they use their cell phones for half an hour a day for more than a decade.
- People using cell phones for 2000 hours have 240% greater risk for malignant brain tumors.

A significant report was released in 2009 by the International EMF Collaborative, a team of international EMF scientists and activists, entitled "Cell Phones and Brain Tumors: 15 Reasons for Concern, Science, Spin and the Truth Behind Interphone".

Another study by an Israeli research group found that there's recently been a sharp 4-fold increase in malignant tumors of the parotid gland on the side of the face the cell phone users generally hold the phone. Parotid tumors have historically been very rare and have shown up in people after the age of 50. Most cases since 2001 have occurred in people under the age of 20.

Read more on cell phones and cancer.

Cell Phones & Low Sperm Count

Two research teams studying male fertility have discovered a link between low sperm count and RF radiation from cell phones. One study was conducted at the Queen's University in Canada; the other at the Medical University of Graz, in Austria.

Both studies had similar results. Men who reported cell phone use had:

- lower levels of the luteinizing hormone (LH), an important reproductive hormone that is secreted by the pituitary gland in the brain
- higher levels of circulating testosterone

Read more on cell phones & low sperm count.

Cell Phones & Miscarriage

D.K. Li et al published a study in the journal *Epidemiology,* in which they asked over 900 women less than 10 weeks into a pregnancy to wear a monitor for 24 hours to measure exposure to electromagnetic radiation.

When they compared exposure to pregnancy outcome, they found that those with higher peak exposures had an 80 percent increase in the risk of miscarriage. The risk was even higher among women with a history of recurrent pregnancy loss and/or infertility.

Read more on miscarriage and electromagnetic fields.

Cell Phones & Children

It is estimated that more than 31 million children use cell phones daily—close to four hours a day. Cell phone radiation danger to children is especially of concern, as children absorb 50% more radiation than adults do, as their skulls are thinner and smaller, and EMFs penetrate much more deeply into their brains. Also their brains are more conducive to radiation due to the higher water and ion concentration in a developing brain.

Brain Tumors: Brain cancer has now surpassed leukemia as the number one cancer killing children, and many scientists believe this is directly linked to the exponential increases in cell phone use and other wireless devices.

One of the most comprehensive studies testing the cell phone–cancer link on children was conducted by Professor Lennart Hardell et al in Sweden. The results of the study indicate that children and teens are 5 times more likely to get brain cancer if they use cell phones.

Autism: A study conducted in 2009 by Dr. Dietrich Klinghardt on autistic children and their mothers during pregnancy shows significant results, strongly suggesting that

"electromagnetic radiation in the sleeping environment of the mothers during pregnancy, as well as electromagnetic radiation in the sleeping environment of children, may be a key contributing factor—if not a causative one—in neurological impairments in children including autism…"

Tamara Mariea, released findings from more than five years of research on clients with autism that point to cell phone radiation stress as one of the potentially major causes of the explosion of autistic cases in the past two decades.

A recent report has been published on the health effects of EMFs on autistic children, citing over 550 citations.

Behavioral Problems: Researcher Leeka Kheifets and colleagues conducted a study in which they found a link between cell phone usage and behavioral problems in children. The cell phones are either those used by the children themselves or by their mothers while pregnant. A survey in 2008 with more than 13,000 children found that those whose mothers used cell phones during pregnancy were more likely to have behavioral problems like hyperactivity and trouble controlling emotions.

This study is far from being the only one showing that the radiation from cell phones poses a hazard to a developing fetus. Studies have shown that electromagnetic fields in that frequency range can affect their liver enzymes, glands, muscles, hormone balance, and heart and bone marrow.

Read more on cell phones and birth defects.

Read more on children and cell phones.

FCC Standards are Way out of Date

Set back in 1996, FCC standards for wireless devices were based on studies with healthy 6'2", 220 lbs men exposed to RF radiation for short periods of time. This is very different from the situation with cell phones today, in which people—including women, children and people in fragile health—are frequently on cell phones for hours a day.

Furthermore, cell phones in 1996 were very different from those used today. And, very importantly, the kind of radiation damage tested for was thermal—not the non-thermal kind that the researchers today who are concerned about health risks are focusing on.

Cell Phone Radiation Health Symptoms

Many health symptoms due to cell phone radiation show up early on and may precede more serious disorders and diseases. They include:

- Chronic colds & flus
- Headaches and "mind-fog"
- Digestive disorders
- Sleep disturbance
- Memory Loss
- Depression/anxiety
- Chronic pain
- Dizziness

http://www.earthcalm.com/cell-phone-radiation-danger

Only ten minutes on a mobile could trigger cancer, scientists believe

Mobile phones can take as little as ten minutes to trigger changes in the brain associated with cancer, scientists claimed yesterday.

They found even low levels of radiation from handsets interfere with the way brain cells divide. Cell division encourages the growth of tumors.

Although the researchers did not come up with evidence that mobile phone signals are harmful, the findings suggest they could be.

Several major studies have also found no link between mobile use and brain tumors, nor a dramatic rise in cancer rates.

But campaigners insist the discovery undermines official advice that the devices are safe.

The guidance is based on the assumption that the phones emit too little radiation to heat the brain dangerously.

However, the new study by the Weizmann Institute of Science in Israel suggests "nonthermal" radiation could pose a risk.

The Israeli scientists exposed human and rat cells in a laboratory to low-level radiation at 875 megahertz - a similar frequency to the one used in many mobile phones.

Although the radiation was far weaker than emissions from a typical handset, it began to switch on a chemical signal inside the cells within ten minutes, the researchers report in the Biochemical Journal.

The chemical signals they detected were involved in the division of cells.

The researchers say the reaction was not caused by heating and claim they have found a separate way in which mobile phones could damage health.

Dr. Rony Seger, a co-author of the study, told the magazine New Scientist: "The significance lies in showing cells do react to cellphone radiation in a non-thermal way."

Although changes in the chemical pathway seen by the Israeli scientists have been linked to several cancers, the researchers say there was no sign of a cancer-causing effect.

Dr. Simon Arthur, a health expert at Dundee University, said the effect was 'unlikely to cause cancer'.

Dr. Dariusz Leszczynski, of the Radiation and Nuclear Safety Authority in Helsinki, said: "If cell-phone radiation cannot induce biological effects then there will never be any health effects.

"On the other hand if we can show this radiation is able to induce biological effects then we have a different story."

A major review of mobile phone safety is due to be published by the Health Protection Agency next month.

The agency's last major report, in 2004, found no evidence mobiles were a serious health risk. It did, however, caution against excessive use, especially by the young.

Dr. Michael Clark, a spokesman for the agency, said: "Because of findings like this that pop up from time to time, a precautionary approach is justified."

Graham Philips, of campaign group Powerwatch, said: "Safety guidelines assume health effects from mobiles can only occur when significant heating of body tissue occurs.

"This study shows biological changes in response to low-level mobile phone radiation - something that could potentially have implications for health.

"Further research is required, however guidance based purely on thermal effects is clearly out of date."

http://www.dailymail.co.uk/news/article-478614/Only-minutes-mobile-trigger-cancer-scientists-believe.html

Cell Phones and Health - California Department of Public Health

Document released pursuant to Moskowitz v. CDPH, Sac. Super. Ct. No. 34-2016-80002358

Cell phones, like other electronic devices, emit a kind of energy called radiofrequency EMFs (electromagnetic fields). Health officials are concerned about possible health effects from cell phone EMFs because some recent studies suggest that long-term cell phone use may increase the risk of brain cancer and other health problems. For those concerned about possible health problems, this fact sheet provides information about how to lower exposure to EMFs from cell phones.

EMFs are types of radiation. They are created by all electronic devices. Some devices, such as watches, create weak EMFs that are considered harmless. Others, like X-ray machines, generate very strong EMFs that can damage cells and tissues, and cause cancer and other health effects. This is why we try to only use X-rays when necessary. Cell phones make relatively weak EMFs, somewhat less than those from microwave ovens, but because they are used frequently and kept close to the head and body, cell phone EMFs can affect nearby cells and tissues.

Several studies have found that people with certain kinds of brain cancer were more likely to have used cell phones for 10 years or more. Most of the cancers were on the same side of the head that people usually held their phones. Although the chance of developing brain cancer is very small, these studies suggest that regular cell phone use increases the risk of developing some kinds of brain cancer. Some studies have also linked exposure to EMFs from cell phones to fertility problems. As more studies are done and we learn more about possible risks for cancer and other health problems linked to cell phone use, the recommendations on this fact sheet may change.

Your exposure to cell phone EMFs depends mostly on your distance from the phone, the strength of the EMF, and how long and how often you use the phone. The farther away the phone is from your body, the lower the exposure. Your cell phone produces stronger EMFs at the start of a call, when it is trying to connect to a cell tower, and also when only one or two bars are showing. Your phone also emits stronger EMFs when used in a moving car, bus, or train, as the phone switches connections from one cell tower to another. Finally, some phones produce stronger EMFs than others.

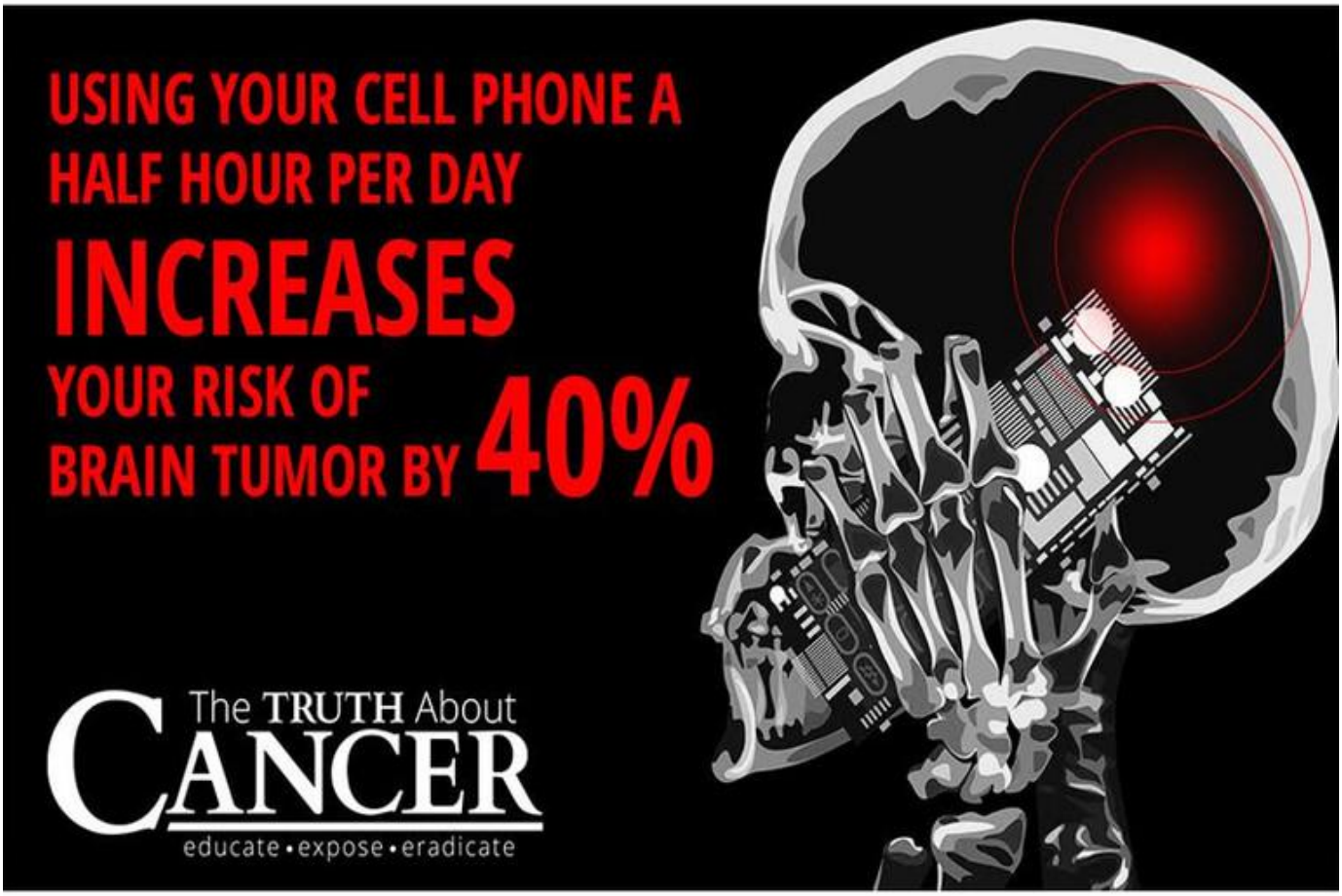
To lower your exposure to EMFs from cell phones: Increase the distance between you and your phone by: • Using the speaker phone. • Sending text messages. • Use a headset and carry your phone away from your body. EMFs from wireless (Bluetooth) and wired headsets are usually weaker than those from a cell phone. • Keep your phone away from your body. A cell phone that is on can emit EMFs even when it is not being used. Do not sleep with your cell phone near you or carry it in a pocket or directly on your body unless the phone is turned off. Limit your cell phone use when reception is weak or increase the distance between you and the phone. When your phone shows only one or two bars, it is emitting stronger EMFs than when three, four, or five bars are showing. Reduce the amount of time spent talking on a cell phone. • Keep cell phone calls short, even when using a wireless or wired headset. • Use speaker phone mode or a corded phone for longer conversations. Corded phones produce very weak EMFs. Take off your headset when you're not on a call. Wireless and wired headsets emit EMFs even when you are not using your phone. Do not rely on devices that claim to shield or neutralize EMFs from cell phones. These devices have not been shown to reduce exposures.

EMFs can pass deeper into a child's brain than an adult's. Also, the brain is still developing through the teen years, which may make children and teens more sensitive to EMF exposures. For these reasons,

parents may want to limit their child's cell phone use to texting, important calls, and emergencies. Pregnant women, children, and teens can also follow the tips for reducing exposure listed above.

http://www.sfchronicle.com/file/198/6/1986-Cell%20Phones%201-26-15.pdf

How Safe is Your Cell Phone?



Apple™ states "The new AirPods offer a game-changing listening experience. Designed with a huge amount of forward-thinking technology inside a tiny device, these wireless headphones combine crystal clear sound with a new sense of freedom."

While this innovation delights tech enthusiasts, prominent public health experts are raising the alarm with regard to the broader issue of microwave cell phone radiation.

Why the concern?

Simply, there is a growing body of scientific evidence that wireless microwave radiation is potentially harmful to human health, including damage to DNA, leakage of the blood-brain barrier, cognitive impairment and cardiac symptoms.

How can this be?

Surely there are safety standards limiting our exposure and manufacturers must comply? And someone is monitoring the rapid rise of Wi-Fi and other digital technology for adverse health effects?

After more than a decade studying and writing about this issue, it seems clear to me the accuracy of safety standards is a key factor.

This is why experts, including Dr. Martin Blank – a cell biologist who published more than two hundred peer-reviewed studies while a professor at Columbia University – are calling for a review of these standards.

Dr. Blank cautions, "We don't feel this radiation and we think it's not doing anything, but it's a very potent biological agent and government safety standards are irrelevant. There is evidence of harm; the standards are not protecting us."

"Government regulators are just plain wrong". The environmental health physician, Dr. David Carpenter, made that hard-hitting statement.

"Irrelevant", "Just plain wrong"?

This is because the standards are set only for radiation powerful enough to heat human tissue. They do not consider the 'low' levels emitted by Wi-Fi, mobile phones and wireless headsets.

While these levels do not heat human tissue, there is significant evidence of harm. Pregnant women, children and youth are especially at risk.

Proximity is a crucial factor, as the strength of this radiation drops off dramatically at distance. This is why experts strongly advise keeping all mobile devices as far as possible away from the body, especially keeping mobile phones away from the head and vulnerable brain tissue.

(You can imagine my distress when I see a pregnant woman resting an iPad or mobile phone on her belly, or see young children on these wireless devices.)

So, back to headphone jacks: wired headsets are considered essential if you want to reduce your risk when using a mobile phone.

Joel Moskowitz, PhD, Director, Center for Family & Community Health School of Public Health University of California, Berkeley is a leading expert in this field. He reported recently, "Apple's new AirPods are wireless earbuds that employ Bluetooth technology to communicate with your smart phone, laptop, or smart watch. If one uses the AirPods many hours a day, the cumulative exposure to the brain from this microwave radiation could be substantial."

Dr. Moskowitz goes on to refer to the risks to the brain from exposure to Bluetooth radiation and the risks of higher levels of radiation.

The concern is also that the user does not have the option of limiting their exposure with a wired headset. This is similar with iPads – even if you want to opt for a safer wired internet connection, you can't do this, as there is no input jack – it can only be connected wirelessly.

Here is an excerpt from my book, A Wellness Guide for The Digital Age, with advice from technical expert Rob Metzinger of Safe Living Technologies:

Headsets, Earpieces – Safer Solutions:

Here is a summary of headset options – worst to best:

Worst – Cell phone held against your head, up to your ear, using a wireless headset, then a conventional wired headset.

Better – The air tube headset is non-conductive thus separating you from the wires and speaker. This makes it better than a wired headset, and certainly much better than a wireless one. For best results, ensure the phone is at a distance and you are not in contact with the wire or the phone. Note: compatible adapters for your particular model of mobile phone may be challenging to find.

NativeUnion.com makes this 'Retro' POP handset for mobiles; it looks just like a corded phone handset and plugs into your mobile phone, or computer, to reduce radiation exposure. The bluetooth model is not advised.

Best – Using a phone with a good quality speaker (away from the body without contacting it) is a safer option but most speakers are poor quality sound and don't allow privacy. This is where the air tube headset comes into play. Note: these steps reduce radiation but mobiles are still not safe.

Safe – Standard landline phone; choose the corded phone. (If you are electro-sensitive, use the speaker function on the landline.)" Switch from cell/cordless phones to corded landlines to maintain your health. Best: one with batteries, not plugged into a wall socket."

Of course, this advice is falling on mostly deaf ears. At a seminar recently someone asked me, "What's a landline?"

https://kashmirobserver.net/2016/features/how-safe-your-cell-phone-11453

Apple's new 'wireless' headphones emit radiation ... right next to your brain

To much fanfare and excitement, Apple has announced that the iPhone 7 will come with wireless earbuds, ditching the much-reviled and ever-tangled cords of conventional earbuds. The wireless earbuds, dubbed "AirPods," will be water-resistant and are, in the words of company CEO Tim Cook, the first step to a "wireless future."

They will also fire dangerous, cancer-causing radiation directly into the brains of users, experts have warned.

The iPhone will communicate via Bluetooth directly with the right earbud, which will send a separate Bluetooth signal to the left earbud. This means the radiation carrying the signal will pass directly through the user's brain.

According to Apple, all Bluetooth devices emit radiofrequency radiation (RFR) within the guidelines set by the Federal Communications Commission (FCC). But according to Joel Moskowitz of the UC Berkeley School of Public Health, more than 200 scientists who study the effects of electromagnetic fields on the body have gone on record criticizing the FCC guidelines as far too lenient.

"We are playing with fire here," Moskowitz said. "You are putting a microwave-emitting device next to your brain."

The public health implications of people doing this on a massive scale are daunting, Moskowitz and other experts have warned.

Traditionally, scientists have claimed that RFR does not carry enough energy to cause cellular or DNA damage -- in contrast to the more high-energy ionizing radiation, such as X-rays, that has been shown to cause cancer.

Yet ionizing or not, a large body of research continues to show negative health effects in humans and other animals exposed to RFR.

"This has been observed over several decades," Moskowitz said. "It's like we keep rediscovering that Bluetooth is harmful and trying to forget it because we don't know how to handle it from a policy standpoint."
Contrary to the claims of industry representatives, studies have in fact established ways that RFR leads directly to health harm.

For example, RFR has been shown to degrade the blood-brain barrier, thereby allowing more toxins to pass into the brain. This is a major concern with placing RFR transmitters directly next to the brain.

"Although we don't know the long-term risks from using Bluetooth devices, why would anyone insert microwave-emitting devices in their ears near their brain when there are safer ways to use a cell phone?" Moskowitz said. "Essentially I recommend using corded headsets or hands-free use of cell phones, not wireless ear buds."

But even without Bluetooth, any cell phone use is hazardous. Cell phones also operate using RFR signals, as do smart meters and wireless networking.

Another mechanism by which RFR can cause health problems -- including cancer -- was identified in a 2015 study published in the journal Electromagnetic Biology & Medicine. The researchers found that numerous prior studies have shown that RFR can induce oxidative stress, a condition in which the body's antioxidant defenses are overwhelmed and free radicals run amok.

Free radicals are molecules that damage cells and DNA, and are considered among the major causes of cancer, heart disease, dementia, and numerous other health problems.

Indeed, all studies that have shown health concerns with cell phone radiation apply equally to Bluetooth, and therefore to Apple's AirPods. Thus, iPhone 7 purchasers should be concerned about the findings of the 2010 industry-funded Interphone study, which found dramatic increases in the risk of brain tumors, acoustic nerve tumors and parotid gland tumors among people who had used cell phones for 10 years or more -- and even higher risks among those who started using phones before age 20.

Earlier this year, scientists from across the United States gathered at a pediatric conference in Baltimore to declare that there is no longer a debate about the cell phone-brain cancer link.

"The weight of the evidence is clear: cell phones do cause brain cancer," said Dr. Devra Davis, president of the Environmental Health Trust.

http://www.naturalnews.com/055296_iPhone_wireless_headphones_brain_cancer.html

Major cell phone radiation study reignites cancer debate

Federal scientists released partial findings Friday from a $25-million animal study that tested the possibility of links between cancer and chronic exposure to the type of radiation emitted from cell phones and wireless devices. The findings, which chronicle an unprecedented number of rodents subjected to a lifetime of electromagnetic radiation starting in utero, present some of the strongest evidence to date that such exposure is associated with the formation of rare cancers in at least two cell types in the brains and hearts of rats. The results, which were posted on a prepublication Web site run by Cold Spring Harbor Laboratory, are poised to reignite controversy about how such everyday exposure might affect human health.

Researchers at the National Toxicology Program (NTP), a federal interagency group under the National Institutes of Health, led the study. They chronically exposed rodents to carefully calibrated radio-frequency (RF) radiation levels designed to roughly emulate what humans with heavy cell phone use or exposure could theoretically experience in their daily lives. The animals were placed in specially built chambers that dosed their whole bodies with varying amounts and types of this radiation for approximately nine hours per day throughout their two-year life spans. “This is by far—far and away—the most carefully done cell phone bioassay, a biological assessment. This is a classic study that is done for trying to understand cancers in humans,” says Christopher Portier, a retired head of the NTP who helped launch the study and still sometimes works for the federal government as a consultant scientist. “There will have to be a lot of work after this to assess if it causes problems in humans, but the fact that you can do it in rats will be a big issue. It actually has me concerned, and I’m an expert.”

More than 90 percent of American adults use cell phones. Relatively little is known about their safety, however, because current exposure guidelines are based largely on knowledge about acute injury from thermal effects, not long-term, low-level exposure. The International Agency for Research on Cancer in 2011 classified RF radiation as a possible human carcinogen. But data from human studies has been “inconsistent,” the NTP has said on its website. Such studies are also hampered by the realities of testing in humans, such as recall bias—meaning cancer patients have to try to remember their cell phone use from years before, and how they held their handsets. Those data gaps prompted the NTP to engage in planning these new animal studies back in 2009. The researchers found that as the thousands of rats in the new study were exposed to greater intensities of RF radiation, more of them developed rare forms of brain and heart cancer that could not be easily explained away, exhibiting a direct dose–response relationship. Overall, the incidence of these rare tumors was still relatively low, which would be expected with rare tumors in general, but the incidence grew with greater levels of exposure to the radiation. Some of the rats had glioma—a tumor of the glial cells in the brain—or schwannoma of the heart. Furthering concern about the findings: In prior epidemiological studies of humans and cell phone exposure, both types of tumors have also cropped up as associations.

In contrast, none of the control rats—those not exposed to the radiation—developed such tumors. But complicating matters was the fact that the findings were mixed across sexes: More such lesions were found in male rats than in female rats. The tumors in the male rats “are considered likely the result of whole-body exposure” to this radiation, the study authors wrote. And the data suggests the relationship was strongest between the RF exposure and the lesions in the heart, rather than the brain: Cardiac schwannomas were observed in male rats at all exposed groups, the authors note. But no “biologically significant effects were observed in the brain or heart of female rats regardless of modulation.” Based on these findings, Portier said that this is not just an associated finding—but that the relationship

between radiation exposure and cancer is clear. "I would call it a causative study, absolutely. They controlled everything in the study. It's [the cancer] because of the exposure."

Earlier studies had never found that this type of radiation was associated with the formation of these cancers in animals at all. But none of those studies followed as many animals, for as long or with the same larger intensity exposures, says Ron Melnick, a scientist who helped design the study and is now retired from the NTP.

The new results, published on Web site bioRXiv, involved experiments on multiple groups of 90 rats. The study was designed to give scientists a better sense of the magnitude of exposure that would be associated with cancer in rodents. In the study rats were exposed to RF at 900 megahertz. There were three test groups with each species of each sex, tested at different radiation intensities (1.5, three and six watts per kilogram, or W/kg), and one control group. (The lowest-intensity level roughly approximates the levels allowed by U.S. cell phone companies, which is 1.6 W/kg.) "There are only 90 animals per group, so because there is a trend—and this is the purpose of these assays where you do multiple doses you extrapolate downward and calculate a risk for humans from those trends—so that information is useful. Probably what caused cancer at the high doses will cause cancer at lower doses but to a lesser degree," Portier says.

Rodents across all the test groups were chronically exposed to RF for approximately nine hours spread out over the course of the day. (Their entire bodies were exposed because people are exposed to such radiation beyond their heads, especially when they carry them or store them in their bras, says John Bucher, the associate director of the NTP.) During the study the rats were able to run around in their cages, and to eat and sleep as usual. The experiments also included both types of modulations emitted from today's cell phones: Code Division Multiple Access and Global System for Mobile. (Modulations are the way the information is carried, so although the total radiation levels were roughly the same across both types, there were differences in how radiation is emitted from the antenna—either a higher exposure for a relatively short time or a lower exposure for a longer time.) Overall, there was no statistically significant difference between the number of tumors that developed in the animals exposed to CDMA versus GSM modulations. With both modulations and tumor types, there was also a statistically significant trend upward—meaning the incidence increased with more radiation exposure. Yet, drilling down into the data, in the male rats exposed to GSM-modulated RF radiation the number of brain tumors at all levels of exposure was not statistically different than in control males—those who had no exposure at all. "The trend here is important. The question is, 'Should one be concerned?' The answer is clearly 'Yes.' But it raises a number of questions that couldn't be fully answered, " says David Carpenter, a public health clinician and the director of the Institute for Health and the Environment at the University at Albany, S.U.N.Y.

The findings are not definitive, and there were other confusing findings that scientists cannot explain—including that male rats exposed to the radiation seemed to live longer than those in the control group. "Overall we feel that the tumors are likely related to the exposures," says Bucher, but such unanswered questions "have been the subject of very intense discussions here."

The NTP released the partial findings on Friday after an online publication called *Microwave News* reported them earlier this week. The program will still be putting out other results about the work in rats and additional findings about similar testing conducted in mice. The NIH told *Scientific American* in a statement, "This study in mice and rats is under review by additional experts. It is

important to note that previous human, observational data collected in earlier, large-scale population-based studies have found limited evidence of an increased risk for developing cancer from cell phone use." Still, the NTP was clearly expecting these findings to carry some serious weight: Ahead of Friday's publication the NTP said on its Web site that the study (and prior work leading to these experiments) would "provide critical information regarding the safety of exposure to radio-frequency radiation and strengthen the science base for determining any potential health effects in humans."

In response to media queries, cell phone industry group CTIA–The Wireless Association issued a statement Friday saying that it and the wireless industry are still reviewing the study's findings. "Numerous international and U.S. organizations including the U.S. Food and Drug Administration, World Health Organization and American Cancer Society have determined that the already existing body of peer-reviewed and published studies shows that there are no established health effects from radio frequency signals used in cellphones," the CTIA statement said.

The Federal Communications Commission, which had been briefed by NIH officials, told *Scientific American* in a statement, "We are aware that the National Toxicology Program is studying this important issue. Scientific evidence always informs FCC rules on this matter. We will continue to follow all recommendations from federal health and safety experts including whether the FCC should modify its current policies and RF exposure limits."

This animal study was designed primarily to answer questions about cancer risks humans might experience when they use phones themselves, as opposed to smaller levels of exposure from wireless devices in the workplace or from living or working near cell phone towers. But it may have implications for those smaller levels as well, Portier says.

The findings shocked some scientists who had been closely tracking the study. "I was surprised because I had thought it was a waste of money to continue to do animal research in this area. There had been so many studies before that had pretty consistently not shown elevations in cancer. In retrospect the reason for that is that nobody maintained a sufficient number of animals for a sufficient period of time to get results like this," Carpenter says.

Exposing rodents to radiation for this type of experiment is a tricky business. First, scientists need to be able to calculate exactly how much the rats should be exposed to relative to humans. Too much exposure would not be a good proxy for human use. And with finely calculated low-level exposure rates, scientists still need to be sure they are not going to heat the animals enough to kill them or to cause other health problems. (Subsequent work will be published on the animals' temperatures.)

The fact that scientists were able to expose animals to nonionizing radiation (like that emitted by cell phones) and those animals went on to develop tumors but that exposure did not significantly raise the animals' body temperatures was "important" to release, Bucher says.

There are safety steps individuals can take, Carpenter says. Using the speakerphone, keeping the phone on the desk instead of on the body and using a wired headset whenever possible would help limit RF exposure. "We are certainly not going to go back to a pre-wireless age," he says. But there are a number of ways to reduce exposure, particularly among sensitive populations."

http://www.salon.com/2016/05/29/it_actually_has_me_concerned_and_im_an_expert_major_cell_phone_radiation_study_reignites_cancer_debate_partner/

Cell Phone Companies Are Panicking Over New Study Linking Cell Phone Use And Cancer

It is no longer speculation. Cellphone radiation poses a cancer risk for humans, the U.S. National Toxicology Program (NTP) reported in March 2016. The article comes as government issues its warning to the public following a $25 million study that rats exposed to GSM or CDMA signals for two-years were at a statistically significant higher risk of cancer.

Since everyone in America is exposed to wireless radiation almost all the time, NTP senior managers think the public should be aware that their cellphones may cause brain tumors.

In the past, many doctors, biologists, government officials, and other professionals believe that cancer from cellphone radiation was impossible. But their faulty view was based on a lack of evidence to connect the two. But now that an established mechanism for RF radiation from cellphones has been documented, these claims no longer seem valid.

For example, the same week these findings were released, a Michigan medical doctor wrote in an opinion piece for the Wall Street Journal: “There is no known mechanism by which mobile phones might cause brain tumors.” He seems to be wrong.

According to the NTP findings, as the intensity of the radiation increases, so does the incidence of cancer among the lab rats.

While rats got cancer, no effect was observed on mice.

Rats were exposed to different exposure levels as well as two different kinds of cell phone radiation.

Rats exposed to cellphone radiation were found to have higher rates of two types of cancer.

The first, glioma, is a tumor of the glial cells in the brain. The second was malignant schwannoma of the heart which is very rare and dangerous.

None of the rats not exposed to cellphone radiation developed either type of cancer.

“The NTP tested the hypothesis that cell phone radiation could not cause health effects and that hypothesis has now been disproved,” Ron Melnick, who led the team that designed the NTP study, said in a telephone interview. “The experiment has been done and, after extensive reviews, the consensus is that there was a carcinogenic effect.”

The safety of cellphones has been a heated debate for more than two decades. But in 2011 when the International Agency for Research on Cancer classified cellphones as a possible human carcinogen.

“This is a major public health concern because the cells which became cancerous in the rats were the same types of cells as those that have been reported to develop into tumors in cell phone epidemiological studies,” Melnick added. “For this to be a chance coincidence would be truly amazing.”

The NTP radiation study was conducted for more than a decade and had a $25 million budget.

http://awm.com/cell-phone-companies-are-panicking-over-new-study-linking-cell-phone-use-and-cancer/

New Expert Warning: Claims That Cellphones Are Safe 'Endanger Public Health' and Are 'Ludicrous'

The widely publicized article claiming that cell phones are safe by the Australian sociologist Simon Chapman contains a number of major errors and cherry-picked data, according to newly published critiques by Environmental Health Trust scientists.

In a series of newly published articles, Environmental Health Trust experts reject a widely-publicized article asserting no connection between brain cancer and mobile phones. Experts say the article published in Cancer Epidemiology by the Australian sociologist Simon Chapman contains a number of errors, false assumptions and cherry-picked data and are calling upon the journal's editor-in-chief to retract the article.

These newly published appraisals (Bandara 2016, Morgan 2016, Wojcik 2016) debunk the claim by Chapman et al that "After nearly 30 years of mobile phone in Australia among millions of people, there is no evidence of any rise in any age-group that could be plausibly attributed to mobile phones."

"Given the radical changes in uses and users of phones today, arguing that the absence of a general epidemic of brain cancer today is proof of safety is ludicrous. Average rates of cancer cannot show us what's happening in the youngest age groups where rates are rising rapidly," adds Devra Lee Davis. "By showing only that part of the data that supports his view, Chapman is playing fast and loose with science and putting us all at grave risk," she adds. "He basically ignores rising brain cancer rates in the U.S. and Australia that have grown rapidly in those under age 65 that have incurred the greatest use of phones for the longest time. Instead he points to the lack of an overall population increase in the disease as proof phones have no effect."

"The assertion that mobile phones are safe is a massive disservice to global public health," says Dr. Anthony B. Miller, senior advisor to the World Health Organization. "New studies from the U.S National Toxicology Program confirm that animals develop the same tumors of the brain that are increased in the heaviest regular cell phone users. We cannot afford to treat people like lab rats and must take steps to reduce exposures at this time, while continuing to study the issue in a serious manner."

"Chapman has Cherry-picked his data," notes L. Lloyd Morgan senior scientist with EHT. "For example, the paper referred an Australian paper that had reported a large increase in brain cancer, 'found an increase in incidence of the aged 65 and over,' but fail to the report the full statement from that same paper: "A significant increasing incidence in glioblastoma multiforme (GBM) was observed in the study period [2000-2008] (annual percentage change [APC] 2.54; 95% confidence interval [CI] 0.4-4.6, n =2275), particularly after 2006. In GBM patients in the [under age] >65-year group, a significantly increasing incidence both for men and women …' Invoking only those data that support his view and ignoring information from the same paper that contradicts his view is a ludicrous and dangerous method of analysis.

Additional concerns are raised about the Chapman report by clinical director and forensic expert Damian Wojcik of New Zealand who adds that the Chapman fails to take into account evidence that the locations of brain tumors that are increasing in the young are precisely those to be expected to be associated with mobile phones. Recent report from the National Cancer Institute Surveillance End-Result

and Epidemiology program confirm that brain cancers located in the cerebellum and frontal and temporal lobe (front and sides of the head where cell phone radiation penetrates the skull) have increased in younger Americans.

The scientist's also point out that Chapman does not analyze information on actual minutes of mobile phone use by a person, but estimates this based only on the number of mobile phone subscriptions.

"It is irresponsible to give assurances on microwave/radiofrequency radiation (from wireless devices) based on just cell phone subscriptions as Chapman does, while ignoring a solid and growing body of scientific studies showing serious health problems in those studies that have information on actual cell phone use," states Dr. Pri Bandara, an Australian clinical researcher, pointing to several research studies indicating increased risk in people who used cell phones for more minutes a day than others.

Morgan noted that there is no funding source for the Chapman paper indicated but Chapman worked with the Australian Mobile Telecommunication Association (AMTA) in the past. Professor Chapman published a book with the AMTA and then a paper in a journal which acknowledged "Funding for this study was provided by the AMTA."

http://www.sbwire.com/press-releases/new-expert-warning-claims-that-cellphones-are-safe-endanger-public-health-and-are-ludicrous-720416.htm

Children Can Absorb 10x More Radiation In Their Bone Marrow Than Adults

Not only is sensitivity to electromagnetic radiation emerging as a major health problem in our society, but start creating policies to curb exposure in our youngest generations, the repercussions as they age could be disastrous to our entire health infrastructure.

Many scientists have claimed that the wave of mobile communications made popular in the last two decades will result in long-term health implications worldwide. An unprecedented level and frequency of tumor growth inside the human brain may be inevitable. Mobile phone owners were urged to limit their use after the World Health Organization admitted they may cause cancer.

Neurosurgeon and researcher Dr. Leif Salford has conducted many studies on radio frequency radiation and its effects on the brain. Dr. Salford called the potential implications of some of his research "terrifying." Some of the most concerning conclusions result from the fact that the weakest exposure levels to wireless radiation caused the greatest effect in causing the blood brain barrier to leak.

A scholarly article on cell phone safety in the journal Electromagnetic Biology and Medicine reports the finding that cell phones used in the shirt or pants pocket exceed the U.S. Federal Communications Commission (FCC) exposure guidelines and that children absorb at least twice as much microwave radiation from phones as do adults. The paper notes that the industry-designed process for evaluating microwave radiation from phones results in children absorbing twice the cellphone radiation to their heads, up to triple in their brain's hippocampus and hypothalamus, greater absorption in their eyes, and as much as 10 times more in their bone marrow when compared to adults.
Earlier research on pregnant mothers who use mobile phones has shown they are likely to give birth to kids with behavioural problems, especially if those children start using mobile phones early themselves. Exposure to radiation from cell phones during pregnancy affects the brain development of offspring, potentially leading to hyperactivity.

A study published in The Journal of the American Medical Association, is among the first and largest to document that the weak radio-frequency signals from cellphones have the potential to alter brain activity.

"Studies of people have shown that both electrical "extremely low frequency" fields (ELF), and communication "radiofrequency" (RF) exposures result in an increased risk of cancer, and that this occurs at intensities that are too low to cause tissue heating. Unfortunately, all of our exposure standards are based on the false assumption that there are no hazardous effects at intensities that do not cause tissue heating. Based on the existing science, many public health experts believe it is possible we will face an epidemic of cancers in the future resulting from uncontrolled use of cell phones and increased population exposure to Wi-Fi and other wireless devices. Thus it is important that all of us, and especially children, restrict our use of cell phones, limit exposure to background levels of Wi-Fi, and that government and industry discover ways in which to allow use of wireless devices without such elevated risk of serious disease. We need to educate decision-makers that 'business as usual' is unacceptable. The importance of this public health issue cannot be underestimated."
– David Carpenter, MD

http://www.getholistichealth.com/46115/children-can-absorb-10x-more-radiation-in-their-bone-marrow-than-adults/

Your cellphone is killing you: What people don't want you to know about electromagnetic fields

The industry doesn't want to admit it, but the science is becoming clearer: Sustained EMF exposure is dangerous

You may not realize it, but you are participating in an unauthorized experiment—"the largest biological experiment ever," in the words of Swedish neuro-oncologist Leif Salford. For the first time, many of us are holding high-powered microwave transmitters—in the form of cell phones—directly against our heads on a daily basis.

Cell phones generate electromagnetic fields (EMF), and emit electromagnetic radiation (EMR). They share this feature with all modern electronics that run on alternating current (AC) power (from the power grid and the outlets in your walls) or that utilize wireless communication. Different devices radiate different levels of EMF, with different characteristics.

What health effects do these exposures have?

Therein lies the experiment.

The many potential negative health effects from EMF exposure (including many cancers and Alzheimer's disease) can take decades to develop. So we won't know the results of this experiment for many years—possibly decades. But by then, it may be too late for billions of people.

Today, while we wait for the results, a debate rages about the potential dangers of EMF. The science of EMF is not easily taught, and as a result, the debate over the health effects of EMF exposure can get quite complicated. To put it simply, the debate has two sides. On the one hand, there are those who urge the adoption of a precautionary approach to the public risk as we continue to investigate the health effects of EMF exposure. This group includes many scientists, myself included, who see many danger signs that call out strongly for precaution. On the other side are those who feel that we should wait for definitive proof of harm before taking any action. The most vocal of this group include representatives of industries who undoubtedly perceive threats to their profits and would prefer that we continue buying and using more and more connected electronic devices.

This industry effort has been phenomenally successful, with widespread adoption of many EMF-generating technologies throughout the world. But EMF has many other sources as well. Most notably, the entire power grid is an EMF-generation network that reaches almost every individual in America and 75% of the global population. Today, early in the 21st century, we find ourselves fully immersed in a soup of electromagnetic radiation on a nearly continuous basis.

The science to date about the bioeffects (biological and health outcomes) resulting from exposure to EM radiation is still in its early stages. We cannot yet predict that a specific type of EMF exposure (such as 20 minutes of cell phone use each day for 10 years) will lead to a specific health outcome (such as cancer). Nor are scientists able to define what constitutes a "safe" level of EMF exposure.

However, while science has not yet answered all of our questions, it has determined one fact very clearly—all electromagnetic radiation impacts living beings. As I will discuss, science demonstrates a

wide range of bioeffects linked to EMF exposure. For instance, numerous studies have found that EMF damages and causes mutations in DNA—the genetic material that defines us as individuals and collectively as a species. Mutations in DNA are believed to be the initiating steps in the development of cancers, and it is the association of cancers with exposure to EMF that has led to calls for revising safety standards. This type of DNA damage is seen at levels of EMF exposure equivalent to those resulting from typical cell phone use.

The damage to DNA caused by EMF exposure is believed to be one of the mechanisms by which EMF exposure leads to negative health effects. Multiple separate studies indicate significantly increased risk (up to two and three times normal risk) of developing certain types of brain tumors following EMF exposure from cell phones over a period of many years. One review that averaged the data across 16 studies found that the risk of developing a tumor on the same side of the head as the cell phone is used is elevated 240% for those who regularly use cell phones for 10 years or more. An Israeli study found that people who use cell phones at least 22 hours a month are 50% more likely to develop cancers of the salivary gland (and there has been a four-fold increase in the incidence of these types of tumors in Israel between 1970 and 2006). And individuals who lived within 400 meters of a cell phone transmission tower for 10 years or more were found to have a rate of cancer three times higher than those living at a greater distance. Indeed, the World Health Organization (WHO) designated EMF—including power frequencies and radio frequencies—as a possible cause of cancer.

While cancer is one of the primary classes of negative health effects studied by researchers, EMF exposure has been shown to increase risk for many other types of negative health outcomes. In fact, levels of EMF thousands of times lower than current safety standards have been shown to significantly increase risk for neurodegenerative diseases (such as Alzheimer's and Lou Gehrig's disease) and male infertility associated with damaged sperm cells. In one study, those who lived within 50 meters of a high voltage power line were significantly more likely to develop Alzheimer's disease when compared to those living 600 meters or more away. The increased risk was 24% after one year, 50% after 5 years, and 100% after 10 years. Other research demonstrates that using a cell phone between two and four hours a day leads to 40% lower sperm counts than found in men who do not use cell phones, and the surviving sperm cells demonstrate lower levels of motility and viability.

EMF exposure (as with many environmental pollutants) not only affects people, but all of nature. In fact, negative effects have been demonstrated across a wide variety of plant and animal life. EMF, even at very low levels, can interrupt the ability of birds and bees to navigate. Numerous studies link this effect with the phenomena of avian tower fatalities (in which birds die from collisions with power line and communications towers). These same navigational effects have been linked to colony collapse disorder (CCD), which is devastating the global population of honey bees (in one study, placement of a single active cell phone in front of a hive led to the rapid and complete demise of the entire colony). And a mystery illness affecting trees around Europe has been linked to Wi-Fi radiation in the environment.

There is a lot of science—highquality, peer-reviewed science—demonstrating these and other very troubling outcomes from exposure to electromagnetic radiation. These effects are seen at levels of EMF that, according to regulatory agencies like the Federal Communications Commission (FCC), which regulates cell phone EMF emissions in the United States, are completely safe.

I have worked at Columbia University since the 1960s, but I was not always focused on electromagnetic fields. My PhDs in physical chemistry from Columbia University and colloid science from the University of Cambridge provided me with a strong, interdisciplinary academic background in biology, chemistry, and physics. Much of my early career was spent investigating the properties of surfaces and very thin films, such as those found in a soap bubble, which then led me to explore the biological membranes that encase living cells.

I studied the biochemistry of infant respiratory distress syndrome (IRDS), which causes the lungs of newborns to collapse (also called hyaline membrane disease). Through this research, I found that the substance on the surface of healthy lungs could form a network that prevented collapse in healthy babies (the absence of which causes the problem for IRDS sufferers).

A food company subsequently hired me to study how the same surface support mechanism could be used to prevent the collapse of the air bubbles added to their ice cream. As ice cream is sold by volume and not by weight, this enabled the company to reduce the actual amount of ice cream sold in each package. (My children gave me a lot of grief about that job, but they enjoyed the ice cream samples I brought home.)

I also performed research exploring how electrical forces interact with the proteins and other components found in nerve and muscle membranes. In 1987, I was studying the effects of electric fields on membranes when I read a paper by Dr. Reba Goodman demonstrating some unusual effects of EMF on living cells. She had found that even relatively weak power fields from common sources (such as those found near power lines and electrical appliances) could alter the ability of living cells to make proteins. I had long understood the importance of electrical forces on the function of cells, but this paper indicated that magnetic forces (which are a key aspect of electromagnetic fields) also had significant impact on living cells.

Like most of my colleagues, I did not think this was possible. By way of background, there are some types of EMF that everyone had long acknowledged are harmful to humans. For example, X-rays and ultraviolet radiation are both recognized carcinogens. But these are ionizing forms of radiation. Dr. Goodman, however, had shown that even non-ionizing radiation, which has much less energy than X-rays, was affecting a very basic property of cells—the ability to stimulate protein synthesis.

Because non-ionizing forms of EMF have so much less energy than ionizing radiation, it had long been believed that non-ionizing electromagnetic fields were harmless to humans and other biological systems. And while it was acknowledged that a high enough exposure to non-ionizing EMF could cause a rise in body temperature—and that this temperature increase could cause cell damage and lead to health problems—it was thought that low levels of non-ionizing EMF that did not cause this rise in temperature were benign.

In over 20 years of experience at some of the world's top academic institutions, this is what I'd been taught and this is what I'd been teaching. In fact, my department at Columbia University (like every other comparable department at other universities around the world) taught an entire course in human physiology without even mentioning magnetic fields, except when they were used diagnostically to

detect the effects of the electric currents in the heart or brain. Sure magnets and magnetic fields can affect pieces of metal and other magnets, but magnetic fields were assumed to be inert, or essentially powerless, when it came to human physiology.

As you can imagine, I found the research in Dr. Goodman's paper intriguing. When it turned out that she was a colleague of mine at Columbia, with an office just around the block, I decided to follow up with her, face-to-face. It didn't take me long to realize that her data and arguments were very convincing. So convincing, in fact, that I not only changed my opinion on the potential health effects of magnetism, but I also began a long collaboration with her that has been highly productive and personally rewarding.

During our years of research collaboration, Dr. Goodman and I published many of our results in respected scientific journals. Our research was focused on the cellular level—how EMF permeate the surfaces of cells and affect cells and DNA—and we demonstrated several observable, repeatable health effects from EMF on living cells. As with all findings published in such journals, our data and conclusions were peer reviewed. In other words, our findings were reviewed prior to publication to ensure that our techniques and conclusions, which were based on our measurements, were appropriate. Our results were subsequently confirmed by other scientists, working in other laboratories around the world, independent from our own.

Over the roughly 25 years Dr. Goodman and I have been studying the EMF issue, our work has been referenced by numerous scientists, activists, and experts in support of public health initiatives including the BioInitiative Report, which was cited by the European Parliament when it called for stronger EMF regulations. Of course, our work was criticized in some circles, as well. This was to be expected, and we welcomed it—discussion and criticism is how science advances. But in the late 1990s, the criticism assumed a different character, both angrier and more derisive than past critiques.

On one occasion, I presented our findings at a US Department of Energy annual review of research on EMF. As soon as I finished my talk, a well-known Ivy League professor said (without any substantiation) that the data I presented were "impossible." He was followed by another respected academic, who stated (again without any substantiation) that I had most likely made some "dreadful error." Not only were these men wrong, but they delivered their comments with an intense and obvious hostility.

I later discovered that both men were paid consultants of the power industry—one of the largest generators of EMF. To me, this explained the source of their strong and unsubstantiated assertions about our research. I was witnessing firsthand the impact of private, profit-driven industrial efforts to confuse and obfuscate the science of EMF bioeffects.

I knew that this was not the first time industry opposed scientific research that threatened their business models. I'd seen it before many times with tobacco, asbestos, pesticides, hydraulic fracturing (or "fracking"), and other industries that paid scientists to generate "science" that would support their claims of product safety.

That, of course, is not the course of sound science. Science involves generating and testing hypotheses. One draws conclusions from the available, observable evidence that results from rigorous and

reproducible experimentation. Science is not sculpting evidence to support your existing beliefs. That's propaganda. As Dr. Henry Lai (who, along with Dr. Narendra Singh, performed the groundbreaking research demonstrating DNA damage from EMF exposure) explains, "a lot of the studies that are done right now are done purely as PR tools for the industry."

http://www.salon.com/2014/04/12/your_cellphone_is_killing_you_what_people_dont_want_you_to_know_about_electromagnetic_fields/

Report of Partial Findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd:

The purpose of this communication is to report partial findings from a series of radiofrequency radiation (RFR) cancer studies in rats performed under the auspices of the U.S. National Toxicology Program (NTP).1

This report contains peer-reviewed, neoplastic and hyperplastic findings only in the brain and heart of Hsd:Sprague Dawley® SD® (HSD) rats exposed to RFR starting in utero and continuing throughout their lifetimes. These studies found low incidences of malignant gliomas in the brain and schwannomas in the heart of male rats exposed to RFR of the two types [Code Division Multiple Access (CDMA) and Global System for Mobile Communications (GSM)] currently used in U.S. wireless networks. Potentially preneoplastic lesions were also observed in the brain and heart of male rats exposed to RFR. The review of partial study data in this report has been prompted by several factors. Given the widespread global usage of mobile communications among users of all ages, even a very small increase in the incidence of disease resulting from exposure to RFR could have broad implications for public health. There is a high level of public and media interest regarding the safety of cell phone RFR and the specific results of these NTP studies.

Lastly, the tumors in the brain and heart observed at low incidence in male rats exposed to GSM- and CDMA-modulated cell phone RFR in this study are of a type similar to tumors observed I some epidemiology studies of cell phone use. These findings appear to support the International Agency for Research on Cancer (IARC) conclusions regarding the possible carcinogenic potential of RFR.

http://biorxiv.org/content/biorxiv/early/2016/05/26/055699.full.pdf

Dangers of living near cell phone towers raised

When Mom asked me to look into possible health hazards posed by cell phone panel antennas that a church in her neighborhood wants to put up, I expected to find reassuring facts to allay Mom's concerns. Instead, I found deeply disturbing data that makes me wonder why the public is not being informed about health risks—and why our government seems intent on covering up troubling truths.

Cell phone companies and the U.S. Food and Drug Administration assert that cell phone towers don't pose health risks to the public. Some studies support this assertion, but other studies suggest just the opposite.

Harvard-trained Dr. Andrew Weil at the University of Arizona's medical center recently observed, "In January 2008, the National Research Council (NRC), an arm of the National Academy of Sciences and the National Academy of Engineering, issued a report saying that we simply don't know enough about the potential health risks of long-term exposure to RF energy from cell phones themselves, cell towers, television towers, and other components of our communications system. The scientists who prepared the report emphasized, in particular, the unknown risks to the health of children, pregnant women, and fetuses as well as of workers whose jobs entail high exposure to RF (radiofrequency) energy….Because so much of cell phone technology is new and evolving, we don't have data on the consequences of 10, 20 or 30 years worth of exposure to the RF energy they emit," Weil concluded. The report called for long-term safety studies on all wireless devices including cell phones, computers, and cell phone towers.

A 2006 report issued by the World Health Organization (WHO) offered some reassurance and found no scientific evidence that radiofrequency signals from cell towers cause adverse health effects. The report noted that up to five times more of the RF signals from FM radio and television (than from cell towers) are absorbed by the body with no known adverse effects on health in the more than 50 years that radio and TV broadcast stations have been operating.

But an Australian study found that children living near TV and FM broadcast towers, which emit similar radiation to cell towers, developed leukemia at three times the rate of children living over seven miles away.

If you live within a quarter mile of a cell phone antenna or tower, you may be at risk of serious harm to your health, according to a German study cited at www.EMF-Health.com, a site devoted to exposing hazards associated with electromagnetic frequencies from cell phone towers and other sources.

Cancer rates more than tripled among people living within 400 meters of cell phone towers or antennas, a German study found. Those within 100 meters were exposed to radiation at 100 times normal levels. An Israeli study found risk of cancer quadrupled among people living within 350 meters (1,148 feet) of a cell phone transmitter—and seven out of eight cancer victims were women. Both studies focused only on people who had lived at the same address for many years.

Other studies have found that levels of radiation emitted from cell phone towers can damage cell tissues and DNA, causing miscarriage, suppressing immune function, and causing other health problems.

Astoundingly, the federal government does not allow rejection of a cell phone tower based on health risks, according to a 2005 article. A Google search found no evidence that this situation has changed.

Yet over 1.9 million cell phone towers and antennae have been approved nationwide without federal studies to assure safety of those living nearby.

How many cell phone towers and antennas are in your neighborhood? Find out at www.antennasearch.com. I plugged in my address on Mt. Helix, hardly an urban stronghold, and was astounded to discover that there are 96 cell phone towers, 286 antennas and 2 proposals for new towers within four miles of my home!

So how about Mom's neighborhood, where an Evangelical church insists a new tower is needed? Mom gets perfectly fine cell phone reception, and so do the neighbors she's spoken with—not surprising since there are already 113 towers and 335 antennas within a four-mile radius.

Churches, schools, fire stations, and other buildings are increasingly erecting cell phone towers or antennas because cell phone companies are willing to pay rental fees of hundreds or even thousands of dollars a month—welcome infusions for cash-strapped budgets. But at what cost to the public's health? There are young children in Mom's neighborhood, less than one block from the proposed cell phone antenna site.

In Sweden, the government requires interventions to protect the public from electromagnetic frequencies. Why isn't the U.S. government paying attention to this potential risk to public safety?

http://www.eastcountymagazine.org/cell_phone_towers_238

Scientific Evidence Shows That Americans' Brains Are Being Fried By Cell Towers

JUNE 23, 2016

New evidence indicates that cell phones are damaging more than just our social lives. Indeed, cell towers may actually be altering the function of your brain by inhibiting your thought process, decreasing your appetite and your ability to sleep and causing irritability. A study recently published by the *British Medical Journal* and led by professor Enrique A. Navarro concluded that the severity of these types of symptoms was directly correlated with cell tower exposure. The closer a person lives to a cell tower, the more pronounced the symptoms will be – regardless of the demographic.

Cell towers rely on electromagnetic switching signals in order to broadcast and receive data. The human body, most especially the brain, also uses electromagnetic impulses to send and transmit messages along different pathways. This is essential for normal function across the body system. Scientists have long suspected that being subject to even low levels of EMF pollution, or electropollution, could have ill effects on the brain and body. This new study supports past suspicions and adds to the current body of proof that cell towers can be harmful.

Electromagnetic hypersensitivity is an increasingly frequent phenomenon that is being dismissed by many doctors and scientists as a made-up condition.

A 2010 meta-analysis found that 80 percent of the reviewed studies indicated that cell phone tower proximity correlated with a higher prevalence of adverse symptoms and cancer, yet many conventional doctors and industry-fed scientists refuse to admit that these effects are real. What is most shocking is that these symptoms have all been reported by people living near towers that currently meet the required safety guidelines. Navarro suggests that this means our current guidelines on cell phone tower safety are not sufficient enough to protect the public. People who live less than 500 meters from a cell phone tower are at an exceptionally high risk, due to the nature of electromagnetic fields. Electropollution severity is calculated by the inverse square of distance. This means that someone who lives twice as close to the cell tower will be subject to four times the amount of radiation. Living within 21 miles of a cell tower means you are exposed to a reasonably significant level of electropollution.

There are presently 190,000 cell towers within the U.S., and that number is continuing to grow. It is suspected that at least people are affected by cell phone towers, if not more.

http://www.emf.news/2016-06-23-scientific-evidence-shows-that-americans-brains-are-being-fried-by-cell-towers.html

Research Findings Presented at International Conference Link Cell Phone Microwave Radiation to Cancer, Low Birth Weight and Sperm Damage

Experts call for strong policy action to protect the public and especially children who are more vulnerable.

Teton Village, WY -- (SBWIRE) -- 02/22/2017 -- Scientists from 10 nations evaluated the latest peer reviewed body of evidence linking adverse health effects to wireless radiation at an expert forum that was held in late January at Hebrew University. The scientists call for policy actions to reduce exposure were recommended, such as legislation that significantly and more protectively reduces human exposure to RF, minimization of wireless in schools and public places, and national campaigns about screen time and children's health.

The event was organized in cooperation with the U.S. National Institute of Environmental Health Sciences (NIEHS) and Environmental Health Trust (EHT). Findings included the large $25 million study by the US National Toxicology Program, and other investigations confirming cancer-promoting effects, along with substantially increased cancer risks to regular long-term cell phone users, and important new studies indicating potential human health risks of 5G communication systems, wireless in schools, and the physical and psychological effects of screen time

According to Dr. Anthony Miller— long-term advisor at the World Health Organization's IARC, and advisor to Environmental Health Trust detailed the current epidemiological research on long-term cell phone users stated that his overall conclusions are that in terms of the 2011 IARC classification, today, radiofrequency fields should be considered probable causes of human cancer. Lecture videos are now available at the Environmental Health Trust conference website.

Evidence of Increased Malignancies and DNA Damage

Dr. Linda Birnbaum, Director of the US National Institute of Environmental Health Sciences, prepared a presentation shared by Dr. Ron Melnick on the National Toxicology Program (NTP) study's research findings on rats exposed to wireless radiation at levels mimicking long- term cell phone exposures. Findings include: increased highly malignant cancers of the brain; increased highly malignant cancer of the heart nerve sheath; and DNA damage in the brain. In addition to increased malignancies and DNA damage, lower litter weights were found in the wireless exposed rats of the NTP study.

"We feel obliged to call for strong actions of precaution by international regulators, above all for children and pregnant women," stated Dr. Fiorella Belpoggi, Director of the Research Department of the Cesare Maltoni Cancer Research Centre Ramazzini Institute.

At conference the Dr. Fiorella Belpoggi of the Italian Ramazzini Institute released new partial findings of their cell phone radiation studies, which found, like the NTP study, lower birth weight in rats prenatally exposed to cell phone radiation. The Ramazzini study radiation exposures were orders of magnitude lower density of Radiofrequency (RF) fields than the NTP study exposures and were set to mimic cell tower radiation exposure levels.

The meeting was co-chaired by Devra Davis, PhD, MPH, visiting Professor of Medicine of The Hebrew University, who provided an update on research findings that link wireless radiation to brain, liver and

skin damage in prenatally exposed animals, and Professor Emeritus of Medicine, physician-researcher Charles Greenblatt, an acclaimed basic researcher and discoverer of ancient DNA.

Videos of Lectures and Presentation Slides are available at the Conference website:
http://ehtrust.org/science/key-scientific-lectures/2017-expert-forum-wireless-radiation-human-health

http://www.sbwire.com/press-releases/research-findings-presented-at-international-conference-link-cell-phone-microwave-radiation-to-cancer-low-birth-weight-and-sperm-damage-774481.htm

How this sign put Berkeley in the center of the cellphone safety debate

City of Berkeley becomes the first to require cellphone retailers to display warnings about radiation

Updated: 10:41 AM PDT Apr 10, 2017

"Berkeley is the first city in the country to get stores to post warnings. It's a small step, but it's an important step," said Joel Moskowitz, PhD, director of UC Berkeley's Center for Family and Community Health at the University's School of Public Health.

In 2009, Moskowitz turned his focus from scientific research on the health effects of tobacco to cellphones after a visiting scholar from the National Cancer Center in South Korea exposed him to scientific literature looking at whether mobile phone use increased the risk of tumors.

"The cellphone manufacturers want you to keep a minimum distance away from your body and you should find out what that distance is," Moskowitz said. "If you keep the device by your body you will exceed the safety limits provided by the FCC."

That message is what Berkeley officials say is the purpose behind the city's "Right to Know" ordinance: To educate the public that information on radiation exposure from mobile devices can be found in phone, tablet and laptop manuals.

"We're just saying let's take the information that's buried in your cellphone and buried in the manual, and put it where someone might have a chance to read it," said Berkeley councilman Kriss Worthington, who co-sponsored the ordinance with former councilman Max Anderson.

The city council voted unanimously to pass the ordinance in May 2015.

That law now has the city in the middle of a federal lawsuit brought by the CTIA, The Wireless Association.

The CTIA is a Washington, D.C.-based trade group that represents the cellphone industry and is fighting in court to stop retailers from displaying the warnings.

A spokesman for the CTIA said the signs violate their First Amendment rights by compelling them to say something they don't agree with.

"It sort of still surprises me that it could become the subject of a federal lawsuit and have so much money spent against it," Worthington said. "We're not trying to tell the cellphone companies to say something horrible about themselves. And the information isn't even horrible, it's basically saying be prudent, be careful."

Radiation from a phone is measured through something called the Specific Absorption Rate (SAR). It measures how fast a given amount of energy is absorbed by the human body, and it's measured in watts per kilogram.

Since 1996, the FCC has required that all cellphones sold in the U.S. not exceed an SAR limit of 1.6 watts per kilogram over 1 gram of tissue.

Mobile devices are tested and must meet the applicable limits for radio frequency exposure at a certain distance from the body.

Senior Research Fellow and cellphone safety advocate Lloyd Morgan says most people don't know radiation warnings exist in a series of sub-menus in their mobile devices.

"There's a 'stay-away distance,' my vocabulary, for a cellphone. You can't keep it closer than 'X' without exceeding the exposure limit," Morgan said. "Good luck finding where that is in a phone."

For example, in an Apple iPhone, you follow these steps to find the information:
Settings > General > About > Legal > RF Exposure

The iPhone 7's instructions say, "Carry iPhone at least 5mm away from your body to ensure exposure levels remain at or below the as-tested levels." The iPhone 5 instructions suggest at least 10mm.

Apple iPads say: "Orient the device in portrait mode with the home button at the bottom of the display, or in landscape mode with the cellular antenna away from your body or other objects."

Apple iPads also warn "a small percentage of people may be susceptible to blackouts or seizures."

"You're being exposed throughout the day as long as the device is on, so you want to keep it away from your body, especially when you're making a call," Moskowitz said. "There's a variety of simple things you can do to reduce your exposure."

The CTIA continues to challenge the City of Berkeley's disclosure ordinance. It refused a phone interview, but issued the following statement:

"We are challenging the City of Berkeley's disclosure ordinance because it violates the First Amendment and contradicts binding court decisions. In fact, the Federal appeals court in California previously invalidated a very similar cellphone ordinance in San Francisco. The scientific evidence refutes Berkeley's ill-informed and misleading mandatory warnings about cellphones, according to the FCC and other experts. For example, as the Food and Drug Administration states on its website, '[t]he weight of scientific evidence has not linked cellphones with any health problems.' With these realities on our side, we are confident that we will prevail."

Berkeley officials say the city wasn't taking a stance on the science.

"There will be continuing research, and we all will be learning more as things go along. In the meantime, I think it's prudent to stop and think and not to be alarmist, but just be careful," Worthington said.

But Moskowitz and Morgan, who say they have been closely following the scientific research on cellphones and health, compare the battle for public awareness about RF radiation to the history of tobacco.

"The cellphone industry is using the same playbook that the tobacco industry used successfully for decades. They've war-gamed the science," Moskowitz said.

Moskowitz has focused much of his career studying Big Tobacco, the tobacco control movement and the public health impacts of tobacco.

"Some scientists tried to argue that cigarette smoke was good for you, citing health professionals saying cigarettes were good for you," Moskowitz said. "And cellphone industries have some research, and it's pretty poor research, that suggests that cellphone radiation may be good for you."

"There's a long tradition of industries being able to delay a major public health problem from common knowledge for decades," Morgan said. "It took 50 years to get tobacco, to get asbestos. Hopefully, this will be faster."

Moskowitz has been fighting a legal battle of his own, trying to bring cellphone safety information to the public.

In 2016, he sued the California Department of Public Health.

It started with an insider tip urging Moskowitz to do some digging for a document on cellphones and health prepared by health professionals with the CDPH.

"In early 2014, I submitted a public records request for this document, which had originally been prepared, I later found out, in 2010," Moskowitz said.

The document is currently marked 'Not for Public Release.'

"It's really a fact sheet about cellphone radiation, which summarizes the research briefly and provides a set of recommendations to the public," Moskowitz said.

The document gives an overview of EMFs, the electromagnetic radiation emitted by some consumer electronics like cellphones. It acknowledges studies that show a link between EMFs and brain cancer and EMFs and fertility problems.

It provides tips on how to lower your risk of over-exposure by keeping a distance between you and your phone or tablet, much like the guidelines that exist within cellphone manuals.

It also says children and teens may be more sensitive to EMF exposure.

"They do not want to admit there is any kind of problem," said Lloyd Morgan.

Morgan closely studies the ongoing scientific research into how EMFs affect the human body.

Learning the CDPH document exists, but was kept in the dark, infuriates him.

"You can't just place a phone against your head. Or against your body," Morgan said. "They know there's a problem. And eventually, the public will know."

The Department of Public Health denied all the public records requests Moskowitz filed starting in 2014.

According to Moskowitz, officials told him they wouldn't release the document because the Centers for Disease Control and Prevention issued similar guidelines on their website.

"I felt the document belongs in the hands of the public. I couldn't understand, and in fact the informants couldn't explain, why the document was suppressed," Moskowitz said.

Moskowitz decided to file suit.

"This is a very serious issue," Moskowitz said. "I thought it would be in the public interest to see if I can make this document see the light of day."

The case was filed in the Sacramento County Superior Court, assigned to Judge Shelleyanne Chang.

In its opposition briefs, the CDPH asserted the "public's health may be harmed" if the document is released and that it will "needlessly confuse and possibly alarm cellphone users."

It goes on to speculate the document might even cause people to flood doctors' offices concerned about their devices.

"The final explanation which came out during the lawsuit was, well, this wouldn't be in the public interest to put this information out there because the cellphone industry is part of the public and they would not be happy to see this information reaching the public," Moskowitz said, citing page 15 of the opposition brief.

In March, the department released the watermarked draft version of the Cellphones and Health guidelines to the San Francisco Chronicle.

The Sacramento Superior Court judge ruled in Moskowitz's favor.

"She saw no reason why the department should not release the document to me. She also ruled in her final ruling that the state could not mark up the document," Moskowitz said.

The California Department of Public Health refused an interview with KCRA.

A spokesman said via e-mail:

"The document has not been released before because it was the subject of pending litigation. We've now had the hearing and received the court's final ruling on the hearing, but the formal order has not yet been issued. We will comply with that order when it is issued, and if it requires us to release all versions of the drafts, we will do so, but attached is one of the drafts from 2015. Please note the draft notation on the document is original as it existed in 2015.

Please also note the information contained in this document by the California Department of Public Health's (CDPH) Division of Environmental and Occupational Disease Control is not original research. CDPH employees examined then-existing scientific research on the potential health effects of cellphone use. The Department also reviewed existing guidance documents (e.g., international, national, state and local public health agencies) at that time and prepared a draft of guidance based on that review. However, the guidance was never finalized or adopted by the Department. The project was discontinued when the Centers for Disease Control and Prevention (CDC) issued national guidance on the same subject."

"Most of the reasons turn out to be quite bogus when you really inspect them," Moskowitz said.

The public will soon have access to the CDPH document.

In her final ruling on March 13, Judge Shelleyanne Chang ruled that the CDPH must now release the cellphone guidelines without a watermark.

Moskowitz is still waiting.

"I've been studying this issue for eight years now and I believe the risk could be quite profound from a health and public health standpoint," Moskowitz said.

http://www.kcra.com/article/how-this-sign-put-berkeley-in-the-center-of-the-cellphone-safety-debate/9171064

iPhone 6 Bendgate: Apple's Instructions Say Not To Keep Your Phone In Your Pocket Anyway

As the Internet lights up with images of the iPhone 6 plus emerging from people's pockets bent like a used paperclip, it may be useful to consider this: Apple explicitly tells you not to carry your phone in your pocket, due to the radiation exposure threat it poses.

In the little handbook that comes with every iPhone (the one that gets discarded almost immediately because, it's a cell phone, we all know what to do with those, right?) Apple also explicitly states that the phone is not supposed to touch your body much, if at all.

In fact, in the manual for the iPhone 5, Apple says users should carry their iPhones a full 10 millimeters (or .39 inches) away from their bodies at all times. That means, if the device is in the pocket of your jeans, it's much too close.

Previous manuals were more explicit. The iPhone 3G safety manual warns that radiation exposure may exceed government standards during "body-worn operation" if the phone is "positioned less than 15 millimeters (5/8 inch) from the body (e.g., when carrying iPhone in your pocket)." The iPhone, Apple says, should always be worn in a belt clip or holster.

Cell phone radiation, measured in radio-frequency exposure, is regulated in the U.S. by the Federal Communications Commission (FCC). All phones must be tested to ensure that they emit a specific absorption rate of not more than 1.6 watts of radio-frequency energy per kilogram of body tissue, a rule designed to prevent harm from the heat generated by radio-frequency waves.

But while cell phones are tested against a simulated human head in the "talking" position, they are not tested against the body (or in a pocket) in the "carrying" position. Instead, the tests assume the user is carrying the phone in a holster, away from the body, whenever the phone is broadcasting at full power. And since radio-frequency energy exposure increases sharply the closer the phone gets to your body, some worry that FCC testing is missing a lot of actual exposure.

In addition, the FCC tests do not consider biological effects caused by anything other than the heat generated from radio-frequency energy, like altered protein expression or DNA damage. Experts and organizations like the Environmental Working Group have expressed concern over the testing rules for cell phones, citing studies that show links between cancers and cell phone radiation exposure. In 2011, a World Health Organization report classified radiation from cell phones as "possibly carcinogenic to humans," particularly as cell phone use relates to an increased risk for glioma, a malignant type of brain cancer.

Then there are the gaps in cell phone radiation testing. The American Academy of Pediatrics, for example, recently urged the FCC to begin taking child users of cellphones into account. "Children are not little adults and are disproportionately impacted by all environmental exposures, including cell phone radiation," their letter to the FCC reads.

Yet the science is inconclusive. The National Cancer Institute points to several studies that have been unable to establish a relationship between cell phone use and cancer.

The FCC is currently conducting an ongoing reassessment of its policies.

"The U.S. has among the most conservative standards in the world. As part of our routine review of these standards, which we began last year, we will solicit input from multiple stakeholder experts,

including federal health agencies and others, to guide our assessment," a spokesman for the FCC tells *Newsweek*.

Radiation from cell phones is not an Apple-only problem, of course. Blackberry's user manual advises .59 inches of separation between the body and the phone. Earlier manuals pushed for nearly a full inch (.98 inch) of separation, and told users to "use hands-free operation if it is available and keep the BlackBerry device at least 0.98 inch (25 millimeters) from your body (including the lower abdomen of pregnant women and teenagers)."

A manual for an earlier Blackberry model—the 8830 World Edition—includes a warning against carrying the phone directly on the body: "Carrying solutions, including RIM-approved carrying solutions and carrying solutions not approved by RIM, that do not come equipped with an integrated belt clip SHOULD NOT be worn or carried on the body."

It adds that users should not try to use the phone where there is not a good signal, because radiation output grows higher and higher as the phone struggles to connect with a tower. Neither Apple nor Blackberry responded to a request for comment at the time of publishing.

Dr. David Carpenter, the director of the Institute for Health and the Environment University at Albany, New York has spent several years reading research on radio-frequency exposure and has testified to Congress on the subject. He says he is very wary of cell phones.

"My personal sense is that the evidence for increases in cancer is quite strong. It's not one hundred percent, but most studies have shown that [people with] high exposures have elevations in leukemia, brain cancers [and] some other kinds of cancers."

He predicts that cancer rates will go up in the coming decades.

"Latency for brain cancer is 20 to 30 years. Cell phones haven't been around for all that long. I think it's likely that we'll see an increase in cases over the next years," Carpenter says.

http://www.newsweek.com/iphone-6-bendgate-apple-says-your-iphone-shouldnt-go-your-pocket-avoid-273313

Mobile phones are 'cooking' men's sperm

Study finds sperm levels of men who kept their phones in their pocket during the day were quite seriously affected in 47 per cent of cases

Fertility experts are warning man that using a mobile for as little as an hour a day is "cooking sperm" and lowering level significantly.

The new study shows that having a mobile phone close to the testicles - or within a foot or two of the body - can lower sperm levels so much that conceiving could be difficult.

The findings have led to a leading British fertility expert to advise men to stop being addicted to mobile phones.

The study - by highly respected specialists - found that sperm levels of men who kept their phones in their pocket during the day were seriously affected in 47 per cent of cases compare to just 11 per cent in the general population.

Professor Martha Dirnfeld, of the Technion University in Haifa, said: "We analysed the amount of active swimming sperm and the quality and found that it had been reduced.

"We think this is being caused by a heating of the sperm from the phone and by electromagnetic activity."

The team monitored more than 100 men attending a fertility clinic for a year.

They found that besides men keeping their phones close to their groin many spoke on the phone while it was charging and kept it only a few centimetres from their bed.

Even keeping the phone on a bedside table appears to raise lower sperm cell counts

The findings are in the journal Reproductive BioMedicine and support a long-feared link between dropping fertility rates in men and the prevalent use of cellular phones.

The quality of sperm among men in Western countries is constantly decreasing and is considered crucial in 40 percent of the cases in which couples have difficulty conceiving a child.

http://www.telegraph.co.uk/news/health/news/12167957/Mobile-phones-are-cooking-mens-sperm.html

The Hidden Health Effects of Cell Towers

Cell towers blanket the globe. The United States is home to more than 300,000 cell sites. They appear innocent. But are they?

Cell towers are the base stations that control mobile phone communication. They may or may not be clearly visible in your neighborhood. Sometimes they are disguised as cacti, trees, or even flags.

Because we can't see, feel or smell the electromagnetic radiation coming from a cell tower (or cell site which includes towers, antenna masts and other base station forms), it's hard to believe there is any potential for harm.

In fact, the Federal Communications Commission, our government's regulating agency, has made sure health concerns aren't addressed when cell tower applications are considered. According to the Telecommunications Act of 1996,

"No State or local government or instrumentality thereof may regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions."

(Localities are permitted to reject a cell tower if the tower is deemed unsightly, which is one reason for the disguises.)

The wireless industry has relied on this legal favoritism, banking on consumer trust in government oversight. After all, wouldn't we know if cell towers (or cell phones) are unsafe?

The FCC already agrees that cell tower workers may be injured by these fields because of the proximity. While the FCC position is solely based on thermal effects of non-ionizing radiation, it is clear the agency agrees that cell tower workers may be at risk of adverse health effects (emphasis mine):

Studies have shown that environmental levels of RF energy routinely encountered by the general public are far below levels necessary to produce significant heating and increased body temperature (References 32, 37, 45, 46, 48 and 54). However, there may be situations, particularly workplace environments near high-powered RF sources, where recommended limits for safe exposure of human beings to RF energy could be exceeded. In such cases, restrictive measures or actions may be necessary to ensure the safe use of RF energy.

How well is the FCC monitoring these levels? Sen. Richard Blumenthal of Connecticut and Rep. Anna Eshoo of California believe the FCC has dropped the ball when it comes to monitoring and regulating the safety of cell towers, especially when it comes to cell site workers. The lawmakers issued a challenge to the FCC on September 17, 2015,

Excessive exposure to RF radiation leads to well-documented potential harms, especially to workers who spend time near the antenna and in the line of the antenna's beam. At sufficient power levels and exposure durations, RF radiation has the ability to heat biological tissue. Thermal effects can include eye damage, sterility, and cognitive impairments.

We urge the FCC and the Occupational Safety and Health Administration (OSHA) to work together to enforce exposure limits and ensure wireless carriers are taking the required precautions to protect the safety of all persons who may be exposed to dangerous levels of RF radiation near wireless towers.

If the FCC agrees that cell tower workers are at risk, and two members of Congress are concerned enough to issue a reprimand, what does this say about the overall safety of cell sites?

The World Health Organization officially classifies electromagnetic radiation a possible 2B carcinogen. (The same category as lead, DDT, and styrene.)

The following studies suggest short-term and long-term health risks within 300-400 meters of a cell tower. (Less than three-tenths of a mile)

- Santini Study

This is a compelling survey of 270 men and 260 women showing changes in symptoms in relation to cell tower proximity. Note the decrease in reported headaches the further from the cell site.

Table I. Percentages of complaints reported compared to responses of a level of « 0 », by persons living in the vicinity of base stations as a function of their distance away from a base station.

Symptoms	Distances from base stations in meters (m)											
	< 10 m		10 to 50 m		50 to 100 m		100 to 200 m		200 to 300 m		> 300 m ...	
	2	3	2	3	2	3	2	3	2	3	2	3
Fatigue	76 *	72 *	63.5*	50.9*	60.6	56.6*	64.2	41.1	66.6*	43.7	40.7	27.2
Irritability	32.8	23.2*	41.7*	25.7*	47.2*	44.1*	25.8	4.1	25	9	18	3.3
Headaches	51 *	47.8*	40 *	26.1*	40.6*	36.7*	60.7*	31.2*	19.3	0	15.6	1.8
Nausea	14.5*	6.9	8.4	3	5.7	3.8	2.4	4,6	0	2.3	2,1	1.1
Loss of Appetite	20.4*	8.3	8	5.5	5	5	6.9	0	4.2	0	3.3	3.3
Sleep Disruption	41.3*	57.1*	41.4*	57.5*	46.9*	58.5*	45.8*	50*	33.3	35.5	13.8	21.1
Depression	16,9	26.8*	21.6	19.7*	11.6	24 *	16.2	3.1	13.6	2.5	10.3	3.7
Feeling of Discomfort	28 *	45.4*	25.2*	18.9	30.6*	12.8	15.7*	0	9.7	5.1	2.4	8.1
Difficulty in concentration	39.3	28.8*	37.5	16.6	34.2	26.4*	25	12.5	43.3	5.5	26.7	7.1
Memory Loss	27.8	25.4*	29.4	26.6*	37.1*	29 *	25	15.6	17.2	11.1	17.9	5.8
Skin Problems	18.1*	17.1*	6.6	10.8	11.1*	11.1	13.9*	7.5	8.7	0	1.2	4.6
Visual Disruptions	14.5	24.3*	23	13.5	22	7.1	2.5	4.9	15	2.8	13.6	4.1
Hearing Disruptions	33.3*	17.4	17.7*	12	8.3	15.5	7.7	7.7	11.6	9.5	5.6	8.7
Dizziness	10	12.5*	17.3*	7,5*	9.6	9.6*	12.2	2.7	7.7	5.2	6.2	0
Movement Difficulties	5.6	7.7*	8.2	1.7	3	3	0	0	2	0	2.9	1
Cardio-vascular Problems	10.1*	13 *	15.3*	9.6	12.3*	7.4	8.7	0	8.5	6.5	1	3

* Significant difference ($p < 0.05$) in comparison to reference subjects found at > 300 m or not exposed, for the responses 2 – « often » and 3 – « very often».

- Kempton West Study (2007)

Researchers measured blood levels of serotonin and melatonin in 25 participants before and after the activation of a new cell site. There were unfavorable changes in almost all participants.

- Naila Study (2004)

Researchers discovered a threefold increase in cancers after five years exposure to microwave radiation from a nearby mobile phone mast transmitter compared to those patients living further away.

- France Questionnaire (2003)

Researchers in France found significant health effects on people living within 300 meters of mobile phone base stations. Fatigue, sleep disturbance, headaches, concentration problems, depression, memory problems, irritability, cardiovascular problems, hearing disruption, skin problems, dizziness, etc.

(For a comprehensive list of studies linking cell towers to adverse health effects, see Electromagnetic Health.)

As noted above current FCC regulations are based on thermal effects. Thanks to the BioIniative Report 2012 we now have a compilation of more than 1800 studies showing biological effects from non-ionizing radiation.

In May 2016, the U.S. government released preliminary findings for a $25 million rat study linking cell phone radiation to cancer. See NTP Study: Cell Phones and Cancer.

What does this say about schools, homes or offices located in a cell tower vicinity?

I recently measured the radiofrequency fields near a cell tower 5 miles from our home. The tower hovers over an Ace Hardware store and equipment rental company. Several housing developments are nearby.

I recorded the following video over a period of four minutes. I watched for unusual spikes.

https://youtu.be/AhiO38PB8q0

The level went as high as 1827 mw**/**m^2**. The BioIniative Report recommends an upper threshold of 0.03** mw**/**m^2. Our home has an RF level of .0005 mw/m^2. (Our RF levels went down after we transitioned away from Wi-Fi. See From Wireless to Wired – Our Family's Journey.)

http://it-takes-time.com/2015/09/22/health-effects-of-cell-towers/

The Hidden Dangers of Cell Phone Radiation

Every day, we're swimming in a sea of electromagnetic radiation (EMR) produced by electrical appliances, power lines, wiring in buildings, and a slew of other technologies that are part of modern life. From the dishwasher and microwave oven in the kitchen and the clock radio next to your bed, to the cellular phone you hold to your ear—sometimes for hours each day—exposure to EMR is growing and becoming a serious health threat.

But there's a huge public health crisis looming from one particular threat: EMR from cellular phones—both the radiation from the handsets and from the tower-based antennas carrying the signals—which studies have linked to development of brain tumors, genetic damage, and other exposure-related conditions.1-9 Yet the government and a well-funded cell phone industry media machine continue to mislead the unwary public about the dangers of a product used by billions of people. Most recently, a Danish epidemiological study announced to great fanfare the inaccurate conclusion that cell phone use is completely safe.10

George Carlo, PhD, JD, is an epidemiologist and medical scientist who, from 1993 to 1999, headed the first telecommunications industry-backed studies into the dangers of cell phone use. That program remains the largest in the history of the issue. But he ran afoul of the very industry that hired him when his work revealed preventable health hazards associated with cell phone use.

In this article, we look at why cell phones are dangerous; Dr. Carlo's years-long battle to bring the truth about cell phone dangers to the public; the industry's campaign to discredit him and other scientists in the field; and what you can do to protect yourself now.
The cellular phone industry was born in the early 1980s, when communications technology that had been developed for the Department of Defense was put into commerce by companies focusing on profits. This group, with big ideas but limited resources, pressured government regulatory agencies—particularly the Food and Drug Administration (FDA)—to allow cell phones to be sold without pre-market testing. The rationale, known as the "low power exclusion," distinguished cell phones from dangerous microwave ovens based on the amount of power used to push the microwaves. At that time, the only health effect seen from microwaves involved high power strong enough to heat human tissue. The pressure worked, and cell phones were exempted from any type of regulatory oversight, an exemption that continues today. An eager public grabbed up the cell phones, but according to Dr. George Carlo, "Those phones were slowly prompting a host of health problems."

Today there are more than two billion cell phone users being exposed every day to the dangers of electromagnetic radiation (EMR)—dangers government regulators and the cell phone industry refuse to admit exist. Included are: genetic damage, brain dysfunction, brain tumors, and other conditions such as sleep disorders and headaches.1-9 The amount of time spent on the phone is irrelevant, according to Dr. Carlo, as the danger mechanism is triggered within seconds. Researchers say if there is a safe level of exposure to EMR, it's so low that we can't detect it.

The cell phone industry is fully aware of the dangers. In fact, enough scientific evidence exists that some companies' service contracts prohibit suing the cell phone manufacturer or service provider, or joining a class action lawsuit. Still, the public is largely ignorant of the dangers, while the media regularly

trumpets new studies showing cell phones are completely safe to use. Yet, Dr. Carlo points out, "None of those studies can prove safety, no matter how well they're conducted or who's conducting them." What's going on here? While the answer in itself is simplistic, how we got to this point is complex.

In December, 2006, an epidemiological study on cell phone dangers published in the Journal of the National Cancer Institute sent the media into a frenzy.10 Newspaper headlines blared: "Danish Study Shows Cell Phone Use is Safe," while TV newscasters proclaimed, "Go ahead and talk all you want—it's safe!" The news seemed to be a holiday gift for cell phone users. But unfortunately, it's a flawed study, funded by the cell phone industry and designed to bring a positive result. The industry's public relations machine is working in overdrive to assure that the study get top-billing in the media worldwide.

According to Dr. George Carlo, the study, by its design, could not identify even a very large risk. Therefore, any claim that it proves there's no risk from cell phones is a blatant misrepresentation of the data that will give consumers a very dangerous false sense of security.

"Epidemiological studies are targets for fixing the outcome because they're observational in nature instead of experimental," Dr. Carlo explains. "It's possible to design studies with pre-determined outcomesthat still fall within the range of acceptable science. Thus, even highly flawed epidemiological studies can be published in peer-reviewed journals because they're judged against a pragmatic set of standards that assume the highest integrity among the investigators."

Key problems with the study are:

There are few discernable differences between who was defined as cell phone users and who wasn't. Thus, people defined as exposed to radiation were pretty much the same as those defined as not exposed to radiation. With few differences, it's nearly impossible to find a risk.

Users were defined as anyone who made at least one phone call per week for six months between 1982 and 1995. So any person who made 26 calls was a cell phone user and therefore considered exposed to radiation. Those with less than 26 calls were non-users. In reality, the radiation exposure between users and non-users defined in this manner is not discernable.

The "exposed" people used ancient cell phone technology bearing little resemblance to cell phones used today. The results, even if reliable, have no relevance to the 2 billion cell phone users today.

From 1982 to 1995, cell phone minutes cost much more than today and people used their phones much less. Thus there was very little radiation exposure.

During the study's time frame, people likely to use their cell phones the most were commercial subscribers. Yet this highest exposed group, in whom risk would most easily be identified, was specifically excluded from the study.

There were no biological hypotheses tested in the study. It was therefore only a numbers game. Ignored were mechanisms of disease found in other studies of cell phone radiation effects, including genetic damage, blood-brain barrier leakage, and disrupted intercellular communication. The study did not discuss any research supporting the notion that cell phones could cause problems in users.

The study itself was inconsistent with cancer statistics published worldwide addressing the Danish population. This study showed a low risk of cancer overall, when in fact Denmark has some of the highest cancer rates in the world. This inconsistency suggested that something in the data does not add up.

The cell phone industry constantly guards its financial interests, but unfortunately, an unwitting public can be harmed in the process, says Dr. Carlo. "Industry-funded studies in many cases now produce industry-desired outcomes. By tampering with the integrity of scientists, scientific systems and public information steps over the lines of propriety that are appropriate for protecting business interests—especially when the casualty of the interference is public health and safety."

In 1993, the cell phone industry was pressured by Congress to invest $28 million into studying cell phone safety. The cause of this sudden concern was massive publicity about a lawsuit filed by Florida businessman David Reynard against cell phone manufacturer NEC. Reynard's wife, Susan, died of a brain tumor, and he blamed cell phones for her death. Reynard revealed the suit to the public on the Larry King Live show, complete with dramatic x-rays showing the tumor close to where Susan held her cell phone to her head for hours each day.

The next day, telecommunications stocks took a big hit on Wall Street and the media had a field day. The industry trade association at the time, the Telecommunications Industry Association (TIA), went into crisis mode, claiming thousands of studies proved cell phones were safe and what Reynard and his attorney said was bunk. TIA reassured the public that the government had approved cell phones, so that meant they were safe. The media demanded to see the studies, but, says Dr. Carlo, "The industry had lied. The only studies in existence then were on microwave ovens. At that time, 15 million people were using cell phones, a product that had never been tested for safety."

- *Originally developed for the Department of Defense, cell phones devices were never tested for safety. They entered the marketplace due to a regulatory loophole.*
- *Questions about cell phone safety arose in the early 1990s, when a businessman filed a lawsuit alleging that cell phones caused his wife's death due to brain cancer.*
- *To address the questions surrounding cell phone safety, the cell phone industry set up a non-profit organization, Wireless Technology Research (WTR). Dr. George Carlo was appointed to head WTR's research efforts.*
- *Under Dr. Carlo's direction, scientists found that cell phone radiation caused DNA damage, impaired DNA repair, and interfered with cardiac pacemakers.*
- *European research confirmed Dr. Carlo's findings. Studies suggest that cell phone radiation contributes to brain dysfunction, tumors, and potentially to conditions such as autism, attention deficit disorder, neurodegenerative disease, and behavioral and psychological problems.*
- *Dr. Carlo brought safety information about cell phones to the public through his book, Cell Phones: Invisible Hazards in the Wireless Age, and by creating the Safe Wireless Initiative and the Mobile Telephone Health Concerns Registry.*

Forced to take action, the cell phone industry set up a non-profit organization, Wireless Technology Research (WTR), to perform the study. Dr. Carlo developed the program outline and was asked to head the research. Oversight of the issue was charged to the FDA, though it could have and probably should have gone to the Environmental Protection Agency (EPA), which fought hard for jurisdiction. But the industry had enough influence in Washington to get whatever overseer it wanted. It simply didn't want to tangle with EPA because, says Dr. Carlo, "… the EPA is tough."

"Anything that's ever made a difference in terms of public health has come from the EPA," he says. "But safety issues that are covered in corruption and questions seem to always have a connection to the FDA, which has been manipulated by pharmaceutical companies since it was born."

When called to help with the cell phone issue, Dr. Carlo was working with the FDA on silicone breast implant research. The choice of Dr. Carlo to head WTR seemed unusual to industry observers. An epidemiologist whose expertise was in public health and how epidemic diseases affect the population, he appeared to lack any experience in researching the effects of EMR on human biology. Based on this, a premature conclusion was drawn by many: Dr. Carlo was an "expert" handpicked by the cell phone industry, and therefore his conclusions would only back up the industry's claim that cell phones are safe.

Dr. Carlo, however, refused to be an easy target. He quickly recruited a group of prominent scientists to work with him, bulletproof experts owning long lists of credentials and reputations that would negate any perception that the research was predestined to be a sham. He also created a Peer Review Board chaired by Harvard University School of Public Health's Dr. John Graham, something that made FDA officials more comfortable since, at the time, the agency was making negative headlines due to the breast implant controversy. In total, more than 200 doctors and scientists were involved in the project.

Once all involved agreed on what was to be done, Dr. Carlo presented the study's stakeholders in the industry, the government, and the public with a strict list of criteria for moving forward.

"The money had to be independent of the industry—they had to put the money in trust and couldn't control who got the funds," he says. "Second, everything had to be peer reviewed before it went public, so if we did find problems after peer review, we could use that information publicly to recommend interventions."

A third requirement was for the FDA to create a formal interagency working group to oversee the work and provide input. The purpose of this was to alleviate any perception that the industry was paying for a result, not for the research itself. But the fourth and last requirement was considered by Dr. Carlo to be highly critical: "Everything needed to be done in sunlight. The media had to have access to everything we did."

The program began, but Dr. Carlo soon discovered that everyone involved had underlying motives."The industry wanted an insurance policy and to have the government come out and say everything was fine. The FDA, which looked bad because it didn't require pre-market testing, could be seen as taking steps to remedy that. By ordering the study, law makers appeared to be doing something. Everyone had a chance to wear a white hat."

Dr. Carlo and his team developed new exposure systems that could mimic head-only exposure to EMR in people, as those were the only systems that could approximate what really happened with cell phone exposure. Those exposure systems were then used for both in vitro (laboratory) and in vivo (animal) studies. The in vitro studies used human blood and lymph tissue in test tubes and petri dishes that were exposed to EMR. These studies identified the micronuclei in human blood, for example, associated with cell phone near-field radiation. The in vivo studies used head only exposure systems and laboratory rats. These studies identified DNA damage and other genetic markers.

Says Dr. Carlo: "We also conducted four different epidemiological studies on groups of people who used cell phones, and we did clinical intervention studies. For example, studies of people with implanted cardiac pacemakers were instrumental in our making recommendations to prevent interference between cell phones and pacemakers. In all, we conducted more than fifty studies that were peer-reviewed and published in a number of medical and scientific journals."

But manipulation by the industry had begun almost immediately at the start of research. While Dr. Carlo and his team had never defined their research as being done to prove the safety of cell phones, the industry internally defined it as an insurance policy to prove that phones were safe. From the outset, what was being said by the cell phone industry in public was different from what was being said by the scientists behind closed doors.

The pacemaker studies were a harbinger of bad things to come. Results showed that cell phones do indeed interfere with pacemakers, but moving the phone away from the pacemaker would correct the problem. Amazingly, the industry was extremely upset with the report, complaining that the researchers went off target. When Dr. Carlo and his colleagues published their findings in the New England Journal of Medicine in 1997,11 the industry promptly cut off funding for the overall program. It took nine months for the FDA and the industry to agree on a scaled-down version of the program to continue going forward. Dr. Carlo had volunteered to step down, since he was clearly not seeing eye-to-eye with the industry, but his contract was extended instead, as no one wanted to look bad from a public relations standpoint.

The research continued, and what it uncovered would be a dire warning to cell phone users and the industry's worst nightmare. When the findings were ready for release in 1998, the scientists were suddenly confronted with another challenge: the industry wanted to take over public dissemination of the information, and it tried everything it could to do so. It was faced with disaster and had a lot to lose.

Fearing the industry would selectively release research results at best, or hold them back at worst, Dr. Carlo and his colleagues took the information public on their own, creating a highly visible war between the scientists and the industry. An ABC News expose on the subject increased the wrath of the industry.

According to Dr. Carlo, "The industry played dirty. It actually hired people to put negative things about me and the other scientists who found problems on the internet, while it tried to distance itself from the program. Auditors were brought in to say we misspent money, but none of that ever held up. They tried every angle possible."

This included discussions with Dr. Carlo's ex-wife to try to figure out ways to put pressure on him, he says. Threats to his career came from all directions, and Dr. Carlo learned from Congressional insiders that the word around Washington was that he was "unstable." But all the character assassination paled in comparison to what happened next.

Toward the end of 1998, Dr. Carlo's house mysteriously burned down. Public records show that authorities determined the cause of the blaze was arson, but the case was never solved. Dr. Carlo refuses to discuss the incident and will only confirm that it happened. By this time, enough was

enough. Dr. Carlo soon went "underground," shunning the public eye and purposely making himself difficult to find.

A cellular phone is basically a radio that sends signals on waves to a base station. The carrier signal generates two types of radiation fields: a near-field plume and a far-field plume. Living organisms, too, generate electromagnetic fields at the cellular, tissue, organ, and organism level; this is called the biofield. Both the near-field and far-field plumes from cell phones and in the environment can wreak havoc with the human biofield, and when the biofield is compromised in any way, says Dr. Carlo, so is metabolism and physiology.

"The near field plume is the one we're most concerned with. This plume that's generated within five or six inches of the center of a cell phone's antenna is determined by the amount of power necessary to carry the signal to the base station," he explains. "The more power there is, the farther the plume radiates the dangerous information-carrying radio waves."

A carrier wave oscillates at 1900 megahertz (MHz) in most phones, which is mostly invisible to our biological tissue and doesn't do damage. The information-carrying secondary wave necessary to interpret voice or data is the problem, says Dr. Carlo. That wave cycles in a hertz (Hz) range familiar to the body. Your heart, for example, beats at two cycles per second, or two Hz. Our bodies recognize the information-carrying wave as an "invader," setting in place protective biochemical reactions that alter physiology and cause biological problems that include intracellular free-radical buildup, leakage in the blood-brain barrier, genetic damage, disruption of intercellular communication, and an increase in the risk of tumors. The health dangers of recognizing the signal, therefore, aren't from direct damage, but rather are due to the biochemical responses in the cell.

Here's what happens:

- Cellular energy is now used for protection rather than metabolism. Cell membranes harden, keeping nutrients out and waste products in.
- Waste accumulating inside the cells creates a higher concentration of free radicals, leading to both disruption of DNA repair (micronuclei) and cellular dysfunction.
- Unwanted cell death occurs, releasing the micronuclei from the disrupted DNA repair into the fluid between cells (interstitial fluid), where they are free to replicate and proliferate. This, says Dr. Carlo, is the most likely mechanism that contributes to cancer.
- Damage occurs to proteins on the cell membrane, resulting in disruption of intercellular communication. When cells can't communicate with each other, the result is impaired tissue, organ, and organism function. In the blood-brain barrier, for example, cells can't keep dangerous chemicals from reaching the brain tissue, which results in damage.

With the background levels of information-carrying radio waves dramatically increasing because of the widespread use of cell phones,Wi-Fi, and other wireless communication, the effects from the near and far-fields are very similar. Overall, says Dr. Carlo, almost all of the acute and chronic symptoms seen in electrosensitive patients can be explained in some part by disrupted intercellular communication. These symptoms of electrosensitivity include inability to sleep, general malaise, and headaches. Could this explain the increase in recent years of conditions such as attention-deficit hyperactivity disorder (ADHD), autism, and anxiety disorder?

"One thing all these conditions have in common is a disruption, to varying degrees, of intercellular communication. When we were growing up, TV antennas were on top of our houses and such waves were up in the sky. Cell phones and Wi-Fi have brought those things down to the street, integrated them into the environment, and that's absolutely new. The recognition mechanism, where protein vibration sensors on the cell membrane pick up a signal and interpret it as an invader, only works because the body recognizes something it's never seen before."

As to increases in brain tumors tied to cell phone use, it's too early to tell due to a lack of hard data, says Dr. Carlo. "We're never going to see that in time to have it matter. Here in the US, we're six years behind in getting the brain tumor database completed, and currently the best data are from 1999. By the time you see any data showing an increase, the ticking time bomb is set."

Epidemic curve projections, however, indicate that in 2006, we can expect to see 40,000 to 50,000 cases of brain and eye cancer. This is based on published peer-reviewed studies that allow calculation of risk and construction of epidemic curves. By 2010, says Dr. Carlo, expect that number to be between 400,000 and 500,000 new cases worldwide.

"This means we're on the beginning curve of an epidemic, with epidemic defined as a change in the occurrence of a disease that is so dramatic in its increase that it portends serious public health consequences," says Dr. Carlo. "This is what's not being told to the public. One of the things that I suggest to people who use a cell phone is to use an air tube headset. If you use a wired headset, the current moving through the wire of the headset attracts ambient informational carrying radio waves and thereby increases your exposure."

The industry took its tricks elsewhere—to Europe, which had picked up the ball and began funding independent research to corroborate or confirm the work of Dr. Carlo and his team. The work was completed in mid-2004 and when it was released,12 it not only provided independent scientific corroboration of the work done by Dr. Carlo's group, but also took the work a step further and showed how the problems were occurring mechanistically. This information formed a biologically plausible hypothesis for how cell phone radiation could be related to so many diseases.

Dr. Carlo noted, "The industry exerted pressure on the scientists who conducted the work, including renowned German scientist Dr. Franz Adlkofer. It first tried to change the conclusions of the work, then to delay its public release. Then Dr. Adlkofer, the lead scientist, was attacked in the media and threatened privately with no more research money, a ruined reputation—similar to what we experienced in the WTR. But this situation attracted the attention of a German documentary filmmaker, who decided to do a film on the cell phone issue."

It was enough to bring Dr. Carlo into view again, as he was asked to participate. The film, The Boiling Frog Principle, by Klaus Scheidsteger, builds on information from his first film, The Cell Phone War, and will be released in 2007. Its intent is to integrate the latest political and scientific evidence from around the world, and bring forth to consumers important information on cell phone dangers that was previously withheld.

Currently in the US, there are seven class action lawsuits moving forward against the cell phone industry, says Dr. Carlo, and nine other cases that are personal injury cases brought by people with brain cancer. In the past two years, two workers compensation awards were given to people with

brain tumors based on a link between their tumors and their cell phone use in the workplace. Both of these cases occurred in California.

"What we have now is a major litigation burden, a vulnerability the cell phone industry has never before been under," Dr. Carlo says. "They're uninsured for these health risk claims and are already positioning themselves for a congressional bailout, like the Savings and Loan crisis of the late 1980s. They'll lose a couple of these lawsuits and once they do, there'll be an onslaught of new litigation against them."

The country can't afford for the cell phone industry to go under, Dr. Carlo says, as it would have a disastrous impact on the entire economy—some estimates say over 30% of investment stocks in retirement funds are tied to telecommunications shares. That's why Congress will figure out a way to bail out the industry.

"The industry thinks they can afford to continue on with this institutional arrogance, endangering millions of men, women and children because, at the end of the day, they believe they'll not be held accountable. They think they can continue to manipulate consumers."

It's been nearly 12 years since the WTR was funded. Despite Dr. Carlo's revealing research and the corroborating research of other scientists from around the world that continue to follow, a search of media reports today on the subject of cell phone dangers tends to suggest one of only two conclusions: There is no risk, or no one has yet proven the risk. That's at odds with more than 300 studies in the peer-reviewed scientific literature supporting an increased risk of disease. Clearly, something doesn't add up.

The industry's manipulation of the media to consider only one study at a time obfuscates the big picture.Individually, there's little to see. But the depth and breadth of the science that points to the problem, and the compilation of studies, make the future look frightening. Like the September 11 tragedy, where no one in government talked to each other and did not see it coming for lack of a big picture view, the health crisis from cell phone use looms darkly.

"When you put all the science together, we come to the irrefutable conclusion that there's a major health crisis coming, probably already underway," warns Dr. Carlo. "Not just cancer, but also learning disabilities, attention deficit disorder, autism, Alzheimer's, Parkinson's, and psychological and behavioral problems—all mediated by the same mechanism. That's why we're so worried. Time is running out. When you put the pieces of the puzzle together, it's such a wide ranging problem. It's unlike anything we've ever seen before."

http://www.lifeextension.com/Magazine/2007/8/report_cellphone_radiation/

Children Are Endangered by Cell Phone Radiation!

Mobile phone firms cynically target children even though they may be most vulnerable to the effects of radiation, a leading scientist, Sir William Stewart warned. Stewart chaired the world's largest investigation into mobile phone safety. The $100 billion a year mobile phone industry asserts that there is no conclusive evidence of harmful effects as a result of electromagnetic radiation.

US scientists tested mobile phone-style radiation on more than 10,000 chicken embryos. Pregnant women have been warned to be wary of using mobile phones after it was found radiation produced by the devices caused defects in the chicken embryos. The cell phone industry continues to down-play the risk and defer to more research.

Children using mobile phones absorb as much as double the amount of radiation through their heads as adults. Dr. Om Ghandi, a leading scientist and professor of electrical engineering at the University of Utah found that young children under 10 years of age could absorb radiation across their entire brain. He found that more radiation is able to go past the ear and into the head since a child's ear is thinner and the telephone is closer to the head. All it takes is two millimeters difference," Dr. Ghandi said.

Until proven otherwise and technology becomes safe, children including teens should not use mobile phones, at all, because they are more at risk from the radiation, and their cell growth and brain wave activity are not yet stable. There is conclusive evidence that the phones have biological effects on humans even where the radio frequency or microwave radiation is emitted at very low levels.

Mobile phones and the new wireless technology could cause a "whole generation" of today's teenagers to go senile in the prime of their lives, research suggests. Proffessor Leif Salford, who headed the research at Sweden's prestigious Lund University, says "the voluntary exposure of the brain to microwaves from hand-held mobile phones" is "the largest human biological experiment ever".

Professor Salford and his team have spent 15 years investigating microwave radiation. Their studies proved radiation could open the blood-brain barrier, allowing a protein called albumin to pass into the brain. Their latest work shows the process is linked to serious brain damage. Professor Salford said neurons that would normally not become "senile" until people reached their 60s may now do so when they were in their 30s. In addition, research indicates that exposure to cell phones' radiation causes red blood cells to leak hemoglobin. Scientists exposed samples of blood to microwave radiation and found that even at lower levels than those emitted by cell phones, the blood cells leaked hemoglobin.

Marketing to Children

Cell phones, which are practically standard equipment for teenagers in today's world, are finding their way into the even smaller hands of preteens. Cell phones designed for preteens have controls that allow parents to limit whom kids can talk to. Preteen cell phones are soon to be marketed nationwide with big expectations that preteen cell phone usage will become a national trend. Paul Saffo of the Institute for the Future in Menlo Park, California says, "It won't be long before no self-respecting kindergartner is going to start school without a cell phone."

The cell-phone industry has continually insisted there is no proven link between cell phones and health problems. But patents for protective devices to reduce the amount of radiation absorbed by the brain suggest that Nokia, Ericsson and Motorola believe otherwise. The big three have come up against multimillion-dollar legal actions by people claiming their health has been damaged.

The $100 billion a year mobile phone industry asserts that there is no conclusive evidence of harmful effects as a result of electromagnetic radiation. The Cellular Telecommunications & Internet Association hired Dr. George Carlo to head up a $28 million research program into possible health effects from cellular phones. The research showed an increased rate of brain cancer deaths, development of tumors, and genetic damage among heavy cell phone users. Dr. Carlo has since broken with the cell phone industry to become a vocal critic, and coauthored a book called Cell Phones: Invisible Hazards in the Wireless Age

Radiofrequency electromagnetic radiation researcher at the University of Washington in Seattle, Dr. Henry Lai showed microwave radiation from mobiles caused genetic damage similar to that found in Alzheimer's and Parkinson's sufferers. To quote Dr. Lai, “It is difficult to deny that RFR at low intensity can affect the nervous system.”

Dr. Lai submitted his research to the Stewart committee showing that radiofrequency electromagnetic radiation (RFR) can penetrate into organic tissues and be absorbed and converted into heat. The microwave oven is a familiar use of RFR.

Another scientist, Dr. Hyland, who is based in the physics department at Warwick University and at the International Institute of Biophysics in Neuss-Holzheim, Germany says that the body is an electro-chemical instrument with exquisite sensitivity and the kind of radiation emitted from mobile phones has an impact on the stability of cells in the body.

Children are particularly vulnerable

Referring to the effect of microwaves from a mobile phone, Dr. Hyland says, "The main effects are neurological, causing headaches, lack of concentration, memory loss and sleeping disorders. It can also cause epilepsy in children. Children are particularly vulnerable because they are still developing their immune systems and are less robust than adults.

Dr. Hyland's research, published in the the respected medical publication, The Lancet, follows his analysis of more than 100 earlier studies involving tens of thousands of people.

Radio waves from mobile phones harm body cells and damage DNA

A study that was conducted by 12 research groups in seven European countries found that in laboratory conditions radio waves from mobile phones harm body cells and damage DNA. The research project, called Reflex study, which took four years and which was coordinated by the German research group Verum, studied the effect of radiation on human and animal cells in a laboratory.

After being exposed to electromagnetic fields that are typical for mobile phones, the cells showed a significant increase in single and double-strand DNA breaks, with damage not always being repaired by the cell. Mutated cells are seen as a possible cause of cancer. DNA carries the genetic material of an organism and its different cells. "There was remaining damage for future generation of cells", said project leader Dr. Franz Adlkofer.

In addition, the Swedish Institute of Environmental Medicine found that ten or more years of mobile phone use almost doubles the risk of acoustic neuroma, or benign tumors on the auditory nerve. "When the side of the head on which the phone was usually held was taken into consideration, we found that the risk of acoustic neuroma was almost four times higher on the same side as the phone was held, and virtually normal on the other side," the institute added. While non-cancerous, acoustic neuroma tumors

that are not removed can grow to sizes where they put pressure on the brain and become life threatening.

Cell phone shields

Dr. Neil Cherry, associate professor in environmental health at Lincoln University, Christchurch, stated " Mobile phone manufacturers should take seriously a Swedish finding that their products are dangerous for teenagers and work on developing safer phones". According to Dr. Cherry numerous patents exist for devices or methods to make phones safer but are not being used by manufacturers.

Dr. Cherry estimates that it is practical to reduce users' exposure by 100 to 1000 times. "The primary methods are to manufacture the handset within a Faraday cage shield," he said.

Alarming claims have surfaced in a research publication in the U.K. that not only are many hands-free devices useless in protecting wireless phone users from radiation that might cause tumors, these products may actually raise the amount of radiation being directed into the head by three times. The earplugs in the hands-free kit acted as aerials and channeled more radiation into the ear model than standard cell phones did. Using a hands-free kit and making a call with a mobile phone clipped to your belt means the phone will generally be working at a higher power level. Using a mobile phone clipped to your waist results in a hotspot of radiation being pumped into the liver and kidneys.

http://www.internationalparentingassociation.org/BrainDevelopment/cellphones.html

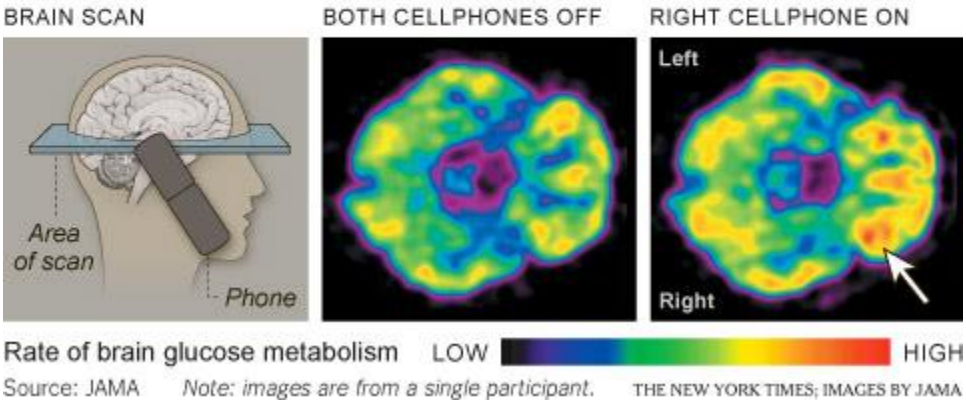
Cellphone Use Tied to Changes in Brain Activity

Researchers from the National Institutes of Health have found that less than an hour of cellphone use can speed up brain activity in the area closest to the phone antenna, raising new questions about the health effects of low levels of radiation emitted from cellphones.

The researchers, led by Dr. Nora D. Volkow, director of the National Institute on Drug Abuse, urged caution in interpreting the findings because it is not known whether the changes, which were seen in brain scans, have any meaningful effect on a person's overall health.

But the study, published Wednesday in The Journal of the American Medical Association, is among the first and largest to document that the weak radio-frequency signals from cellphones have the potential to alter brain activity.

CELLPHONES AND THE BRAIN Researchers tested 47 people by placing a cellphone at each ear. Both phones were off in one test, and in the other test the right phone was on a muted call. After 50 minutes, brain scans showed increased consumption of glucose, or sugar, in areas of the brain near the activated phone.



Source: JAMA *Note: images are from a single participant.* THE NEW YORK TIMES; IMAGES BY JAMA

"The study is important because it documents that the human brain is sensitive to the electromagnetic radiation that is emitted by cellphones," Dr. Volkow said. "It also highlights the importance of doing studies to address the question of whether there are — or are not — long-lasting consequences of repeated stimulation, of getting exposed over five, 10 or 15 years."

Although preliminary, the findings are certain to reignite a debate about the safety of cellphones. A few observational studies have suggested a link between heavy cellphone use and rare brain tumors, but the bulk of the available scientific evidence shows no added risk. Major medical groups have said that cellphones are safe, but some top doctors, including the former director of the University of Pittsburgh Cancer Center and prominent neurosurgeons, have urged the use of headsets as a precaution.

Dr. Volkow said that the latest research is preliminary and does not address questions about cancer or other heath issues, but it does raise new questions about potential areas of research to better understand the health implications of increased brain activity resulting from cellphone use.

"Unfortunately this particular study does not enlighten us in terms of whether this is detrimental or if it could even be beneficial," Dr. Volkow said. "It just tells us that even though these are weak signals, the human brain is activated by them."

Most major medical groups, including the American Cancer Society, the National Cancer Institute and the Food and Drug Administration, have said the existing data on cellphones and health has been reassuring, particularly a major European study released last year by the World Health Organization that found no increased risk of rare brain tumors among cellphone users.

When asked to comment on the latest study, the leading industry trade group, CTIA – The Wireless Association, released a statement emphasizing recent studies that have shown no elevated cancer risk associated with cellphone use.

"The peer-reviewed scientific evidence has overwhelmingly indicated that wireless devices, within the limits established by the F.C.C., do not pose a public health risk or cause any adverse health effects," said John Walls, vice president of public affairs for the trade group, adding that leading global health groups "all have concurred that wireless devices are not a public health risk."

But the new research differed from the large observational studies that have been conducted to study cellphone use. In Dr. Volkow's study, the researchers used brain scans to directly measure how the electromagnetic radiation emitted from cellphones affected brain activity..

The randomized study, conducted in 2009, asked 47 participants to undergo positron emission tomography — or PET — scans, which measure brain glucose metabolism, a marker of brain activity. Each study subject was fitted with a cellphone on each ear and then underwent two 50-minute scans.

During one scan, the cellphones were turned off, but during the other scan, the phone on the right ear was activated to receive a call from a recorded message, although the sound was turned off to avoid auditory stimulation.

Whether the phone was on or off did not affect the overall metabolism of the brain, but the scans did show a 7 percent increase in activity in the part of the brain closest to the antenna when the right phone was turned on. The finding was highly statistically significant, the researchers said. They said the activity was unlikely to be associated with heat from the phone because it occurred near the antenna rather than where the phone touched the head.

In the past, any concerns about the health effects of cellphones have been largely dismissed because the radiofrequency waves emitted from the devices are believed to be benign. Cellphones emit nonionizing radiation, waves of energy that are too weak to break chemical bonds or to set off the DNA damage known to cause cancers. Scientists have said repeatedly that there is no known biological mechanism to explain how nonionizing radiation might lead to cancer or other health problems.

But the new study opens up an entirely new potential area of research. Although an increase in brain glucose metabolism happens during normal brain function, the question is whether repeated artificial stimulation as a result of exposure to electromagnetic radiation might have a detrimental effect.

Although speculative, one theory about how an artificial increase in brain glucose metabolism could be harmful is that it could potentially lead to the creation of molecules called free radicals, which in excess can damage healthy cells. Or it may be that repeated stimulation by electromagnetic radiation could set

off an inflammatory response, which studies suggest is associated with a number of heath problems, including cancer.

Among cancer researchers and others interested in the health effects of cellphones, the study, listed in the medical journal under the heading "Preliminary Communications," was met with enthusiasm because of the credibility of the researchers behind it and the careful methods used.

"It's a high-quality team, well regarded, and if nothing else they're showing that radiation is doing something in the brain," said Louis Slesin, editor of Microwave News, a newsletter on the health effects of electromagnetic radiation. "The dogma in the cellphone community says that it doesn't do anything. What she's shown is that it does do something, and the next thing to find out is what it's doing and whether it's causing harm."

Dr. Ronald B. Herberman, former director of the Pittsburgh Cancer Institute and now chief medical officer for the Intrexon Corporation, a biotechnology company in Germantown, Md., said, "I think it's a very well-designed study, and they have clearly shown that there is biologic activity being induced in the nerve cells in the region where the antenna is the closest." Dr. Herberman said skeptics about the risks of cellphones have focused on the fact that the type of radiation they emit is too weak to break chemical bonds and cannot plausibly be implicated in cancer. However, the new research suggests a potentially different pathway for cancer and other health problems to develop.

"I think it's an important new direction to go in for biologists to start delving deeper into sorting out what might be going on," Dr. Herberman said.

In an editorial accompanying the Journal article, Henry C. Lai, a University of Washington professor of bioengineering who has long raised concerns about cellphone safety, said he hoped the data would broaden the focus of cellphone research and health.

"The bottom line is that it adds to the concern that cellphone use could be a health hazard," said Dr. Lai. "Everybody is worried about brain cancer, and the jury is still out on that question. There are actually quite a lot of studies showing cellphone radiation associated with other events, like sleep disturbances. But people have not been paying a lot of attention to these other types of studies."

https://well.blogs.nytimes.com/2011/02/22/cellphone-use-tied-to-changes-in-brain-activity/

Are wireless phones linked with brain cancer risk?

Swedes who talked on mobile or cordless phones for more than 25 years had triple the risk of a certain kind of brain cancer compared to those who used wireless phones for less than a year, a new study suggests.

The odds of developing glioma, an often deadly brain cancer, rose with years and hours of use, researchers reported in the journal Pathophysiology.

"The risk is three times higher after 25 years of use. We can see this clearly," lead researcher Dr. Lennart Hardell told Reuters Health in a telephone interview.

His finding contrasts with the largest-ever study on the topic - the international Interphone study, which was conducted by the International Agency for Research on Cancer and funded in part by cell phone companies. That study, published in 2010, failed to find strong evidence that mobile phones increased the risk of brain tumors.

Even if the odds of developing a glioma were doubled or tripled, however, the risk would still remain low.

A little more than 5 out of 100,000 Europeans (or 0.005 percent) were diagnosed with any kind of malignant brain tumor between 1995 and 2002, according to a 2012 study in the European Journal of Cancer (bit.ly/1xIlQam). If the rate triples, the odds rise to about 16 out of 100,000 (or 0.016 percent).

Hardell, an oncologist from University Hospital in Orebro, Sweden, and his colleague Michael Carlberg matched 1,380 patients with malignant brain tumors to people without such tumors and compared their wireless phone use.

People who reported using wireless phones for 20 to 25 years were nearly twice as likely to be diagnosed with glioma as those who reported using them for less than a year, the study found. Those who used cell and cordless phones for more than 25 years were three times more likely to develop one of these tumors.

The study did not show an association of wireless phones with malignant brain tumors other than glioma.

Participants who recalled talking the most – more than 1,486 hours – on wireless phones were twice as likely to develop glioma compared to those who said they used the devices the fewest hours – between one and 122 hours, the study found.

Case control studies such as this suffer from a number of limitations, however, the most serious being the need for participants to remember their behavior patterns from decades earlier.

Dr. Gabriel Zada, a neurosurgeon at the University of Southern California's Keck School of Medicine, who wasn't involved in Hardell's study, advises precautionary measures, such as using the phone's speaker or a hands-free headset.

But he told Reuters Health the new study failed to answer his patients' questions about why they developed brain tumors.

"A lot of people ask me, 'Why did I get this brain tumor?'" he said. "There are a lot of different theories. It's a much more convoluted picture than just saying cell phones caused this."

In a 2012 study, Zada reported that rates of malignant tumors in parts of the brain closest to where people hold their phones rose significantly in California from 1992 to 2006 – although the incidence of gliomas throughout the brain decreased (1.usa.gov/1tZffI2).

U.S. cell phone use tripled between 2000 and 2010, according to CTIA - the Wireless Association, which represents manufacturers. But in the U.S. overall, rates of cancer in parts of the brain that would be more highly exposed to radiofrequency radiation from cell phones had not gone up at the time of a 2010 report in the journal Neuro-Oncology (bit.ly/10W3F6z).

Zada believes the current study underscores the need for more research.

"It is more evidence suggesting a possible association between brain tumors and cell phones," he said. "But it's certainly not convincing that cell phones cause brain cancer."

A World Health Organization panel of 31 scientists from 14 countries classified mobile phones as "possibly carcinogenic" in 2011. The U.S. Federal Communications Commission is currently reassessing the safe radiation exposure limits it adopted in 1996.

Cell phones emit radiofrequency energy, which can be absorbed by tissues closest to where the phone is held, the National Cancer Institute says on its website. "Studies thus far have not shown a consistent link between cell phone use and cancers of the brain, nerves, or other tissues of the head or neck," it says.

Hardell is one of the few researchers who include cordless phones when studying cell phones and cancer risk. He believes emissions from the base stations of cordless phones can be problematic, especially when users sleep next to them.

Children may be most vulnerable to wireless phone emissions, Hardell said. They absorb more radiofrequency electromagnetic fields, he writes, because of their small heads, thinner skulls and higher brain conductivity.

"Girls tend to put the smart phone below the pillow," he said. "It's a bad habit to go to bed with your smart phone."

Zada also believes developing brains may be more susceptible and recommends against sleeping with cell phones.

Nevertheless, he said: "It's hard to make formal recommendations because the data is lacking. It's not smoking and lung cancer because it's not proven."

http://www.reuters.com/article/us-brain-cancer-mobilephone-idUSKCN0IV26Y20141111

Has radiation from cell phones and microwaves caused brain tumor cases to double in Denmark?

February 10, 2017

A new report by the Swedish Radiation Protection Foundation, Stralskyddsstiftelsen, has concluded that ever-increasing rates of both brain and central nervous system (CNS) tumors, particularly in Denmark, may be caused by persistent exposure to radiation from mobile phones, microwaves, and other "smart" technology devices that pervade modern society.

Published on January 20, the report shows that such tumors have become increasingly more prevalent since 1990, and especially since 2004 when mobile phones really started to become popular. The data suggests that increasing rates of cancer in the brain, spinal cord cover, CNS spinal cord, and cranial nerves are directly correlated with the increasing use of radioactive devices, including in young people.

Individuals who are more likely to use smart technology devices like Apple iPhones or Wi-Fi enabled tablet devices and laptop computers are much more prone to develop cancer in these areas than those who don't. In fact, such cancers are so prevalent that they are almost on par with rates of melanoma, a type of skin cancer that is much more common.

While there have been claims made by the US National Cancer Institute and the Swedish Radiation Authority that this phenomenon isn't occurring, this just does not align with Stralskyddsstiftelsen's extensive research into the subject over the past several decades, which points to some serious anomalies. It would seem that government authorities are either failing or are refusing to acknowledge the dangers of electromagnetic radiation.

"Case control studies repeatedly show increased risks for CNS tumors from mobile and cordless phone use," the group's latest report emphasizes. "Ever since 2010 all studies investigating risks for brain tumors from mobile phone use over 30 minutes to one hour a day over several years have found increased risks for CNS tumors (glioma, acoustic neuroma and also meningioma)."

"Today 75% of Swedish 16 year old girls use their 'smart phone' over three hours a day and they have been wrongly informed that there are no health risks observed, often with reference to incorrect claims about brain tumor incidence trends."

Thousands of published studies link 'smart' technology use to cancer

Authorities in the US, Sweden, and elsewhere can deny all they want the correlative, and potentially causative, links between the use of smart devices and cancer, but the science speaks for itself. There are hundreds, if not thousands, of published studies and reports that show cancer rates increasing right alongside smart device usage.

For instance, a report by EMFWise Health Effects of Wireless Radiation states that, because microwave radiation can directly penetrate the body, there are serious immune risks associated with the use of these appliances. Some of these risks include alterations of immune cells, changes in lymphocytes, reduced lymphocyte count and hypersensitivity that manifests as autoimmunity.

Non-thermal microwave radiation directly impacts water, it turns out, and the human body is made up of as much as 70 percent water. When interacting with this radiation, the water in the human body is disrupted, which in turn disrupts the complex communications apparatus that exists in the body's cellular network, which uses water to send and receive information.

Similar problems exist for mobile phones, which come into direct contact with the head, hands, and other parts of the body. Electromagnetic pollution ends up interfering with the body wherever the phone is resting, whether via the leg through a pants pocket, the brain as it's pressed against the ear or in the arm as it's held in one's hand.

At this time, industry-funded research on the matter directly conflicts with independent research in most cases. The former presents a cohort of evidence, only 32 percent of which suggests harmful effects, while 70 percent of the latter's research shows harmful effects.

http://newstarget.com/2017-02-10-has-radiation-from-cell-phones-and-microwaves-caused-brain-tumor-cases-to-double-in-denmark.html

Tree damages in the vicinity of mobile phone base stations

Abstract: Since 2005, on the occasion of medical examinations of sick residents living near mobile phone base stations, changes in nearby trees (crown, leaves, trunk, branches, growth) were observed at the same time as clinical symptoms in humans occurred. Both deciduous and coniferous trees as well as shrub species were affected. The assessment of tree diseases is neither impeded by psychological impacts nor by change of location. Impacts of radiofrequency electromagnetic fields (RF-EMF) from radar, radio and TV on plant life have been scientifically demonstrated over the past 80 years. Since 2005, the influence of modulated RF-EMF - that are used in mobile phone telephony - has been investigated in lab experiments. Several research groups reported about the impacts on germination, growth and cell metabolism. Only a few scientific papers have been published to date on research concerning the health conditions of trees in the vicinity of mobile phone base stations. These papers are indicating harmful impacts. For this reason, between 2007 and 2013, the status of trees standing in the neighbourhood of 620 mobile phone base stations was documented. In the radio shadow of buildings or that one of other trees, the trees stayed healthy. However, within the radiation field, damages were observed on exposed trees. Additionally, unilateral crown damage, beginning on the side facing the antenna, strongly indicates a causal relationship with RF-EMF. In the following, examples of crown damages and of premature colouring of leaves are presented. The authors believe, that scientific research is urgently needed to examine these observations.

Conclusion

Observations, that trees are getting damages by radiofrequency electromagnetic fields of mobile phone base stations, accumulate. Often, commonly recognized factors cannot explain the damage patterns. Therefore, the immediate scientific investigation of trees in the radiation field of mobile phone base stations as well as the evaluation of aerial photography is necessary. Synchronously and shortly, exposure tests by using young trees have to be carried out.

In fact this conclusion is well supported by a WHO statement from 1999: that scientific studies on effects of low EMF exposure on animals and plants are urgently needed (MATTHES et al. 2000), a statement which can only be characterized as remarkable.

http://kompetenzinitiative.net/KIT/wp-content/uploads/2016/06/Tree-damages-in-the-vicinity-of-mobile-phone-base-stations.pdf

Study links bee decline to cell phones

A new study has suggested that cell phone radiation may be contributing to declines in bee populations in some areas of the world.

Bee populations dropped 17 percent in the UK last year, according to the British Bee Association, and nearly 30 percent in the United States says the U.S. Department of Agriculture.

Parasitic mites called varroa, agricultural pesticides and the effects of climate change have all been implicated in what has been dubbed "colony collapse disorder" (CCD).

But researchers in India believe cell phones could also be to blame for some of the losses.

In a study at Panjab University in Chandigarh, northern India, researchers fitted cell phones to a hive and powered them up for two fifteen-minute periods each day.

After three months, they found the bees stopped producing honey, egg production by the queen bee halved, and the size of the hive dramatically reduced.

It's not just the honey that will be lost if populations plummet further. Bees are estimated to pollinate 90 commercial crops worldwide. Their economic value in the UK is estimated to be $290 million per year and around $12 billion in the U.S.

Andrew Goldsworthy, a biologist from the UK's Imperial College, London, has studied the biological effects of electromagnetic fields. He thinks it's possible bees could be affected by cell phone radiation.

The reason, Goldsworthy says, could hinge on a pigment in bees called cryptochrome.

"Animals, including insects, use cryptochrome for navigation," Goldsworthy told CNN.

"They use it to sense the direction of the earth's magnetic field and their ability to do this is compromised by radiation from [cell] phones and their base stations. So basically bees do not find their way back to the hive."

Goldsworthy has written to the UK communications regulator OFCOM suggesting a change of phone frequencies would stop the bees being confused.

"It's possible to modify the signal coming from the [cell] phones and the base station in such a way that it doesn't produce the frequencies that disturb the cryptochrome molecules," Goldsworthy said.

"So they could do this without the signal losing its ability to transmit information."

But the UK's Mobile Operators Association -- which represents the UK's five mobile network operators -- told CNN: "Research scientists have already considered possible factors involved in CCD and have identified the areas for research into the causes of CCD which do not include exposure to radio waves."

Norman Carreck, Scientific director of the International Bee research Association at the UK's University of Sussex says it's still not clear how much radio waves affect bees.

"We know they are sensitive to magnetic fields. What we don't know is what use they actually make of them. And no one has yet demonstrated that honey bees use the earth's magnetic field when navigating," Carreck said.

http://www.cnn.com/2010/WORLD/europe/06/30/bee.decline.mobile.phones/index.html

How Your Cell Phone Is Killing Bees And Starving The Planet

Believe it or not, bees are pretty important. They pollinate the food we eat. And their declining population is a major concern for some scientists.

Now a new study says cell phones are to blame.

A Swiss scientist named Daniel Favre conducted the study, and concluded cell phone signals can cause bees to make extra noise, which is a signal to leave the hive. When cell phones are placed near a hive, it acts as a barrier, keeping bees from returning.

When worker bees abandon the hive, the hive as a whole suffers. Thus, the decline in bee population, and a major scare for food scientists.

http://www.businessinsider.com/cell-phones-are-killing-bees-2011-5

It's Official – Cell Phones are Killing Bees

Scientists may have found the cause of the world's sudden dwindling population of bees – and cell phones may be to blame. Research conducted in Lausanne, Switzerland has shown that the signal from cell phones not only confuses bees, but also may lead to their death. Over 83 experiments have yielded the same results. With virtually most of the population of the United States (and the rest of the world) owning cell phones, the impact has been greatly noticeable.

Led by researcher Daniel Favre, the alarming study found that bees reacted significantly to cell phones that were placed near or in hives in call-making mode. The bees sensed the signals transmitted when the phones rang, and emitted heavy buzzing noise during the calls. The calls act as an instinctive warning to leave the hive, but the frequency confuses the bees, causing them to fly erratically. The study found that the bees' buzzing noise increases ten times when a cell phone is ringing or making a call – aka when signals are being transmitted, but remained normal when not in use.

The signals cause the bees to become lost and disoriented. The impact has already been felt the world over, as the population of bees in the U.S. and the U.K. has decreased by almost half in the last thirty years – which coincides with the popularization and acceptance of cell phones as a personal device. Studies as far back as 2008 have found that bees are repelled by cell phone signals.

Bees are an integral and necessary part of our agricultural and ecological systems, producing honey, and more importantly pollinating our crops. As it is unlikely that the world will learn to forgo the convenience of cell phones, it is unclear how much they will contribute to the decline of bees, and their impact on the environment.

http://inhabitat.com/its-official-cell-phones-are-killing-bees/

Cell phone signals really are killing the bees, study shows

If there's one thing people around the world love to do — in fact, need to do — it's eat. Unfortunately, another thing everyone likes to do is talk on their cell phones. And according to a new study, these two activities are completely at odds because of a cell phone signal's confusing effects on one key player: bees.

Researcher Daniel Favre of the Swiss Federal Institute of Technology has found that wireless signals cause honeybees to become so disoriented that they finally just die. Favre's team conducted 83 separate experiments that tested bees' reactions to a nearby cellphone.

The team found that honeybees made 10 times the amount of noise when a cell phone made or received a call than they did when the phone was in off or standby mode. As Fast Company reports, this noise (generally known as "worker piping") usually signals the bees to leave the hive. But when the reaction is triggered by a cellular signal, the bees just became tragically befuddled.

So, what about a cell phone signal makes bees suicidally crazy? As Favre's report explains: "Worker piping in a bee colony is not frequent, and when it occurs in a colony, that is not in a swarming process, no more than two bees are simultaneously active…The induction of honeybee worker piping by the electromagnetic fields of mobile phones might have dramatic consequences in terms of colony losses due to unexpected swarming."

It's the "dramatic…colony losses" part that everyone should be concerned about. Honeybees are responsible for pollinating about 70 percent of the 100 or so crops on the entire planet that humans use for food.

So-called "colony collapse disorder" among the world's bee population has been recorded since 1972. But it wasn't until 2006 that the drop in the bee population took a nosedive, with beekeepers noting a 30 to 90 percent loss of their bee colonies, up from 17 to 20 percent in previous years.

Favre's study corroborates a 2008 report that showed that honeybees would not return to their hive when a cell phone was placed nearby, which sparked the theory that wireless signals are the problem.

There are other reasons scientists believe the world's crucial bee population is plummeting, things like the use of clothiandin, a pesticide used to treat corn seeds. But Favre's study shows that our cell phone habit is playing a major role in the current bee holocaust. New iPhone, anyone?

http://www.digitaltrends.com/mobile/cell-phones-signals-really-are-killing-the-bees-study-shows/

Report of Possible Impacts of Communication Towers on Wildlife Including Birds and Bees

Executive Summary

India is one of the fastest growing mobile telephony industries in the world. It is estimated that by 2013, 1 billion plus people will be having cell phone connection in India. To support this growth of cell phone subscriber in the country, there has also been a tremendous growth of infrastructure in the form of mobile phone towers. Today, in absence of any policy on infrastructure development and location of cell phone towers, large numbers of mobile phone towers are being installed in a haphazard manner across urban and rural areas including other sparsely populated areas in India. The transmission towers are based on the electromagnetic waves, which over prolonged usage have adverse impacts on humans as well as on other fauna. The adverse effects of electromagnetic radiation from mobile phones and communication towers on health of human beings are well documented today. However, exact correlation between radiation of communication towers and wildlife, are not yet very well established. The Ministry of Environment and Forests usually receives several questions regarding this issue. In view of one such Lok Sabha Starred question regarding 'Ill effects of Mobile Towers on Birds' received on 11th August, 2010, an 'Expert committee to Study the possible Impacts of Communication Towers on Wildlife including Birds and Bees' was constituted on 30th August, 2010 by Ministry of Environment and Forest, Government of India.

Conclusion

The review of existing literature shows that the EMRs are interfering with the biological systems in more ways than one and there had already been some warning bells sounded in the case on bees (Warnke 2007; vanEngelsdorp et al. 2010; Gould 1980; Sharma and Neelima R Kumar 2010) and birds, which probably heralds the seriousness of this issue and indicates the vulnerability of other species as well. Despite a few reassuring reports (Galloni et al. 2005), a vast majority of published literature indicate deleterious effects of EMFs in various species. The window of frequency range and exposure time required to make measurable impacts would vary widely among species and unfortunately we do not have any such data available for most of our free-living floral and faunal species in India. There is an urgent need to focus more scientific attention to this area before it would be too late. Microwave and radiofrequency pollution appears to constitute a potential cause for the decline of animal populations (Balmori 2006; Balmori and Hallberg 2007; Balmori Martínez 2003; Joris and Dirk 2007; Summers-Smith 2003) and deterioration of health of plants and humans living near radiation sources such as phone masts. Studies have indicated the significant non-thermal long-term impacts of EMFs on species, especially at genetic level which can lead to various health complications including brain tumours (glioma), reduction in sperm counts and sperm mobility, congenital deformities, Psychiatric problems (stress, 'ringxity', sleep disorders, memory loss etc.) and endocrine disruptions. However similar aspects are yet to be studied among animal populations. Pollution from EMRs being a relatively new environmental issue, there is a lack of established standard procedures and protocols to study and monitor the EMF impacts especially 22 among wildlife, which often make the comparative evaluations between studies difficult. Moreover, there are no long-term data available on the environmental impacts of EMRs as of now. Well-designed long-term impact assessment studies would be required to monitor the impact of ever-increasing intensities of EMRs on our biological environment. Meanwhile the precautionary principle should prevail and we need to better our standards on EMF to match the best in the world. Studies on impact of Cell phone tower radiation on Birds and wildlife are almost nonexistent from India. There is an urgent need for taking up well designed studies to look into this aspect. Available information from the country on the subject of EMF impacts is restricted to few reports from honey-

bees. However, these studies are not representative of the real life situations or natural levels of EMF exposure. More studies need to be taken up to scientifically establish if any, the link between the observed abnormalities and disorders in bee hives such as Colony Collapse Disorder (CCD).

http://www.moef.nic.in/downloads/public-information/final_mobile_towers_report.pdf

Impacts of radio-frequency electromagnetic field (RF-EMF) from cell phone towers and wireless devices on biosystem and ecosystem – a review

Abstract: This paper summarizes the effect of radio-frequency electromagnetic field (RF-EMF) from cell towers and wireless devices on the biosphere. Based on current available literature, it is justified to conclude that RF-EMF radiation exposure can change neurotransmitter functions, blood-brain barrier, morphology, electrophysiology, cellular metabolism, calcium efflux, and gene and protein expression in certain types of cells even at lower intensities. The biological consequences of such changes remain unclear. Short-term studies on the impacts of RF-EMF on frogs, honey bees, house sparrows, bats, and even humans are scarce and long-term studies are non-existent in India. Identification of the frequency, intensity, and duration of non-ionizing electromagnetic fields causing damage to the biosystem and ecosystem would evolve strategies for mitigation and would enable the proper use of wireless technologies to enjoy its immense benefits, while ensuring one's health and that of the environment.

Conclusion: The Department of Telecommunication (DoT) in India has set new norms for cell phone towers with effect from September 1, 2012 (The Hindu, 2012). Exposure standards for RF-EMF radiation has been reduced to one-tenth of the existing level and SAR from 2 to 1.6 W/kg. This came after the Ministry of Environment and Forests (MOEF) set up an Inter-Ministerial Committee (IMC) to study the effects of RF-EMF radiations on wildlife (Figure 2) and concluded that out of the 919 research papers collected on birds, bees, plants, other animals, and humans, 593 showed impacts, 180 showed no impacts, and 196 were inconclusive studies. They conclude that there are no long-term data available on the environmental impacts of RF-EMF radiations in India. The population of India is increasing as well as the cell phone subscribers and the cell towers as supporting infrastructure. Hence, there is an urgent need to fill the gaps and do further research in this field with emphasis on the effects of early life and prenatal RF-EMF radiation exposure in animals, dosimetry studies, cellular studies using more sensitive methods, and human epidemiological studies, especially on children and young adults on behavioral and neurological disorders and cancer. Meanwhile, one can take the precautionary principle approach and reduce RF-EMF radiation effects of cell phone towers by relocating towers away from densely populated areas, increasing height of towers or changing the direction of the antenna.

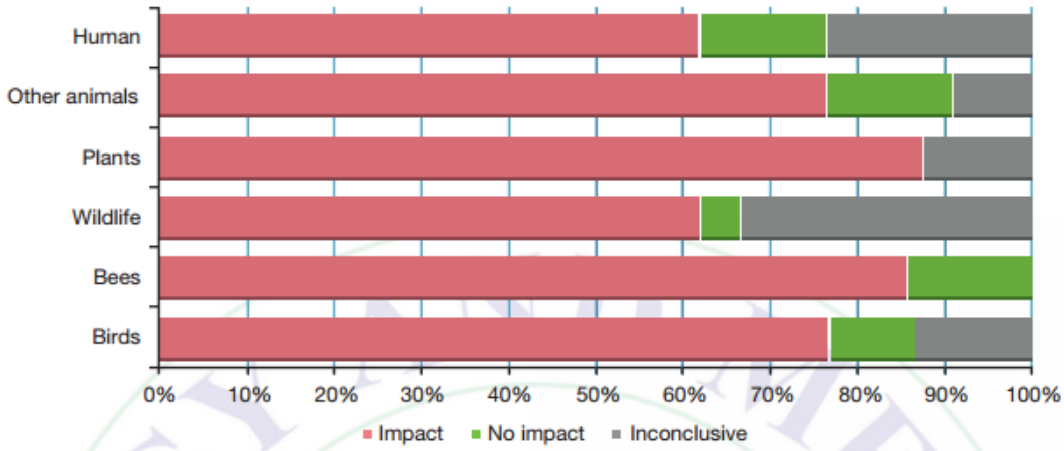


Figure 2: Percentage of studies that reported harmful effect of EMR in various groups of organisms (n = 919), MOEF Report (2010).

http://www.biolmedonline.com/Articles/Vol4_4_2012/Vol4_4_202-216_BM-8.pdf

Cell Phones are the Cigarettes of the 21st Century

A comparison of cell phone use, which continues its meteoric rise and cigarette smoking, is illustrative. Just a few of the similarities between the two habits include:

Manufacturers and industry leaders who either hide or debunk unfavorable study results and continue to promote their products despite awareness of the significant dangers to public health

Government conflict of interest created by lobbies for both industries and revenues collected from use taxes

Expensive, effective marketing campaigns aimed at every segment of society, including children

Massive amounts of scientific data proving beyond a shadow of a doubt the direct link between these products and life-threatening damage to the human body

The addictive nature of both products

The primary distinction between cell phone use and cigarettes is that smoking has been around long enough to confirm it can, indeed, be a fatal habit. According to a 2008 World Health Organization (WHO) report, tobacco use kills 5 million people a year worldwide, and is a risk factor in six of the eight leading causes of death.

These are just a few recent examples of study data linking electromagnetic radiation and cell phone use to a stunning array of serious health concerns:

- At a recent Senate Committee hearing, witnesses testified that cell phone use has been linked to salivary gland tumors
- Wearing a cell phone on your hip – either on your belt or in a pocket – has been linked to decreased bone density in the pelvic region. All the other vital organs located in your pelvic region – your liver, kidney, bladder, colon and reproductive organs – are also susceptible to radiation damage.
- Proximity to cell phone towers causes an increase in the symptoms of electromagnetic hypersensitivity, including fatigue, sleep disturbances, visual and auditory disturbances, and cardiovascular effects, just to name a few.

Thanks to a multimillion-dollar research study funded by none other than the Cellular Telephone Industry Association (CTIA), which certainly didn't set out to uncover these results, we now have proof of:

A significant increase in cell phone users' risk of brain tumors at the brain's outer edge, on whichever side the cell phone was held most often.

A 60 percent greater chance of acoustic neuromas, a tumor affecting the nerve that controls hearing, among people who had used cell phones for six years or more.

A higher rate of brain cancer deaths among handheld mobile phone users than among car phone users (car phones are mounted on the dashboard rather than held next to your head)

In addition to this research, a review of 11 long-term epidemiologic studies published in the journal Surgical Neurology revealed that using a cell phone for 10 or more years approximately doubles the risk of being diagnosed with a brain tumor on the same side of the head where the cell phone is typically held.

Australia has seen an increase in pediatric brain cancers of 21 percent in just one decade. This is consistent with studies showing a 40 percent brain tumor increase across the board in Europe and the U.K. over the last 20 years.

Brain cancer has now surpassed leukemia as the number one cancer killer in children.

In addition to the widespread concern about brain cancer, scientists have found that information-carrying radio waves transmitted by cell phones and other wireless devices can:

- Harm your blood cells and cause cellular changes
- Damage your DNA
- Cause nerve-cell damage
- Possibly accelerate and contribute to onset of autism, and trigger Alzheimer's disease (You may have read the recent spin that cellphone use can cure Alzheimer's, but you should know that study involved exposures that were nothing like a cell phone exposure, even though the publicity suggested otherwise. More on this soon.)
- Damage your eyes
- Cause sleep disruptions, fatigue and headaches

http://articles.mercola.com/sites/articles/archive/2010/02/04/cell-phones-are-the-cigarettes-of-the-21st-century.aspx

Pediatricians Warn Cell Phone Radiation Poses Cancer Risk to Children

Following a study last May that linked wireless radiation to deadly heart and brain cancers, the American Academy of Pediatrics (AAP) has issued a series of recommendations that warn parents of the dangers cell phones and other wireless devices present to their children. The initial study was carried out by the US National Toxicology Program over a period of two years. It found that rats suffered DNA damage in their brain cells as well as a high probability of developing brain tumors and malignant Schwann cell tumors in the heart. Dr. Ronald L. Melnick, a toxicologist at the National Institutes of Health, said that the cancer risks for children are even greater due to greater penetration and absorption of cell phone radiation as well as a higher susceptibility to tissue-damaging agents. Dr. Jennifer Lowry, chair of the AAP council on Environmental Health Executive Committee, seconded these claims warning that "[cell phones] are not toys. They have radiation that is emitted from them and the more we can keep it off the body and use [phones] in other ways, it will be safer."

The AAP had previously expressed concern about the dangers of cell phone radiation. 5 years ago, an Egyptian study showed that living in proximity to mobile phone base stations increases the risk for developing various problems such as headaches, memory problems, dizziness, depression, and insomnia. Though this study focused on short-term effects, the AAP had previously warned that it was important to consider the possible cumulative damage from the electromagnetic radiation emitted by cell phones and supported further research. The US National Toxicology Program study only confirmed the AAP's suspicions that cumulative exposure to cell phone radiation has damaging effects on human health, especially children whose bodies are still developing.

Pediatricians also expressed their concern over the legal limits of cell phone radiation established by the Federal Communications Commission (FCC). The FCC's allowable limit is currently 1.6 W/kg, but this standard has not been revised since 1996 despite that fact the cell phone use has increased dramatically and that cell phone technology has grown by leaps and bounds. In addition, the FCC's limit is based on the devices' potential effect on fully-grown adults based on 20-year-old, outdated science. The limit does not consider the effect of cell phone radiation on children even though children's skulls are thinner and more readily absorb radiation. These facts also led the AAP to recommend a government review of cell phone radiation standards that "protect children's health, reflect current cell phone use patterns, and provide meaningful consumer disclosure." However, it appears doubtful that the FCC will make changes anytime soon as cell phone manufacturers are likely to fight against any new regulations that would further reduce the radiation limit.

http://www.trueactivist.com/pediatricians-warn-cell-phone-radiation-poses-cancer-risk-to-children/

EEG Changes Due to Experimentally Induced 3G Mobile Phone Radiation

Abstract

The aim of this study was to investigate whether a 15-minute placement of a 3G dialing mobile phone causes direct changes in EEG activity compared to the placement of a sham phone. Furthermore, it was investigated whether placement of the mobile phone on the ear or the heart would result in different outcomes. Thirty-one healthy females participated. All subjects were measured twice: on one of the two days the mobile phone was attached to the ear, the other day to the chest. In this single-blind, cross-over design, assessments in the sham phone condition were conducted directly preceding and following the mobile phone exposure. During each assessment, EEG activity and radiofrequency radiation were recorded jointly. Delta, theta, alpha, slowbeta, fastbeta, and gamma activity was computed. The association between radiation exposure and the EEG was tested using multilevel random regression analyses with radiation as predictor of main interest. Significant radiation effects were found for the alpha, slowbeta, fastbeta, and gamma bands. When analyzed separately, ear location of the phone was associated with significant results, while chest placement was not. The results support the notion that EEG alterations are associated with mobile phone usage and that the effect is dependent on site of placement. Further studies are required to demonstrate the physiological relevance of these findings.

Introduction

Mobile phone usage has become an integrated part of modern society. In recent years, number and level of usage of mobile phones has increased rapidly. In 2013, 6.8 billion mobile phone subscriptions were registered [1]. In recent years, new technology of 3rd generation (3G) or universal mobile telecommunication system (UMTS), using the 1.9–2.1 GHz frequency band has been introduced, followed by the 4th generation. Although there are some worries [2] about the potential negative effects of RF-EMF on health, large sections of the population are avid customers. The number of studies investigating whether or not RF-EMF has adverse health effects has increased rapidly. The research field is broad since several areas are explored, ranging from carcinogenesis and infertility to basic effects on physiological parameters. In general, results are conflicting and inconclusive [3–6]. While a number of studies demonstrate influence of radiation on health, others cannot replicate these findings. Nevertheless, the International Agency for Research on Cancer concluded that there is “limited evidence in humans” and in 2011 it was decided to classify mobile phone radiation in group 2B—possibly carcinogenic [2]. In contrast, the 2012 overview report of the Mobile Telecommunications and Health Research (MTHR) Programme concluded that there is no evidence of carcinogenic effects due to exposure to mobile phone signals [7]. However, examining possible effects due to long-term exposure and the effects on other outcomes were suggested as priority research areas. Also in the WHO Research Agenda for Radiofrequency Fields of 2011, “provocation studies to identify neurobiological mechanisms underlying possible effects of RF on brain function, including sleep and resting EEG” are considered to have a high priority [8].

The effects of mobile phone radiation on electroencephalography (EEG) have been studied since the mid-nineties [9]. There are a number of studies which have investigated the effects of mobile phone radiation on resting EEG, on sleep EEG, on the performance of cognitive tasks, and on event related potentials (ERP) of conscious sensory stimuli. Apart from a relative consistent finding [9–15] of an increased power in the alpha band, no consistent results have been reported. A possible contributing factor to these varying results may be found in the diversity of designs and in the statistical analyses.

Some examples are: type of exposure (network 2G/3G and a real mobile phone versus a radiating module), duration of exposure (ranging from minutes to several hours), and statistical tests (parametric versus non-parametric tests). Apart from these methodological aspects, it has been suggested that source of funding might influence the results [16]. It has been shown that 87% of brain activity studies are sponsored by the mobile phone industry [4]. Although this does not necessarily imply that the results of these articles are biased, the issue of conflict of interest cannot be neglected.

To shed further light on this topic, it was decided to set up a basic experiment to investigate whether EEG is influenced by mobile phone radiation. The focus on EEG as the dependent variable was deliberate since functioning of brain tissue is based on electrochemical processes [17] and interference by an electromagnetic device (mobile phone) placed directly against the head is, from a physical point of view, very likely to occur. Despite this plausible physical interference mechanism, adverse effects are rarely reported.

Before setting up the experiment, several methodological issues were considered. First, in most studies a control session was included on a separate day [12–15,18]. It is known, however, that resting EEGs can differ across days, even without any intervention [19]. Therefore, it was decided to compare an exposure condition with two control measurements, directly preceding and following the exposure condition. In addition, a control-exposure-control session was conducted on two different days in order to test whether the location of placement of the mobile phone might be of influence. Apart from the obvious placement of the mobile phone on the ear, it was decided to also place the phone on the chest. Any differences in outcome between placement locations may be informative about a working mechanism. Third, an actual mobile phone was used instead of a GSM module or other method to simulate mobile phone radiation. This decision was made to represent reality as accurately as possible. In order to ensure that the radiation did not have a direct effect on the measurement equipment, shielded EEG electrodes were used. Finally, multilevel random regression analysis was used instead of ANOVA techniques. The main reason is that EEG data show hierarchical clustering in at least four levels: subjects, sessions, conditions and EEG segments. Multilevel regression analysis also allows modulation of random effects (regression coefficients may vary between subjects) as well as the incorporation of an autoregressive covariance structure (since consecutive EEG segments are highly correlated).

Two a priori hypotheses were tested. Based on existing literature, an increase in alpha activity during exposure was expected. Second, because of the smaller distance to the brain, the influence on the EEG of radiation was expected to be larger with ear placement as compared to chest placement.

Discussion

In this placebo-controlled, single-blind, cross-over study, we investigated whether a 15 minute RF-EMF exposure by a 3G mobile phone impacts EEG activity. It was demonstrated that the results (and conclusions) strongly depend on the method of analysis. Analysed in the traditional fashion, that is, not controlling for the nested structure of the data, no significant differences could be demonstrated (see Table 2), a finding which is in accordance with several other studies [18,25–28]. However, when the data were analysed with an appropriate multilevel statistical model, 'radiation' proved to be a significant predictor of the alpha, slow beta, fast beta, and gamma frequency bands over almost all brain regions (Figs (Figs11 and and2).2). There is a trend for the radiation effect to be stronger on the ipsilateral side. The positive significant time effect (segment) within conditions, observed in all regions and frequency bands, was unexpected and an explanation is lacking at this moment. Guided by the significant

placement*radiation interactions, separate analyses for the ear and heart placements made clear that the radiation effect was mainly present in sessions where the mobile phone was placed on the ear (Figs (Figs33 and and4).4). To our knowledge, this ear-heart contrast has not been studied before. The present data suggest that a greater distance to the brain in case of the chest placement results in less EEG effects.

Although there are some studies which found an increase in the alpha frequency band due to RF-EMF [9–15], the extent to which the different EEG bands are affected in the present study has not been reported in literature to date. This discrepancy needs clarification and probably has to be sought in methodological differences with other studies. As mentioned above, the type of statistical approach is an important factor in this issue. The multilevel approach is the preferred approach given the present study design. As stated in the introduction, this approach allows for modelling clustered data, to correct for autocorrelation, and for modelling random effects. In addition, in this study radiation was used as the predictor of primary interest instead of a general condition (exposed vs. non-exposed conditions) effect. This was made possible by connecting the radiation detector to the amplifier. Another methodological difference may lie in the usage of shielded electrodes (most articles do not describe this specific information) which prevents a direct influence of RF-EMF on the wires. Yet another difference is that in the present study an actual mobile phone was used functioning within the UMTS bandwidth (instead of 2G). The studies which also used UMTS do not find EEG effects [18,27,29]. A final difference pertains to the control measurement. Whereas most studies had the control session on a separate day, the present study used a crossover moment in the same session, directly preceding and following the exposure session.

Some limitations have to be considered. First, the study was performed with adult female subjects only. The generalizability of the results to, for example, male subjects, children, and the elderly has to be demonstrated in future research. Second, a sample size of thirty-one is relatively small. Future studies with larger sample sizes are required. Two other critical points are exposure time and follow up measurements. In this study, only one exposure condition (15 minutes) was used and a (long term) follow up measurement was not included. It would be interesting to investigate what the effects are of other (shorter or longer) exposure periods to mobile phone radiation, as well as to find out what the effects are of frequent experimental exposure to radiation in the long term. Fifth, no inner ear temperature was measured. As there is evidence that mobile phones cause a thermal, heating effect [30], it could be argued that inner ear temperature fluctuations between the conditions may have confounded the findings. On the other hand, it has also been reported that any changes in cerebral blood flow due to mobile phone radiation, assessed by positron emission tomography, are unlikely to be temperature-related [31,32]. This issue needs further investigation. Sixth, the experiment was performed in a non-shielded room, thus including environmental background radiation. It would be ideal to carry out such experiments in a radiation-free environment. As a seventh point of concern, in retrospect it would have been preferable to not enter the experimenting room in-between conditions to change phones. Ideally the phone should be programmed from outside the room. Furthermore, a note should be made with respect to the number of tests performed. For example, Fig 1 contains eighteen test results. When corrected with the Bonferroni procedure, only two p-values (slow-beta left and midline) would remain significant. However, at least some of the findings would hold up under such a correction and it should be noted that the Bonferroni method is actually overly conservative for multiple correlated tests. [33] Instead, the ‘False discovery rate’ (FDR) was used to correct for multiple testing.

Most results were still significant after correction. Finally, information on other (psycho)physiological and biological measures may be included in future work.

The question is whether the (temporary) EEG changes, induced by mobile phone radiation, have clinical/adverse consequences. Answering this question is complex and beyond the scope of the present manuscript. First, it is unknown whether mobile phones change EEG activity in the long term. Second, EEG is a reflection of very complex cerebral processes. It is thought that the activity in the different frequency bands represents underlying cortical functions. An example is the thalamocortical network, which plays an important role in the generation of alpha activity [34]. Beta activity, however, only plays a role in the cortex and can, for example, be related to active concentration [35]. Since the functional role of the different frequency bands is still not fully understood, it is also hard to draw conclusions on the (clinical) implications of EEG changes.

In future studies other indicators of brain activity may be included. For example, transcranial magnetic stimulation is a method to test brain excitability. There are several indications that brain excitability is modified due to mobile phone radiation [36–38].

This study attempted to approach the question whether or not mobile phones cause (short-term) changes in EEG activity. There was evidence that mobile phone radiation is associated with increased activity of the alpha, beta, and gamma frequency bands in nearly every brain region. The distance of the mobile phone to the brain was relevant, a larger distance resulting in less or no EEG interference. Replication of the present findings and investigation of possible long term (clinically relevant) effects is urgently required.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4459698/

Effects of radiofrequency electromagnetic fields on the human nervous system

Abstract

The effects of exposure to radiofrequency electromagnetic fields (EMF), specifically related to the use of mobile telephones, on the nervous system in humans have been the subject of a large number of experimental studies in recent years. There is some evidence of an effect of exposure to a Global System for Mobile Telecommunication (GSM)-type signal on the spontaneous electroencephalogram (EEG). This is not corroborated, however, by the results from studies on evoked potentials. Although there is some evidence emerging that there may be an effect of exposure to a GSM-type signal on sleep EEG, results are still variable. In summary, exposure to a GSM-type signal may result in minor effects on brain activity, but such changes have never been found to relate to any adverse health effects. No consistent significant effects on cognitive performance in adults have been observed. If anything, any effect is small and exposure seems to improve performance. Effects in children did not differ from those in healthy adults. Studies on auditory and vestibular function are more unequivocal: neither hearing nor the sense of balance is influenced by short-term exposure to mobile phone signals. Subjective symptoms over a wide range, including headaches and migraine, fatigue, and skin itch, have been attributed to various radiofrequency sources both at home and at work. However, in provocation studies a causal relation between EMF exposure and symptoms has never been demonstrated. There are clear indications, however, that psychological factors such as the conscious expectation of effect may play an important role in this condition.

https://www.ncbi.nlm.nih.gov/pubmed/20183535

Evaluation of Mobile Phone and Cordless Phone Use and Glioma Risk Using the Bradford Hill Viewpoints from 1965 on Association or Causation

Abstract

Objective. Bradford Hill's viewpoints from 1965 on association or causation were used on glioma risk and use of mobile or cordless phones. Methods. All nine viewpoints were evaluated based on epidemiology and laboratory studies. Results. Strength: meta-analysis of case-control studies gave odds ratio (OR) = 1.90, 95% confidence interval (CI) = 1.31-2.76 with highest cumulative exposure. Consistency: the risk increased with latency, meta-analysis gave in the 10+ years' latency group OR = 1.62, 95% CI = 1.20-2.19. Specificity: increased risk for glioma was in the temporal lobe. Using meningioma cases as comparison group still increased the risk. Temporality: highest risk was in the 20+ years' latency group, OR = 2.01, 95% CI =1.41-2.88, for wireless phones. Biological gradient: cumulative use of wireless phones increased the risk. Plausibility: animal studies showed an increased incidence of glioma and malignant schwannoma in rats exposed to radiofrequency (RF) radiation. There is increased production of reactive oxygen species (ROS) from RF radiation. Coherence: there is a change in the natural history of glioma and increasing incidence. Experiment: antioxidants reduced ROS production from RF radiation. Analogy: there is an increased risk in subjects exposed to extremely low-frequency electromagnetic fields. Conclusion. RF radiation should be regarded as a human carcinogen causing glioma.

https://www.ncbi.nlm.nih.gov/pubmed/28401165

Fetal radiofrequency radiation exposure from 800-1900 mhz-rated cellular telephones affects neurodevelopment and behavior in mice

Abstract

Neurobehavioral disorders are increasingly prevalent in children, however their etiology is not well understood. An association between prenatal cellular telephone use and hyperactivity in children has been postulated, yet the direct effects of radiofrequency radiation exposure on neurodevelopment remain unknown. Here we used a mouse model to demonstrate that in-utero radiofrequency exposure from cellular telephones does affect adult behavior. Mice exposed in-utero were hyperactive and had impaired memory as determined using the object recognition, light/dark box and step-down assays. Whole cell patch clamp recordings of miniature excitatory postsynaptic currents (mEPSCs) revealed that these behavioral changes were due to altered neuronal developmental programming. Exposed mice had dose-responsive impaired glutamatergic synaptic transmission onto layer V pyramidal neurons of the prefrontal cortex. We present the first experimental evidence of neuropathology due to in-utero cellular telephone radiation. Further experiments are needed in humans or non-human primates to determine the risk of exposure during pregnancy.

https://www.ncbi.nlm.nih.gov/pubmed/22428084

Prenatal and Postnatal Cell Phone Exposures and Headaches in Children

Abstract

OBJECTIVE:
Children today are exposed to cell phones early in life, and may be at the greatest risk if exposure is harmful to health. We investigated associations between cell phone exposures and headaches in children.

STUDY DESIGN:
The Danish National Birth Cohort enrolled pregnant women between 1996 and 2002. When their children reached age seven years, mothers completed a questionnaire regarding the child's health, behaviors, and exposures. We used multivariable adjusted models to relate prenatal only, postnatal only, or both prenatal and postnatal cell phone exposure to whether the child had migraines and headache-related symptoms.

RESULTS:
Our analyses included data from 52,680 children. Children with cell phone exposure had higher odds of migraines and headache-related symptoms than children with no exposure. The odds ratio for migraines was 1.30 (95% confidence interval: 1.01-1.68) and for headache-related symptoms was 1.32 (95% confidence interval: 1.23-1.40) for children with both prenatal and postnatal exposure.

CONCLUSIONS:
In this study, cell phone exposures were associated with headaches in children, but the associations may not be causal given the potential for uncontrolled confounding and misclassification in observational studies such as this. However, given the widespread use of cell phones, if a causal effect exists it would have great public health impact.

https://www.ncbi.nlm.nih.gov/pubmed/23750182

Reduction of Phosphorylated Synapsin I (Ser-553) Leads to Spatial Memory Impairment by Attenuating GABA Release after Microwave Exposure in Wistar Rats

Abstract

Background

Abnormal release of neurotransmitters after microwave exposure can cause learning and memory deficits. This study investigated the mechanism of this effect by exploring the potential role of phosphorylated synapsin I (p-Syn I).

Methods

Wistar rats, rat hippocampal synaptosomes, and differentiated (neuronal) PC12 cells were exposed to microwave radiation for 5 min at a mean power density of 30 mW/cm^2. Sham group rats, synaptosomes, and cells were otherwise identically treated and acted as controls for all of the following post-exposure analyses. Spatial learning and memory in rats was assessed using the Morris Water Maze (MWM) navigation task. The protein expression and presynaptic distribution of p-Syn I and neurotransmitter transporters were examined via western blotting and immunoelectron microscopy, respectively. Levels amino acid neurotransmitter release from rat hippocampal synaptosomes and PC12 cells were measured using high performance liquid chromatograph (HPLC) at 6 hours after exposure, with or without synapsin I silencing via shRNA transfection.

Results

In the rat experiments, there was a decrease in spatial memory performance after microwave exposure. The expression of p-Syn I (ser-553) was decreased at 3 days post-exposure and elevated at later time points. Vesicular GABA transporter (VGAT) was significantly elevated after exposure. The GABA release from synaptosomes was attenuated and p-Syn I (ser-553) and VGAT were both enriched in small clear synaptic vesicles, which abnormally assembled in the presynaptic terminal after exposure. In the PC12 cell experiments, the expression of p-Syn I (ser-553) and GABA release were both attenuated at 6 hours after exposure. Both microwave exposure and p-Syn I silencing reduced GABA release and maximal reduction was found for the combination of the two, indicating a synergetic effect.

Conclusion

p-Syn I (ser-553) was found to play a key role in the impaired GABA release and cognitive dysfunction that was induced by microwave exposure.

http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0095503

Purkinje cell number decreases in the adult female rat cerebellum following exposure to 900 MHz electromagnetic field

Abstract

The biological effects of electromagnetic field (EMF) exposure from mobile phones have growing concern among scientists since there are some reports showing increased risk for human health, especially in the use of mobile phones for a long duration. In the presented study, the effects on the number of Purkinje cells in the cerebellum of 16-week (16 weeks) old female rats were investigated following exposure to 900 MHz EMF. Three groups of rats, a control group (CG), sham exposed group (SG) and an electromagnetic field exposed group (EMFG) were used in this study. While EMFG group rats were exposed to 900 MHz EMF (1h/day for 28 days) in an exposure tube, SG was placed in the exposure tube but not exposed to EMF (1h/day for 28 days). The specific energy absorption rate (SAR) varied between 0.016 (whole body) and 2 W/kg (locally in the head). The CG was not placed into the exposure tube nor was it exposed to EMF during the study period. At the end of the experiment, all of the female rats were sacrificed and the number of Purkinje cells was estimated using a stereological counting technique. Histopathological evaluations were also done on sections of the cerebellum. Results showed that the total number of Purkinje cells in the cerebellum of the EMFG was significantly lower than those of CG ($p<0.004$) and SG ($p<0.002$). In addition, there was no significant difference at the 0.05 level between the rats' body and brain weights in the EMFG and CG or SG. Therefore, it is suggested that long duration exposure to 900 MHz EMF leads to decreases of Purkinje cell numbers in the female rat cerebellum.

https://www.ncbi.nlm.nih.gov/pubmed/20691167

The 2100MHz radiofrequency radiation of a 3G-mobile phone and the DNA oxidative damage in brain

Abstract

We aimed to evaluate the effect of 2100MHz radiofrequency radiation emitted by a generator, simulating a 3G-mobile phone on the brain of rats during 10 and 40 days of exposure. The female rats were randomly divided into four groups. Group I; exposed to 3G modulated 2100MHz RFR signal for 6h/day, 5 consecutive days/wk for 2 weeks, group II; control 10 days, were kept in an inactive exposure set-up for 6h/day, 5 consecutive days/wk for 2 weeks, group III; exposed to 3G modulated 2100MHz RFR signal for 6h/day, 5 consecutive days/wk for 8 weeks and group IV; control 40 days, were kept in an inactive exposure set-up for 6h/day, 5 consecutive days/wk for 8 weeks. After the genomic DNA content of brain was extracted, oxidative DNA damage (8-hydroxy-2'deoxyguanosine, pg/mL) and malondialdehyde (MDA, nmoL/g tissue) levels were determined. Our main finding was the increased oxidative DNA damage to brain after 10 days of exposure with the decreased oxidative DNA damage following 40 days of exposure compared to their control groups. Besides decreased lipid peroxidation end product, MDA, was observed after 40 days of exposure. The measured decreased quantities of damage during the 40 days of exposure could be the means of adapted and increased DNA repair mechanisms.

https://www.ncbi.nlm.nih.gov/pubmed/26775761

Association between number of cell phone contracts and brain tumor incidence in nineteen U.S. States

Abstract

Some concern has arisen about adverse health effects of cell phones, especially the possibility that the low power microwave-frequency signal transmitted by the antennas on handsets might cause brain tumors or accelerate the growth of subclinical tumors. We analyzed data from the Statistical Report: Primary Brain Tumors in the United States, 2000–2004 and 2007 cell phone subscription data from the Governing State and Local Sourcebook. There was a significant correlation between number of cell phone subscriptions and brain tumors in nineteen US states ($r = 0.950$, $P < 0.001$). Because increased numbers of both cell phone subscriptions and brain tumors could be due solely to the fact that some states, such as New York, have much larger populations than other states, such as North Dakota, multiple linear regression was performed with number of brain tumors as the dependent variable, cell phone subscriptions, population, mean family income and mean age as independent variables. The effect of cell phone subscriptions was significant ($P = 0.017$), and independent of the effect of mean family income ($P = 0.894$), population ($P = 0.003$) and age (0.499). The very linear relationship between cell phone usage and brain tumor incidence is disturbing and certainly needs further epidemiological evaluation. In the meantime, it would be prudent to limit exposure to all sources of electro-magnetic radiation.

https://link.springer.com/article/10.1007/s11060-010-0280-z

Effects of mobile phone radiation (900 MHz radiofrequency) on structure and functions of rat brain

Abstract

OBJECTIVES:
The goals of this study were: (1) to obtain basic information about the effects of long-term use of mobile phones on cytological makeup of the hippocampus in rat brains (2) to evaluate the effects on antioxidant status, and (3) to evaluate the effects on cognitive behavior particularly on learning and memory.

METHODS:
Rats (age 30 days, 120 ± 5 g) were exposed to 900 MHz radio waves by means of a mobile hand set for 4 hours per day for 15 days. Effects on anxiety, spatial learning, and memory were studied using the open field test, the elevated plus maze, the Morris water maze (MWM), and the classic maze test. Effects on brain antioxidant status were also studied. Cresyl violet staining was done to assess the neuronal damage.

RESULT:
A significant change in behavior, i.e., more anxiety and poor learning was shown by test animals as compared to controls and sham group. A significant change in the level of antioxidant enzymes and non-enzymatic antioxidants, and an increase in lipid peroxidation were observed in the test rats. Histological examination showed neurodegenerative cells in hippocampal sub regions and the cerebral cortex.

DISCUSSION:
Thus our findings indicate extensive neurodegeneration on exposure to radio waves. Increased production of reactive oxygen species due to exhaustion of enzymatic and non-enzymatic antioxidants and increased lipid peroxidation indicate extensive neurodegeneration in selective areas of CA1, CA3, DG, and the cerebral cortex. This extensive neuronal damage results in alterations in behavior related to memory and learning.

https://www.ncbi.nlm.nih.gov/pubmed/24861496

A Challenging Issue in the Etiology of Speech Problems: The Effect of Maternal Exposure to Electromagnetic Fields on Speech Problems in the Offspring

Abstract

Background

Nowadays, mothers are continuously exposed to different sources of electromagnetic fields before and even during pregnancy. It has recently been shown that exposure to mobile phone radiation during pregnancy may lead to adverse effects on the brain development in offspring and cause hyperactivity. Researchers have shown that behavioral problems in laboratory animals which have a similar appearance to ADHD are caused by intrauterine exposure to mobile phones.

Objective

The purpose of this study was to investigate whether the maternal exposure to different sources of electromagnetic fields affect on the rate and severity of speech problems in their offspring.

Methods

In this study, mothers of 35 healthy 3-5 year old children (control group) and 77 children and diagnosed with speech problems who had been referred to a speech treatment center in Shiraz, Iran were interviewed. These mothers were asked whether they had exposure to different sources of electromagnetic fields such as mobile phones, mobile base stations, Wi-Fi, cordless phones, laptops and power lines.

Results

We found a significant association between either the call time (P=0.002) or history of mobile phone use (months used) and speech problems in the offspring (P=0.003). However, other exposures had no effect on the occurrence of speech problems. To the best of our knowledge, this is the first study to investigate a possible association between maternal exposure to electromagnetic field and speech problems in the offspring. Although a major limitation in our study is the relatively small sample size, this study indicates that the maternal exposure to common sources of electromagnetic fields such as mobile phones can affect the occurrence of speech problems in the offspring.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4576876/

Effects of Cell Phone Radiofrequency Signal Exposure on Brain Glucose Metabolism

Abstract

Context

The dramatic increase in use of cellular telephones has generated concern about possible negative effects of radiofrequency signals delivered to the brain. However, whether acute cell phone exposure affects the human brain is unclear.

Objective

To evaluate if acute cell phone exposure affects brain glucose metabolism, a marker of brain activity.

Design, Setting, and Participants

Randomized crossover study conducted between January 1 and December 31, 2009, at a single US laboratory among 47 healthy participants recruited from the community. Cell phones were placed on the left and right ears and positron emission tomography with (18F)fluorodeoxyglucose injection was used to measure brain glucose metabolism twice, once with the right cell phone activated (sound muted) for 50 minutes ("on" condition) and once with both cell phones deactivated ("off" condition). Statistical parametric mapping was used to compare metabolism between on and off conditions using paired t tests, and Pearson linear correlations were used to verify the association of metabolism and estimated amplitude of radiofrequency-modulated electromagnetic waves emitted by the cell phone. Clusters with at least 1000 voxels (volume >8 cm3) and $P < .05$ (corrected for multiple comparisons) were considered significant.

Main Outcome Measure

Brain glucose metabolism computed as absolute metabolism (µmol/100 g per minute) and as normalized metabolism (region/whole brain).

Results

Whole-brain metabolism did not differ between on and off conditions. In contrast, metabolism in the region closest to the antenna (orbitofrontal cortex and temporal pole) was significantly higher for on than off conditions (35.7 vs 33.3 µmol/100 g per minute; mean difference, 2.4 [95% confidence interval, 0.67–4.2]; $P = .004$). The increases were significantly correlated with the estimated electromagnetic field amplitudes both for absolute metabolism ($R = 0.95$, $P < .001$) and normalized metabolism ($R = 0.89$; $P < .001$).

Conclusions

In healthy participants and compared with no exposure, 50-minute cell phone exposure was associated with increased brain glucose metabolism in the region closest to the antenna. This finding is of unknown clinical significance.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3184892/

900 MHz electromagnetic field exposure affects qualitative and quantitative features of hippocampal pyramidal cells in the adult female rat

Abstract

The effects of electromagnetic fields (EMFs) emitted by mobile phones on humans hold special interest due to their use in close proximity to the brain. The current study investigated the number of pyramidal cells in the cornu ammonis (CA) of the 16-week-old female rat hippocampus following postnatal exposure to a 900 megahertz (MHz) EMF. In this study were three groups of 6 rats: control (Cont), sham exposed (Sham), and EMF exposed (EMF). EMF group rats were exposed to 900 MHz EMF (1 h/day for 28 days) in an exposure tube. Sham group was placed in the exposure tube but not exposed to EMF (1 h/day for 28 days). Cont group was not placed into the exposure tube nor were they exposed to EMF during the study period. In EMF group rats, the specific energy absorption rate (SAR) varied between 0.016 (whole body) and 2 W/kg (locally in the head). All of the rats were sacrificed at the end of the experiment and the number of pyramidal cells in the CA was estimated using the optical fractionator technique. Histopathological evaluations were made on sections of the CA region of the hippocampus. Results showed that postnatal EMF exposure caused a significant decrease of the pyramidal cell number in the CA of the EMF group ($P<0.05$). Additionally, cell loss can be seen in the CA region of EMF group even at qualitative observation. These results may encourage researchers to evaluate the chronic effects of 900 MHz EMF on teenagers' brains.

https://www.ncbi.nlm.nih.gov/pubmed/19230827

Chronic prenatal exposure to the 900 megahertz electromagnetic field induces pyramidal cell loss in the hippocampus of newborn rats

Abstract

Widespread use of mobile phones which are a major source of electromagnetic fields might affect living organisms. However, there has been no investigation concerning prenatal exposure to electromagnetic fields or their roles in the development of the pyramidal cells of the cornu ammonis in postnatal life. Two groups of pregnant rats, a control group and an experimental group, that were exposed to an electromagnetic field were used. For obtaining electromagnetic field offspring, the pregnant rats were exposed to 900 megahertz electromagnetic fields during the 1-19th gestation days. There were no actions performed on the control group during the same period. The offspring rats were spontaneously delivered--control group (n = 6) and electromagnetic field group (n = 6). Offspring were sacrificed for stereological analyses at the end of the 4th week. Pyramidal cell number in rat cornu ammonis was estimated using the optical fractionator technique. It was found that 900 megahertz of electromagnetic field significantly reduced the total pyramidal cell number in the cornu ammonis of the electromagnetic field group ($P < 0.001$). Therefore, although its exact mechanism is not clear, it is suggested that pyramidal cell loss in the cornu ammonis could be due to the 900 megahertz electromagnetic field exposure in the prenatal period.

https://www.ncbi.nlm.nih.gov/pubmed/19671630

Mobile Phone Use, Blood Lead Levels, and Attention Deficit Hyperactivity Symptoms in Children: A Longitudinal Study

Abstract

Background

Concerns have developed for the possible negative health effects of radiofrequency electromagnetic field (RF-EMF) exposure to children's brains. The purpose of this longitudinal study was to investigate the association between mobile phone use and symptoms of Attention Deficit Hyperactivity Disorder (ADHD) considering the modifying effect of lead exposure.

Methods

A total of 2,422 children at 27 elementary schools in 10 Korean cities were examined and followed up 2 years later. Parents or guardians were administered a questionnaire including the Korean version of the ADHD rating scale and questions about mobile phone use, as well as socio-demographic factors. The ADHD symptom risk for mobile phone use was estimated at two time points using logistic regression and combined over 2 years using the generalized estimating equation model with repeatedly measured variables of mobile phone use, blood lead, and ADHD symptoms, adjusted for covariates.

Results

The ADHD symptom risk associated with mobile phone use for voice calls but the association was limited to children exposed to relatively high lead.

Conclusions

The results suggest that simultaneous exposure to lead and RF from mobile phone use was associated with increased ADHD symptom risk, although possible reverse causality could not be ruled out.

http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0059742

Effect of low level microwave radiation exposure on cognitive function and oxidative stress in rats

Abstract

Use of wireless communicating devices is increasing at an exponential rate in present time and is raising serious concerns about possible adverse effects of microwave (MW) radiation emitted from these devices on human health. The present study aimed to evaluate the effects of 900 MHz MW radiation exposure on cognitive function and oxidative stress in blood of Fischer rats. Animals were divided into two groups (6 animals/group): Group I (MW-exposed) and Group II (Sham-exposed). Animals were subjected to MW exposure (Frequency 900 MHz; specific absorption rate 8.4738 x 10(-5) W/kg) in Gigahertz transverse electromagnetic cell (GTEM) for 30 days (2 h/day, 5 days/week). Subsequently, cognitive function and oxidative stress parameters were examined for each group. Results showed significant impairment in cognitive function and increase in oxidative stress, as evidenced by the increase in levels of MDA (a marker of lipid peroxidation) and protein carbonyl (a marker of protein oxidation) and unaltered GSH content in blood. Thus, the study demonstrated that low level MW radiation had significant effect on cognitive function and was also capable of leading to oxidative stress.

https://www.ncbi.nlm.nih.gov/pubmed/23720885

Cognitive impairment and neurogenotoxic effects in rats exposed to low-intensity microwave radiation

Abstract

The health hazard of microwave radiation (MWR) has become a recent subject of interest as a result of the enormous increase in mobile phone usage. The present study aimed to investigate the effects of chronic low-intensity microwave exposure on cognitive function, heat shock protein 70 (HSP70), and DNA damage in rat brain. Experiments were performed on male Fischer rats exposed to MWR for 180 days at 3 different frequencies, namely, 900, 1800 MHz, and 2450 MHz. Animals were divided into 4 groups: group I: sham exposed; group II: exposed to MWR at 900 MHz, specific absorption rate (SAR) 5.953 × 10(-4) W/kg; group III: exposed to 1800 MHz, SAR 5.835 × 10(-4) W/kg; and group IV: exposed to 2450 MHz, SAR 6.672 × 10(-4) W/kg. All the rats were tested for cognitive function at the end of the exposure period and were subsequently sacrificed to collect brain. Level of HSP70 was estimated by enzyme-linked immunotarget assay and DNA damage was assessed using alkaline comet assay in all the groups. The results showed declined cognitive function, elevated HSP70 level, and DNA damage in the brain of microwave-exposed animals. The results indicated that, chronic low-intensity microwave exposure in the frequency range of 900 to 2450 MHz may cause hazardous effects on the brain.

https://www.ncbi.nlm.nih.gov/pubmed/25749756

Maternal mobile phone exposure alters intrinsic electrophysiological properties of CA1 pyramidal neurons in rat offspring

Abstract

Some studies have shown that exposure to electromagnetic field (EMF) may result in structural damage to neurons. In this study, we have elucidated the alteration in the hippocampal function of offspring Wistar rats (n = 8 rats in each group) that were chronically exposed to mobile phones during their gestational period by applying behavioral, histological, and electrophysiological tests. Rats in the EMF group were exposed to 900 MHz pulsed-EMF irradiation for 6 h/day. Whole cell recordings in hippocampal pyramidal cells in the mobile phone groups did show a decrease in neuronal excitability. Mobile phone exposure was mostly associated with a decrease in the number of action potentials fired in spontaneous activity and in response to current injection in both male and female groups. There was an increase in the amplitude of the afterhyperpolarization (AHP) in mobile phone rats compared with the control. The results of the passive avoidance and Morris water maze assessment of learning and memory performance showed that phone exposure significantly altered learning acquisition and memory retention in male and female rats compared with the control rats. Light microscopy study of brain sections of the control and mobile phone-exposed rats showed normal morphology.Our results suggest that exposure to mobile phones adversely affects the cognitive performance of both female and male offspring rats using behavioral and electrophysiological techniques.

https://www.ncbi.nlm.nih.gov/pubmed/24604340

Neurodegenerative changes and apoptosis induced by intrauterine and extrauterine exposure of radiofrequency radiation

Abstract

Adverse health effects of radiofrequency radiation (RFR) on the ongoing developmental stages of children from conception to childhood are scientifically anticipated subject. This study was performed to identify the effects of global system for mobile communications (GSM) modulated mobile phone like RFR in 1800MHz frequency on oxidative DNA damage and lipid peroxidation beside the apoptotic cell formation, using histopathological and immunohistochemical methods in the brain tissue of 1-month-old male and female New Zealand White rabbits that were exposed to these fields at their mother's womb and after the birth. Oxidative DNA damage and lipid peroxidation levels were investigated by measuring the 8-hydroxy-2'-deoxyguanosine (8-OHdG) and malondialdehyde (MDA) levels, respectively. Histopathological changes were observed using by hematoxylin and eosin (HE) staining. Apoptotic cells were detected in the examined organs by terminal deoxynucleotidyl transferase-mediated dUTP nick end-labeling (TUNEL) staining. For both male and female infants; 8-OHdG levels increased in the group exposed to RFR in both intrauterine and extrauterine periods compared to the infants that were never exposed to RFR and the ones were exposed when they reached one month of age ($p<0.05$). MDA results were different for male and female rabbits. There was no difference between all female infant groups ($p>0.05$), while only intrauterine exposure significantly causes MDA level increase for the male infants. HE staining revealed mild lessions in neuronal necrobiosis in brain tissues of female rabbits that had only intaruterine exposure and male rabbits had only extrauterine exposure. Gliosis were mildly positive in brain tissues of rabbits that are exposed only intrauterine period, also the group exposed both intrauterine and extrauterine periods. However, there was no apoptotic change detected by TUNEL staining in the brain tissues of all groups.

https://www.ncbi.nlm.nih.gov/pubmed/26520616

Effects of radiofrequency radiation exposure on blood-brain barrier permeability in male and female rats

Abstract

During the last several decades, numerous studies have been performed aiming at the question of whether or not exposure to radiofrequency radiation (RFR) influences the permeability of the blood-brain barrier (BBB). The objective of this study was to investigate the effect of RFR on the permeability of BBB in male and female Wistar albino rats. Right brain, left brain, cerebellum, and total brain were analyzed separately in the study. Rats were exposed to 0.9 and 1.8 GHz continuous-wave (CW) RFR for 20 min (at SARs of 4.26 mW/kg and 1.46 mW/kg, respectively) while under anesthesia. Control rats were sham-exposed. Disruption of BBB integrity was detected spectrophotometrically using the Evans-blue dye, which has been used as a BBB tracer and is known to be bound to serum albumin. Right brain, left brain, cerebellum, and total brain were evaluated for BBB permeability. In female rats, no albumin extravasation was found in in the brain after RFR exposure. A significant increase in albumin was found in the brains of the RF-exposed male rats when compared to sham-exposed male brains. These results suggest that exposure to 0.9 and 1.8 GHz CW RFR at levels below the international limits can affect the vascular permeability in the brain of male rats. The possible risk of RFR exposure in humans is a major concern for the society. Thus, this topic should be investigated more thoroughly in the future.

https://www.ncbi.nlm.nih.gov/pubmed/22047463

Effects of prenatal exposure to a 900 MHz electromagnetic field on the dentate gyrus of rats: a stereological and histopathological study

Abstract

Electromagnetic fields (EMFs) inhibit the formation and differentiation of neural stem cells during embryonic development. In this study, the effects of prenatal exposure to EMF on the number of granule cells in the dentate gyrus of 4-week-old rats were investigated. This experiment used a control (Cont) group and an EMF exposed (EMF) group (three pregnant rats each group). The EMF group consisted of six offspring (n=6) of pregnant rats that were exposed to an EMF of up to 900 megahertz (MHz) for 60 min/day between the first and last days of gestation. The control group consisted of five offspring (n=5) of pregnant rats that were not treated at all. The offspring were sacrificed when they were 4 weeks old. The numbers of granule cells in the dentate gyrus were analyzed using the optical fractionator technique. The results showed that prenatal EMF exposure caused a decrease in the number of granule cells in the dentate gyrus of the rats ($P<0.01$). This suggests that prenatal exposure to a 900 MHz EMF affects the development of the dentate gyrus granule cells in the rat hippocampus. Cell loss might be caused by an inhibition of granule cell neurogenesis in the dentate gyrus.

https://www.ncbi.nlm.nih.gov/pubmed/18761003

Effects of prenatal and postnatal exposure to GSM-like radiofrequency on blood chemistry and oxidative stress in infant rabbits, an experimental study

Abstract

We aimed to investigate the potential hazardous effects of prenatal and/or postnatal exposure to 1800 MHz GSM-like radiofrequency radiation (RFR) on the blood chemistry and lipid peroxidation levels of infant rabbits. A total of 72 New Zealand female and male white rabbits aged 1-month were used. Thirty-six female and 36 male were divided into four groups which were composed of nine infants: (i) Group 1 were the sham exposure (control), (ii) Group 2 were exposed to RFR, 15 min daily for 7 days in the prenatal period (between 15th and 22nd days of the gestational period) (prenatal exposure group). (iii) Group 3 were exposed to RFR 15 min/day (14 days for male, whereas 7 days for female) after they reached 1-month of age (postnatal exposure group). (iv) Group 4 were exposed to RFR for 15 min daily during 7 days in the prenatal period (between 15th and 22nd days of the gestational period) and 15 min/day (14 days for male, whereas 7 days for female) after they reached 1-month of age (prenatal and postnatal exposure group). Results showed that serum lipid peroxidation level in both female and male rabbits changed due to the RFR exposure. However, different parameters of the blood biochemistry were affected by exposure in male and female infants. Consequently, the whole-body 1800 MHz GSM-like RFR exposure may lead to oxidative stress and changes on some blood chemistry parameters. Studies on RFR exposure during prenatal and postnatal periods will help to establish international standards for the protection of pregnants and newborns from environmental RFR.

https://www.ncbi.nlm.nih.gov/pubmed/23526187

Mobile phone use and risk for intracranial tumors and salivary gland tumors - A meta-analysis

Abstract

Results of epidemiological studies on the association between use of mobile phone and brain cancer are ambiguous, as well as the results of 5 meta-analysis studies published to date. Since the last meta-analysis (2009), new case-control studies have been published, which theoretically could affect the conclusions on this relationship. Therefore, we decided to perform a new meta-analysis. We conducted a systematic review of multiple electronic data bases for relevant publications. The inclusion criteria were: original papers, case-control studies, published till the end of March 2014, measures of association (point estimates as odds ratio and confidence interval of the effect measured), data on individual exposure. Twenty four studies (26 846 cases, 50 013 controls) were included into the meta-analysis. A significantly higher risk of an intracranial tumor (all types) was noted for the period of mobile phone use over 10 years (odds ratio (OR) = 1.324, 95% confidence interval (CI): 1.028-1.704), and for the ipsilateral location (OR = 1.249, 95% CI: 1.022-1.526). The results support the hypothesis that long-term use of mobile phone increases risk of intracranial tumors, especially in the case of ipsilateral exposure. Further studies are needed to confirm this relationship. Int J Occup Med Environ Health 2017;30(1)27-43.

https://www.ncbi.nlm.nih.gov/pubmed/28220905

Cell phone use and behavioral problems in young children

Abstract

BACKGROUND:
Potential health effects of cell phone use in children have not been adequately examined. As children are using cell phones at earlier ages, research among this group has been identified as the highest priority by both national and international organizations. The authors previously reported results from the Danish National Birth Cohort (DNBC), which looked at prenatal and postnatal exposure to cell phone use and behavioral problems at age 7 years. Exposure to cell phones prenatally, and to a lesser degree postnatally, was associated with more behavioral difficulties. The original analysis included nearly 13 000 children who reached age 7 years by November 2006.

METHODS:
To see if a larger, separate group of DNBC children would produce similar results after considering additional confounders, children of mothers who might better represent current users of cell phones were analyzed. This 'new' dataset consisted of 28 745 children with completed Age-7 Questionnaires to December 2008.

RESULTS:
The highest OR for behavioral problems were for children who had both prenatal and postnatal exposure to cell phones compared with children not exposed during either time period. The adjusted effect estimate was 1.5 (95% CI 1.4 to 1.7).

CONCLUSIONS:
The findings of the previous publication were replicated in this separate group of participants demonstrating that cell phone use was associated with behavioral problems at age 7 years in children, and this association was not limited to early users of the technology. Although weaker in the new dataset, even with further control for an extended set of potential confounders, the associations remained.

https://www.ncbi.nlm.nih.gov/pubmed/21138897

Prenatal and postnatal exposure to cell phone use and behavioral problems in children

Abstract

BACKGROUND:
The World Health Organization has emphasized the need for research into the possible effects of radiofrequency fields in children. We examined the association between prenatal and postnatal exposure to cell phones and behavioral problems in young children.

METHODS:
Mothers were recruited to the Danish National Birth Cohort early in pregnancy. When the children of those pregnancies reached 7 years of age in 2005 and 2006, mothers were asked to complete a questionnaire regarding the current health and behavioral status of children, as well as past exposure to cell phone use. Mothers evaluated the child's behavior problems using the Strength and Difficulties Questionnaire.

RESULTS:
Mothers of 13,159 children completed the follow-up questionnaire reporting their use of cell phones during pregnancy as well as current cell phone use by the child. Greater odds ratios for behavioral problems were observed for children who had possible prenatal or postnatal exposure to cell phone use. After adjustment for potential confounders, the odds ratio for a higher overall behavioral problems score was 1.80 (95% confidence interval = 1.45-2.23) in children with both prenatal and postnatal exposure to cell phones.

CONCLUSIONS:
Exposure to cell phones prenatally-and, to a lesser degree, postnatally-was associated with behavioral difficulties such as emotional and hyperactivity problems around the age of school entry. These associations may be noncausal and may be due to unmeasured confounding. If real, they would be of public health concern given the widespread use of this technology.

https://www.ncbi.nlm.nih.gov/pubmed/18467962

The influence of microwave radiation from cellular phone on fetal rat brain

Abstract

The increasing use of cellular phones in our society has brought focus on the potential detrimental effects to human health by microwave radiation. The aim of our study was to evaluate the intensity of oxidative stress and the level of neurotransmitters in the brains of fetal rats chronically exposed to cellular phones. The experiment was performed on pregnant rats exposed to different intensities of microwave radiation from cellular phones. Thirty-two pregnant rats were randomly divided into four groups: CG, GL, GM, and GH. CG accepted no microwave radiation, GL group radiated 10 min each time, GM group radiated 30 min, and GH group radiated 60 min. The 3 experimental groups were radiated 3 times a day from the first pregnant day for consecutively 20 days, and on the 21st day, the fetal rats were taken and then the contents of superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), malondialdehyde (MDA), noradrenaline (NE), dopamine (DA), and 5-hydroxyindole acetic acid (5-HT) in the brain were assayed. Compared with CG, there were significant differences ($P<0.05$) found in the contents of SOD, GSH-Px, and MDA in GM and GH; the contents of SOD and GSH-Px decreased and the content of MDA increased. The significant content differences of NE and DA were found in fetal rat brains in GL and GH groups, with the GL group increased and the GH group decreased. Through this study, we concluded that receiving a certain period of microwave radiation from cellular phones during pregnancy has certain harm on fetal rat brains.

https://www.ncbi.nlm.nih.gov/pubmed/22268709

Possible cause for altered spatial cognition of prepubescent rats exposed to chronic radiofrequency electromagnetic radiation

Abstract

The effects of chronic and repeated radiofrequency electromagnetic radiation (RFEMR) exposure on spatial cognition and hippocampal architecture were investigated in prepubescent rats. Four weeks old male Wistar rats were exposed to RF-EMR (900 MHz; SAR-1.15 W/kg with peak power density of 146.60 µW/cm(2)) for 1 h/day, for 28 days. Followed by this, spatial cognition was evaluated by Morris water maze test. To evaluate the hippocampal morphology; H&E staining, cresyl violet staining, and Golgi-Cox staining were performed on hippocampal sections. CA3 pyramidal neuron morphology and surviving neuron count (in CA3 region) were studied using H&E and cresyl violet stained sections. Dendritic arborization pattern of CA3 pyramidal neuron was investigated by concentric circle method. Progressive learning abilities were found to be decreased in RF-EMR exposed rats. Memory retention test performed 24 h after the last training revealed minor spatial memory deficit in RF-EMR exposed group. However, RF-EMR exposed rats exhibited poor spatial memory retention when tested 48 h after the final trial. Hirano bodies and Granulovacuolar bodies were absent in the CA3 pyramidal neurons of different groups studied. Nevertheless, RF-EMR exposure affected the viable cell count in dorsal hippocampal CA3 region. RF-EMR exposure influenced dendritic arborization pattern of both apical and basal dendritic trees in RF-EMR exposed rats. Structural changes found in the hippocampus of RF-EMR exposed rats could be one of the possible reasons for altered cognition.

https://www.ncbi.nlm.nih.gov/pubmed/26033310

Maternal exposure to a continuous 900-MHz electromagnetic field provokes neuronal loss and pathological changes in cerebellum of 32-day-old female rat offspring

Abstract

Large numbers of people are unknowingly exposed to electromagnetic fields (EMF) from wireless devices. Evidence exists for altered cerebellar development in association with prenatal exposure to EMF. However, insufficient information is still available regarding the effects of exposure to 900 megahertz (MHz) EMF during the prenatal period on subsequent postnatal cerebellar development. This study was planned to investigate the 32-day-old female rat pup cerebellum following exposure to 900MHz EMF during the prenatal period using stereological and histopathological evaluation methods. Pregnant rats were divided into control, sham and EMF groups. Pregnant EMF group (PEMFG) rats were exposed to 900MHz EMF for 1h inside an EMF cage during days 13-21 of pregnancy. Pregnant sham group (PSG) rats were also placed inside the EMF cage during days 13-21 of pregnancy for 1h, but were not exposed to any EMF. No procedure was performed on the pregnant control group (PCG) rats. Newborn control group (CG) rats were obtained from the PCG mothers, newborn sham group (SG) rats from the PSG and newborn EMF group (EMFG) rats from the PEMFG rats. The cerebellums of the newborn female rats were extracted on postnatal day 32. The number of Purkinje cells was estimated stereologically, and histopathological evaluations were also performed on cerebellar sections. Total Purkinje cell numbers calculated using stereological analysis were significantly lower in EMFG compared to CG ($p<0.05$) and SG ($p<0.05$). Additionally, some pathological changes such as pyknotic neurons with dark cytoplasm were observed in EMFG sections under light microscopy. In conclusion, our study results show that prenatal exposure to EMF affects the development of Purkinje cells in the female rat cerebellum and that the consequences of this pathological effect persist after the postnatal period.

https://www.ncbi.nlm.nih.gov/pubmed/26391347

Microwave radiation induced oxidative stress, cognitive impairment and inflammation in brain of Fischer rats

Abstract

Public concerns over possible adverse effects of microwave radiation emitted by mobile phones on health are increasing. To evaluate the intensity of oxidative stress, cognitive impairment and inflammation in brain of Fischer rats exposed to microwave radiation, male Fischer-344 rats were exposed to 900 MHz microwave radiation (SAR = 5.953 x 10(-4) W/kg) and 1800 MHz microwave radiation (SAR = 5.835 x 10(-4) W/kg) for 30 days (2 h/day). Significant impairment in cognitive function and induction of oxidative stress in brain tissues of microwave exposed rats were observed in comparison with sham exposed groups. Further, significant increase in level of cytokines (IL-6 and TNF-alpha) was also observed following microwave exposure. Results of the present study indicated that increased oxidative stress due to microwave exposure may contribute to cognitive impairment and inflammation in brain.

https://www.ncbi.nlm.nih.gov/pubmed/23986973

Wi-Fi

Wi-Fi Radiation: An Invisible Threat to Your Health?

We have long been told that the form of radio frequency radiation that Wi-Fi devices utilize is non-ionizing. That is to say it doesn't have sufficient energy to break the bonds that hold molecules together, and that there is no heating effect… so therefore it is harmless. Or at least that's what we're told.

But thousands of peer reviewed studies now tell a different story. Wi-Fi radiation may not cause a thermal heating effect, and it might be non-ionizing – but it is far from harmless.

Independent research dating back some 80 years links Wi-Fi radiation to a long list of adverse biological effects, including:

- DNA chain breaks
- Increased blood-brain-barrier permeability
- Disruption to brain glucose metabolism
- Creation of stress proteins
- Disruption of cell metabolism

Studies also associate Wi-Fi radiation exposure with such symptoms as fatigue, irritability, headaches, and digestive disorders. Long-term exposure to Wi-Fi radiation has been linked with many serious diseases – including cancer.

Numerous studies link Wi-Fi radiation exposure with cancer. Notably, the German telecommunications company T-Mobile carried out a major independent study. It found that *"on the cellular level, a multitude of studies found the type of damage from high frequency electromagnetic fields which is important for cancer initiation and cancer promotion."*

In 2011, the World Health Organization classified radio frequency radiation of the type used by Wi-Fi devices as a Group 2B possible carcinogen. A study conducted by the University of Vienna have found Wi-Fi exposures to cause genotoxicity as they break single and double strand DNAs in our body. This indicates that there are effects that may potentially surface with our future generations.

Safety standards do exist for radio frequency radiation emissions, but these standards are only based on thermal heating effects. That is to say they only consider these exposures to be harmful if they heat tissue. But these safety standards do not protect us from adverse biological effects which are thought to be the precursor to serious diseases. Scientists have already raised the alarm regarding this issue.

In 2015, scientists from around the world united for the *International EMF Scientist Appeal* based on the results of over 2,000 research papers. The appeal is the collective voice of 190 scientists from 39 different countries. They are calling for tighter regulations and more security measures when dealing with electromagnetic field exposures generally, and Wi-Fi in particular.

Last year, 15-year-old English schoolgirl Jenny Fry was found hanged in woodland near her home. According to her parents she suffered from electrical sensitivity, making it impossible for her to sit in Wi-Fi classrooms and have Wi-Fi at home. The school refused to remove the Wi-Fi. Speaking at the inquest her mother said, "I believe that Wi-Fi killed my daughter."

https://thetruthaboutcancer.com/Wi-Fi-radiation/

10 Shocking Facts about the Health Dangers of Wi-Fi

Wi-Fi is convenient but many have raised doubts concerning the safety of unseen forces that permeate everything around us. Since the introduction of Wi-Fi in 1997, researchers have performed dozens of studies to explore the subject. The results are clear and shocking — Wi-Fi can negatively affect overall health and brain health, especially in children.

Perhaps most shocking is that this information is not new or even that controversial. In fact, in 2008 the well-renowned publication Scientific American ran a piece called "Mind Control by Cell Phone" which explained the danger Wi-Fi has on the human brain. [1] Let's further explore the potential dangers of Wi-Fi with these 10 facts.

1. **Contributes to the development of insomnia**
   Have you ever felt more awake after using Wi-Fi or even struggled to sleep through the night? Reports of these phenomena have been frequent and even prompted a study in 2007 that evaluated low-frequency modulation from cell phones and its impact on sleep. Participants were exposed to the electromagnetic signals from real phones or no signal from fake phones. Those exposed to the electromagnetic radiation had a significantly more difficult time falling asleep and changes in brainwave patterns were observed. [2]

   It's been suggested that sleeping near a phone, in a home with Wi-Fi, or in an apartment building with many Wi-Fi signals can create chronic sleep problems as the constant bombardment of Wi-Fi pollution interferes with falling asleep and sleep patterns. For many, sleep deprivation is just the start for larger problems. The development of depression and hypertension have also been linked to inadequate sleep. [3]
2. **Damaging to Childhood Development**
   Exposure to non-thermal radio frequency radiation from Wi-Fi and cellular phones can disrupt normal cellular development, especially fetal development. A 2004 animal study linked exposure to delayed kidney development. [4] These findings were supported by a 2009 Austrian study. In fact, the disruption of protein synthesis is so severe that authors specifically noted, "This cell property is especially pronounced in growing tissues, that is, in children and youth. Consequently, these population groups would be more susceptible than average to the described effects." [5] In short, bathing the developmentally young in Wi-Fi increases their risk of developmental issues.
3. **Affects Cell Growth**
   When a group of Danish ninth graders experienced difficulty concentrating after sleeping with their cell phones by their head, they performed an experiment to test the effect of wireless Wi-Fi routers on garden cress. One set of plants was grown in a room free of wireless radiation; the other group grew next to two routers that released the same amount of radiation as a cell phone. The results? The plants nearest the radiation didn't grow. [6]
4. **Derails Brain Function**
   Just as the Danish high schoolers noticed problems with concentration, scientists have begun to look at the impact of 4G radiation on brain function. Using MRI technology, research performed just last year found that persons exposed to 4G radiation had several areas of reduced brain activity. [7]
5. **Reduces Brain Activity in Females**

A group of 30 healthy volunteers, 15 men and 15 women, were given a simple memory test. First, the entire group was tested without any exposure to Wi-Fi radiation — no problem. Then, they were exposed to 2.4 GHz Wi-Fi from a wireless access point for about 45 minutes. During that portion of the testing, brain activity was measured and the women had a noticeable change in brain activity and energy levels. [8] Sorry ladies! But guys, don't get too comfortable…

6. **Neutralizes Sperm**
   …Because we've known for a long time that the heat generated by laptops kills sperm. Well, now it turns out that heat isn't the only threat to a man's virility. Research has found exposure to Wi-Fi frequencies reduce sperm movement and cause DNA fragmentation. [9] Both human and animal testing has confirmed that exposure negatively affects sperm. [10] [11]
7. **May Impact Fertility**
   And, it's not just sperm. The results of an animal study suggest that some wireless frequencies may prevent egg implantation. During the study, mice exposed 2 hours a day for 45 days had significantly increased oxidative stress levels. The cellular damage and impact on DNA structure from exposure suggest a strong possibility of abnormal pregnancy or failure of the egg to implant. [12]

   The Karolinska Institute in Sweden released a warning in 2011, stating:
   - "Pregnant women are cautioned to avoid using wireless devices themselves and distance themselves from other users,"
   - "Current US [and Canada]…standards for radio frequency and microwave radiation from wireless technology are entirely inadequate," and
   - "Safety standards also ignore the developing fetus…" [13]
8. **Provokes Cardiac Stress**
   If you think your heart races when surrounded by wireless networks or 3G or LTE cell phones, it may not be in your head. A study involving 69 subjects reported that many of them experienced a real physical response to electromagnetic frequencies. Exactly what was the physical response? Increased heart rate — similar to the heart rate of an individual under stress. [14]
9. **Linked to Cancer?**
   This is extremely controversial but we can't ignore that plenty of animal models indicate that exposure to electromagnetic radiation increases the risk of tumor development. While human studies are rare, reports and case studies abound. One such case involves a young 21-year-old woman who developed breast cancer. What makes this case unique was that her family did not have a predisposition to breast cancer… and she developed the tumor right on the spot she carried her cell phone in her bra. [15]

http://www.globalhealingcenter.com/natural-health/10-shocking-facts-health-dangers-Wi-Fi/

Can Wi-Fi Signals Stunt Plant Growth?

A Danish science experiment by a group of 9th-graders has gained worldwide interest and may have us rethinking the proliferation of wireless devices in our homes.

Five girls from Hjallerup Skole, a primary education school in Denmark, began the experiment after noticing that when they slept with their cellphones near their heads overnight, they had trouble focusing the next day, according to Danish News site DR.

The resources weren't available to conduct an experiment around wireless signals affecting brain activity, so instead the girls decided to monitor the growth of plants near Wi-Fi routers - and the results were a bit shocking.

Six trays containing the seeds of a garden cress herb were placed in a room without a Wi-Fi router, and six trays were placed in a different room and next to two Wi-Fi routers which, according to the girls' calculations, emitted about the same type of radiation as an ordinary cellphone, reports DR.

During the 12 days of the experiment, the seeds in the six trays away from the Wi-Fi routers grew normally, while the seeds next to the routers did not. In fact, the project photos show that many of the seeds placed near the routers turned brown and died.

"This has sparked quite a lively debate in Denmark regarding the potential adverse health-effects from mobile phones and Wi-Fi-equipment," Kim Horsevad, biology teacher at Hjallerup Skole told ABC News.

Horsevad said that some of the local debate over the experiment has been over whether the negative effects were due to the cress seeds drying from the heat emitted by the computer/Wi-Fi routers used in the experiment. But she explained that the students kept the cress seeds in both groups sufficiently moist during the whole experiment, and the temperatures were controlled thermostatically.

A similar study was conducted about three years ago in the Netherlands when researchers noticed that some trees in urban areas were showing "bark lumps," according to Popular Science. The experiment, conducted by Wageningen University, involved exposing 20 ash trees to various kinds of radiation for three months. The trees chosen to test tolerance to heavy Wi-Fi signals began to show typical signs of radiation sickness, including a "lead-like shine" on their leaves.

As for the attention the girl's science fair project is getting, Horsevad said neuroscience professor Olle Johanssen with the Karolinska Institute in Sweden has expressed great interest.

"[Johanssen] will probably be repeating the experiment in controlled, professional, scientific environments," said Horsevad. "One would therefore generally be advised to await the results of his experiments before basing any important decisions on the outcome of the girls' experiment."

http://abcnews.go.com/blogs/technology/2013/05/can-Wi-Fi-signals-stunt-plant-growth/

Oh my...what's in Wi-Fi?

Second grader patterns science fair project after Danish experiment

When the school district rolled out the Ipads this year, Aiden Fitchett noticed something new; as he did when seated near the wireless projector any time a teacher used one for a presentation: headaches. Bad ones. Bad enough that the 8-year-old second grader would come home crying from the pain.

His mom, biologist Rachel Fitchett, made a correlation between Aiden's headaches and the circumstances: wireless fidelity waves or Wi-Fi, which has been associated with causing physical effects in a small percentage of the population.

"I knew the health risks associated with Wi-Fi and asked the teacher to relocate him and the headaches stopped," Rachel says.

While that was great, the situation still puzzled Aiden's inquisitive mind. So when Science Fair time rolled around he knew exactly what he wanted to delve into.

"I want to know why I get headaches when I'm around wireless devices but not the wires," Aiden says. "We use a laptop at home, and we have a television set, and it's only around wireless that I get the headaches."

So Aiden set about to answer his question. Patterning his experiment after a Danish experiment by a group of 9th grade students, Aiden and his mom bought some garden cress seeds, growing trays and napkins and got to work.

Aiden placed an equal amount of garden cress seeds atop two napkins, which he placed inside two growing trays. Each was watered until damp. One tray was placed six inches from a wired laptop which was kept on the whole time.

The other tray was placed six inches from a Wi-Fi router in a neighbor's home which was turned on the whole time as well.

Both trays received sunlight from west windows, and both rooms were kept at 69 degrees. The trays were watered daily with the same amount of water.

After six days, the results—similar to those in the Danish experiment—were stunning.

"At first Aiden was excited as the seeds started to grow, but by the second to the last day one of his notations on the Wi-Fi sprouts was 'strange,'" Rachel says.

In the Danish experiment, the cress seeds placed near the Wi-Fi device did not sprout at all. While Aiden's Wi-Fi seeds sprouted, they did not look anything like the robust sprouts growing in the wired room.

The sprouts tasted different as well. Garden cress is a fast-growing herb with a peppery, tangy flavor and smell. The wired seeds tasted strong and peppery—so much so that Aiden had to run for a glass of water. The Wi-Fi seeds had little taste at all. In fact, Aiden said they tasted "like water."
Aiden's conclusion?

"The garden cress are living and growing just like me," he says. "The ones by the Wi-Fi were not healthy and looked crazy. Wireless devices must send things through the air that are not good for my body."

Aiden's mom tends to agree—although in more scientific terms.

"Results clearly showed reduced DNA repair capacity and cell proliferation , hence mimicking the growth of cancerous cells," she says. "The Garden Cress seeds exposed to wireless signals were in fact mutated and unhealthy."

Rachel believes when the wireless signals are intensified by use of multiple devices, so is the negative effect.

"The more that are together, the more concentrated the ill effects are," she says.

Aiden's headaches continued during computer class, so he has since been pulled.

"He's a very bright kid who excels in all subjects, Rachel says. "He doesn't need to get whatever it is they're getting in there."

http://www.tricitytimes-online.com/Articles-News-i-2014-04-02-218015.112113-Oh-mywhats-in-Wi-Fi.html

Checkout 5 Ways Your Wi-Fi Could be Causing You Harm

Wi-Fi is a technology that allows electronic devices to connect to a wireless LAN (WLAN) network, mainly using the 2.4 gigahertz (12 cm) UHF and 5 gigahertz (6 cm) SHF ISM radio bands. A WLAN is usually password protected, but may be open, which allows any device within its range to access the resources of the WLAN network.

The Wi-Fi Alliance defines Wi-Fi as any "wireless local area network" (WLAN) product based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards. However, the term "Wi-Fi" is used in general English as a synonym for "WLAN" since most modern WLANs are based on these standards. "Wi-Fi" is a trademark of the Wi-Fi Alliance. The "Wi-Fi Certified" trademark can only be used by Wi-Fi products that successfully complete Wi-Fi Alliance interoperability certification testing.

Devices which can use Wi-Fi technology include personal computers, video-game consoles, smartphones, digital cameras, tablet computers, digital audio players and modern printers. Wi-Fi compatible devices can connect to the Internet via a WLAN network and a wireless access point. Such an access point (or hotspot) has a range of about 20 meters (66 feet) indoors and a greater range outdoors. Hotspot coverage can be as small as a single room with walls that block radio waves, or as large as many square kilometers achieved by using multiple overlapping access points.

Depiction of a device sending information wirelessly to another device, both connected to the local network, in order to print a document.
Wi-Fi is less secure than wired connections, such as Ethernet, precisely because an intruder does not need a physical connection. Web pages that use TLS are secure, but unencrypted Internet access can easily be detected by intruders. Because of this, Wi-Fi has adopted various encryption technologies. The early encryption WEP proved easy to break. Higher quality protocols (WPA, WPA2) were added later. An optional feature added in 2007, called Wi-Fi Protected Setup (WPS), had a serious flaw that allowed an attacker to recover the router's password. The Wi-Fi Alliance has since updated its test plan and certification program to ensure all newly certified devices resist attacks.

Many are on edge because they can't imagine a world without the internet. But every good thing has it's bad side and it's better to educated yourself to be safe.
Insomnia

When exposed to electromagnetic radiation, you will have more difficulty falling asleep. So when you can't sleep maybe you should just turn off your phone.

Affects cell growth
Sleeping with your phone next to your head can affect your ability to concentrate.
Experiment: One set of plants was grown in a room free of wireless radiation; the other group grew next to two routers that released the same amount of radiation as a cell phone.
Result: The plants closest to the radiation didn't grow.

Reduces brain activity in females

Experiment: A group of 30 healthy volunteers, 15 men and 15 women, were given a simple memory test. First, the entire group was tested without any exposure to Wi-Fi radiation and the results were fine.

Then, they were exposed to 2.4 GHz Wi-Fi from a wireless access point for about 45 minutes.

Result: During that portion of the testing, brain activity was measured and the women had a noticeable change in brain activity and energy levels.

Effects on fertility

Results of experiments on animals show that some specific wireless frequencies can prevent egg implantation. According to the Global Healing Center, during the study, mice exposed 2 hours a day for 45 days had significantly increased oxidative stress levels.

Cardiac stress

Your heart reacts when surrounded by wireless networks including 3G and LTE phones. Your heart rate increases as if you are under stress. You may have not noticed this because you weren't aware of the dangers.

http://nigeriana.org/technology/checkout-5-ways-Wi-Fi-causing-harm/

Wi-Fi Radiation Is Killing Trees, New Study Finds

Studies on the impact of wireless radiation on humans are endlessly inconclusive, but a recent study on the effects of Wi-Fi radiation on trees--yes, trees--indicates that our woody friends may be much more vulnerable than we are. And trees can't even enjoy the benefits of Wi-Fi. It's all very unjust.

The study, conducted by Wageningen University, investigated findings that trees in areas with high Wi-Fi activity (urban areas, especially) were suffering from symptoms that couldn't be tied to typical bacterial or viral causes. The symptoms included bleeding (!), fissures in the bark, the death of parts of leaves, and abnormal growth.

To test the hypothesis that the mystery illness was caused by radiation poisoning, the researchers took 20 ash trees and exposed them to various kinds of radiation for three months. Sure enough, the ash trees exposed to Wi-Fi signals showed telltale signs of radiation sickness, including a "lead-like shine" on their leaves, indicating the oncoming death of those leaves. In the Netherlands, a whopping 70% of urban trees are suffering from radiation poisoning, up from only 10% five years ago--understandable, considering the explosion in Wi-Fi use in the past five years.

Of course, trees in rural or even simply non-urban environments are pretty much unaffected, but theoretically, all deciduous trees in the Western world could be affected.

The researchers are planning several more studies to figure out the precise effects of radiation on plant life. In the meantime, they don't really offer any preliminary solutions, but I'm sure they'd approve of wrapping every urban tree you see in tin foil, root to leaf. *(Note: Wrapping public trees in tin foil may be illegal in your city, state, arrondissement, or prefecture. PopSci cannot be held responsible if you are arrested for such activities.)*

http://www.popsci.com/technology/article/2010-11/wi-fi-radiation-killing-trees

Wi-Fi radiation from laptops, smartphones is damaging your sperm

The latest in a long line of radiation vs. sperm studies has shown, yet again, that you really ought to take your laptop off your lap. The report, published in the Fertility and Sterility journal by some Argentinian scientists, details how semen samples from 29 healthy, potent men suffered significant damage when placed underneath a Wi-Fi-connected laptop.

In a control test — with the sperm kept away from Wi-Fi emissions, but at the same under-laptop temperature — 14% of the sperm died within four hours, and 3% showed DNA damage. When placed underneath a laptop for four hours, 25% of the sperm died and 9% showed DNA damage. The important finding here is that Wi-Fi electromagnetic (EM) radiation damaged the sperm — almost every other study has focused on increased temperature (which also damages sperm, incidentally).

Before you go out and buy a lead jockstrap, though, bear in mind that this is ex vivo — the sperm were outside the testes — and the scientific study does not go as far as to say that that EM radiation actually affects your chance of getting a girl pregnant. Basically, it's entirely possible that the (thin) skin of your testicles is enough to stop Wi-Fi signals from cooking your little men — and furthermore, you constantly produce sperm throughout the day, so unless you preface every conception attempt by having a laptop on your lap for four hours, you should be OK (though I fear I probably just described the standard evening setup for most households…)

Perhaps more importantly, though, this study does show that very weak, low-frequency radiation does have an effect on sperm. We might know the extent of that effect, but this is proof that we at least ought to be careful. If anything, it reaffirms that we shouldn't keep a notebook on our lap for a significant amount of time — and the same should be said of an iPad, Kindle Fire, or your choice of Wi-Fi-enabled gizmo. You probably shouldn't keep Wi-Fi permanently enabled on your smartphone, either.

http://www.extremetech.com/extreme/106977-Wi-Fi-radiation-from-laptops-smartphones-is-damaging-your-sperm

Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation

In recent years, the use of portable computers (laptops, connected to local area networks wirelessly, also known as Wi-Fi) has increased dramatically. Laptops have become indispensable devices in our daily life, offering flexibility and mobility to users. People using Wi-Fi may be exposed to radio signals absorbing some of the transmitted energy in their bodies. Portable computers are commonly used on the lap (1, 2, 3), therefore exposing the genital area to radio frequency electromagnetic waves (RF-EMW) as well as high temperatures (3, 4).

Infertility is a common worldwide condition that affects more than 70 million couples of reproductive age (5). It has been suggested that male fertility has declined during the past several decades (6). Such decline has been attributed to the direct or indirect exposure to certain environmental factors such as RF-EMW (7).

Extremely low frequency magnetic fields can initiate a number of biochemical and physiological alterations in biological systems of different species (8, 9, 10, 11, 12). Many of these effects have been associated with free-radical production (13, 14). Free radicals are causative factors of oxidative damage of cellular structures and molecules such as lipids, proteins, and nucleic acids. Free radicals react with polyunsaturated fatty acids in cell membranes promoting a process called lipid peroxidation. In human spermatozoa the presence of unesterified polyunsaturated fatty acids is causally associated with the induction of reactive oxygen species (ROS) generation and lipid peroxidation (15). Damage may occur at the membrane level, leading to immotility and cell death, or at the DNA level. DNA integrity is essential to normal conception. Sperm DNA fragmentation has been associated with impaired fertilization, poor embryonic development, high rates of miscarriage, and increased incidence of morbidity in the offspring, including childhood cancer (16, 17). It has been proposed that genetic and environmental factors would be involved in the etiology of sperm DNA damage (18).

The RF-EMW from mobile phones may cause DNA damage (19), in addition to decreased motility and viability (20, 21). Increased levels of intracellular ROS (22) would be the cause of these deleterious effects.

Portable computers using Wi-Fi emit RF-EMW and are typically positioned close the male reproductive organs. Their potential negative effects on male germ cells have not been elucidated. To assess this potential association we used an in vitro model incubating human sperm in the presence of an active portable computer connected to the internet by Wi-Fi. Sperm viability, motility, and DNA fragmentation were the main study end points.

To our knowledge, this is the first study to evaluate the direct impact of laptop use on human spermatozoa. Ex vivo exposure of human spermatozoa to a wireless internet-connected laptop decreased motility and induced DNA fragmentation by a nonthermal effect. We speculate that keeping a laptop connected wirelessly to the internet on the lap near the testes may result in decreased male fertility. Further in vitro and in vivo studies are needed to prove this contention.

http://www.fertstert.org/article/S0015-0282(11)02678-1/fulltext

How Does The iPad Influence Your Health: What You Are Not Being Told is This…

Aside from the wide misconception that iPad or other tablets don't emit much radiation, there's growing evidence that links wireless radiation to leukemia, autism, ADHD, cancer, and Alzheimer's.

And according to the World Health Organization, wireless radiation has been classified as a potential carcinogen, being ranged in the same class with DDT, lead, and tailpipe exhaust in terms of ability to cause cancer.

On the other hand, non-ionizing or microwave radiation not only damages the brain, but also the sperm of lab animals. For one thing, tablets are microwave transmitters, which means every few seconds they send out short but strong bursts of pulsed radiation. And this radiation can pose serious risks on children's rapidly-developing nervous and immune systems, resulting in brain maturation and reproductive damage. What this microwave radiation does is disturb DNA, deteriorate the brain's protecting barrier, and discharge highly reactive and damaging free radicals. Sadly, the bone marrow of a child's head absorbs 10 times more radiation than an adult, whereas those of infants and toddlers even more.

According to research, adults who have consistently used wireless gadgets for at least ten years are at a greater risk of brain cancer (glioma and acoustic neuroma), salivary gland cancer, and even rare eye cancers on that side of the head where the cell phone was most held (Davis, 2010). Moreover, a number of men diagnosed with testicular cancer had the cancer appear in the testicle closest to the pant pocket where they usually kept their cell phone (Davis, 2013).

Ways to reduce your EMF exposure when using an iPad or other Tablets:

- Try to use your iPad tablet on airplane mode and Wi-Fi to Off as this will stop the connection radiation.
- Avoid using your iPad on your lap. Hold it further away from the body as every inch decreases the power of radiation exposure to a greater extent.
- Reduce the time spent using wireless devices.

http://chere1.com/ipad-influence-health-not-told/

STEALTH CANADA—deep-sixing the science on wireless radiation

Health Canada is inspiring activism in even the most passive Canadians (especially those harmed by wireless microwave radiation from Wi-Fi, cell phones etc)—motivating them to protect their own health, ensure their own survival, stand up for their rights, and tap into their compassion and humanity—since Health Canada seems incapable of doing any of these things for them.

Teachers, too, are being challenged to become empowered. If they dare to test the levels of radiation coming from Wi-Fi routers in their school, to protect their own health as well as the health of the schoolchildren, or if they turn the router off when not in use, they can lose their job. One teacher in BC—Maria Plant—who has been teaching for 30 years, was forced to retire because the Wi-Fi in her school became intolerable, and she now has such severe electro-sensitivity, as a result, that she can no longer lead a normal life. "It's been emotionally and physically devastating to slowly succumb to this disorder of EHS [electromagnetic hypersensitivity]," she says, "as it forced me to give up the two loves of my life: teaching and physical outdoor activity, because my inner ear and balance are most severely affected by radiofrequency signals."

Yet fighting for your rights can be hard to do when you're ill, and Plant says that EHS has resulted in depression and a crippling sense of defeat. "Sometimes, it feels as if it would be easier to just quit living," she says. "My personal life and relationships have fallen apart and I can no longer engage in social activism or contribute as a teacher and Union Rep. It has torn me from my close-knit community and the life-long friends who were my source of joy and support."

Paying for alternative medicines, therapies and specialists can be tough for a single adult, but the financial burden of selling her home and moving several times, working part-time for five years, and losing her last five years of pension contributions has been overwhelming for Plant.

Worst of all, she says, is the ridicule and humiliation from uninformed doctors, specialists, colleagues and parent groups, friends, associates and family members who mocked her symptoms. "They did not believe me when I told them that wireless radiation was the cause of my illness, or the cause of the anxiety and the flu-like symptoms (vomiting, dizziness, head pain, eye pain etc.) that my vulnerable seven-year-old students reported while working near the Wi-Fi routers at school."

If adults can be so severely affected, imagine what these high levels of non-stop microwave radiation are doing to young schoolchildren. One of them—12-year-old Tyler from Victoria, BC (pictured below)—can no longer go to school as the Wi-Fi radiation causes severe headaches, vomiting, insomnia, night terrors and fatigue. Three school districts in BC have refused to accommodate him by turning off the Wi-Fi routers or hard-wiring the computers—which could so easily be done. Instead, Tyler is being denied his right to an education, not to mention being able to socialize with his friends, build important life skills such as communication and team-building, take part in sports, build his self-esteem or do any of the things that teenagers normally do as part of their healthy development.

What kind of government refuses to allow children such as Tyler to go to school without being harmed—and knowingly harms all the other children who may not yet be feeling the radiation's effects? Why should any child—or adult—be denied this fundamental right, and instead be excluded and forced to function in isolation as if *they* were the problem rather than the toxic environment?

http://olgasheean.com/stealth-canada-deep-sixing-the-science-on-wireless-radiation/

Effects of 2.4 GHz radiofrequency radiation emitted from Wi-Fi equipment on microRNA expression in brain tissue.

Abstract

PURPOSE:
MicroRNAs (miRNA) play a paramount role in growth, differentiation, proliferation and cell death by suppressing one or more target genes. However, their interaction with radiofrequencies is still unknown. The aim of this study was to investigate the long-term effects of radiofrequency radiation emitted from a Wireless Fidelity (Wi-Fi) system on some of the miRNA in brain tissue.

MATERIALS AND METHODS:
The study was carried out on 16 Wistar Albino adult male rats by dividing them into two groups such as sham (n = 8) and exposure (n = 8). Rats in the exposure group were exposed to 2.4 GHz radiofrequency (RF) radiation for 24 hours a day for 12 months (one year). The same procedure was applied to the rats in the sham group except the Wi-Fi system was turned off. Immediately after the last exposure, rats were sacrificed and their brains were removed. miR-9-5p, miR-29a-3p, miR-106b-5p, miR-107, miR-125a-3p in brain were investigated in detail.

RESULTS:
The results revealed that long-term exposure of 2.4 GHz Wi-Fi radiation can alter expression of some of the miRNAs such as miR-106b-5p (adj p* = 0.010) and miR-107 (adj p* = 0.005). We observed that mir 107 expression is 3.3 times and miR- 106b-5p expression is 3.65 times lower in the exposure group than in the control group. However, miR-9-5p, miR-29a-3p and miR-125a-3p levels in brain were not altered.

CONCLUSION:
Long-term exposure of 2.4 GHz RF may lead to adverse effects such as neurodegenerative diseases originated from the alteration of some miRNA expression and more studies should be devoted to the effects of RF radiation on miRNA expression levels.

https://www.ncbi.nlm.nih.gov/pubmed/25775055?dopt=Abstract

Schools

Inviting Discussion about Safer Tech Use in Schools – Katie Singer

2/7/2017

In one generation, use of electronic technologies has exploded, creating dramatic environmental and cultural changes, including in classrooms. As we read, write, research, meet and express ourselves, electronics offer extraordinary possibilities. Meanwhile, to develop self-respect, empathy, humor, awareness of themselves and others and social skills, children still depend on human contact in a real (not virtual) world.

Electronics are tools, not substitutes for human teachers or peers. Every community still needs children who are familiar with the real world around them; who learn (from other people) to think critically and ethically; who are well versed in biology, chemistry, physics, literature, music and art. Students need to create and imagine from their own minds, not to follow a computer programmer's choices or direction. For healthy development, children need time without electronics, in nature, socializing with each other and contributing to their communities. Youth need purpose. They need to participate in person-to-person conversation about real world problems and solutions.

Prudent integration of technology use in classrooms requires that school board members work with administrators, teachers and parents to clarify educational priorities, identify problems and determine best practices. Basing purchasing decisions solely on an IT director's recommendations may lead to technology dominating a classroom–rather than serving as a tool that enhances learning.

Indeed, most schools implement wide use of technology even though its effects (including among children) are largely unknown. Because no federal agency regulates children's use of electronics, schools must create their own guidelines.

This paper aims to encourage discussion about safer, more responsible use of technology in educational settings. It presents critical issues and options for consideration:

Screen-time contact is no substitute for in-person relating. For healthy neurological, social and emotional development, infants, children and teenagers need to relate with adults, each other and the natural world. Because technology use can contribute to aggressive behavior, depression and neurological problems including autism, ADHD and addiction, users need to learn limits.
Common educational software tracks students' preferences, interests, social contacts and locations. Software manufacturers collect this data from each student and can use it for lifelong marketing tools. Students and parents need protection from such tracking. Further, wireless technologies increase vulnerability to hacking. Schools therefore need wired Internet access.
Wireless devices and infrastructure emit man-made electromagnetic radiation (EMR). Scientific studies have shown the high likelihood that EMR exposure causes brain and heart cancer, DNA damage, neurological harm, general malaise, medical implant malfunctioning and more. To reduce students' EMR exposure, schools need to provide wired Internet access.
During a power outage, schools without a corded telephone on a copper legacy landline may be unable to reach first responders.
Because current federal law regarding telecommunications prohibits municipalities from determining cellular antenna placement based on health or environmental concerns, parents, teachers and children

may have little control over their EMR exposure. School communities need to exercise their rights to reduce their exposure within existing legal parameters.
In the event of security breeches or health damages caused by school-issued computers, who is liable? To what extent can a school board ensure that students' data and health are safe? Before authorizing tech purchases, do school boards need to study whether computer use improves learning and/or harms development?
To begin discussion, school administrators, board members, teachers, parents and students might adopt a routine of asking questions such as:
* What are the long-term consequences of using electronic devices–to health (including brain development), social skills and community?
* Could we do this activity without an electronic device?
* Could we balance screen-time with time in nature and with others?
* How can we minimize exposure to man-made electromagnetic radiation?
* What steps might prevent tech addiction?
* What steps minimize hacking risks?
* Online, how/can we maintain privacy? Why/does privacy matter?
* Until what age (or the achievement of what skills) should children not learn computer coding or programming?
* Given federal and municipal mandates, what limits can schools and households reasonably impose to support safer tech use?

Screen-time, addiction and ADHD
The situation: In the 1970s, four-year-olds who could delay eating a marshmallow for fifteen minutes (by singing to themselves, making up a game or napping) became more confident and skilled adults, more able to cope with stress.[1] Now, temptations are electrified. Microwaves (frequencies required for mobile devices to operate) increase activity of brain endorphins or endogenous opioids, the biological base of addiction to opium, alcohol and morphine.[2]

Like all electronics users, children need skills in delaying gratification (i.e. waiting to check messages) and limiting screen time.

Dr. Nicholas Kardaras, author of Glow Kids: How Screen Addiction is Hijacking Our Kids–and How to Break the Trance, has found treating heroin and crystal meth addicts easier than "lost-in-the-matrix video gamers or Facebook-dependent social media addicts." Dr. Kardaras reports that one out of three children now uses a tablet or smartphone before they can talk.[3]

Integrative child psychiatrist Dr. Victoria Dunckley, MD, author of Reset Your Child's Brain, reports that screen time overloads the sensory system, fractures attention and depletes mental reserves. It desensitizes the brain's reward system, can increase suicide risk and reduce physical activity levels.[4] Even 30 minutes of computer use can disturb sleep; and interactive screen-time (playing video games and/or manipulating a screen with a keyboard, mouse or touch) is more detrimental to brain development than non-interactive, passive TV watching.[5]

Pediatric occupational therapist Chris Rowan explains that technology use's
* sedentary nature is causally related to obesity, diabetes, developmental delay, illiteracy and learning difficulties.[6],[7],[8],[9]
* isolating factor can escalate mental illnesses including ADHD, autism and depression and create difficulties in self-regulation.[10],[11]

* overstimulation factors into ADHD, aggression, sleep disturbance and chronic stress.[12],[13],[14],[15]

Screen-time based sedentary behavior can contribute to childhood and adolescent depression.[16]

Using a portable screen device also impacts sleep.[17]

"Distracted" walking and driving injuries and fatalities are on the rise. A Mayo Clinic study finds that text messaging appears to produce a unique brainwave form that can cause epileptic and nonepileptic seizures. This "texting rhythm" was also found in iPad users.[18]

Options:
* Minimize use of electronic devices until reading, writing and math skills are established on paper.
* Do not offer computer time as a reward, a babysitter or pacifier.
* Ban cell phones in classrooms. Some schools ban them during hallway and lunch breaks, confiscate the phone for 1-30 days with the first violation, and, with the second violation, until the school year ends. Bans require school board support and sufficient warning to parents and students. At Monte del Sol (charter high school) in Santa Fe, New Mexico, Principal Dr. Robert Jessen reports that with the ban, students face teachers during class and talk to each other during lunch breaks. A study from the Univ. of Texas and Louisiana State Univ. found that test scores rose by up to 6% in schools with strict cell phone bans.[19]
* Teach parents and students to identify symptoms of excessive screen time: aggressive behavior, disrupted academic or social performance. If use becomes problematic, consider Dr. Dunckley's three-week electronic fast to "detox" and determine the student's healthy tech threshold.[20]
* Encourage movement, hiking, sports, chess, book reading, hand-writing, theatrical productions, painting, pottery-making, conflict resolution skills, research by in-person interviews, playing music, learning a second language, composting kitchen scraps and growing and preparing food.
* According Jocelyn Glei, author of Unsubscribe: How to Kill Email Anxiety, Avoid Distraction and Get Real Work Done, on average, people check email eleven times per hour. Such frequency decreases productivity. To help children develop healthy work habits, teach them to check email in batches–say two or three times per day.
* Provide Wi-Fi-free and tech-free areas for students and staff.
* Encourage teachers and parents to model self-awareness and self-regulation around screen-time limits.

Activities:
* Create "Personal Tech Contracts" and ongoing discussions about responsible tech use.[21],[22]
* Establish "crews" that meet daily over years with the same students and teachers to help children build real relationships.
* Encourage discussion about how tech influences our relationships.
* Recognize the danger of texting while driving. Encourage students and families to pledge to stop texting and driving. Texting takes your eyes off the road for an average of five seconds. At 55 mph, that's like driving the length of a football field–completely blind. Car crashes caused by texting and driving kill an average of eleven teens each day and injure 330,000 people every year.[23]
* Invite discussion: What is addiction? What are signs of tech addiction? What do camps in China do to remedy tech addiction?[24] What steps prevent tech addiction? What screen-time limits are healthy for you?
* Read and discuss Jerry Mander's Four Arguments for the Elimination of Television, Quill, 1978.

* View and discuss "Screenagers," Delaney Ruston, MD's documentary about teen cell phone use. www.screenagersmovie.com

Security and Privacy
The situation: School-issued computers likely collect info about students' Social Security numbers, food preferences, friends' names, grades and discipline records. School-issued computers may contain geo-trackers that provide students' exact locations. Without regulations, manufacturers (i.e. Apple and Pearson) who sell computers and software to schools may collect students' info to create "data-mined profiles" for lifetime marketing tools.

Further, according to applied physicist Dr. Ronald M. Powell, "The second you go wireless, you expose yourself to greater risk of interception. Fiber optic systems (fios) will always be able to carry data faster and more securely than any wireless system." Staff and student data can be hacked.[25],[26] Thirteen percent of educational organizations have been hacked–more than three times the rate of ransomware (payment for releasing data taken "hostage") found in healthcare and more than that of the financial sector.[27]

Computer-based assessments of students and Smarter Balanced Test Scores have led to unfair test administration, security and privacy issues related to test data, violation of students' rights, delivery of tests on faulty networks and technology, and long-term motivational problems that likely result from misdiagnosing students with unfit assessments.[28],[29]

Options:
* Eliminate wireless service and devices. Opt for fiber optics (fios) and wired phones, computers, mice and printers. For affordable fiber connections, see Harvard's Berkman Center for Internet and Society's Maximizing K-12 Fiber Connectivity Through E-Rate.[30]
* Teach users not to use physical addresses or birthdates in email addresses or passwords, not to reply to email from strangers, and to open an attachment only when you know the sender and expect the attachment.
* Teach staff and students that each device (i.e. a tablet, chromebook, or smartphone) has its own security practice.
* Establish email security protocols, monitor key third party vendors, track vendors' security ratings and avoid file sharing.

Activities
* Interview people who've been hacked. What happened? What advice do they have to prevent hacking?

Invite discussion: Do you prefer mobility (which risks hacking) or wired-only communications (which decreases hacking risks)?

2a. Critical thinking and tech design

The situation: According to Tristan Harris, former Design Ethicist at Google, tech product designers limit and even control users' thinking by creating a menu of choices. For example, in response to the question, "Where can we go to talk?" a server might offer a menu of bars–and not include nearby parks or diners.[31]

Activities:
* As they conduct research for school reports, encourage students to ask, What are the menu providers' goals? What's not on the menu? Does the menu serve my real needs or distract me? Does the server provide websites with opinions or well-referenced reports?
* Read and discuss Dr. Kenneth J. Saltman's Scripted Bodies: Corporate Power, Smart Technologies and the Undoing of Public Education, Routledge, 2017.

EMR exposure
The situation: In living creatures, every cell functions by electro-chemical signals.[32] Our physiological functions (i.e. sleep, digestion, decision-making and locating home) ultimately depend on cues from the Earth's electromagnetic fields, the solar wind and other natural sources.

Electronics (including cell phones, tablets, compact fluorescent bulbs, cordless phones) and infrastructure (such as cellular antennas; Wi-Fi routers; "smart" digital, wireless utility meters; powerlines and transformers) emit man-made electromagnetic radiation (EMR). In May, 2011, The World Health Organization classified EMR as a 2B carcinogen.[33] In May, 2016, NIH's National Toxicology Program found that 2G cell phone radiation causes brain and heart tumors and DNA damage.[34] A Feb., 2016 report published by the journal Neuro-Oncology and funded by the American Brain Tumor Association finds that malignant brain tumors are the most common cause of cancer-related deaths in adolescents and young adults aged 15-39, and the most common cancer occurring among 15-19 year olds.[35] (Leukemia used to be the leading cancer among children, but now it is #2, behind brain cancer, signaling an environmental change.) In September, 2016, the American Academy of Pediatrics issued recommendations to reduce exposure to cell phones.[36]

Because children's skulls are thinner and their brains contain more fluid than adult skulls and brains, children absorb proportionately more radiation than adults. The effects of EMR exposure on a child's development may have lifetime impacts,[37] including on their fertility.[38]

Neither wireless devices nor the infrastructure that they require have been proven safe for children, pregnant women, people with medical implants, the general population or wildlife.

Options:
* Get informed about the health and environmental effects of EMR-exposure. Studies are posted at www.saferemr.com (from UC/Berkeley's School of Public Health) and www.bioinitiative.org.
* Recognize that every reduction in EMR-exposure is worthwhile.
* Encourage students and staff to keep mobile devices off when not in use. To ensure that a device is off, test its EMR emissions. Www.magneticsciences.com/ rents meters for reasonable fees.
* Choose wired connections–for phones, web access, mice, printers.[39]
* For affordable fiber connections, see Harvard's Berkman Center's Maximizing K-12 Fiber Connectivity Through E-Rate.[40]
* Avoid or correct equipment that defaults to wireless.
* Teach school nurses, teachers, parents and students to identify common symptoms of EMR exposure, including bloody noses, sleep disturbances, headaches, fatigue, rashes, migraines, dizziness, nausea and aggressive behavior.[41],[42]
* Recognize the short and long-term effects of near, whole body, second-hand, combined and cumulative EMR exposures.[43]
* See "Schools, Unions and PTA Actions," an int'l list of schools that have removed Wi-Fi, posted by the Environmental Health Trust.[44]

* Create Wi-Fi and tech-free zones for children and staff.

Activities:
* Learn which diseases correlate with different kinds of EMR exposure. http://www.bioinitiative.org/rf-color-charts/
* At parent-teacher meetings, encourage family time without electronics and keeping Wi-Fi off for at least 12 hours each night. Read "Calming Behavior in Children with Autism and ADHD."[45]
* Stage contests between classrooms and schools to reduce EMR emissions.

3a. Cell phones and health

The situation in the mid-1990s, to determine cell phone safety, the FCC took the temperature of a 220-pound mannequin's head before and after six minutes of cell phone use. Because this mannequin's temperature did not change by two degrees Celsius, the FCC determined that mobiles are safe.[46] In other words, to determine safety, the FCC considered only the immediate, thermal effects of cell phone use.

The FCC has not tested non-thermal effects of EMR exposure, including for children's or pregnant women's cell phone use, nor for combined, chronic or cumulative exposures.

In 2015, Dr. Om Gandhi, Professor of Electrical Engineering at the University of Utah, co-chair of the Institute of Electrical and Electronics Engineers' (IEEE's) Subcommittee on RF Safety Standards (1988-97), wrote: "it is very hard to understand why" FCC's safety guidelines only consider the head of a mannequin whose size is in the 90th percentile of US military recruits–and do not consider children's head size when creating safety guidelines.[47]

Cell phone radiation contributes to brain and heart tumors and damages DNA.[48] It weakens the blood-brain barrier.[49]

In utero EMR exposure results in an 85% greater risk for behavioral problems by the time children reach school age. [50]

Options:
* Keep devices in airplane mode with Wi-Fi and Bluetooth off, especially in class and around others.
* Do not keep a phone in a bra, pant pockets or shirt pocket. Make the bra a no-phone zone.
* To decrease RF exposure, download images and videos only via a wired (fiber optic, cable or DSL) connection.
* Maintain landlines and corded telephones as long as possible and/or until fiber optics are in place.
* Mitigating EMR emitted by a cell phone or voice over Internet protocol (VOIP) is unique to each situation. Could local electrical engineers help students to measure and reduce emissions?
* Create protected areas to prevent second-hand EMR exposure (received by people and wildlife near cell towers, routers, "smart" meters and/or people using mobile devices).

Activities:
* View "Cell Phones Cause Cancer."[51]
* View "Save the Girls" [52] and "Save the Males."[53]
* View Dr. Devra Davis' talk at the University of Melbourne.[54]

* Read your cell phone manufacturer's warning. For one week, abide by it–i.e. keep your phone at least 7/8" from your head.
* Make your own flier with warnings and solutions about cell phone use.
* Invite discussion: Should cell phones have warning labels at the point of sale, as Berkeley, California requires?[55] How/could pregnant women limit their cell phone use? For ideas see www.babysafeproject.org.

3b. Wi-Fi and health

The situation: No medical organization has deemed that Wi-Fi is safe. No pre-market safety testing (including by FDA or EPA) was conducted on Wi-Fi. Wi-Fi presents whole body EMR-exposure to users and non-users. Faculty and students who work or study near routers may receive more intense exposure.

British biologist Dr. Andrew Goldsworthy, retired lecturer from Imperial College, explains: "Just after birth, a child's brain goes through an intense period of becoming aware of new sensory input. He or she recognizes his or her mother's face, her expressions, and eventually, other people and their relationships. During this process, the neurons in the brain make countless new connections, and the brain stores what the child learns. Connections that are rarely used are pruned. This pruning process is completed by the time of sexual maturation.[56]

"If the child is exposed to radiofrequency fields during this pruning process, the production of too many and often spurious signals will generate frequent random connections. These will not be pruned, even though they may not make sense. Because the pruning process in children exposed to RF fields may be more random, these children–who may have more brain cells than the rest of us–may lack the mindset for normal patterns of social interaction. This may then contribute to various autistic behaviors.

"Like mobile phone signals, Wi-Fi signals can also cause cell membranes to leak and calcium ions to flow through them in a relatively uncontrolled manner.[57] In the classroom, this may result in children's brains losing the ability to concentrate.

"Further, electromagnetic radiation (such as that emitted by Wi-Fi, cell phones, cell towers and 'smart' meters) may affect the body like light does at night–and inhibit melatonin production. Melatonin is a sleep hormone and a powerful antioxidant. It can reverse oxidative stress that results from radiation exposure.[58]

"While scientists explore further how EMR exposure reduces melatonin production and study whether EMR-induced oxidative stress contributes to autism–along with many other questions–we ought to first do no harm to our children. Wi-Fi should therefore be considered an impediment to learning, rather than an aid. Wi-Fi may be particularly hazardous to pregnant teachers, since exposing the brain of a fetus or a very young child to EMR may prevent normal brain development."[59]

In a 2013 letter to the Los Angeles Unified School District, Dr. Martha Herbert, MD, PhD, pediatric neurologist at Harvard Medical School wrote: "EMF/RFR from Wi-Fi and cell towers can exert a disorganizing effect on the ability to learn and remember, and can also be destabilizing to immune and metabolic function." She urged the LAUSD to "opt for wired technologies."[60]

Dr. Hugh Taylor, MD, head of Yale Medical School's Ob/Gyn Department, recommends that pregnant women (including pregnant teachers, students and parents) "avoid prolonged or direct exposure to Wi-Fi routers." (www.babysafeproject.org.)

A recent study from the California Department of Health found that three percent of Californians (770,000 people) experience radio-frequency sickness (headaches, rapid heartbeats, memory problems, insomnia, nausea, fatigue, tinnitus) with EMR exposure.

Www.ehtrust.org has compiled an international list of schools and countries that have banned Wi-Fi.[61]

Options:
* Read applied physicist Dr. Ronald M. Powell's report on school Wi-Fi.[62]
* Read Dr. Joel Moskowitz's report on Wi-Fi in schools.[63]
* Install wired connections. Until Internet access is wired, every router needs an on-off switch. When not in use, keep routers off.
* Encourage students and teachers to keep routers off at night.

Activities:
* Per classroom, have students make signs to encourage keeping Wi-Fi off when not in use.
* Research policies about Wi-Fi in schools and libraries in France, Israel and other countries.[64]
* Invite discussion: What do we win and what do we lose with mobility? With wired connections? Which is better for the short-term: mobility or wired connections? Which is better for the long-term? How/can we orient ourselves for the long-term?

3c. Cellular antennas and health

The situation: Studies find that people living near cellular antennas experience fatigue, headache, sleep disruption, irritability, depression, memory loss, dizziness, nausea, increased risk of cancer, tremors, loss of appetite, rashes, visual disruptions and overall discomfort.[65]

People who live within 350 meters (about 1000 feet) of a cellular antenna for more than a decade experience a four-fold increase in cancer rates. Among women, the increase is tenfold.[66],[67]

People who live within 200 to 500 feet of an antenna report genetic, growth and reproductive effects; increases in the blood-brain barrier's permeability; behavioral, molecular, cellular and metabolic effects; and an increased risk of cancer.[68]

Many schools already have cellular antennas on campus. [69] Do staff and parents deserve to know about antenna sitings? Should staff and students be able to work and study in a building without cellular antennas?

5G will support the Internet of Things (IoT, machine-to-machine communication) at speeds 100-fold faster than 4G.[70] 5G will operate with millimeter wave signals that have been tested only minimally for health and environmental effects. (Skin and eyes may have most significant effects.)[71] What choices will schools have regarding 5G antenna placement?

Options:

* Provide easy access to a map of routers, smart meters, cellular antennas, wireless chargers, electrical/mechanical rooms, solar power inverters and other electrical hot spots on school property.
* Learn diseases associated with exposure to hot spots and transmitters.[72]
* If EMR levels on campus are high, allow students and staff to transfer to a school with lower levels.
* Explore legal options for preventing cellular antennas on campus.
* Read applied physicist Dr. Ronald M. Powell's "Cell Towers and Health."[73]

3d. EMR exposure on school vehicles

The situation: In a moving vehicle, every time a mobile device connects to a new cell tower (approximately every mile), the device goes to maximum power. Much of the EMR gets trapped within the vehicle (a metal box).

Wi-Fi on school buses traps yet more EMR.

Computers used by vehicles including hybrid and electric cars can emit especially high electromagnetic fields.

Options:
* Keep mobile devices off in school vehicles.
* Do not allow Wi-Fi on school buses.
* Test vehicles' EMR emissions. Do not allow children, pregnant women and people with implants to sit in seats with high levels.

3e. Electronic interference with medical implants

The situation: According to NIH, in year 2000, 8-10% of the American population had a medical implant (i.e. an insulin pump, cochlear implant, pacemaker or neurostimulator).[74] Nearness to a metal detector, refrigerator, air conditioner, mobile phone or tablet, Wi-Fi router, wireless recharger, an electric or hybrid car can cause a medical implant to malfunction or shut off.[75] For example, walking through a library's metal detector can shut off a person's deep brain stimulator. The person would have a few seconds to reset–or they'd shake so badly that they could not reset the implant without help.

Option:
* Post signs to alert and protect people with implants, i.e.:

WARNING electromagnetic radiation (EMR) in this area could cause a medical implant to malfunction or shut off

Activities:
* View 2009 talk by Dr. Gary Olhoeft (geophysicist and electrical engineer) about electronic interference with his deep brain stimulator. [76]
* Read Katie Singer's 2015 talk, "Aiming to First Do No Harm: The Education of an Electronics' User," about the FCC's definition of "harmful interference" and the reality of living with an implant. [77]

3f. Grounding and wiring errors and "chopped" current

The situation: Buildings that have no wireless service may still generate dangerous magnetic fields and/or stray voltage from grounding and/or wiring errors. If clean, man-made electricity (which may not exist, inpractice) is a smooth AC wave at 50 or 60 Hz, high frequencies or pulses on the wires can "chop" current, disrupt power quality and harm health. "Chopped" current is also called harmonics or "dirty" power.

"Smart" utility meters, wiring errors and any device with a power supply (including a wired computer) or an electronic ballast (including compact fluorescent bulbs) can chop current, disrupt power quality and harm health. Sitting in or near a room with wired computers or even near one computer can thereby contribute to a child's EMR exposure.

Options:
* To correct grounding and wiring errors, refer to Karl Riley's Tracing EMFs in Building Wiring and Grounding, 2nd ed. www.magneticsciences.com
* To locate and correct electric, magnetic and RF fields and "dirty" power on school property, hire independent engineers to conduct an annual survey. Follow up corrections with another survey. Encourage students to participate in the surveys and the corrections. Shut down rooms with dangerous levels of exposure. Note that finding a reliable surveyor may not be easy. (See applied physicist Dr. Ronald M. Powell's review of a survey of RF levels in Montgomery County, Maryland Schools.[78])
* Read the American Medical Association's 2016 paper about LEDs' human and environmental effects.[79] Do not use mercury vapor lights, compact fluorescents or LEDs with electronic ballasts. These produce "dirty" power that radiates out from electrical wires. Prefer incandescent bulbs. (They do not generate chopped current.)

Activities:
* Read "Is Dirty Electricity Making You Sick?" by Michael Segell, Prevention, Nov. 3, 2011.
* Learn to install battery and/or solar-powered DC lights.
* Invite discussion: Should wiring and grounding errors be determined and cleaned up before deploying new technologies?

Emergency preparedness
The situation: In the event of a power outage, only hard-wired, corded telephones on copper legacy landlines will work. Cell phones and voice over Internet protocols (VOIPs, i.e. Magic Jack and Skype) require electricity and therefore will not work in a power outage.

Note: the FCC and 13 states have passed legislation that will "sunset" copper legacy landlines by 2020. Only cell phones and VOIPs will be available.

Options:
* Maintain copper legacy landlines and corded landline telephones as long as possible.
* Maintain industrial strength battery backup for phone systems that require electricity.

4a. Lithium ion batteries

The situation: Lithium ion batteries are used in laptops, smart phones, e-cigarettes, "smart" meters and many other electronic devices. They are light and store lots of energy per weight. They can also explode; they are also flammable. [80]

Option:
* In the event of an explosion or fire caused by a device with a lithium ion battery, keep a fire extinguisher nearby.

Rules, regulations and liability re cell towers and phones
The situation: Section 704 of the 1996 Telecommunications Act prohibits municipalities from denying a permit to install a cellular antenna based on health or environmental effects of exposure to radiofrequency emissions. Underwriters like Lloyds of London will not insure for health or property damages caused by wireless radiation.[81]

Activities:
* Teach staff and students to measure electric, magnetic and radiofrequency fields and "dirty" power emitted by their own devices. Www.magneticsciences.com rents meters for reasonable fees.
* When introducing students to an electronic device, encourage them to read and abide by the manufacturer's warnings in the product's manual.
* View "Broadcast Blues," a documentary about the Golden, Colorado area's health and legal battles in the late 90s around radio and TV broadcasting antennas placed on Lookout Mountain.[82]
* View "Blood in the Mobile," a Danish documentary about coltan, a mineral mined primarily in Congo that holds charge in every mobile device. More people have been murdered over coltan than were murdered in any other event since WWII.[83]
* View "We the People 2.0," Matthew Schmid's documentary about municipalities like Pittsburgh enacting ordinances that effectively prevent fracking or toxic sludge in their areas.[84] Could such a community rights ordinance work with cellular antenna placement?
* Invite discussion: Given that federal and manufacturers' guidelines regarding EMR emissions do not recognize non-thermal, biological harm, and some people want to reduce exposure, what regulations can individuals, households, schools and/or businesses reasonably create? What regulations should they create? Could you create model guidelines for a household or school?

Endnotes, Sources, Original Article: http://www.electronicsilentspring.com/safer-schools/

Message to Schools and Colleges about Wireless Devices and Health

March 11, 2017
Ronald M. Powell, Ph.D

If wireless devices, such as Wi-Fi, are used in your schools and colleges, then the health of your students, your faculty, and your staff can be at risk. This is a difficult problem but an addressable one if you act.

Background: Wireless devices transmit information using radiofrequency/microwave radiation. The international biomedical research community has been studying the biological impact of such radiation for decades, but more intensely in recent years. Thousands of peer-reviewed studies published in biomedical research journals have contributed to our understanding of this impact. So many serious biological effects have been found that immediate responsive action is warranted. Further, these biological effects are occurring at levels of radiation far lower than earlier understood. Simply stated, a worldwide health crisis is emerging and is becoming a hallmark of the 21st Century. The international biomedical research community is trying to warn us; but we, in the USA, are not yet listening. I hope this message will help to change that.

As a scientist, I urge you to look into the **health impact of the radiofrequency/microwave radiation** produced by wireless devices. Examples of wireless devices of concern in our environment are Wi-Fi in all of its forms; cell phones and cell towers (especially those located on school grounds); cordless phones; wireless computers, whether desktop, laptop, or tablet versions; wireless baby monitors; wireless smart electricity meters; emerging wireless smart appliances; and microwave ovens (because they always leak radiation).

This crisis is the consequence of many factors. Here are some of them:

- All living things are bioelectrical in nature. That is why electrocardiograms and electroencephalograms work. They, of course, measure the tiny electrical signals that operate the heart and the brain. The critical tasks performed by these tiny electrical signals, and so many other electrical signals in all living things, can be disrupted by man-made radiofrequency/microwave radiation.
- The levels of man-made radiofrequency/microwave radiation in our environment are increasing exponentially and already exceed, by many orders of magnitude, the levels at which all life on Earth evolved. Simply stated, we are drowning in a rising sea of radiofrequency/microwave radiation.
- The invisible nature of radiofrequency/microwave radiation leaves the public and the decision-makers unaware of the rising levels of radiation around them.
- The genuine usefulness of wireless devices promotes denial of the risks.
- The intense advertising, the economic power, and the political power of profitable wireless industries enable them to dominate the public dialogue and to hold sway over government regulators and legislators.
- Current Federal standards for limiting the exposure of the public to radiofrequency/microwave radiation are outdated and overly permissive. Those standards are based on thermal heating alone. In effect, the Government claims that if you are not cooked too much by the radiation, then you are fine. Those Federal standards ignore the many biological effects that occur at much lower levels of radiation, leaving the public unprotected.

- Federal and state governments are advocating unlimited expansion of wireless technology, and are even co-funding such expansion and mandating the acceptance of wireless technology by the public. Such actions reflect a widespread lack of understanding of, or willful blindness to, the underlying science and its consequences for public health.
- Some of the more serious consequences of exposure to radiofrequency/microwave radiation (such as DNA damage, cancer, and infertility) are especially nefarious because they give no early warning signs.
-
- Other consequences of exposure do give early warning signs (such as sleep disruption, headaches, fatigue, ringing in the ears, memory loss, dizziness, heart arrhythmia, and many others); but those signs are too often dismissed because they can have other causes as well, complicating identification of the true cause.
- The absence of routine training of physicians in the biological effects of radiofrequency/microwave radiation makes it difficult for physicians to identify the causes and to provide responsive guidance.
- Even aware individuals cannot control their exposure in any environment shared with others, because the radiation around them, much like second-hand smoke, is forced on them by unaware individuals. Only governments can fully solve this problem, but they are currently part of the problem. For now the public will have to protect itself, and that will require public education and action.

Fortunately, many of the services that wireless devices offer can be realized with much safer wired devices. The wired devices achieve connectivity with fiber-optic, coaxial, or Ethernet cables. The wired devices are faster, more reliable, and more cyber secure. They are, however, less mobile, often less convenient, and somewhat more expensive to install. But those drawbacks pale in comparison to the benefits of good health.

Simply stated, schools and colleges can protect their students, staff, and faculty from the health risks posed by wireless devices, including Wi-Fi, by converting to safe wired connectivity. If your institution lacks the resources to convert now, do consider shutting down your wireless devices anyway and converting as soon as you can. You can advance learning without leaving a trail of illness behind you, some of which can be lifelong.

Regards,
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My background
I am a retired U.S. Government scientist (Ph.D., Applied Physics, Harvard University, 1975). During my Government career, I worked for the Executive Office of the President, the National Science Foundation, and the National Institute of Standards and Technology. For those organizations, respectively, I addressed Federal research and development program evaluation, energy policy research, and measurement development in support of the electronics and electrical-equipment

industries and the biomedical research community. I currently interact with other scientists and with physicians around the world on the impact of the environment – including the radiofrequency/microwave environment – on human health.

https://www.scribd.com/document/289778053/Message-to-Schools-and-Colleges-about-Wireless-Devices-and-Health

School officials may be personally liable for exposing children to wireless radiation

School districts, school boards and school medical health officers in Canada have been notified that Lloyd's of London has now excluded any liability coverage for injuries, "directly or indirectly arising out of, resulting from or contributed to by electromagnetic fields, electromagnetic radiation, electromagnetism, radio waves or noise." This includes the radio frequency radiation emitting from Wi-Fi and other wireless devices in schools.

On February 18, 2015, the UK agent for Lloyd's stated, "the Electromagnetic Fields Exclusion (Exclusion 32) is a General Insurance Exclusion and is applied across the market as standard. The purpose of the exclusion is to exclude cover for illnesses caused by continuous long-term non-ionizing radiation exposure i.e. through mobile phone usage."

This decision is important because Lloyd's of London, one of the largest insurance companies in the world, often leads the way in protection by taking on risks that no one else will. But, the decision is not surprising because Lloyd's refused to cover mobile phone manufacturers against risks to users' health more than a decade ago in 1999.

What (exactly) are the risks associated with Wi-Fi radiation?

In 2011, the World Health Organization designated radio frequency radiation of the type emitted by Wi-Fi devices to be a 'class 2B possible human carcinogen.' Many independent experts now think this classification downplays the significant dangers posed by wireless technology – especially when you consider the thousands of peer-reviewed, non-industry funded studies by scientists and medical experts that show that Wi-Fi radiation is harmful, especially to children.

According to Associate Professor Olle Johansson from the Department of Neuroscience at the Karolinska Institute in Stockholm "the debate is over". He says, "the spectrum of possible health problems arising is extraordinarily wide – from brain tumors and leukemia to exhaustion, decreased memory and concentration and just feeling uncomfortable."

Professor Johansson goes on to say, "The allowed radiation limits throughout the world are insane, to say the least. We are talking about values up to 1,000,000,000,000,000,000 (10 to the 18th) times higher than nature's background radiation, to which the human body has adapted through many 100,000 of years, and within a couple of decades, we have all been surrounded by biblical levels of artificial radio-waves, well knowing that they have major impacts on both human and animal health."

Princeton University recently removed its position statement on wireless safety from their website after parents raised concerns that Princeton's information was "outdated and inaccurate." Earlier, this year, France banned Wi-Fi in nursery schools. In addition, schools in Germany, Austria, Israel and Australia have pulled the plug on Wi-Fi altogether.

http://www.naturalhealth365.com/wi-fi-radiation-electromagnetic-fields-lloyds-of-london-1356.html

Reykjavik Appeal on wireless technology in schools

We, the signers, are concerned about our children's health and development in schools with wireless technology for teaching. A vast amount of scientific studies have shown considerable medical risks with long-term exposure to Radiofrequency Radiation (RFR) from wireless devices and networks well below the recommended reference levels from the International Commission on Non-Ionizing Radiation Protection (ICNIRP). We ask the authorities to take their responsibility for our children's future health and wellbeing.

In May 2011 the International Agency for Research on Cancer (IARC) at WHO classified RFR as a Group 2B carcinogen, i.e., 'possibly' carcinogenic to humans. Since then more scientific studies on exposure to RFR in humans, animals and biological material have strengthened the association of an increased risk for cancer, especially brain tumors. Several laboratory studies have shown mechanistic effects in carcinogenesis such as oxidative stress, down regulation of mRNA and DNA damage with single strand breaks. The IARC cancer classification includes all sources of RFR. The exposure from mobile phone base stations, Wi-Fi access points, smart phones, laptops and tablets can be long-term, sometimes around the clock, both at home and at school. For children this risk may be accentuated because of a cumulative effect during a long lifetime use. Developing and immature cells can also be more sensitive to exposure to RFR. Based on scientific studies no safe level of this radiation has been established and therefore we have no safety assurances.

Besides the cancer risk, RFR may also affect the blood-brain barrier to open and let toxic molecules into the brain, hurt neurons in hippocampus (the brain center for memory), down or up regulate essential proteins in the brain engaged in the brain's metabolism, stress response and neuro-protection and affect neurotransmitters. Sperms exposed to Wi-Fi have been seen with more head defects and DNA damage. RFR can increase oxidative stress in cells and lead to increase of pro-inflammatory cytokines and lower capacity to repair DNA single and double strand breaks.

Cognitive impairments in learning and memory have also been shown. Results from the OECD's PISA performance surveys in reading and mathematics show decreasing results in countries that have invested most in introducing computers in school. Multitasking, too many hours in front of a screen, less time for social contacts and physical activities with risk for aches in neck and back, overweight, sleep problems, and information technology (IT)- addiction are some of the known risks and side effects of IT. They stand in marked contrast to the often claimed, but largely unproven possible benefits.

We ask the school authorities in all countries to acquire knowledge about the potential risks of RFR for growing and developing children. Supporting wired educational technologies is a safer solution than potentially hazardous exposures from wireless radiation. We ask you to follow the ALARA (As Low As Reasonably Achievable) principle and Council of Europe Resolution 1815 to take all reasonable measures to reduce exposure to RFR.

Practical rules for schools concerning children and wireless technology.

- No wireless networks in preschool, kindergarten and schools.
- A hard wired direct cable connection is recommended to each classroom for the teacher to use during lessons.
- Prefer wired telephones for personnel in preschool, kindergarten and schools.

- Prefer cabled connection to Internet and printers in schools and turn off Wi-Fi settings in all equipment.
- Prefer laptops and tablets that can be connected by cable to Internet.
- Students should not be allowed to use cell phones in schools. They can either leave them at home or the teacher collects them in turned off mode before first lesson in the morning.

Children, Screen time and Wireless Radiation – International Conference Reykjavik February 24, 2017

http://www.stralskyddsstiftelsen.se/wp-content/uploads/2017/03/Reykjavik-Appeal-170224-2.pdf

Maryland State Advisory Council Recommends Reducing School Wireless to Protect Children

03/03/2017

Children's environmental health experts respond to new US study linking wireless radiofrequency radiation to cancer after the American Academy of Pediatrics recommends reducing radiofrequency exposures.

After reviewing new and growing evidence on health risks of wireless radiation, the Maryland State Children's Environmental Health and Protection Advisory Council (CEHPAC) issued a Report advising the Department of Education to recommend local school districts reduce classroom wireless radiation exposures by providing wired-rather than wireless-internet connections. CEHPAC's health experts include Governor appointed pediatricians, Maryland State House/Senate appointees and representatives of the Department of Education and Department of Health. Theodora Scarato, MSW, of the Environmental Health Trust, first brought the issue to the Council's attention three years ago, in February of 2014. The Council cited the recent US National Toxicology Program (NTP) findings of increased rates of rare malignant cancers in animals, as well as children's unique vulnerability to the radiation in their recommendations to minimize exposure.

Several countries, such as France, Israel and Cyprus, already have protective measures minimizing school wireless radiation exposures as national policy. However, CEHPAC's action to issue recommendations to reduce classroom wireless exposures is the first of its kind by an expert state body in the United States.

The Children's Environmental Health and Protection Advisory Council recommends:

1. "The Maryland State Department of Education should recommend that local school systems consider using wired devices" "Wi-Fi can be turned off" and instead "a wired local area network (LAN) can provide a reliable and secure form of networking...without any microwave electromagnetic field exposure."

2. New construction and renovations: "If a new classroom is to be built, or electrical work is to be carried out in an existing classroom, network cables can be added at the same time, providing wired (not wireless) network access with minimal extra cost and time."

3. The Maryland State Department of Education should recommend that local school systems use strategies to minimize exposures: "Have children place devices on desks to serve as barrier between the device and children's bodies; Locate laptops in the classroom in a way that keeps pupil heads as far away from the laptop screens (where the antennas are) as practicable; Consider using screens designed to reduce eyestrain; Consider using a switch to shut down the router when it is not in use."

4. "The Maryland Department of Health and Mental Hygiene should provide suggestions to the public on ways to reduce exposure: Sit away from Wi-Fi routers, especially when people are using it to access the internet. Turn off the wireless on your laptop when you are not using it. Turn off Wi-Fi on smartphones and tablets when not surfing the web. Switch tablets to airplane mode to play games or watch videos stored on the device."

5. "The General Assembly should consider funding education and research on electromagnetic radiation and health as schools add Wi-Fi to classrooms."

6. The Maryland Department of Health and Mental Hygiene should "ask the United States Department of Health and Human Services to formally petition the FCC to revisit the exposure limit to ensure it is protective of children's health and that it relies on current science."

7. The Report should be shared with the United States Department of Health and Human Services, Federal Communications Commission, Maryland State Department of Education and Maryland General Assembly.

"While this report focused on Wi-Fi radiation in schools, there are additional concerns about mobile phones and cell phone towers. CEHPAC plans to look at these broader issues over the next year," the CEHPAC Council Report states.

"Our children's healthy future rests on the responsible actions of today," stated Scarato. "21st century learning should include 21st century science," Scarato pointed to research that found wireless alters brain development in addition to increasing cancer. "Corded non-wireless connections in school are an important part of a safe and healthy school environment, respecting not only our children but also the teachers and staff."

Referring to the fact that US wireless public exposure limits were set in 1996, without testing for long term safety, the CEHPAC Council Report also stated that, "decades-old standards need updating in light of new science." Such statements are in line with the American Academy of Pediatrics, which has also called for a regulatory review and states that children's brains are less mature and can absorb proportionately twice the wireless radiation as an adult because of children's thinner skulls that contain more fluid.

"If you plan to watch a movie on your device, first download it, then switch to airplane mode while you watch in order to avoid unnecessary radiation exposure," recommends the American Academy of Pediatrics as part of its "Ten Tips on Cell Phone Radiation."

In response to the 2016 NTP study findings of a cancer link, the American Academy of Pediatrics, Consumer Reports, Obstetricians and several Medical Associations issued recommendations to reduce cell phone and wireless exposures to children. The American Academy of Pediatrics has also repeatedly called on the United States government to strengthen wireless exposure regulations to protect children and pregnant women.

The Council heard testimony from health organizations and from parents who reside in multiple counties in the State of Maryland, including Montgomery County, Prince Georges County, Anne Arundel County, Baltimore County and Howard County. The Council also received hundreds of pages of expert scientific material and comments prior to the final Report, which the Council has posted on their website.

"Parents have a right to know if there is an environmental hazard in the classroom and actions that can be taken to reduce exposure. The stakes are so high for our children, yet we are way behind what has been happening around the world. Over 20 countries have taken steps and in some cases passed legislation to protect their youngest and most vulnerable citizens and it is time we do the same for

ours," stated Montgomery County parent Laura Simon, pointing to countries like France, Cyprus and Israel.

"I was shocked to learn no government health agency had reviewed the issue from a health and safety standpoint considering how fast Wi-Fi was being installed in schools across the State." Scarato described the process of how she brought the health issue of children's exposures to wireless in schools to Maryland State agencies almost three years ago, by first writing letters of concern about the school radiation exposures.

Dr. Sharfstein, then Secretary of the Maryland Department of Health, initially responded to Scarato's concern by stating, "It is fair to say there are legitimate questions about the long-term health implications of microwave radiation" and that the Department of Health "would be interested in the advice and counsel of groups such as the Children's Environmental Health and Protection Advisory Council."

Scarato pointed out that the Education Department representative on the Council voted in favor of the CEHPAC recommendations to reduce wireless exposures. The Maryland State Department of Education (MSDE) also had responded to Scarato's initial concerns by referring her to CEHPAC, which "exists for the purpose of identifying environmental hazards that may affect children's health and recommending solutions to those hazards."

Medical researchers are pointing to an array of psychological, emotional and physiological health issues screens pose to children at the same time that schools are integrating wireless networks and one to one device initiatives into classrooms.

In 2017, Maryland lawmakers heard testimony on Bill HB866, a first in the nation bill to create uniform screen safety guidelines for screen use in public schools "to protect children from the documented health hazards posed by daily use of digital devices." In response to wireless radiation health concerns, many schools worldwide are replacing wireless systems with wired systems, and limiting time children spend on screens.

http://www.sbwire.com/press-releases/first-state-in-the-nation-maryland-state-advisory-council-recommends-reducing-school-wireless-to-protect-children-777904.htm

Cyprus Removes Wi-Fi from Kindergartens and Halts Wireless Deployment Into Public Elementary Schools

03/06/2017

The Cyprus Minister of Education and Culture issued a Decree on January 31, 2017, marked „urgent" to all Directors of Kindergartens and Primary Schools, with specific measures to eliminate and minimize wireless radiation exposure to children in schools. „We have taken the decision to have the wireless network Wi-Fi disabled in all Public kindergartens in Cyprus," reads the Decree. Wireless is to be removed from all Cyprus kindergartens, and wireless installations have been halted in elementary schools and limited to administrative offices.

"The Ministry of Education does not intend to proceed with the installation of wireless points and Wi-Fi access classrooms in elementary schools."

The Decree reminds teachers that wired internet is already available in all classrooms if the internet is needed for educational purposes. Wireless is only to be used, if needed, in the administrative areas of elementary schools, and wireless is not to be used in the classrooms.

However, if the use of Wi-Fi is deemed necessary for a specific educational program, the Decree stipulates that, „necessary measures to protect children should be taken, and wireless access points should remain inactive when not in use for teaching purposes." Furthermore, „the consent of parents should be ensured in advance." The Decree instructs the School Directors to assure parental consent and send a letter to the parents of children who will participate in programs involving wireless technology – informing the parents of the reason and duration of Wi-Fi usage.

Alongside their other campaigns about tobacco smoke and toxic chemicals, The Cyprus National Committee on Environment and Child Health initiated a nationwide campaign several years ago to raise awareness about cell phone and wireless radiation exposures to children. The multimedia public awareness campaign was lauded at an international conference on Wireless and Health held at the Israel Institute for Advanced Studies at Hebrew University in January of 2017, and organized in cooperation with the U.S. National Institute of Environmental Health Sciences (NIEHS) and Environmental Health Trust (EHT).

Dr. Stella Michaelidou, President of the National Committee on Environment and Child Health shared public service video announcements and brochures about children and pregnancy at the conference. „This Committee has developed tools that are a model for other countries to follow," stated Devra Davis, PhD, MPH, of the Environmental Health Trust at the conference.

Several countries already have health policies in place to reduce school children's exposure to wireless. Cypress now joins France, Brazil, Ghent in Belgium, and Israel in banning wireless in kindergarten classrooms and enacting strong measures to minimize wireless exposures in elementary schools. France passed comprehensive new legislation in 2015 and has developed tools to inform the public about how to reduce exposure, similar to the efforts underway in Cyprus. Canada's Standing Committee on Health of the House of Commons also issued a report recommending a public education campaign.

In the United States, the Maryland State Children's Environmental Health and Protection Advisory Council recently issued a Report advising the Department of Education to recommend all school districts in the State of Maryland install wired—rather than wireless—internet connections for classrooms. This

action represents the first action of a state advisory body to issue guidance on wireless exposures. In Massachusetts and Oregon, several Bills have been proposed to address the health issues posed by electromagnetic radiation in schools and raised by consumers, researchers and medical professionals as concerns about school wireless exposures gains momentum in the United States.

http://www.satprnews.com/2017/03/06/cyprus-removes-wi-fi-from-kindergartens-and-halts-wireless-deployment-into-public-elementary-schools/

Radiofrequency Radiation in Communities and Schools Actions by Governments, Health Authorities and Schools Worldwide

See source for document.

http://ehtrust.org/wp-content/uploads/International-Policy-Precautionary-Actions-on-Wireless-Radiation.pdf

Wi-Fi banned from pre-school childcare facilities in a bold move by French government

The French National Assembly has adopted a bill to limit exposure to electromagnetic fields (EMFs) generated by wireless technologies - cell phones, tablets, Wi-Fi etc. This bill will mean the following:

- A ban on Wi-Fi in all childcare facilities for children under the age of 3.
- Cell phone manufacturers will have to recommend the use of hand-free kits.
- A ban on all advertising targeting children under 14.

Children's EMF exposures are a particular cause for concern. Studies show that children's brains can absorb up to three times as much radiation compared to adults.

A recent International Agency for Research on Cancer (IARC) report suggested that EMF exposures can be more devastating in children because their:

- Brain tissue is more conductive.
- Skull is thinner.
- Smaller brains and softer brain tissue allows radiation to penetrate more effectively.
- Potentially longer period of exposure due to use beginning at an earlier age.

This new French bill seems to have taken these concerns into account.

EMFs are widespread in our daily environment. Anything electrical creates an electromagnetic field. According to the French national Agency for Food, Environmental and Occupational Safety (ANSES):

- The biggest source of EMF exposure by far is cell phones.
- Cell towers exposures are developing very rapidly with the deployment of 4G, but average exposure is well below that of phones.
- Electrical power lines, transformers and railway lines are also sources of EMFs.

•Wireless devices in our personal environment expose us to radiofrequency EMFs: computers and tablets, Wi-Fi, Bluetooth and electronic chips, as well as fluorescent lights, microwave ovens, induction hotplates and washing machines.

ANSES now urges "limiting exposure of the population", particularly to cell phones. It also encourages the use of an earpiece.

ANSES already rang the alarm bell in October 2013. After evaluating more than 300 international studies, the agency published a report highlighting the biological effects of EMFs on humans and animals concerning sleep, male fertility and cognitive performance.

A spokesperson for ANSES stated that "the massive development of technologies relying on radiofrequencies, leading to intensive exposure of the population, specifically more sensitive persons, which cannot be avoided". They went on to say that the deployment of 4G "will be accompanied by increased exposure of the public".

French exposure limits are based on a 2002 decree. They are set at 61 volts per meter (V/m) for 3G and 4G, the same as in the USA. The Council of Europe recommends an exposure limit of 0.6 V/m, some 100 times lower.

Switzerland and Liechtenstein and eight Member States of the European Union (Belgium, Bulgaria, Greece, Italy, Lithuania, Luxembourg, Poland, Slovenia) have adopted more restrictive limits than those of France.

In Europe there is a growing recognition of the plight of persons suffering ill health from exposure to electromagnetic fields, a condition known as electrical hypersensitivity or electrical sensitivity. This new bill requires that the French government provides Parliament with a report detailing "the opportunity to create areas of limited electromagnetic radiation, notably in the urban environment". It also requires that the conditions of electrosensitives by taken into account in the workplace.

Though this bill has to be adopted by the French Senate for it to be made into law, clearly this bill reflects the buildup of public opinion in France and other European countries that EMF exposures are dangerous and the public needs protecting. How long before US public opinion is successful in introducing similar protective legislation?

http://www.naturalnews.com/043695_electrosensitivity_Wi-Fi_French_government.html

Could Wi-Fi in schools be harming our kids?

Students in Lindsay Freedman's split Grade 3/4 class at Red Willow Public School are working away on tablets, laptops and iPods. It's Bring Your Own Device day, a regular occurrence here, and supplementing the devices brought from home are 20 school-owned iPads. Freedman walks around the classroom, marveling at her students' instant embrace of the online presentation app she's just introduced. "They're an instant motivator," she says, referring to the tools in their hands.

Red Willow belongs to the Peel District School Board (near Toronto), one of several across Canada that have adopted Wi-Fi throughout its schools, an embrace of 21st-century technologies designed to "ensure that our students can thrive in a future that can't be predicted," as Peel's promotional brochure puts it.

Though most parents and educators celebrate the move, some are raising concerns about the possible health impacts of the radio-frequency (RF) radiation on which wireless technologies operate. Exposure levels to this kind of radiation, which fall in the same frequency bandwidth on the electro-magnetic spectrum as radios, televisions and mobile phones, continue to rise as wireless technologies become more prevalent.

Canada's current guidelines on RF exposure are in line with those of the International Commission on Non-Ionizing Radiation Protection – the largest regulatory body in this field. But many other jurisdictions have adopted considerably lower limits, either as a precautionary measure or because they view the science differently.

How is it that health agencies reach such different conclusions when faced with the same scientific evidence? Why are some Canadian schools installing Wi-Fi while France is limiting exposure? Switzerland heavily favors wired Internet connections in schools, yet Israel is pulling it out of its lower grades altogether.

While most Western bodies have deemed the scientific evidence on health effects inconclusive, many European jurisdictions are choosing to err on the side of caution until more is known. In a resolution in 2011, the Council of Europe recommended that the As Low As Reasonably Achievable (ALARA) principle be applied to electromagnetic radiation, fearing "there could be extremely high human and economic costs if early warnings are neglected." It also condemned the "lack of reaction to known or emerging environmental or health risks and virtually systematic delays in adopting or implementing effective preventive measures."

Lichtenstein, Italy and Belgium responded by drastically lowering their exposure guidelines. In France, a bill currently before the Senate insists on a principle of moderation where RF radiation is concerned. If passed, Wi-Fi will be banned from maternity wards and child-care facilities, communities would have to be consulted before any installations in schools, and if installed, all routers would have to be accessible to teachers who could turn them off when not in use. Laurence Abeille, the Green MP behind the bill, had originally proposed a ban in all schools around students up to the age of six. She had to water it down to gain broad support in the National Assembly, but feels public concern in France is rising. This spring, a 32-year-old man received medical benefits from the local health authority in Essonne, south of Paris, for his electro-hypersensitivity – a first in France.

Switzerland prides itself on having among the most stringent regulations on electromagnetic radiation in the world. As of 2000, it has supplemented its exposure limits (which are in keeping with Canada's) with much more restrictive limits for installations of power lines, television and radio transmitters, and mobile phone base-stations in well-frequented locations. The new regulations were accompanied by an aggressive public awareness campaign about the health risks of RF radiation. Swisscom, the national telecom company, promotes its line of low-radiation "Ecomode" phones and routers as "safer" – openly acknowledging the risks inherent in these devices. And for 10 years, Swisscom has been installing wired Internet connections in Swiss schools for free. Why not wireless? As company spokesman Carsten Roetz wrote in an e-mail, "because there's no reason to put a radiation source that isn't absolutely necessary in schools." Of Switzerland's 6,800 schools, Roetz estimates that fewer than 100 have opted for wireless connections.

In March of this year, the Jerusalem Post reported that the Israeli Education Ministry had ordered radiation testing in all Israeli schools, banned Wi-Fi from pre-schools and kindergartens, and restricted its use to one hour a day for students up to Grade 3. The move came in response to persistent complaints from parents whose children suffer from some form of electromagnetic hypersensitivity.

Russia's exposure limits for RF radiation are 100 times lower than Canada's. While Russian schools can choose to install Wi-Fi, they are the exceptions, says Oleg Grigoriev, chairman of the Russian National Committee on Non-Ionizing Radiation Protection (an expert group that reports to the Russian parliament). He says damage to children's cognitive function caused by long-term exposure to low-strength electromagnetic fields has long since been demonstrated by Russian researchers. Russia, he explains, began experimenting with the impacts of electromagnetic fields on the nervous system a century ago, and, as a result, does not consider its approach precautionary, but rather "science-based."

While faced with the same scientific evidence, these countries have adopted very different rules on exposure. It's all about managing risk. Marc Saner, a professor at the Institute for Science, Society and Policy at the University of Ottawa, affirms that scientific evidence is just one element in the multi-factorial nature of risk management in public policy. "The focus on risk reflects many things – a country's history of science, its trade interests, the pet causes of its movie stars … Policy decisions are always a few steps away from data, there's always an emotional component."

Most Canadian school boards are introducing Wi-Fi, but at a slower rate than Peel – slower not because of concern about exposure, but because installation is more complicated in older schools with thicker walls. Toronto's school board aims to have at least partial Wi-Fi in all its schools by 2016, and is adding zones regularly. Because Wi-Fi exposure has been deemed safe in Canada, the expansion proceeds without notification.

Paradoxically, outside the schools' walls, Toronto's Board of Health insists on a "prudent avoidance policy" with respect to cell tower locations, keeping RF radiation levels in areas of the city "where people normally spend time" 100 times lower than what federal guidelines insist on – much like in Switzerland. The Board argues that as long as radiation sources in the urban environment continue to increase, the cumulative effect is unknown and caution is warranted. The policy has been in place since 1999.

In Canada, the lack of public concern about Wi-Fi exposure in schools seems at odds with a culture of parenting that's often called hyper-cautious. Here, public awareness on the issue of exposure has been

mainly focused on cellphones. The science at play is beyond the reach of most citizens, and many would rather not entertain the possibility that these incredibly useful technologies may pose a risk.

"We're not just talking about Wi-Fi in schools," Saner says. "We're asking much bigger questions, like what is education? Are these devices good for society generally? Is this speed of innovation a good thing? The stakes here are huge."

http://www.theglobeandmail.com/life/health-and-fitness/health/is-there-such-a-thing-as-too-much-Wi-Fi/article18592972/

Teen Allergic to Wi-Fi Commits Suicide, Parents Say

The mother of a teen who committed suicide after suffering from what she calls a rare allergy to Wi-Fi is accusing her daughter's school of failing to protect her.

Jenny Fry, 15, was found hanging from a tree near her home in the U.K. last June. Her story is now coming to light because of a legal investigation into the cause of Jenny's death.

Her mother, Debra Fry, told the Mirror that Jenny suffered from blinding headaches, fatigue, concentration problems, and bladder issues that she says were caused by electro-hypersensitivity syndrome (EHS), a condition in which electromagnetic radiation emitted from wireless technology, including Wi-Fi, cellphones, and cell towers, causes debilitating physical symptoms.

Although Jenny's parents had removed Wi-Fi from their home, which helped, it was still present at her school. "Both Jenny and I were fine at home, but Jenny continued to be ill at school in certain areas," said Fry.

Jenny received several detentions in school, not for being disruptive in class, but because she'd often have to leave the classroom to find an area away from Wi-Fi where she could concentrate.

Fry had shared information about Wi-Fi's potential problems with the head teacher of Jenny's school, Simon Duffy, but according to Fry, Duffy told her there was an equal amount of information that shows Wi-Fi is harmless.

"I also had a heated exchange with teachers telling them Jenny was allergic to Wi-Fi, and that it made no sense making her take detentions in rooms that were making her ill," said Fry. "The least they could do was allow her to take them in rooms where she felt able to concentrate, but they wouldn't listen."

Fry believes Jenny's suicide attempt was meant to be a cry for help. A police statement said that on the day Jenny died, she had texted a friend twice, telling the friend about her intentions to commit suicide and stating where she was, according to the Mirror. But her friend didn't have her phone with her to see the texts in time.

"Jenny left letters for us where she said she couldn't cope with her allergies from Wi-Fi anymore," Fry told the Telegraph. "She left them for us in case things went too far, but I don't believe she wanted to die."

Arthur Firstenberg, a leading anti-electromagnetic health activist, admits that EHS is not a simple subject, but that it's not taken seriously enough by the medical community. Firstenberg believes there are genuine health issues stemming from the escalation of wireless technology, and that schools have a responsibility to keep children safe. "Imagine if this was a toxic chemical, and the school suddenly decided to spray the chemical throughout the school just because other schools were doing it," Firstenberg told Yahoo Parenting. "Don't people have a responsibility for what they do, regardless of whether others are doing it too?"

"Just because Wi-Fi is new and all around us doesn't mean it is safe," Fry told the Telegraph. "Wi-Fi and children do not mix. Much more research needs to be done into this because I believe that Wi-Fi killed my daughter."

Jenny's parents are now trying to raise awareness about the dangers of Wi-Fi. Fry added, "I am not against a bit of technology, but I do feel schools should be aware that some children are going to be sensitive to it and reduce its use."

https://www.yahoo.com/news/teen-allergic-to-Wi-Fi-commits-suicide-parents-say-223912154.html

Cell Phone Usage Inside Schools

My kids have been educated on the dangers of electromagnetic radiation (EMR) from cell phones, cordless phones and Wi-Fi networks, so they were aware enough to come home and tell me how they're unwillingly getting exposed to EMR at their school – via other kids' cell phones and the wireless computers in the computer room.

My children have told me that many children in their classes own cell phones, which are allowed to remain turned on, whilst in the classroom. Whether these phones are set to ring or just vibrate is not the issue. If they are turned on, then they are transmitting (and receiving) to the nearest cell phone tower continually and emitting electromagnetic radiation (EMR) throughout the classroom.

My son has also told me that all the computers in the computer room are wireless. Again, as computers on a Wi-Fi network are in the "ultra-high frequency range" and nearly up to the "super high frequency" range (see info below on radiation frequencies from NASA), this likewise is transmitting very high EMR to the children (and teachers) in that classroom.

When we were in Singapore in 2001, there was huge coverage in all the newspapers because 20-year-olds throughout the city were having heart attacks and they couldn't figure out why. Then, someone figured out it was because it was the fashion at that time for young people to wear their cell phones on decorative cords around their necks. This meant that their cell phones were hanging right next to – you guessed it – their heart. So a warning went out in all the local newspapers, telling kids not to wear their cell phones on these cords. But funnily enough, no one I've spoken to in Canada (or the U.S.) ever heard about that. And no one thought about warning people not to wear their cell phones clipped to their belt, or in their pocket.

Of course there are huge revenues at stake with wireless technology and until recently, not much long-term hard data on the risks or effects. But as you can see from the first reference listed below (from the head of a cancer research institute), that has now changed, and there IS enough data in place for respected scientists and doctors to conclude that cell phone and other ultra-high frequency wireless devices are not safe for long-term, or cumulative human use – *especially* for children.

I have also listed my own research below – including hard data from NASA's website, that has led me to completely avoid cell phone, cordless phone and wireless computer usage in my family and my house.

Many people are comparing cell phones and Wi-Fi network usage to cigarettes – which were also once thought to be a "private" choice, but later acknowledged as a public health issue – where your choice affects my health.

I encourage you to review the research and sources below – of the thousands of references available (over 2,000 scientific, peer-reviewed studies), I have included only a few of the most pertinent.

And if you would like a set of "action tools" that you can download and hand out to neighbours, schools, other parents, etc. to help get Wi-Fi removed from your school, they're all available at my kids' site: www.RadiationEducation.com

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Associated Press

Thurs., July 24, 2008

PITTSBURGH – The head of a prominent cancer research institute issued an unprecedented warning to his faculty and staff Wednesday: Limit cell phone use because of the possible risk of cancer.

The warning from Dr. Ronald B. Herberman, director of the University of Pittsburgh Cancer Institute, is contrary to numerous studies that don't find a link between cancer and cell phone use, and a public lack of worry by the U.S. Food and Drug Administration.

Herberman is basing his alarm on early unpublished data. He says it takes too long to get answers from science and he believes people should take action now — especially when it comes to children.

In the memo he sent to about 3,000 faculty and staff Wednesday, he says children should use cell phones only for emergencies because their brains are still developing.

Adults should keep the phone away from the head and use the speakerphone or a wireless headset, he says. He even warns against using cell phones in public places like a bus because it exposes others to the phone's electromagnetic fields.

"Although the evidence is still controversial, I am convinced that there are sufficient data to warrant issuing an advisory to share some precautionary advice on cell phone use," he wrote in his memo.

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CBC News

Saturday, July 12, 2008

"Toronto's department of public health is advising teenagers and young children to limit their use of cellphones to avoid potential health risks."

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Dr. Robert Becker, M.D., one of the first medical pioneers to study natural electrical currents in the human body and to caution about electropollution, answers the question, "Can EMR exposure cause harm?" in this interview. Dr. Becker was twice nominated for the Nobel Prize in Medicine.

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Good summation article on CELL PHONE RISKS TO CHILDREN by Dr. Joseph Mercola:

Children today will experience previously unimaginable exposure to information-carrying radio waves from mobile phones because they start out using them at a very early age.

I am absolutely convinced that the explosion of cell phone usage around the world is a health disaster in waiting, and contributing to the rapid rise in several neurological epidemics, such as autism and early-onset of Alzheimer's.

One reason for this is that the information-carrying radio waves from cell phone base stations and cell phones make children's exposure to vaccines and heavy metals much more dangerous than they typically are. EMR can actually trap heavy metals inside your cells, causing cellular damage and

hindering your body from detoxifying. For this reason — while I realize that most people will not get rid of their cell phones because of their convenience — I would still urge you to not let your kids use them.

I am so convinced this danger is real, on par with the dangers of tobacco, which all the "experts" claimed was safe, that I'm writing an entire book on the subject, due out in 2009.

And, I'm not alone in trying to educate the public. In fact, some European countries are already working on public health campaigns designed to warn school-age children of the dangers, by putting up posters in schools and community halls.

Will Europe Ban Cell Phones for "Under-age" Use?

The Vienna Medical Association is demanding the removal of zero tariffs and the banning of mobile phone advertising targeting children and adolescents. Says Erik Huber, environment advisor for the association: "Children under the age of 16 should never use a mobile phone."

Many scientists and government agencies in Europe have already accepted that EMF from cell phones does pose health risks, reflected in Huber's statement, "Scientists do not argue anymore whether mobile phones are harmful, but how harmful they are."

Don't be Deceived – SAR is Not an Indication of Safety

Although the National Research Council's report states that Specific Absorption Rates (SAR) for children are likely to be higher than for adults, let's not get confused.

Because the danger from most land-based portable phones, cell phones and Wi-Fi routers is NOT from the magnetic radiation or the microwave carrier wave for which typical SAR ratings are given on phones. Unless you have massive exposures like you might expect in a microwave oven, these thermal effects are insignificant.

So simply lowering the allowable SAR will NOT make cell phones safer.

Instead, nearly all the biological damage comes from the modulated signals that are carried ON the carrier microwave. These modulated information carrying radio waves resonate in biological frequencies of a few to a few hundred cycles per second, and can stimulate your cellular receptors causing a whole cascade of pathological consequences that can culminate in fatigue, anxiety, neurological decline, and ultimately cancers.

The density of your child's skull is also far less than yours, and therefore their brain is far more susceptible to these information-carrying radio waves.

This Deserves Your SERIOUS Attention

The studies showing the long-term risks of cell phone use are just beginning to come in because cell phone use didn't become widespread until the late 1990s. It typically takes at least 10 to 20 years for cancers to show up, so now is the time when these risks will become apparent.

It is almost as if NO ONE was smoking and then all of a sudden nearly 90 percent of the planet started. Of course, we would not see any spectacular increase in major damage for more than 10 years. It takes time for this damage to accumulate and be noticed.

Unfortunately, most people fail to correlate common symptoms and health problems to their exposure to cell phones and other radio frequencies, perhaps because these conditions can so easily be attributed to other causes (including so-called "unknown" causes) as well.

Take a look at these common illnesses and ailments, which have all been scientifically linked to cell phone information carrying radio waves:

* Alzheimer's, senility and dementia
* Parkinson's
* Autism
* Fatigue
* Headaches
* Sleep disruptions
* Altered memory function, poor concentration and spatial awareness

Although cancer and brain tumors are most often cited as the potential health risks from cell phone radiation, as you can see, cancer is not the only, or most common danger that you and your children face.

Protecting Yourself and Your Children From Dangerous RF

The best way to protect yourself would be to simply not use a cell phone and revert back to a corded phone. At the very least I would urge you to not let your kids use them or severely limit their use. Their developing nervous systems and thinner skulls are simply too vulnerable to cell phone damage.

If you choose to keep your cell phone, make sure you use a non-Blue Tooth headset. Also remember, even when you're not using your phone, keep it as far away from your body as possible. Do not keep it on your belt or in your pocket as the radiation WILL penetrate your body wherever the phone is attached. According to a scientific study published in Fertility and Sterility in May 2007, statistically significant changes were found in men's sperm count and health of the sperm, based on cell phone use.

Their conclusion?

"Use of cell phones decreases the semen quality in men by decreasing the sperm count, motility, viability and normal morphology. The decrease in sperm parameters was dependent on the duration of daily exposure to cell phones, and independent of the initial semen quality."

So, make sure you stow your cell phone in a bag, briefcase, or your car's glove compartment.

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Dr. Carolyn Dean MD ND recently shared this information:

Last September Dr. Devra Lee Davis, an epidemiology professor from the University of Pittsburgh testified before the U.S. Senate…

"Dr. Davis," asked Senator Tom Harkin, chairman for Health & Human Services, "you said that a cell phone should not be kept any closer than an inch to your body?"

Dr. Davis nodded.

"Where does that come from?" asked Senator Harkin.

"That actually comes from the BlackBerry manual," replied Dr. Davis, "as well as from the iPhone manual. If you read the manual– which almost none of us does — that is what they say."

Seeing is believing… so I found a PDF copy of iPhone's "Important Product Information Guide" online which states: "iPhone's SAR measurement may exceed the FCC exposure guidelines for body-worn operation if positioned less than 15 mm (5/8 inch) from the body…"

The BlackBerry manual takes it 10mm further by advising: "…keep the device at least 0.98 inches (25mm) away from your body…"

So if you can't avoid cell and cordless phones entirely — at least do what the industry's own manuals suggest: Avoid any direct physical contact while they are activated.

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An article in the Los Angeles Times reported:

"Belgium, France, Finland, Germany, Russia and Israel have publicly discouraged use of cellphones by children. (Independent research in Sweden last year concluded there was an astonishing 420% increased chance of getting brain cancer for cellphone users who were teenagers or younger when they first started using their phones.) France has gone so far as to issue a generalized national cellphone health warning, banned cellphones in elementary schools and considered outlawing marketing the phones to children."

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WI-FI RESEARCH

You can go here to NASA's site to get an easily understood definition of exactly what electromagnetic radiation is, and the distinction between the different types of waves.

This article tells you what wavelength/frequency wireless computer devices work with (frequency and wavelength are inter-related as explained in the NASA article):

Once we know the frequency wireless (Wi-Fi) technology uses, we can then compare that to Radios and TVs.

FM Radio is in the 88 – 110MHz range

Analogue TV (what most people have in their homes) is at 400 – 600MHz

Digital TV is at 600 – 1000MHz.

Here's a great definition of radio frequency and then an excellent chart showing the strength of the various frequencies:

Radio frequency is also abbreviated as rf or r.f. – any frequency within the electromagnetic spectrum associated with radio wave propagation. When an RF current is supplied to an antenna, an electromagnetic field is created that then is able to propagate through space. Many wireless technologies are based on RF field propagation.

These frequencies make up part of the electromagnetic radiation spectrum:

- Ultra-low frequency (ULF) — 0-3 Hz
- Extremely low frequency (ELF) — 3 Hz – 3 kHz
- Very low frequency (VLF) — 3kHz – 30 kHz
- Low frequency (LF) — 30 kHz – 300 kHz
- Medium frequency (MF) — 300 kHz – 3 MHz
- High frequency (HF) — 3MHz – 30 MHz
- Very high frequency (VHF) — 30 MHz – 300 MHz
- Ultra-high frequency (UHF)– 300MHz – 3 GHz
- Super high frequency (SHF) — 3GHz – 30 GHz
- Extremely high frequency (EHF) — 30GHz – 300 GHz

CONCLUSION: WI-FI IS NOT SAFE FOR FREQUENT, ONGOING USAGE

So, based on the information gathered above, here's where each item (cell phones, radio, TV, wireless computers) lies in terms of intensity of electromagnetic radiation:

FM Radio is 88-110 MHz –> Low frequency electromagnetic radiation

Cell phones are 824-869 MHz –> Ultra-high frequency electromagnetic radiation.

Wireless computers/internet are 2.4 GHz –> Ultra-high frequency electromagnetic radiation (but nearly up into Super High frequency range).

Therefore, surprise-surprise, wireless computers and their networks are NOT SAFE for frequent, ongoing human use! And when salespeople, politicians and presidents of wireless companies tell you that "there's no problem, it's the same as FM Radio" – you will know they are lying, or misinformed.

Worrying also is current TV transmission at 400-600 MHz (Ultra-high frequency) and Digital TV in the 600-1000MHz range (also Ultra-high frequency). But at least one tends to sit a good distance away from a TV!

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For lots more info on this issue, check out the EMR Network (a non-profit organization).

http://blog.listentoyourgut.com/cell-phone-usage-inside-schools/

Landlines

Saving Your Landline May Save Your Life

See source for publication.

https://wirelessaction.files.wordpress.com/2016/09/saving-your-landline-may-save-your-life-sccma-bulletin_may-2016.pdf

Mauk said her landline was the only thing working in her house after the 2015 windstorm

Lee Ann Mauk spent nine days without power after Spokane's 2015 windstorm. She couldn't turn lights on, take a hot shower or keep food frozen. But through it all, her landline phone kept working.

"We didn't have stoves. We didn't have hot water. We didn't have refrigerators. But we did have our phone," she said.

It's no secret that the number of households with landlines is dwindling across the United States.

As of December 2015, the most recent data available from the Federal Communications Commission, Spokane County had 96,000 active residential landlines. That's about one for every two households. That number is down from the June 2014 FCC count, which showed 106,000 residential landlines in Spokane.

In Kootenai County, the number for both snapshots was 40 percent.

We asked readers to weigh in about whether they had a landline and why on Facebook and got nearly 100 responses.

Those who still have landlines said the ability to reach kids at home, power outages and call quality were all reasons to keep the phone around.

Jenny Louie said she uses her landline to sign up for things that require a phone number, and so she doesn't have to get her 11-year-old a cellphone.

"We need a phone at home that they can use in case of emergency," she wrote. Others pointed out schools still teach young kids to dial 911 on a landline.

Some readers said they felt more secure in an emergency knowing 911 dispatch can read their location off a landline. But it's not quite that simple, said Spokane fire communications dispatch chief Jay Atwood.

Traditional landlines that rely on cables, usually provided by CenturyLink in Spokane County, transmit an address to 911 dispatch. But cellphones often do, too, and in many cases, the location is fairly accurate.

"Sometimes it can be really precise and sometimes it's a quarter-mile off," Atwood said.

Cellphone location pinpointing is a county-by-county technology. Spokane has had it for years, Atwood said, and tends to be ahead of the curve. Smaller or more rural counties may not have that ability.

What can be a problem are landlines that use the internet to transmit calls. Those landlines, called voice over internet protocol, or VOIP, are usually the ones that come bundled with Comcast or other cable TV service.

Atwood said VOIP landlines come up with the subscriber's address, based on whatever information they have in their account. If someone's recently moved and hasn't updated that information, 911 could end up with the wrong address.

Regardless of how a call comes in, 911 dispatchers always ask for a location to avoid confusion.

"We always confirm the address no matter what," Atwood said. "It's never one of those things we take for granted."

Some people said they keep a landline around because of spotty cellphone service at home. Surprisingly, FCC data show little correlation between how rural a county is and the percentage of households with landlines.

Landline coverage is highest by far in Wahkiakum County in southwestern Washington, at 82 percent. But Whitman County saw the lowest coverage in the state, at just 39 percent. Other more rural counties, including Asotin, Adams, Douglas, Kittitas and Walla Walla, are between 40 and 50 percent, while 54 percent of King County households still have a landline.

Among readers who had given up a landline, telemarketers were a big reason. Many said they didn't see the point of paying for an extra service, cheap though it can be. Some said they got rid of it when their children got old enough to have cellphones.

"I got rid of mine when I got comfortable with having just a cellphone, but I have been thinking a lot about getting a landline again. I never missed a call when the house phone rang like I do with my cell," wrote Vicki Denz, who's in her early 50s.

State regulations have shifted over the past three years to reflect the declining number of people using landlines. The state Utilities and Transportation Commission used to regulate the price phone companies could charge for service, since they usually had a monopoly. In 2014, they stopped price regulations on landlines in most areas because of the competition provided by VOIP, Skype, cellphones and other options.

"There wasn't a need to discipline prices under regulation anymore because the assumption, and I think it still holds, is that the marketplace will discipline their prices," said Brian Thomas, the director of policy for the commission. The commission does still regulate consumer safety, including 911 availability.

The Department of Social and Health Services used to require a landline phone for foster parents, but dropped that requirement around 2013. Now, regulations say only that parents must "have access to a working telephone at all times" while children are at home.

Mauk's house has a functioning rotary phone, along with a more modern device upstairs. She still uses the rotary dial to make calls, though it can be tricky if she has to go through an automated menu after reaching her local pharmacy.

http://www.spokesman.com/stories/2017/feb/11/about-half-of-spokane-households-still-have-a-land/

A Landline Might Be Your Best Option during a Storm

Think about how much life has changed since Hurricane Andrew, some 24 years ago. We likely had that wall phone in the kitchen with the really, really, really long cord. We got most of our news from television, radio or newspapers. The web was something Spiderman produced as he battled villains.

Imagine if we had today's technology back then. We could text, Snap, Tweet, Facebook-message, Instagram, etc. all of our loved ones instantly how we were dealing with the post storm damage and stress. We could jump on the utilities apps to see all we need to know about when we might get power back. There are probably apps that let us know which gas station has fuel, which stores have bread and milk or the closest emergency center for aid of any kind.

Wait, no, we probably couldn't do all those things because today's technology is dependent on energy and Wi-Fi. And after a storm like Andrew, we would likely be out of both. So, we might have to go into the attic and pull out the old wall unit after all.

Mimi Whitefield of the Miami Herald recently wrote about this strange phenomenon and shared her ideas on how to communicate if another big storm comes through.

WLRN: I use my phone as an alarm, as a radio and my source of news oftentimes. Looking at my checklist, I'm not prepared. Do you think people are ready for another storm?

Whitefield: Well, we may not be prepared. We have all these technological advances. There are all these apps out there that help you deal with natural disasters, weather, lots of information, but you're not necessarily going to be getting those if the power goes out and inevitably it does during a storm.

The telephone companies such as Verizon and AT&T say that their towers and their systems are able to withstand quite a bit of wind damage and storm damage. But are they confident their systems can withstand an Andrew?

I think with each storm and each natural disaster they learn a little bit more. They will move their personnel and their equipment into an area that they think is going to get slammed and they've got these mobile cell phone units. But of course these things can't move into an area until after the debris is cleared. And so they have a lot more capacity, they are a lot more robust than they were 10 years ago when the last major hurricane hit Florida, but it's kind of an unknown about how they will be able to perform it...if a major hurricane hits.

What did you take away from researching and writing this story and has it changed anything in the way you view what you have to do to get ready?

I think I may go out and buy some battery packs and these are relatively inexpensive. You can probably get one for $20-$25 but you can plug your cell phone in there, you could maybe plug your laptop, a fan, some lights, unless you are really able to splurge for a generator, but you want to have power. And even the ability of news organizations dependent on power, dependent on the Internet to get their message out there, could be challenged as well.

I remember specifically with Andrew and we were trying to call our families everywhere else to let them know what was going on. And I know my mom was going days trying to get through trying to get through. Did they [phone companies] learn anything from the experiences after Andrew?

What they recommend, because they really don't want to jam up the phone lines and the cell networks, is well in advance of a storm designate a friend or someone in your family as your central contact point. Try to get in touch with that person and that person try to get in touch with everyone else after a storm, like your information central. So instead of calling 10 friends and family members you're making that one call. I think that obviously could help quite a bit. You cannot go on your cell phone during a storm for entertainment or to play games. It's basically for an emergency, that and you're likely to get denial of service.

One thing that has changed a lot, about 47 percent of American households are cell-phone-only households. I do have a landline at my house and I keep it specifically for this reason, but I have wireless phones. They will not work because they're dependent on electricity, so I keep an old style telephone and I pull it out whenever the weather is bad.

http://wlrn.org/post/ready-go-old-school-landline-might-be-your-best-option-during-storm

Landlines: The 'Dinosaur Phone Technology' That Could Save You in a Crisis

As cell phone service has grown reliable and more widely available, many households have given up their landline telephones.

Today, about two-thirds of younger Americans use cell phones only, and about 40 percent of households overall have given up landlines.

This, though, can be a problem during an emergency.

Some, but not all, cell towers have backup generators, but during Hurricane Sandy they provided only an additional four to six hours of power. In Long Island, N.Y., every single cell phone tower eventually failed, leaving an entire community holding worthless cells phones.

"There was one woman in particular who passed away, of natural causes, an elderly woman," city manager Jack Schnirman told *NPR*. "And her daughter had to walk literally a mile and a half from her home to police headquarters just to say, 'Listen, my mom has passed, and I thought I should tell somebody."

Said college student Colleen Marron, "It was scary because you don't know what is going on. You feel helpless."

Additionally, cell towers are not designed to handle a mass of people calling all at once.

Landline phones, assuming they are not wireless, generally work during a power outage. This is because power is sent to the phones through the phone line from the power companies. The power companies have battery backup and backup generators so that their operations can continue for well over a week during a power outage.

The lines often are underground, preventing them from being damaged during a storm. That's a selling point for landline companies who are trying to maintain customers.

"When the power's out, a landline phone connection will work more than 99.9 percent of the time," says a TDS Telecom website. "It's required by the FCC. This means you can still reach 911 and friends

and family; they can all reach you, too. Even if a major storm (tornado or hurricane) comes through the area. It might take out the cell tower, but it can't take out the underground phone lines."

In other words, during a power outage, cell phone towers will exhaust their battery power within a matter of hours, while landlines will work for well over a week, maybe more (depending on the ability of the phone company to keep its generators running).

http://www.offthegridnews.com/how-to-2/landlines-the-dinosaur-phone-technology-that-could-save-you-in-a-crisis/

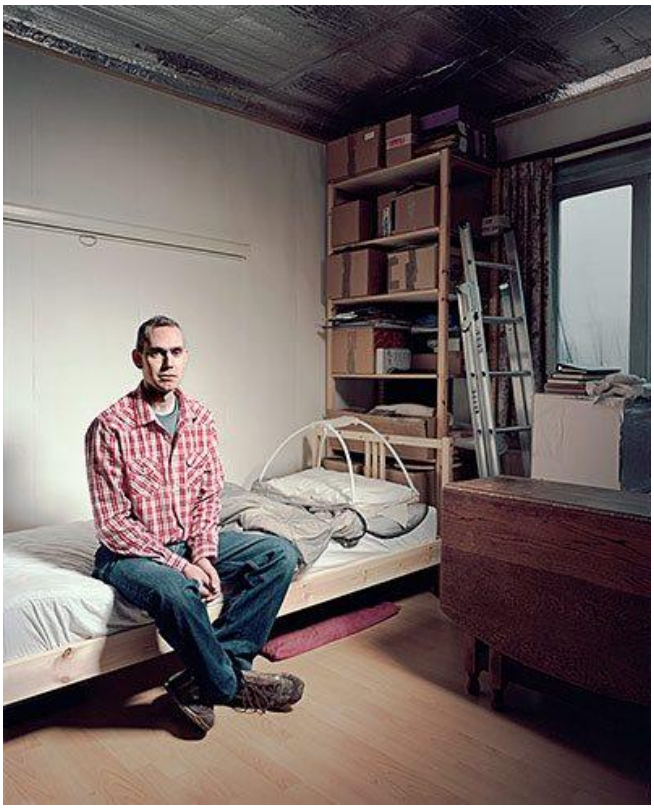
Electromagnetic Hypersensitivity

Electrosensitivity: is technology killing us?

Is modern life making us ill? Yes, say those who suffer from electrosensitivity. Are they cranks, or should we all be throwing away our mobile phones?

Tim Hallam, Leamington Spa

Tim is a science and history of art graduate from Cambridge University. He has insulated his bedroom and has fitted foil on the walls, under the floor and on the ceiling. He sleeps in a custom-made silver-coated sleeping bag every night, which helps block out electromagnetic fields. Tim can't work in an office environment and the condition has severely impacted his career aspirations. He currently drives a supermarket delivery van. 'Where I'm living now, it's not a great situation,' he says. 'I'm lucky that the shielding worked to a large degree. But I would love to live somewhere I didn't have to live in a metal box and sleep in a bag, where I could go to a cafe and see my friends, go to the cinema – all those things that people take for granted.'



Damian May, Reading

Damian is a cabinet maker and runs a property-maintenance business. He discovered he suffered from electrosensitivity after buying a Nintendo Wii for his family for Christmas. It triggered severe headaches and body pains. His electrosensitivity has made it very difficult for him to run his company, because he finds it painful to work in areas with Wi-Fi or mobile phones. He has turned off everything wireless in his home, has insulated his office and is campaigning to have Wi-Fi removed from his son's school.

Eileen O'Connor, Merseyside

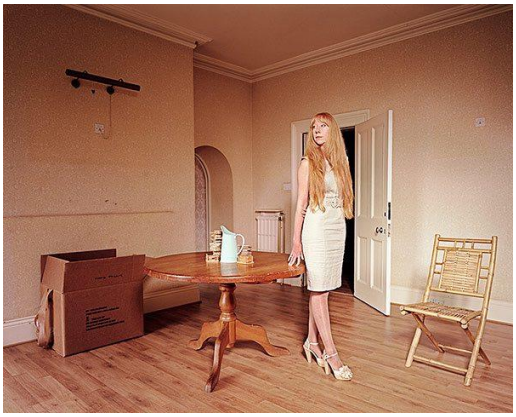
Eileen lived 100m from a mobile phone mast for many years in Wishaw. She experienced many symptoms typical of electrosensitivity, but could not work out the cause. When she was diagnosed with breast cancer aged 38 and discovered that a number of her neighbors had similar symptoms and cancers, she became part of a very public campaign to have the mast removed. She is a director for The Radiation Research Trust charity and works with the International EMF Alliance. 'It's heartbreaking to see people who are not getting support at the family,' she says. 'It's awful. It's a double insult, really – not only are you suffering with this terrible condition, but then you've got people who think you're going crazy at the same time.'

Chris McKenzie, Cumbria

In 2008, when Chris moved into his own flat, he quickly became ill and suffered headaches, body pains and insomnia. He attributed this to exposure to Wi-Fi, which he had never lived with before. His family found it hard to understand the condition, especially when he wore a tin foil hat at home and stopped work as a stone mason. His mother sent him to a psychologist for help, and he was placed on heavy medication and sent to a psychiatric ward against his will. 'There were questions coming everywhere, they were putting words into my mouth. They were saying, "You know this isn't real, don't you?" I got dragged away to a psychiatric ward with people who have serious mental conditions.' He sought help from the charity Electrosensitivity UK and was later released. He now lives on his own and has made various attempts to shield his home from electromagnetic fields with carbon paint and aluminum foil.

Doctor Erica Mallery-Blythe, Lincolnshire

Erica worked as an emergency medical doctor for 12 years in trauma rooms across the UK and abroad. In 2008 she became interested in radiation research and is now a medical advisor for the charity Electrosensitivity UK. She advises EHS sufferers on how to improve their health, and in serious cases has given refuge at her rural home to people needing to escape their home environments. 'It's very uncharted territory in terms of what exactly EHS is, and how many people it's affected. My own personal instinct is just like with so many other things we see in life, it's a bit of a bell-shaped curve. You've got some people who show almost no reaction whatsoever to an EMF challenge, and others you would say have EHS, who are at the other side of that curve, and their life is utterly turned upside down by it, given the modern world. Most people will probably fall somewhere in between.'



Clare Woodward, Devon

Clare worked as a computer programmer for nine years and then retrained as a complementary therapist. When her family moved into a new house in Devon, she began suffering from insomnia and heart palpitations, which she attributed to a mobile phone and Tetra* mast very close by. They have since insulated their home at great expense with carbon paint and specialist windows.

**Tetra - Terrestrial Trunked Radio – is a powerful two-way radio system primarily used by the emergency services*

Hannah Metcalfe, Kent

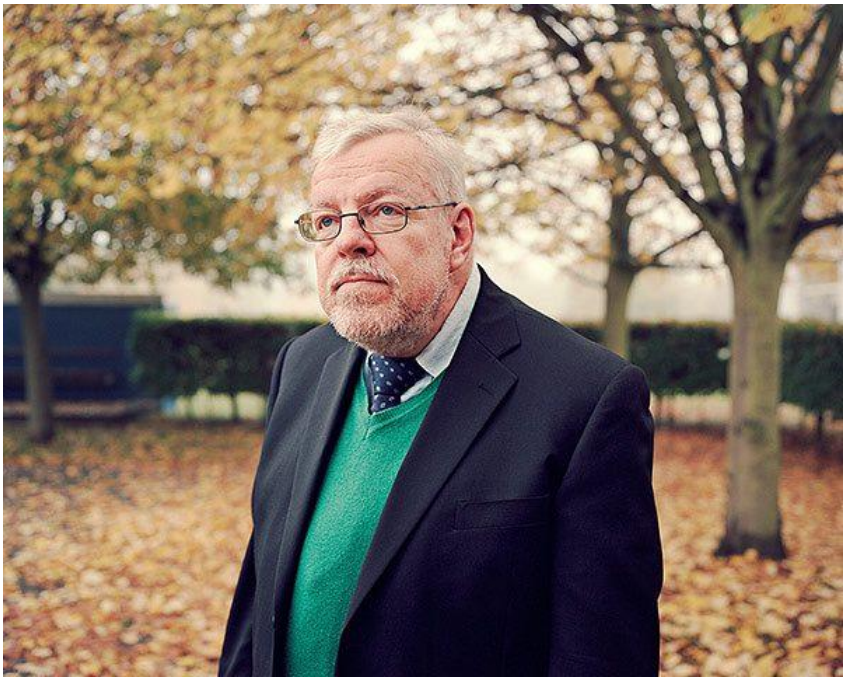
Hannah suffered from psoriasis as a child and started sun bed treatment at the age of nine to help clear up her skin. In her late 20s, she started developing severe migraines and fatigue when working in offices with fluorescent lights. She always felt discomfort when using a mobile phone. The severity of her symptoms got worse when she later discovered a sensitivity to Wi-Fi. She gave up her job as a trainee criminal solicitor in 2010 and now lives with her husband and two children on a farm in Kent. 'When I realized that Wi-Fi was making me ill, I also turned off the digital phone, so [there] was nothing wireless in the house. I went from feeling like this sluggish person to feeling so vibrant and alive, with so much energy. It's just amazing to feel well.'

Freda Thornhill, retired teacher
Freda's first symptoms of electrosensitivity began in 1999 while using computers and CRT monitors at school. The condition became so severe that she had to give up her job. She is now also affected by mobile phones and Wi-Fi, and spends extended periods of time away in her 'lifeboat van' so she can escape the electromagnetic fields at home.

Jenny Layton, Devon
When she developed unexplained headaches, tinnitus, heart palpitations and insomnia, she and her GPs were at a loss as to the cause. After months of research, she finally attributed her symptoms to a new neighbor who had set up Wi-Fi next door.

Michelle Berriedale-Johnson, London
Michelle has run a series of magazines and websites for 20 years, covering issues related to food allergy and intolerance. Her electrosensitivity began after heavy use of mobile phones and CRT computer monitors for work. She is now also affected by Wi-Fi and has insulated much of her home. She is photographed wearing a jacket made from a silver-coated material that reduces the strength of electromagnetic fields.

Professor Olle Johansson, department of neuroscience, Karolinska Institute, Sweden
'From the very beginning, it was said that this was just a post-menopausal problem in women. Then men started to report electro hypersensitivity, and the self-proclaimed experts said it's actually only elderly [people], because they are afraid of new technology. We then started to get children and teenagers and young people, and they rolled out a new explanation, which was that it's actually people with higher education. And it went on like this. But today you can see that any political color, any income class, both sexes, all age groups, are affected.'



Raphael Cuesto, London

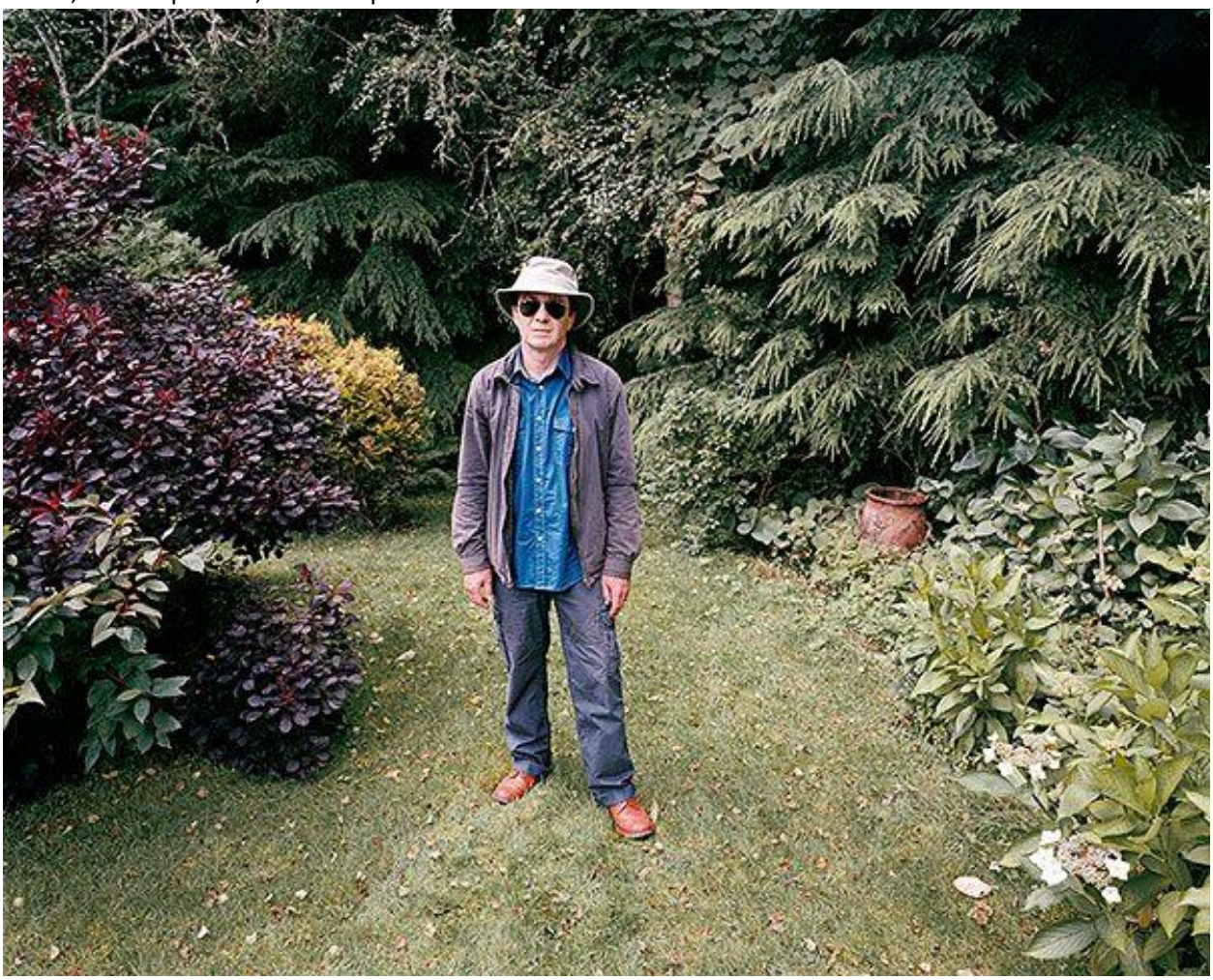
In 2004, while working for a telecommunications company in Kuala Lumpur, Raphael noticed that he was developing pains in his arms and hands every time he worked on his laptop. His symptoms got worse and he began getting headaches and heart palpitations when using his mobile for only a few minutes, and this progressed to almost immediate pain when he brought the phone near his head. He decided to stop using his mobile altogether and left his job. He is now a teacher. 'When you spend a minute on the phone and get palpitations, you know you have to do something about it. I remember one day turning [over] a piece of paper and writing in the middle of the page, "Jobs without a mobile phone." I had to change everything.'

Ray Parsons, Weston-Super-Mare, retired joiner

When Ray started developing severe fatigue and body pains in his late 40s, he initially thought he had developed ME. After eight years of analyzing his symptoms, he concluded that he was, in fact, suffering from electrosensitivity. He is photographed in his sitting room, where he has fitted a silver-coated netting over the window that reduces the strength of electromagnetic fields.

Steve Miller, Cornwall

Steve is a successful record producer. His electrosensitivity to Wi-Fi and mobile phones has forced him radically to change his lifestyle and to give up touring almost entirely. 'I went to see a friend in Falmouth and he's surrounded by student flats and Wi-Fi coming in from all directions. I put up with it for a while because I thought, 'I'm being rude, there's something other than this, something's wrong with me'. By the time I actually managed to leave, I staggered out of the building, couldn't drive for an hour – I didn't feel safe to drive – and then felt rotten for next two days. It was at that point I spoke to a GP about it and he said you're probably electrosensitive to pulsed microwave radiation, which is, wireless, phone masts, mobile phones, cordless phones.'



https://www.theguardian.com/society/gallery/2013/mar/29/electrosensitivity-technology-killing-us-photographs

Electromagnetic Hypersensitivity: Evidence For A Novel Neurological Syndrome

ABSTRACT

Objective: We sought direct evidence that acute exposure to environmental-strength electromagnetic fields could induce somatic reactions (EMF hypersensitivity).

Methods: The subject, a female physician self-diagnosed with EMF hypersensitivity, was exposed to an average (over the head) 60-Hz electric field of 300 V/m (comparable to typical environmental-strength EMFs) during controlled provocation and behavioral studies.

Results: In a double-blinded EMF provocation procedure specifically designed to minimize unintentional sensory cues, the subject developed temporal pain, headache, muscle-twitching, and skipped heartbeats within 100 s after initiation of EMF exposure ($P < 0.05$). The symptoms were caused primarily by field transitions (off-on, on-off) rather than the presence of the field, as assessed by comparing the frequency and severity of the effects of pulsed and continuous fields in relation to sham exposure. The subject had no conscious perception of the field as judged by her inability to report its presence more often than in the sham control.

Discussion: The subject demonstrated statistically reliable somatic reactions in response to exposure to subliminal EMFs under conditions that reasonably excluded a causative role for psychological processes.

Conclusion: EMF hypersensitivity can occur as a bona fide environmentally-inducible neurological syndrome.

DISCUSSION

Appropriately controlled provocation studies are required to establish the existence of EMF hypersensitivity and to understand the relative importance of psychological and nonpsychological processes in mediating any observed symptoms. A working laboratory definition of EMF hypersensitivity formulated in symptomological terms is therefore needed to permit recognition of hypersensitivity reactions when they occur. In previous provocation studies the assumption was made that true hypersensitive subjects would exhibit more or less the same symptoms in response to repeated provocations. The assumption led to experimental designs that involved averaging across exposed and control groups, which is an inherently insensitive statistical procedure for detecting real but variable responses [3, 4]. The assumption is particularly inapplicable to EMF hypersensitivity because intra- and inter-subject variability are its salient features [1, 2]. We defined EMF hypersensitivity as the occurrence of any medically recognized symptom in response to provocation using an environmentally relevant EMF; there was no requirement that the same symptom must reoccur when the EMF provocation was repeated. This definition avoided the problem of masking real effects and more appropriately matched the laboratory procedure to the known characteristics of EMF hypersensitivity [1, 2]. We focused on a single self-reported subject and employed a procedure in which she served as her own control. While controlling for artifacts, chance, and somatization, the question whether she reliably exhibited any symptomatic responses to an EMF was addressed; the alternative hypothesis was that she did not exhibit EMF-triggered symptoms. The laboratory conditions were controlled in such a way that a putative role of psychological processes could reasonably be identified. The subject developed symptoms in association with the presentation of a pulsed electric field significantly ($P < 0.05$) more often than could reasonably be explained on the basis of chance (Table 3). Several considerations

suggested that the statistical link was a true causal association with a subliminal EMF. First, the subject's environment was carefully controlled to avoid putative confounding factors. The testing took place in an acoustically quiet environment and the presence of uncontrolled environmental EMFs was nil. The environmental conditions during the field-exposure and shamexposure intervals were identical except that during the sham-exposure intervals, at a point far removed form the subject's field of view, the wires carrying the plate voltage were disconnected. A key aspect of our laboratory procedure was the elimination of sensory cues that could serve as conscious markers of the electric field leading to a somatization reaction. All appropriate precautions were taken to eliminate potential confounders. Second, the occurrence of symptoms was significantly associated with the type of EMF (Table 4). The symptomatic response was associated with the pulsed EMF, which maximized occurrence of the number of transient changes in the EMF (off-on and on-off), not with the presence of the field, as expected on the basis of prior animal studies where the issue of somatization was irrelevant [9]. Finally, in a behavioral study specifically designed to assess awareness of the field, yes response rates were 8.7% and 9.9% in the field and sham conditions, respectively, which provided no evidence for a psychological role in the development of the subject's symptoms. We therefore conclude with a reasonable level of certainty that the causal association we found between the presence of the EMF and the subject's symptoms was mediated by a subconscious neural process. Although chance was an unlikely explanation for the association, that possibility could not be excluded. The existence of the neurological syndrome reported here was previously suspected, but not documented. The mechanism for the subject's symptoms of headache, visual disturbances, and somatic musculoskeletal discomfort following exposure to EMFs is unknown. Based on clinical evaluation, intermittent seizure activity is not a credible explanation, although a deeper epileptic focus with partial seizure activity may have escaped the detection of surface EEG electrodes. The abnormal findings in the subject's medical workup included the abnormal MR image (cortical dysplasia and polygyric changes) and extensive sleep discontinuity and fragmentation manifested in the overnight polysomnogram; the possible association of these findings with the subject's syndrome of EMF hypersensitivity is unknown. Our aim here was to concentrate on the previously unaddressed question whether acute exposure to weak EMF could produce real but not precisely predictable somatic effects mediated by nonpsychological processes. Within the limitations of the study we concluded that we demonstrated the neurological syndrome in the subject we studied. The question of whether EMF hypersensitivity is a significant public-health problem was not addressed here. The EMF we employed was equivalent in strength and pulse structure to EMFs pervasively present in the environment [1, 2], and our results were consistent with the possibility that environmental EMFs can directly trigger clinical symptoms. Nevertheless resolution of the public-health issue depends on a deeper understanding of how internal EMFs caused by environmental EMFs are related to physiological process, and of the role of psychological factors and co-morbidities in the exposed population in exacerbating the processes resulting in disease.

http://electromagnetichealth.org/wp-content/uploads/2011/08/McCarty_Marino_2011_EMF_ES__neurological_syndrome_Int_J_Neurosci_July.pdf

Electromagnetic Field Sensitivity

Abstract

A multiphase study was performed to find an effective method to evaluate electromagnetic field (EMF) sensitivity of patients. The first phase developed criteria for controlled testing using an environment low in chemical, particulate, and EMF pollution. Monitoring devices were used in an effort to ensure that extraneous EMF would not interfere with the tests. A second phase involved a single-blind challenge of 100 patients who complained of EMF sensitivity to a series of fields ranging from 0 to 5 MHz in frequency, plus 5 blank challenges. Twenty-five patients were found who were sensitive to the fields, but did not react to the blanks. These were compared in the third phase to 25 healthy naive volunteer controls. None of the volunteers reacted to any challenge, active or blank, but 16 of the EMF-sensitive patients (64%) had positive signs and symptoms scores, plus autonomic nervous system changes. In the fourth phase, the 16 EMF-sensitive patients wer rechallengd twice to the frequencies to which they were most sensitive during the previous challenge. The active frequency was found to be positive in 100% of the challenges, while all of the placebo tests were negative. We concluded that this study gives strong evidence that electromagnetic field sensitivity exists, and can be elicited under environmentally controlled conditions.

Introduction

Interaction mechanisms that underlie the health and biological effects of electromagnetic fields (EMF) on humans have been studied by many authors.1,2,3,4,5,6 This subject was reviewed recently at the 1990 spring meeting of the American Physical Society .7 Choy et. al.8 investigated individuals with multiple sensitivities who reported reactions to various types of electrical equipment, including power lines, electronic office equipment such as typewriters and computer terminals, video display terminals, household appliances (such as hair dryers), and fluorescent lights.

This paper presents preliminary data on electromagnetic field tests using a square wave generator to evaluate the EMF sensitivity of patients reporting such sensitivities under environmentally controlled and monitored conditions.

Results

Phase I. The EMF measurements were quite reproducible. We found that the lights. and air handling equipment had to be off during the tests because of their electromagnetic field output. Baseline studies on patients were completed without remarkable result.

Phase II. Of the total of 100 patients tested in the single-blind study, 50 reacted to several of the placebos in addition to the active challenges, and were excluded from further study. Twenty-five subjects who did not react to any active challenges were also excluded. A final 25 subjects who did react to active challenges, but not to blanks, were selected for the third phase of the study (Table 1).

Phase III. The 25 subjects selected from phase II were rechallenqed, and 16 (64%) reacted positively to the active challenges. The total number of positive reactions to the 336 active challenges in the 16 patients was 179 (53%), as compared to 6 positive reactions out of 60 blanks (7.5%). There were no reactions to any challenge, active or placebo, in the volunteer group of naive subjects (Table 2).

When evaluating frequency response, 75% of the 16 patients reacted to 1 Hz, 75% to 2.5 Hz, 69% to 5 Hz, 69 % to 10 Hz, 69% to 20 Hz, and 69% to 10 KHz (Table 3). No patient reacted to all 21 of the active frequencies in the challenges. The average was 11 reactive frequencies per patient, with a range of 1 to 19 positive responses.

The principal signs and symptoms produced were neurological (tingling, sleepiness, headache, dizziness, unconsciousness), musculoskeletal (pain, tightness, spasm, fibrillation), cardiovascular (palpitation, flushing, tachycardia, edema), oral/respiratory (pressure in earss tooth pains, tightness in chest, dyspnea), gastrointestinal (nausea, belching), ocular (burning), and dermal (itching, burning5 prickling pain) (Table 4). Most reactions were neurological.

Phase IV. In the 16 patients again rechallenged in a double-blind manner, using only the single frequency to which they were most sensitive, all reported reactions to the active frequencies when challenged. None reacted to the placebos (Table 5). Signs and symptoms in all 16 patients were positive as was the autonomic nervous system dysfunction, as measured by the iriscorder (Table 6, Figure 1). Examples of changes were a 20% decrease in pulmonary function and a 40% increase in heart rate. In the 16 patients with positive reactions to EMF challenges, two had delayed reactions; gradually became depressed and finally became unconscious. Eventually, they awoke without treatment. Symptoms lasted from 5 hours to 3 days.

Discussion

Since it has been found that electromagnetic fields can affect health, researchers have investigated these phenomena in vivo and in vitro, in animals10,11,12 and humans.1,2,3,4,5,6,7 No individual had been specifically challenged in an attempt to reproduce acute symptoms until Smith and Monro5 followed by Choy, Monro, and Smith,8 who used a series of oscillators of varying frequency to trigger symptoms in electrically sensitive patients. We modified this procedure by developing controlled environmental area, where baselines were constantly monitored for particulates, pollutants, and extraneous fields. Here, controlled EMF output was applied so that data would be more reproducible.

Several factors have led us to believe that we have reproducible results. Meticulous construction of environmental rooms made a great difference in the reproducibility of test results. Prior to the use of such facilities and careful monitoring, a variety of factors, such as diet, exposure to chemicals, EMF, or dust gave rise to symptoms which would have been mistaken for placebo reactions. Such effects were minimized here, as evidenced by the sinail number of placebo reactions. A few patients reacted to the tields generated by the monitoring devices (Iriscorder, EKG, and computers) and had to be dropped from the study as too fragile for accurate analysis. Some patients reacted to the fields generated by the fluorescent lights, and others did not present the same signs and symptoms at each challenge, even though the reactions were significant when contrasted with the blank responses. The Iriscorder data were objective, however, and were always reproducible (Figure 1).

We also noted that patients sometimes had delayed or prolonged responses. Therefore, care had to be taken to be certain that the patient had returned to baseline before the next challenge. This carry-over was first noted when evaluating responses to placebo challenges. Such a response could usually be explained and eliminated by use of longer intervals between challenges.

In this study, of the 100 patients who expressed suspicion of EMF sensitivity, 75 actually responded to fields, whereas none of the controls did. Of the 75, 25 had no reactions to blanks, whereas 50 did, and

thus were discarded from the study; even though we felt that some of the reactions to blanks might be evidence of delayed reaction to previous frequencies, or prolonged response to the previous positive challenge, as well as true placebo reactions.

We learned that challenge with 21 frequencies was impossible on many sensitive patients. They were often unwell for several hours or days, which confused the data from repeat challenges on subsequent days. Hence, we selected the one frequency of maximum sensitivity for repeat challenges in the phase IV studies.

When one compares the various groups to controls, it is clear that there is a group of patients who have unstable response systems which appear different from those of the individuals who acted as controls. These studies show that EMF sensitivity could be elicited under environmentally controlled conditions. As a result of the weak field levels and short exposure time, the responses were mild except in two patients whose symptoms were so severe (e.g., drop attack, severe itching) that they received intravenous vitamin C, magnesium, and oxygen as a result of the prolonged and delayed reactions.

Signs and symptoms appeared similar to those seen in food or chemically sensitive patients at the Environmental Health Center-Dallas, and included neurological, musculoskeletal, cardiovascular, respiratory, gastrointestinal, dermal, and ocular changes. The neurological symptoms were most comon. Similar responses have been recorded by others in the literature.5,6,7,6,13,14 In 1972, after the Soviets reported that electrical utility workers were suffering from listlessness, fatigue, and nausea, Subrohmangam and coworkers13 investigated and reported decisive changes in cardiac function and bioamine levels when pulses of 0.01 and 0.1 Hz were used. They found significant changes in the hypothalamus in response to the EMF fields.

In these studies, the preponderance of reactions occurred at one to 10 Hz, which accords well with their observations. However, many reactions also occurred at 50 and 60 Hz, as well as some up to 5 MHz. We conclude that in any given individual susceptibility may develop to any frequency and produce reactions.

Static magnetic fields are known to cause increased blood pressure on some individuals.14 Choy and coworkers8 found that EMF reactions in EMF sensitive patients were not limited to the nervous system, but occurred in the same systems as in these studies, which basically corroborate theirs, though neurological symptoms predominated in our experiments.

Over the past 30 years, numerous investigations with animals and a few epidemiological studies of human populations have been devoted to assessing the relationship of microwave exposure to cataract development. The severity and speed of formation depends not only on intensity, but also on wavelength and duration of exposure.16-21 McCally et al.22 reported damage to corneal epithelium in Cynomolgus monkeys after 2.45 GHz irradiation for 6everal hours at only 20-30 mW/cm^2 (CW) or even 10-15 mW/cm^2 with pulsed fields. Therefore, the results of Paz23 strongly suggests that the potential for eye injury exists in surgery where EMF fields are present.

In our experience, the patients' clinical responses could not always be reproduced completely, but the objective Iriscorder, EKG, and respirometer could be. However, the responses were definitely different from controls or placebo challenges. In our experience over the years, we have found partial reproduction of symptoms on repeat challenge to be as significant as total reproduction. Therefore, significant differences from controls in objective ineasurementa were deemed valid.

There are several explanations for lack of exact reproducibility. These are the following: (a) the patients total body loads were different at different exposure periods. For example, some patients may only respond to EMF when in a reactive hypersensitive state;5,8 (b) tissue resistance could influence the effect of the EMF. Zimerman24 reported that electrical resistance of skin decreased with increasing temperature and increased with progressive drying, as might be expected; (c) injections of antigen neutralizing substances prior to test may have reduced the response to EMF. One patient with asthma was sensitive to high voltage power lines a well as low voltage house wiring. He experienced muscle spasms in head, neck, arms, and legs. This patient was also sensitive to dust, weeds, dust mites, and some foods. He reacted in our tests to 2.5 and 60 Hz and to 5 and 50 KHZ with tightness in the chest. He then received an antigen shot to neutralize his hypersensitivity reactions. Five months later, he was unreactive to EMF; (d) weather changes might affect the results, since we know that the weather can influence the propagation of EMF, as may alterations in the geomagnetic fields. Since humidity, pollution, temperature, etc. can affect resistance and total body load, weather should perhaps affect the results. Adverse weather (inversions, for example) may increase pollution load, while good weather lessens it. There is some evidence of resonance between geomagnetic fields and an applied ac magnetic field,25 which implies that the results may depend in part at least upon the strength and orientation of the geomagnetic field in the test area; and (e) different wave forms might cause different responses. In these experiments, we used only square wave inputs to the coils. Consequently, we do not know whether other wave forms (sine, sawtooth, triangular, etc.) might induce different types or intensities of reactions.

Thus far, definitive information has not been sufficient to identify a plausible mechanism for EMF interactions with biological tissue. Interactions appear to take place at the cell surface, perhaps acting on receptor sites and altering ion and molecular transport across the membranes.25 Further work remains to be done in the field.

It is clear that EMF sensitivity is a real phenomenon in some environmentally sensitive patients, because some had consistent reactions while none of the controls did. This study must be considered as only preliminary, but the evidence clearly points to sensitivity in some people.

In conclusion, it is evident that EMF testing is at a rudimentary stage; but clearly EMF sensitivity exists and can be elicited under environmentally controlled conditions. Further studies are needed to investigate the effects of EMF fields on human health.

http://www.aehf.com/articles/em_sensitive.html

Science: Plant and Animal Electromagnetic Sensitivity

Introduction

- **Animal Electromagnetic Sensitivity long known:**
  Animal sensitivity to electromagnetic exposure has been known as long as human electromagnetic sensitivity. The biological effects of the electric eel were known in ancient times. From the 17th century scientists studied how electricity and magnetism affected both animals and humans. Many modern studies depend on animal or plant research to establish biological pathways before moving on to human studies to verify low-level effects of electromagnetic exposure.
- **Animal and plants do not experience Electrophobia:**
  One great advantage of animal and plant studies is that there is no likelihood of confusion between real Electromagnetic Sensitivity and psychological Electrophobia, since animals and plants cannot be conditioned by a cognitive, as opposed to a behaviorally conditioned fear, and cannot therefore suffer from a 'Nocebo' effect, although anyway studies show that the 'Nocebo' effect is not part of real human Electromagnetic Sensitivity.

Plant Electromagnetic Sensitivity

The electromagnetic sensitivity of plants is now well established. It is used in many aspects of horticulture and agriculture. Since many biological electromagnetic effects have 'windows' or bands of effects, and these effects can be opposite to those of other 'windows', care is needed to apply the appropriate frequency.

A school experiment on the growth of cress under Wi-Fi and non-Wi-Fi conditions became international news.

- Daniel Bean: "Can Wi-Fi Signals Stunt Plant Growth?" (ANC News, 2013)

The increase in fungus and viral attacks on different species of trees has been linked with reduced immune systems because of man-made electromagnetic pollution, as has reduced anthocyanin production.

- Katie Haggerty (2010) "Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings: Preliminary Observations" (Int J Forestry Res. 2010)
- Dan Nosowitz: "Wi-Fi Radiation is killing trees, new study finds" (Popular Science, 2010)
- René Schoemaker: "Study finds Wi-Fi makes trees sick" (Macworld, 2010)

Trees near cellphone towers show increased disease, starting on the side closest to the tower. Experts say that cellphone towers should be banned because of the damage they are causing to nearby trees.

- Waldmann-Selsam C et al: "Tree damage in the vicinity of mobile phone base stations" (Umwelt-medizin-gesellschaft. 2013; trans.)

- Waldmann-Selsam C et al: "Radiofrequency radiation injures trees around mobile phone base stations" (Sci Total Environ., 2016)
- Waldmann-Selsam C et al: "Trees in Bamberg and Hallstadt in the radiation field of 65 mobile phone base stations: Examples from a documentation about 700 trees (2006-2016)" (Sci Total Environ. 2016)

The effects are specific to types of plants, parts of plants, and exposures. Wi-Fi may be particularly harmful to some plants.

- Grémiaux A et al: "Low-amplitude, high-frequency electromagnetic field exposure causes delayed and reduced growth in Rosa hybrid" (J Plant Physiol., 2016)
- Soran ML et al: "Influence of microwave frequency electromagnetic radiation on terpene emission and content in aromatic plants" (J Plant Physiol., 2014)
- Stefi AL et al: "The effect of the non ionizing radiation on cultivated plants ofArabidopsis thaliana (Col.)" (Flora, 2016)

About 90% of studies on cellphone radiation on plants show physiological changes:

- Halgamuge MN: "Review: Weak radiofrequency radiation exposure from mobile phone radiation on plants" (Electromagn Biol Med., 2016)

Plants' environmental sensitivity, memory and cognitive control:

Plants show the ability to learn behaviors from sensitivity to electromagnetic and other environment factors, even though they lack an animal's nervous system, suggesting that pathways like calcium-based regulation can include memory and drive cognitive processes based on a variety of stress sensitivities. As with humans, not all plants display this learnt behavior by association, with about 60% responding and 40% not responding. The metabolic state of the plant and electromagnetic cues from visible light are also significant, with learnt behavior occurring according to the internal circadian rhythm mainly in subjective day. Epigenetic mechanisms help with transcriptional regulation to build systemic acquired resistance at distant sites.

- Baluška F et al.: "On Having No Head: Cognition throughout Biological Systems" (Front Psychol., 2016)
- Crisp PA et al.: "Reconsidering plant memory: Intersections between stress recovery, RNA turnover, and epigenetics" (Sci Adv., 2016)
- Dener E et al.: "Pea Plants Show Risk Sensitivity" (Curr Biol., 2016)

- Espinas NA et al.: "Epigenetic Control of Defense Signaling and Priming in Plants" (Front Plant Sci., 2016)
- Gagliano M et al.: "Experience teaches plants to learn faster and forget slower in environments where it matters" (Oecologia, 2014)
- Gagliano M et al.: "Learning by Association in Plants" (Sci Rep., 2016)

Insect Electromagnetic Sensitivity

It is well established that some insects are especially electrosensitive, including bees and ants.

- Cammaerts MC: "Is electromagnetism one of the causes of the CCD? A work plan for testing this hypothesis" (2017)
- Cammaerts MC et al.: "GSM 900 MHz radiation inhibits ants' association between food sites and encountered cues" (2012)
- Cammaerts MC et al.: "Food collection and response to pheromones in an ant species exposed to electromagnetic radiation" (2013)
- Favre D: "Mobile phone-induced honeybee worker piping" (2011)
- Gould JL et al.: "Orientation of Demagnetized Bees" (1980)
- Panagopoulos D et al: "Effect of GSM 900-MHz Mobile Phone Radiation on the Reproductive Capacity of Drosophila melanogaster" (2004)
- Sharma VP et al.: "Changes in honey bee behaviour and biology under the influence of cell phone radiations" (2010)

Animal Electromagnetic Sensitivity

This is now well established for a wide range of biological conditions.

- Geomagnetic effects

bird and animal migration (Kishkinev DA e al, 2014)

nest-building (Malkemper EP et al, (2015)

animal orientation and location in:
bats (Tian LX et al, 2015)
cattle and deer (Begall S et al, 2008)

dogs (Hart V et al, 2013)

fish (Takebe A et al, 2012)

lizards (Diego-Rasilla FJ et al, 2017)

- Pre-Seismic Eelectromagnetic Sensitivity:

  Sensitivity to pre-seismic changes in the electromagnetic environment, especially if transmitted through water, either sea water or water on land, appears to correlate with established effect before earthquakes on a variety of animals.

  In 373 BCE, animals including rats, weasels and snakes left the Greek city of Helice before an earthquake and tsunami:
  "For five days before Helike disappeared, all the mice and martens and snakes and centipedes and beetles and every other creature of that kind in the city left in a body by the road that leads to Keryneia." [quinque enim diebus priusquam pessum iret Helice, omnes in ea mures, mustelae, serpentes, scolopendrae verticilli, et alia hujusmodi animalia, magnis copiis exibat per viam, quae ducit Coriam] (Claudius Aelianus, *De Natura Animalium*, XI.19)

  Before the February 4 1975 earthquake at Haicheng, China, there were reports of anomalous animal behaviour, including among animals such as rats, snakes appearing frozen on roads, cows and horses becoming restless and agitated, rats appearing drunk, chickens refusing to enter their coops and geese frequently taking flight (Adams RD, 1976; Anon., 1977)

  Since 2000 many studies have suggested that animals are sensitive to the electromagnetic changes before earthquakes.

  In 2003 Dr Kiyoshi Shimamura in Japan reported a jump in dog bites and other dog-related complaints before and after earthquakes. He examined records of complaints from public health centres affected by the 1995 earthquake in Kobe and found that accounts of dogs barking "excessively" went up by 18% on average in the months before the earthquake. Above the epicentre on Awaji Island, there was a 60% increase in complaints compared with a year earlier. (Alok Jha: "Can dogs really predict earthquakes?" Guardian, October 2 2003)

  Another study concerned toads at L'Aquila, Italy, in 2009. Since then studies have included anomalous behaviors in many other animals, including ants, cows, pets such as cats and dogs, and milk yields in cows 340 km from the subsequent epicenter.

  Ceteceans, such as whales and dolphins, show, through mass beachings, sensitivity to changes in electromagnetic energy, probably including geomagnetic changes before earthquakes:
  Klinowska M: "Cetacean live stranding sites relate to geomagnetic topography" 1985

  "It is my observation, confirmed over the years, that mass suicides of whales and dolphins that occur sporadically all over the world, are in someway related to change and disturbances in the electromagnetic field coordinates and possible realignments of geotectonic plates thereof."
  Dr Arunachalam Kumar, professor of anatomy, Kasturba Medical College, Mangalore,

Karnataka, India,
December 4 2004 (Michael McCarthy: "Did whale beaching foretell disaster?" February 2 2005)

Toads may show sensitivity to changes in electromagnetic energy through changes in breeding patterns before earthquakes:

"Our study is one of the first to document animal behaviour before, during and after an earthquake, It was a serendipitous thing that happened. One day there were no toads. I was actually very annoyed. I thought my research was all going down the drain. And the earthquake happened, and then they all started coming back the day after."
Rachel Grant, Open University, Milton Keynes, England, 2011

Common toads (Bufo bufo) showed a dramatic change in behaviour five days before an earthquake shook L'Aquila, Italy in April 2009. Grant and her colleague found the toads abandoning spawning days before the shaking started. She has been studying frog reproduction during the lunar cycle for four years, and was at a site 74 km from the epicentre of the quake with her assistant between the new moons of March and April. This meant they were watching the 'seismic toads' before, during, and after the magnitude 6.3 event. Male toads usually stay at the breeding sites until spawning is complete, but 96% them abandoned the pool five days before the quake and numbers remained low until 10 days afterwards. The number of amplexed pairs—where males grasp females tightly with their arms—declined to zero just three days before the earthquake and stayed low until the last aftershock.
(Janet Fang: "Toads 'predict earthquakes'" Nature.com, March 31 2010)

One suggested mechanism is ionization of the air at the ground-to-air interface where positive airborne ions cause changes in stress hormone levels in animals and humans. Another mechanism is the electric field and current induced in the animal as it passes through the magnetic field, or where a change in the magnetic field induces an electric field in the organism. It has been shown that magnetic fields of below 10 nT, well below the Earth's background magnetic field, can induce these currents and thus cause biological effects in sensitive animals. Some relevant studies:
Kirschvink JL, 1982; Klinowska M, 1985; Kirschvink JL, 2000; Grant RA et al, 2011; Berberich G et al, 2013; Freund FT et al, 2013; Fidani C et al, 2014; Yamauchi H et al, 2014

- Disturbance of natural electromagnetic environment:

ants' foraging and avoidance nest location (Cammaerts MC et al, 2012) (Cammaerts MC et al, 2014)m

bee foraging and failure to return to hive, perhaps related to colony collapse disorder (Liang CH et al, 2016).

birds unable to adapt to RF fields (Wiltschko R et al, 2015).

mice nesting show clockwise shift (Malkemper EP et al, 2015).

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- Biological Mechanisms:

Most of the mechanisms and pathways established for human Electromagnetic Sensitivity were first shown for animals such as rats and mice (see: Science - Mechanisms)

Bees detect electric fields using mechanosensory hairs (Sutton GP et al, 2016)

Two different magneto-reception systems have been proposed for bird and fish navigation:

- bio-magnetite

- cryptochromes

- or possibly MagR, a protein combining both (Cyranoski D, 2015)

Marine sensitivity

The latest studies indicate that much marine life is sensitive to man-made electrical and sonar pollution.

1. There are three main sources:

(a) Cathodic currents used to slow marine corrosion on metal hulls of ships, pipe-lines, oil platform rigs, marine wind turbine installations, floating platforms.
(b) Microwave pulsed microwave radiation from ship and shore radar and communications.
(c) Sonar detection from military and fishing ships.

2. The effects on marine life include the following.

(a) Coral reef corrosion or oxidation, where calcium (a mineral or metal) carbonate structures are especially affected.
(b) Fish and cetaceans, which can be overheated by, for instance, lock-on radar systems.
(c) Fish and cetaceans, which can be adversely and cumulatively affected by low-level electrical currents induced by radar and radio frequency transmissions,
(d) Divers if not wearing dry suits, where approaching within 3,000 feet of a ship can cause cardiac arrest.

- Jeff Centaurid: "On the brink radio, no.178: Stewart Simonson (3) 'Marine electrification scenario'" (SoundCloud, November 10 2016, 59 minutes)
- Chris D'Angelo: "26 Countries Gather In Hawaii For Massive War Game" (Huffington Post, June 28 2016)

- Jessica Else: "Military and Marine Life: PMRF, researchers meet to discuss possible effects of base's activity on coral, other sea life" (The Garden Island, April 3 2016)
- Jim Mendoza: "Military exercises in Pearl Harbor may impact garage doors" (Hawaii News Now, 2014)
- Stewart Simonson "Evidence for increased coral bleaching and disease from accelerated marine corrosion due to electromagnetic pollution and induced stray electrical currents in seawater" (2015)
- Ramsay Wharton: "25K military personnel converge in Hawaii for RIMPAC war games" (Hawaii News Now, June 24 2016)

Animal sensitivity

1. Animals best suited to formulate EM exposure limits

Because animals are more easily studied objectively than humans, it has been suggested that their sensitivity could be used for formulating biological safety limits. This could be true for the Fruit Fly (Margaritis LH et al, 2014).

2. Animal Electromagnetic Hyper-Sensitivity

A growing number of anecdotal reports show that the there are variations in the degree of sensitivity to electromagnetic exposure displayed by animals, just as there are among humans. This is an inevitable consequence of biological diversity even with a single species, including genetic variants and differences in diet, habitat and behavior. People with Electromagnetic Sensitivity often report that their pet cat or dog, if the animal is particularly sensitive to electromagnetic exposure, prefers to find an area of the house or yard for sleep which the use of an electronic meter shows is the area with the lowest level of electromagnetic pollution. Similarly, an especially sensitive pet avoids typically avoids areas with especially high electrosmog.

Need for new radiation limits to protect wildlife

Since wildlife is affected as much as humans by the high levels of man-made radiation on Earth, new biological non-thermal safety limits are needed to protect wildlife as well as humans.

- Albert M. Manville: "A Briefing Memorandum: What We Know, Can Infer, and Don't Yet Know about Impacts from Thermal and Non-thermal Non-ionizing Radiation to Birds and Other Wildlife" (2016)

Solar Biological Effects

For hundreds of years it has been known that plants in particular show responses to solar electromagnetic events, such as the sunspot cycle. These effects are more difficult to detect in humans, but attempts through chronobiology often show similar patterns (Hrushesky WJM et al, 2011).

Lunar Biological Effects

A potentially important theory has recently been proposed (Bevington, 2015), that some lunar biological effects, which have been established since ancient times for most plants, some animals and some humans, may relate to variations in electromagnetic exposure at the phases of the lunar Full Moon at night, or at New Moon's lunar wake in daytime. If confirmed, this would explain many plant and animal observations, in addition to human behavioral and medical changes among those especially sensitive to electromagnetic exposure.

http://www.electrosensitivity.co/science--plant-and-animal-electromagnetic-sensitivity.html

Will We All Become Electrosensitive?

Each year an increasing number of people claim to suffer from electrosensitivity (see, e.g., compilation of references given in Table 1), also known as being electrically hypersensitive (EHS). There are also other diseases, such as fibromyalgia and burn-out syndrome, that have symptoms similar to those exhibited by people suffering from electrosensitivity. In Sweden, electrosensitivity is recognized as a handicap, but there is still controversy surrounding the diagnosis of the disease. The mainstream view by governmental and medical authorities is that this handicap is a psychological phenomenon with no basis in physical or medical mechanisms (Swedish National Board of Health and Welfare, SNBHW, 1995), whereby perpetuating the misconception that only a small fraction of the population is concerned about electrosensitivity or the proximity of new radio transmission masts. The number of reported cases of electrosensitivity has been steadily increasing since it was first documented in 1991. Data presented here are estimates and are based on large sample inquiries where different sets of questions have been used. To determine whether the statistics indicate a sub-population of electrosensitivity or if the total population is at stake, we plotted reported prevalence estimates over time in a normal distribution diagram (Table 1 and Figure 1). Contrary to the views of mainstream medical authorities, Figure 1 shows that the group of electrosensitive people around the world, including Sweden, is not just a small fraction that deviates from the rest of the healthy population. Instead, it points at the possibility that electrosensitivity will be more widespread in the near future. The extrapolated trend indicates that 50% of the population can be expected to become electrosensitive by the year 2017.

http://www.next-up.org/pdf/EHS2006_HallbergOberfeld.pdf

Corded or cordless: have you made the connection?

This weekend, I'm going out to dinner. Hardly cause for a blog, you might say—or even a Facebook status update, given that most people go out for dinner several times a month or week. For me, though, it's a rare event. In fact, I haven't had dinner at a restaurant or a friend's place for over two years. It's not because I can't eat. (Boy, can I eat!) It's not because I haven't been invited out, either. (I do have friends.) And it's not because I'm broke or have BO. No. The reason I haven't been out is because there's Wi-Fi everywhere, generating harmful radiation that affects me so badly I can barely function. And it's not worth the risk of getting another brain tumor, no matter how good the food is.

This time, we're going to a friend's place—a friend who has shown himself to be exceptionally caring and considerate. He has offered to switch off his Wi-Fi when we arrive and even asked his neighbor if he'd be willing to do the same, if necessary. The neighbor agreed, and I love them both already. To be sure that our friend's home was radiation-free, however, my man Lewis took my gauss meter and went to check the place out. (I love my man, too …and it seems to me that a lot more loving happens when Wi-Fi is turned off.) He was surprised to find that the levels of radiation were sky-high. Yet the Wi-Fi had been switched off, so where was it coming from? It wasn't from a Smart meter and it wasn't coming from the neighbors' place.

It turned out that it was coming from a cordless phone system. Our friend has three cordless phones in his house, and they were emitting shockingly high levels of radiation—*500 times higher* than the radiation from a Samsung cell phone (known for its particularly strong signals). When the base unit was unplugged and the handsets disabled, the meter readings dropped down to minimal levels.

If you have a digital enhanced cordless technology (DECT) phone in your house, you're almost certainly being exposed to far more radiation than your system can tolerate, over time—and you may be unaware of how it's affecting you. Some people are concerned about the radiation from their cell phone, but few ever think about cordless phones, which are far more harmful. These phones emit the same type of pulsed microwave radiation as cell phones, but they never 'power down'. They are always transmitting and the pulses they emit are far more aggressive than those used in cell phones. With long-term use, cordless phones have been found to increase the risk of brain tumors, including acoustic neuromas—previously considered to be rare. (My hubby tells me I'm one in a million, but even I got one of these growths, which are rapidly becoming common.) Several studies of analogue cell phone, digital cell phone and cordless phone use have revealed that all three types of phones were linked with increased tumor rates. Research by Swedish scientists confirms that the risk of cancer is greater for those who use either DECT cordless phones or cell phones—and even greater for those who use both.

A German medical physicist and researcher at the University of Luebeck, Dr. Leberecht von Klitzing, has researched the biological effects of DECT systems. He took blood samples from children who had cordless phones in their homes and found that the red blood corpuscles did not mature properly, resulting in listlessness and/or aggression, pallor, sleeplessness and many other symptoms—all of which could be reversed when the phones were removed.

According to Lloyd Burrell of electricsense.com, we'd do well to follow the advice of respected Harley Street physician, Dr. David Dowson, who says: "Having a cordless phone is like having a mobile [cell phone] mast in your house. I'd recommend anyone who has one to switch to a plug-in phone."

Yes, it's inconvenient. If you use a corded phone, you won't be able to walk around the house while you're on a call. You might actually have to sit down and focus on the conversation, rather than doing the laundry or making dinner as you talk. But I can tell you from personal experience that it's far, far less inconvenient than having brain surgery, which can cramp your style in unimaginable ways.

According to Dr. Magda Havas, an expert in electromagnetic radiation who petitioned for first-generation DECT phones to be banned in Canada, serious health effects occur near DECT phone base units. "[A]t a distance of just beyond 3 meters from my DECT phone base unit (according to studies of RF radiation)," she says, "EEG brain waves are altered. At 2.8 meters, motor function, memory and attention of children are affected. At 1.7 meters, sleep is disturbed. At 30cm, memory is impaired and, at closer distances, the immune system is affected, REM sleep is reduced, insulin levels drop, and there are pathological changes in the blood–brain barrier. Studies also show that there is a 100% increase in adult leukemia between 45 and 130cm from the phone and a similar increase in childhood leukemia between 35 and 260cm."

Havas also reports that studies of 356 people, exposed long term to high-frequency pulsed electromagnetic fields associated with DECT phones and/or cell phone base stations, revealed a disturbingly long list of effects.

The following symptoms increased with greater proximity to the phone base:

- sleep disturbance, fatigue, depression
- headaches, restlessness, irritability
- mental confusion, difficulty concentrating, forgetfulness
- learning difficulties, trouble finding words
- frequent infections, sinusitis, lymph node swellings, allergies
- joint and limb pains, nerve and soft tissue pains
- numbness or tingling
- tinnitus, hearing loss
- giddiness, impaired balance
- visual disturbances, eye inflammation, dry eyes
- tachycardia, episodic hypertension, collapse
- hormonal disturbances, thyroid disease
- night sweats, frequent urge to urinate
- weight increase, nausea, loss of appetite
- nose bleeds, skin complaints
- tumors and diabetes.

Many of these symptoms are now associated with the rapidly growing phenomenon of electromagnetic hypersensitivity (EHS), and they're a healthy, normal reaction to an invisible threat.

Because DECT phones are so powerful and because the radiation instantly passes through walls, you can be exposed to this radiation even if you don't own a DECT phone …but your neighbors do.

http://olgasheean.com/corded-or-cordless-have-you-made-the-connection/

Electromagnetic Hypersensitivity, It is real!

Wikipedia continues to categorize Electromagnetic Hypersensitivity as "pseudoscience." Ask these people if this is all in their head. Especially, the children's stories that are posted on this page. There is nothing that is "pseudoscience" about this! Plus a medical code, though it is not billable, exists in the ICD10 as **W90.0 Exposure to radiofrequency** which is under **W90 Exposure to other nonionizing radiation** and here is a camera photo of the ICD10 Manual.

Cell Phone Victim Testimonials

1. **Tiffany Frantz** - At the age of 21, developed breast cancer in the exact location of where she kept her cell phone. In fact the images of her cancer outline the exact size of her phone on her chest and how it laid upon her. Watch her story at: https://youtu.be/ZWN838VCUv4.
2. **Attorney Jimmy Gonzalez** - Please do not forget Attorney Jimmy Gonzalez from Florida who died of three cancers all related to where his cell phone was. Here is his testimony at https://youtu.be/lzOjK6PHUas.
3. **Matt Huck** - You can read the 20 page story at http://truthandfactsneverlie.info/blog/my-full-story which is downloadable at the bottom in PDF format.
4. **Donna Jaynes** - At the age of 38, she developed breast cancer exactly where she kept her cell phone. Watch her story here: https://youtu.be/BJib5GHxOsE.
5. **Alan Marks** - He won a lawsuit that enabled the city of Berkeley to warn cell phone users from his experiences of having a cell phone for over 20 years. A brain tumor specialist in Sweden remarked how Alan was "the poster boy" for people about the increased risk of one developing cancer due to their prolonged cell phone activities. His story available at http://www.jweekly.com/article/full/58831/cancer-calling-east-bay-couple-on-a-mission-to-warn-of-cell-phone-risks/
6. **Paul Prischman** - He died at the age of 42 due to a cell phone induced cancer. Listen to his widow at https://youtu.be/aBwk4WbM6CA

Cell Phone Tower Victim Testimonials

1. **Eileen O'Connor -** One of the victims of the Wishaw mobile phone mast and the cancer cluster tower. Here is a copy of her presentation: http://www.radiationresearch.org/pdfs/eileen_my_story.pdf. Her information is available on cell phone masts; http://www.radiationresearch.org/campaigns/mobile-phone-masts
2. **Fairfax County, Virginia Children -** These children ask to stop a cell tower from being put up in their playground. Video link is: https://youtu.be/dEDxOBZhZwY
3. **A woman's story about rooftop antennas –** She shares her daughter's and her story at: https://youtu.be/-G3CWrgDS5E

Smart Meter Victim Testimonials

1. **Connie -** Watch her story about smart meters at: https://youtu.be/3TIRwrR0llE
2. **Sandy Aiders -** Her husband and she suffer from being harmed by smart meters. Watch Sandy tell their story at: https://youtu.be/1zzRP_J7P-c?t=3m32s

Wi-Fi Victim Testimonials

1. **Teenagers and Childrens testimonies to Wi-Fi –** Watch that here: https://youtu.be/jvkxO8xLqMQ
2. **Jenny Fry -** At the age of 15, she committed suicide because no one would support her with her realization that Wi-Fi at her school was the cause of her problem. Did the medical field help or investigate, NO! Her story is at http://www.dailymail.co.uk/news/article-3339511/Schoolgirl-15-hanged-developing-allergic-reaction-Wi-Fi-school.html
3. **Sixth Grader -** This girl's comments can be watched at: https://youtu.be/E7oj-ZXBAF4?list=PL2TxgdaZ0lgDyO6MdGnBQrNG7pfs8fKOW
4. **Student at Onteora School District -** This student talks about their health at: https://youtu.be/6Z3d8FxFhQk
5. **Student Story -** Here is a video of a female student: https://youtu.be/tNpKShvxar0?t=45s

Electromagnetic Hypersensitive Testimonials - Microwave Sickness Testimonials

You can call it what you want, but these people below suffer just like the ones above. They give it a name, it's "Electromagnetic Hypersensitivites" however the German's in the early 20th Century called it "Microwave Sickness." Once your life has been destroyed by man-made radiation, there is no "cure all" fix to make things the way they were before. You can do things to ease the pain, even put a Band-Aid fix on it. However, this does not cure it but will only help make you feel that you are almost whole once again. Please respect the "canaries in the coal mine."

1. **Candy -** Her comments can be seen at: http://time.com/golden-cage/
2. **Reverend Carsten Häublein -** He committed suicide after suffering from wireless radiation and after ten years of suffering took his own life. His story is at http://ehsfighback.blogspot.com/2014/02/when-priests-commit-suicide.html
3. **Sarah Riley -** Her story is available at: https://youtu.be/1zzRP_J7P-c?t=9m40s
4. Andrew McAfee – His story is available by watching "Search for a Golden Cage:" http://time.com/golden-cage/
5. **Dafna Tachover -** Take part in her journey to find a place of residency due to being harmed by technology. Watch at: http://time.com/golden-cage/
6. **David Wientjes –** David's wife and David started having symptoms to wireless radiation from antennas put up near them. Watch his comments at: https://youtu.be/1zzRP_J7P-c?t=57s.
7. **Silvia Wilson -** She moved across the Atlantic Ocean to find relief. Her story is available at; http://www.bbc.com/news/uk-england-lincolnshire-21386477
8. **Jennifer Wood -** Hear her story at: http://time.com/golden-cage/

Supporter Testimonials

1. **Virginia Farver –** She lost her son Rich Farver at the age of 29 to glioblastoma multiforme (GBM) brain cancer on October 11, 2008 which was a direct consequence of having a cell phone. This cancer was in direct location of where Mr. Farver held his cell phone. Story can be found at We Are The Evidence.
2. **Traci Frantz -** She is the mother of Tiffany Frantz, who at the age of 21, developed breast cancer in the exact location where she kept her cell phone. In fact the images of her cancer outline the exact size of her phone on her chest and how it laid upon her. Watch Tiffany's story at: https://youtu.be/ZWN838VCUv4

http://truthandfactsneverlie.info/supporters-victims

Further Testimonials & Stories

Direct Testimony of Joshua Hart

BEFORE THE NEW MEXICO PUBLIC REGULATION COMMISSION

***Case No. 15-00312-UT**, 7/11/2016*

IN THE MATTER OF THE APPLICATION OF PUBLIC SERVICE COMPANY OF NEW MEXICO FOR PRIOR APPROVAL OF THE ADVANCED METERING INFRASTRUCTURE PROJECT, DETERMINATION OF RATEMAKING Case No. 15-00312-UT PRINCIPLES AND TREATMENT, AND ISSUANCE OF RELATED ACCOUNTING ORDERS

PUBLIC SERVICE COMPANY OF NEW MEXICO,

Q. Please state your name and address.

A. Joshua Hart, Post Office Box 682 Portola, CA 96122

Q. Briefly state your occupation, educational background and current employment.

A. Currently I am Director of Stop Smart Meters!, an organization fighting the forced deployment of utility meters that harm health, violate civil liberties and endanger public safety. I have worked in the energy industry, as an urban and transportation planner, environmental advocate, and freelance journalist. I obtained my MSc in Transport Planning in the UK at University of West England, Bristol in 2008, and completed research entitled *Driven to Excess*, presenting the social and quality of life impacts of car traffic on local residents. The research was covered in over 100 international media outlets including the *BBC*, the *Guardian*, *Tehran Times*, and the *Daily Mail*. Part of this work included the creation and implementation of a series of surveys and questionnaires. I have been interviewed by PBS Newshour, as well as hundreds of other local and national news outlets. My writing has appeared in *the Wall Street Journal, Surveyor Magazine*, *Walk Magazine*, *Make Magazine*, and Lonely Planet's anthology *Flightless: Incredible Journeys without Leaving the Ground*. Attached as Exhibit A is a copy of my CV.

Q. Briefly describe your professional experience.

A. I have worked for a number of professional health and environmental advocacy organizations, including the Rails-to-Trails Conservancy, San Francisco Bicycle Coalition and a UK-based pedestrian advocacy organization called Living Streets. Since 2010, I have been director of California-based Stop Smart Meters! I have studied the relevant literature regarding aspects of the current "smart grid" deployment including studies on RF health and environmental impacts.

Q. Have you authored any papers or journal articles?

A. I carried out a master's dissertation between 2007-2008 at the University of the West of England entitled *Driven to Excess: Impacts of Motor Vehicles on the Quality of Life of Residents of Three Streets in Bristol UK.* A journal article based on the research results was published in June 2011 in Volume 17.2 of *World Transport, Policy and Practice.*

Q. Briefly describe your work and experience related to the study of electromagnetic fields and radio frequency ("RF") waves in the 30 MHz to 300 GHz range, as related to smart meters.

A. As a grassroots journalist and advocate, I have investigated hundreds of cases of reported health and environmental impacts of smart meters. I have also read hundreds of scientific reports on the subject and attended multiple workshops, public forums, and conferences regarding RF, electromagnetic fields, and health.

Q. In your role as Director of Stop Smart Meters! have you obtained information confirming that utility customers have been injured by smart meters?

A. Yes. I have personally interviewed, read first person accounts and listened to first and second hand accounts of smart meter victims suffering from a wide range of health effects from mild to severely debilitating. I am familiar with well over twelve hundred such accounts that have been documented. Many of these victims became sick before they knew a smart meter had been installed either on their home or in their neighborhood. Many didn't even know what a smart meter was before they were injured. Some of these people have become so sensitized to RF that they have been forced from their homes

because of proximity to area meters and other wireless infrastructure or have been forced to leave their jobs because of RF in the workplace. For many people who have become sensitized to RF, they have remained so even after the removal of the smart meter. It is astoundingly clear that smart meters can cause illness and that lasting sensitivity to RF can result from instantaneous exposure and/or chronic exposure over time.

Q. Have you obtained information about smart meters being implicated in house fires and appliance failures and fires?

A. Yes. Thousands of such fires, explosions, and electrical problems have been reported over the past 6-7 years. We have reported on a number of such fires and electrical faults on StopSmartMeters.org. A series of 26 smart meter fires forced Peco Energy in Pennsylvania to halt their smart meter deployment in August 2012. Hundreds of thousands of smart meters have been recalled, across several US states and Canadian provinces due to fire safety problems.

Q. Have you gathered accounts of illness from smart meters and if so please describe how?

A. Yes, Stop Smart Meters! has collected complaints about smart meters related to RF health impacts, fires, overcharging, and other issues since October 2011. We worked with a web professional who volunteered to design and manage the website http://smartmeterhelp.com. Results of online surveys came in from all over the country, were entered into a SQL database, and complaints from California periodically forwarded to Governor Jerry Brown, the customer's utility company, the California Public Utilities Commission, and the California Department of Public Health, who set up a special e-mail address to receive smart meter health complaints. More than 1400 written complaints in total were received. A significant percentage were health complaints. The attached declarations (Exhibits B) were received in response to an email request to those complainants who entered an electronic complaint at smartmeterhelp.com.

Q. Are the attached Exhibits B true and accurate copies of the declarations received by Stop Smart Meters! from people who had responded to your online survey?

A. Yes. I have reviewed each of the attached declarations. They are all true and accurate copies of the declarations received by Stop Smart Meters!

Q. Is there anything else you would like the Commission to know?

A. Given the strong peer-reviewed science now linking wireless radiation to disease, and given my own firsthand experience, a policy decision to blanket entire New Mexican communities with smart meters and associated infrastructure poses a serious threat to public health and safety. Particularly relevant are the results of a recent study from the National Toxicology Program which found significant 3 levels of DNA damage, and brain and heart cancer in rodents exposed to ambient RF— of a similar type to that emitted by wireless utility smart meters. This is consistent with the smart meter health complaints we have received. In areas of RF safety, privacy, fair and transparent billing practices, national security, efficiency and fire safety, basic electromechanical analog meters remain superior.

EDUCATION

MSc Transport Planning
June 2008
University of the West of England, Bristol

Bachelor of Arts in Psychology
Minor in History, June 1998
University of California at Santa Cruz

EMPLOYMENT

Director, Stop Smart Meters! StopSmartMeters.Org July 2010- present

• Educated the public about the health, safety, and privacy impacts of digital "smart" meters, through broadcast, print, and online media
• Provided technical assistance to dozens of groups and individuals opposing the smart grid and organizing locally
• Interpreted the science on biological effects of wireless for the public benefit

Consultant, San Francisco County Transportation Authority May 2006 to August 2007
• Researched environmental impacts of automobiles to inform a proposed shift from auto level of service (LOS) to auto trips generated (ATG) as an environmental review threshold
• Collaborated with colleagues to identify strategies to bring San Francisco's environmental review processes into line with latest knowledge on environmental impact of automobiles
Program Director, San Francisco Bicycle Coalition January 2003 to April 2005
• Initiated and ran SFBC's BikeEd Program, based on the League of American Bicyclists BikeEd curriculum, teaching safe cycling skills to thousands of adults citywide.
• Organized members and allied community groups to support improvements in the City's bicycle route network, as well as changes in policies to support greater levels of cycling, testifying at dozens of City Hall hearings and meetings.
• Ran publicity campaigns to educate motorists and cyclists on safe roadway sharing
CA Project Coordinator, Rails-to-Trails Conservancy January 2000-June 2002
• Provided in-depth technical assistance to a variety of local advocacy organizations and public agencies around California working on rail-trail conversions
• Gave presentations to elected officials and community groups about the benefits, proper design, and management of public trails and on-road bicycle and pedestrian facilities
• Organized statewide legislative trail advocacy day in Sacramento to support the efforts of dozens of organizations engaged in trail policy development
• Researched and authored Tunnels on Trails, a study of 78 bike/ pedestrian tunnels in the United States (2001) as well as The Mission Creek Bikeway Concept Plan (2002)
Energy Sales Coordinator, Green Mountain Energy June 1999- December 1999
• Negotiated partnerships with retail outlets in San Francisco, Oakland, San Diego, and Santa Cruz as part of the California storefront tabling program
• Trained/ managed Field Consultants in sales strategy, environmental policy, and data concerning climate destabilization, energy use, and transport
League Cycling Instructor, League of American Bicyclists June 1998-June 2006
• Underwent intensive teacher's training program (both on and off road) and became accustomed with strategies for teaching the leading US cycling curriculum
• Organized, planned, and taught BikeEd classes to community groups and businesses with an emphasis on the environmental benefits of decreased auto dependence
ADDITIONAL SKILLS
• Attended Spin Project media training course, which advised on media strategy for charitable organizations San Francisco April 2004
• Extensive experience dealing with television, radio, and print media concerning a range of cycling, environmental, and climate messages

Another testimonial provided by Joshua Hart, MSc can also be found here:
http://www.mainecoalitiontostopsmartmeters.org/wp-content/uploads/2013/01/Exhibit-11-Hart-Web.pdf

Collateral Damage: Speaking Out Against Wireless Harm

The following is an anonymous testimonial from a sufferer of electromagnetic hypersensitivity:

For those of you obsessed with your wireless technology, I need to ask–why are my children and I considered acceptable collateral damage so you can have your wireless convenience? Have you utterly lost your sense of humanity? Maybe you don't feel any health effects (yet) from this technology, but many of us do–millions of us–and we are suffering. Do you not care? I want to know why you don't care. I want to know why your wireless gadgets are worth more to you than my children's health or my health or our lives. What in God's name is so important about your texting that we have become inconsequential?

You wouldn't force a child who is allergic to peanuts to live in a home filled with peanuts, would you? Would you force a peanut-allergic child to endure such a potentially deadly assault on their immune system? But Super Wi-Fi, smart meters, Wi-Fi, etc. are essentially doing just that to people like us who are sensitive. Perhaps you don't acknowledge the problem because the radiation is invisible (you can at least SEE peanuts). Yet we are being bombarded by toxic radiation everywhere we go, whether we like it or not–and we have become inconsequential because you want what you want: your wireless convenience. I want to know why–even if you are seemingly unaffected by this technology–I want to know why you don't care about those of us who ARE affected.

I want to know why you think it is okay for me to get severe migraines every time I have to go into a public place that uses Wi-Fi. Nowadays, that means a debilitating migraine nearly every single day. I want to know why you think it is okay for my child to be drowning in his own mucus and struggling to breathe because his immune system goes berserk when he's exposed to this radiation. I want to know why you think it is okay that my other child has profound memory loss, insomnia, and can't think straight due to these frequencies. Or didn't you know that pulsed microwave radiation (now classified as a Class 2B carcinogen) causes these symptoms??? Well now you know, and according to experts nearly 35% of the population (50% by 2017) is in the same boat as us with these or other symptoms (although most don't even know what's making them sick). I want to know why you are not speaking out on our behalf. Because now that you know, there is no excuse. You are, by your silence, saying it is okay for us to suffer. Please tell me how to explain to my children that you having wireless convenience is more important than their health or their lives. Please tell me as a mother how to cope with watching my children needlessly suffer. Try to put yourself in my shoes.

I don't care if this technology is "popular" or if "everyone is using it"; this is not okay. It is not okay to say "well it's not going away so you'll just have to live with it." Many of us who are sick from this radiation are now too ill to speak out. Many of us struggle just to find a safe place to live, shop, or go to school. We can't even safely go to a doctor or a hospital without getting seriously ill because of Wi-Fi exposure. There are electrosensitive people living in tents in the mountains and the deserts of our country because they can't live anywhere else due to the amount of radiation in our communities.

I post info on this subject all the time. Some of you read it (thank you if you do), but I'm sure many of you don't bother because you're not affected (yet) or you haven't figured out that your health problems are being caused by it. Or maybe you just don't want to hear it because you love your wireless gadgets so much. But what about those of us who are fully aware this technology is making us sick? Do we not

matter to you? Maybe it's just easier for you to think we are imagining it. Well if you think you're not affected, think again.

I don't know about you, but I'm sick and tired of kids dying from leukemia, cancer, and brain tumors (are they perhaps sitting underneath a wireless access point at school? using a cell phone themselves? or just frying in Mom or Dad's car while the parents use their cell phone?) Now, appallingly, I see parents giving their toddlers smartphones to keep them busy and help them "get through the day." I am sick of cell towers going up outside schools and residential neighborhoods. I'm sick of Distributed Antenna System (DAS) units (the equivalent of a cell antenna) being installed on the telephone wires right outside people's bedroom windows–and they don't even know because the radiation is invisible.

I'm disgusted by the number of children being drugged for "ADHD" and "behavior problems" (how can they think or behave properly when bombarded by whole-body radiation from Wi-Fi at school???) I'm sick of getting yet another phone call that my sister, my cousin, or my friend has breast cancer (oh that's right, they have a wireless digital utility meter on their house, Wi-Fi in their home/office, and/or they use a cell phone). I'm tired of hearing about my friends' husbands dying from kidney and bladder cancer (can you say laptop???)

I want to know where all the bees have gone (they used to be EVERYWHERE when we were kids). I want to know how the hell we're going to grow food if all the pollinators are dead! I'm tired of flocks of birds dropping dead out of the sky, and millions of bats (also pollinators) dying of mysterious fungal diseases (the immune system cannot function properly in the presence of these frequencies). If you think you're not affected by all this, please think again.

Please care enough to acknowledge that this technology is essentially free license to commit genocide in slow motion against those of us who cannot tolerate these frequencies. And you or your child may be next if/when your body can't tolerate it anymore either. So please have the moral fortitude and common human decency to do something about it, because those of us who are getting sick from it can't do it alone anymore. We need your help. The problem has gotten too big and soon there will be no escaping it (Super Wi-Fi is on its way). If you are truly a human being, start acting like one. Please don't accept what is happening to your fellow human beings. Please care about me and my kids and others like us. Please care about those who are being affected and don't even realize it yet. Please do something about this.

It is not okay to essentially cripple and/or kill off an entire segment of the population for the sake of wireless convenience. We, as a species, should be better than that.

http://stopsmartmeters.org/2012/02/29/collateral-damage-speaking-out-against-wireless-harm/

On the run …from the silent, invisible foe

I'm on the run—a fugitive, darting furtively from one safe house to another. When I dare to go out, I cover my face and as much of my body as I possibly can. I've become invisible, silent and stealthy. I haven't been seen out in public for a long time. Think about it: when was the last time you saw me out there, in person, openly socializing? Exactly. See what I mean?

I'm trying not to let it get to me, trying not to get paranoid and start imagining things that aren't really there, on top of what I know is there. Who am I fleeing? No one. What crime have I committed? None. Yet I'm on the run from the biggest, stealthiest, most insidious take-over of all time. And I'm all alone. The corporate giants hold all the cards and the government won't help. They know I've figured out what's really going on, but they don't want anyone else to know. There is nowhere safe for me to go and no safe way for me to get there.

Sometimes, when I'm dehydrated and desperate for some human contact, I slink into a café for a drink. But then my heart starts to pound, my whole body breaks into a sweat, my head throbs, I feel dizzy and I get the shakes—not milk shakes, just plain old body shakes. People are looking at me and reaching for their phones …and suddenly everyone feels like a threat. It's as if they've all become part of some unspoken conspiracy and there's no one I can trust. I've barely drunk my fizzy water but I have to leave.

This has been going on for a while—over two years—and I'm running out of stamina and safe places to hide. It's taken a toll on my health, aging and debilitating me. My nervous system is in perpetual 'fight or flight' mode, and I'm unable to relax, rest or be at peace. I've hardly any friends left, and I can't remember the last time I went to a restaurant, the movies or a dinner party. I'm a recluse and a social pariah, and I doubt that more than a handful of people will miss me if I disappear.

I've tried fighting back, but the enemy is slippery, skillful and beyond my reach. It's protected and sanctioned by the powers that be, and I'm just a little person—someone they can easily quash. I'm taking legal action, but even the courts are in the pockets of these predators, and their legal 'experts' have been won over with misinformation and political spin.

There are others like me, but we're widely dispersed, so it's hard to muster a force strong enough to make an impact. Plus, like me, they're tired of fighting for what's right. I can see why some of them decided to take their own lives. I've considered it—not because I feel suicidal, but because it feels as if there's nowhere left for me to go. I feel cornered, surrounded, stuck in a cycle of diminishing returns.

Yet I refuse to be a victim and I won't go down without a darn good fight. In fact, I'll fight and not go down. I know I'm being challenged to find a powerful solution. I'm smart, creative and good with words, and I've done some interesting stuff in my life—for WWF International and the United Nations in Switzerland. I've published books, been on TV and radio, been featured in local and national newspapers, and have helped others find their own powerful voice. I've written about the deeper truth of what it means to be human. But the truth is not enough, it seems, and I'm running out of time.

If anyone reads this, what will they think? That I've lost my marbles? That I'm some kind of conspiracy nut with an axe to grind against the establishment?

You can look me up, if you're curious. It's so wonderfully easy to do that, these days. Just touch-and-type and all the information in the universe is at your fingertips. But when you reach for your iPhone, think of me. When you're in the elevator with half a dozen other people with their heads down, when

you're pressed against other intently texting bodies on the bus, or when you're e-mailing while walking down the street—think of me being on the run …from the 20-foot aura of radiation coming from your phone, extending all around you, instantly penetrating cement, metal, plastic, clothing, cars, skin, muscles, tissue and bone, damaging red blood cells within minutes, causing cellular leakage of calcium, killing neurons, inhibiting your brain, reducing your libido, affecting your memory, disrupting your sleep cycles, and slowly chipping away at your health without you ever feeling a thing.

And you probably won't feel a thing, until the damage is done (and even then you'll blame it on everything but your phone). I was just like you—loving my electronic gadgets and blissfully oblivious to their effects …until I got a brain tumor. But I sure am feeling it now.

So, think of me when you're on your phone, and remember that you're just like me—with the same red blood cells, the same nervous system and all the other bodily bits that react exactly as they're meant to, when exposed to electromagnetic radiation. If I can get a brain tumor, so can you. It may be hard to accept, but death doesn't just happen to other people, while you're busy texting.

I'm leaving, now—heading off to a teepee in the forest so my body can reconnect with the earth and (hopefully) bounce back. Like so many others reacting to all this radiation, I'm being forced to disconnect. But if you're committed to non-stop wireless living, you're already disconnected—from the deeper truth about the damaging effects, from your body's subtle messages, and from the changes already taking place inside you, masquerading as fatigue, stress, ADD, insomnia or other seemingly 'normal' ailments—as well as the far more disturbing neurological conditions, autism, dementia and infertility that are now affecting so many people. You simply haven't yet connected the dots.

I have special radiation-shielding fabrics to protect me when I go out. But the only reason I need to cover up is because of the corporate cover-up. You're not getting the facts. And the cell phone companies and Internet service-providers are not your buddies. Intent on keeping you addicted to your gadgets (and too engrossed to connect any of those dots), they will happily collude with you in your denial of the dangers.

But the body—that delicate electrical system that can't be upgraded or replaced with the latest technology? The body never lies.

http://olgasheean.com/on-the-run-from-the-silent-invisible-foe/

My Life Living 6 Feet Under Cell Phone Towers

If you told me three months ago not to hold a cell phone to my head or body, and that if I did, to at least have the battery pack facing outwards, I would have listened but it would not have changed my mind. If you told me to exchange my cordless phones for good old-fashioned corded phones, I would have listened, but it would not have changed my mind, I liked my cordless phones thank you very much. If you told me three months ago to use an Ethernet cable with my laptop and keep Airport mode turned off, or to move the Wi-Fi antennae from my bedroom and to turn it off at night or when not in use, or to get rid of all Wi-Fi all together, I would have listened, while thinking to myself "that's a lot of work, why would I want to do all of that?" If you told me thee months ago that baby monitors should not be placed near babies or to ask my 14yr. old daughter to text more than talk, and not sleep with her phone or computer on the pillow beside her, I would have listened but still it might not have changed a thing. If you told me three months ago that the microwave radiation emitted by cell phones, cordless phones, Wi-Fi antennas, cell towers and masts, WLAN and other wireless technology was an invisible culprit causing thousands of people to experience all manner of symptoms from insomnia to high blood pressure, and should be avoided completely or at least whenever possible, I would have listened, but still I might not have changed a thing. After all, the government was there to protect our health and they were approving these things, and the mass media told all of us these devices are safe to our health. But before three months ago I hadn't spent more than a month living 6 feet under as well as in front of cell towers that were placed on my balcony roof. Before three months ago I was healthy, vital and slept like a baby. I didn't wake up with numb hands and feet, my body feeling prickly all night and tingling or vibrating almost all day. I didn't spend night after night in a hyper active state, as though electricity was running through me. Before three months ago I lived in a beautiful home that I loved, it was my sanctuary. I didn't have a hissing or buzzing or high-pitched ring in my ear, known as tinnitus or microwave hearing, mostly when in that home. I didn't get tension headaches ever, or feel like there is an invisible band around my head creating pressure. I didn't feel bouts of nausea on a regular basis, sometimes accompanied by a metallic taste in my mouth, and I didn't get dizzy spells. I wasn't afraid I might have a heart attack as I slept on a makeshift floor mattress in my apt and felt my heart race all night while my body from top to toe became increasingly numb and tingly. I wasn't without focus and direction and unable to concentrate. I'd never gotten shocks touching my bed mattress, home light switches, pots on my stove, and with every stroke of my cats. Before three months ago my daughter didn't have more than one unexplainable rash that hurt 'in' the skin as she described it, she didn't have headaches or feel nauseous and dizzy in our home, or experience the blood in her hand going cold. She never had sleepless nights. Before three months ago I hadn't abandoned my home at the advice of someone who could have sold me thousands of dollars worth of products and equipment by convincing me they would alleviate this situation. Instead I was told, "you have to get out of there, if you care about you and your daughters health you're going to have to move". I had never couch surfed with my 14yr old in tow while tying to maintain some semblance of a normal life or schedule for her. Before three months ago I hadn't researched everything I could find to educate myself about the real dangers of exposure to microwave radiation, or electromagnetic frequencies. I wasn't fully aware of cell towers and this invisible Wireless web that continues to be woven above all of our heads. I couldn't tell the difference between a Bell cell tower, a Rogers cell tower, a Globealive or Wind cell tower or a Telus cell tower. I'd never heard of Industry Canada or Spectrum, Canada Safety Code 6, or the Bioinitiative report. I hadn't spoken to Health Canada, Industry Canada, Canadian Environmental Legal Association, Environmental Health Clinic, Environmental Health Association, The Environmental Protection Office,

The Toronto Environmental Alliance, Public Health office, Canadian Association of Physicians for the Environment, my City Counselors office, trying to find some-any answers as to how safe it is to live in such close proximity to a cell tower. So far none of them have told me it's not safe, but thankfully I have better judgment, a body that is telling me the truth, and Liala, Kevin and Magda to confirm what I already knew. Before three months ago I hadn't spent 15 days getting 2 hours sleep a night because my body was still vibrating all the time, and the rest of the night in tears while feeling like I was losing my mind from sleep deprivation combined with the physical stress of feeling fight or flight 24 hours a day. I didn't have a clear and unpleasant physical reactions to my cell phone, the usage of cell phones by people in close proximity to me, the touch of my computer keyboard, or the experience of sitting close to the monitor for too long. I didn't feel my legs tingling-and going cold and slightly numb if I spent too much time in the same room as a Wi-Fi station. I didn't feel nauseous and have sharp pains go through my hand and up my arm if I held a cordless phone or a cell phone while in use. I didn't feel nauseous if I sat for too long or too close to a television. I do now. Before three months ago I couldn't tell you when I was standing within two to four blocks from a cell tower installation. I never thought twice about leaning on walls or in close proximity to the electrical wiring in a building, or lying on the floor above a basement for the same reasons. I never had to consider the effects of my neighbors Wi-Fi antennas and cordless phone base station broadcasting through any wall that stood between us. Before three months ago I hadn't heard the words Electro Sensitive or Electro Hypersensitive. I hadn't spent hours and hours on the phone trying to find a good doctor, preferably one who knew what a cell tower was and the possible effects of living 6 feet under or in front of one, only to find that it is nearly impossible to find any doctor at all taking new patients. Unfortunately for me, the ones that were, who offered the kinds of analysis or treatment I needed, cost an arm and or a leg or a plane ticket which I didn't have to spare at that time. Before three months ago I hadn't slept in six locations over a period of nine days in the middle of a three week period, while trying to find a place where I could get a good nights sleep because even after friends and family pulled the plug on the Wi-Fi, cordless phones, and everything but the fridge, my body was reacting to the wireless technology from the neighbors, emitting through the walls to where I slept. Before three months ago I hadn't heard of EMF Solutions, Earthcalm, Magda Havas, Jim Vella, the Weep Initiative, the Electro-sensitive Society, a Qlink, a gauss meter or an Electro smog meter. I hadn't read stories from hundreds of people around the world whose lives have been profoundly impacted by something we can't see or hear (for the most part) but can most definitely feel… by microwave radiation, and electromagnetic frequencies emitting at levels not meant for human consumption, by something we are led to believe is harmless and benefits us in more ways than it bombards us, in favor of convenience and especially someone's bottom line, over our continued health and longevity. Three months ago my life got turned upside down by exposure to microwave radiation while living 6 feet under and in front of 10 Cell towers. I am now preparing to move to a home yet to be found, and challenged by the fact that I have to consider my recently acquired sensitivities more than the location, size, and cost. There is no doubt in my mind or my body as to when and where this all began. There is no doubt in me at all, that human beings are affected on a biological level by exposure to microwave radiation well below the levels considered safe by Health Canada's Safety Code 6. A lot can happen in three months, and like anyone else, I don't like being blindsided. I share this with you not because I expect you to listen, but because I do want you to pay attention. Pay attention to the choices that are yours to make, and especially to the ones that are made for you. Because even if I had listened to every piece of advice in terms of precaution, I still would have had no choice about whether or not I

wanted to live in a neighborhood rife with cell towers... or should I say live and sleep 6 feet under and in front of 10 of them. Pay attention now, before you have to pay dearly.

Sincerely Veronica C.

http://www.magdahavas.com/wordpress/wp-content/uploads/2010/02/My_Life_6_Feet_Under_Cell_Towers.pdf

Paul's EMF Refugee Story

Paul Doyon, Building Biology Certified Electromagnetic Radiation Specialist (EMRS), speaking to you from a "normal" wired pay phone in Upper Lake, CA

A New Job at Kyushu University

In August of 2004, I received word that I would be hired as an Associate Professor at Kyushu University, one of Japan's top universities. I was 42 years old and my future was bright. I had at the time been living in Japan for approximately 15 years and had earned MA's in Teaching (TESOL) and Advanced Japanese Studies, not to mention my BA in Psychology before coming to Japan 15 years earlier. I was fluent in Japanese and had numerous publications under my belt. My future looked bright and if I had continued on that trajectory I would have certainly earned my Ph.D. or Ed.D. in Applied Linguistics and would be now a tenured professor at one of Japan's numerous universities. Things did not, however, work out that way.

Starting to Get Sick

In and around March of 2005 I started to develop a host of symptoms and I was extremely sick for six months before I was even aware — let alone even imagined — that the two cell towers within about 200 meters (and another about 500 meters away) from my apartment and perhaps the Wi-Fi from my neighbors' apartments bleeding into mine might have had something to do with the host of symptoms — insomnia, anxiety attacks, loss of appetite, rapid weight loss, excessive thirst, swollen lymph nodes, intestinal disturbances, increased sensitivities, weakened immune system, dry and irritated eyes, etc. — I was experiencing at the time. I had been eating a healthy diet consisting of mainly organic fruits and vegetables, brown rice, tofu, healthy meats, lots of Japanese tea, and was doing yoga every morning, and going to the gym three or four times a week. I was doing everything one is supposed to do to stay healthy and was quite perplexed as to why I was getting sick.

Six months earlier, in November of 2004, I had started my new job as an Associate Professor at Kyushu University in Fukuoka, Japan and had moved into their staff housing also in the city of Fukuoka with my wife and son (both who also experienced health complaints, though not as severe as mine).

I started to wake up earlier and earlier until I got to the point where I could not sleep anymore. I developed extreme thirst: I remember that I would go to the vending machine at the university during breaks and between classes to guzzle several bottles of water or oolong tea. I developed very bad skin allergies. My eyes became extremely red and irritated. My lymph nodes started to become swollen and painful. I was experiencing extreme fatigue. Most of the time I felt nauseated. I was getting heart pain and palpitations. I would wake up in the middle of the night dripping in sweat. I had intestinal disturbances. I needed to go to the bathroom several times a night. I started to develop brain fog and forgetfulness. I also started to experience anxiety attacks with things that never bothered me before like getting on the elevator, being left alone, driving through a tunnel, etc. Furthermore, I lost my appetite and I dropped about 20 kilograms (about 44 pounds) in a month.

Chronic Fatigue Syndrome

I started googling my symptoms and finally concluded that I had been experiencing what was being described in the literature as "Chronic Fatigue Syndrome" (CFS) and started reading everything I could on the subject. I read Martin Pall's work about free radicals, Garth Nicolson's work about mycoplasma infections, Andrew Cutler's work on heavy metal toxicity, and Michael Goldberg's work on Neurological Immune Endocrine Dysfunction and how autism, ADHD, CFS, and Alzheimer's were all connected. To be honest, there are probably at least 100 theories about this condition and I joined every Yahoo group addressing one or more of these. I eventually went to Kyushu University Hospital to talk with their CFS expert. (While the literal translation for CFS is 慢性疲労症候群 [manseihiroushoukougun] , they actually call it 自律神経失調症" [jiritushinkeishcchoushou] or "autonomic nervous system disorder.") He did some tests on me for a number of viral infections, toxoplasmosis, and (at my request) mycoplasama and told me basically that there was pretty nothing he could do for me and that my situation would worsen until I was pretty much just bedridden all the time.

He wanted to give me anti-depressants/anti-anxiety medication and I had him prescribe me antibiotics instead, as I had been by that point reading Dr. Garth Nicolson's theories on mycoplasma infections and believed that that might have been the major cause of my problems — though I later came to a different conclusion — as I was later to learn that the same symptoms described a disease identified by the Russians in the early 70s as "Microwave Sickness.".

Another interesting fact I discovered was that people in the USA started experiencing these same symptoms in 1984, the same year the first commercial cellphone network was set up across the country. CFS was initially dubbed by the media as Yuppie Flu. Well, if you think about it, yuppies were indeed the first people to start using computers and cellphones. In fact, the first Apple Macintosh made its debut the same year, along with commercial usage of the first MMR machines.

It's the Electropollution, Stupid

I eventually had to stop working I was so sick. I was frantically searching for the cause and a cure reading whatever I could find on the web. I was following the blog of a guy in Europe who was suffering from both CFS and Crohn's Disease and who had lots of interesting scientific theories about what was causing his problem when one day he wrote (to paraphrase him):

"It is the electropollution. I went to my parents' house in the French countryside and all my symptoms disappeared. I went back and measured the EMFs in my Amsterdam apartment and the EMFs were through the roof."

That really made me start thinking. I did feel better at night when people were not using their cell phones (in spite of the fact that I could not sleep without sleeping pills at the time). I also felt better out in the country away from all the cell towers in the city — though it was not 100%. I was also able to correlate my anxiety attacks with peak cell-phone usage times in Japan as I had a technician (really a PR man) from Nippon Telephone and Telegraph (NTT) come to my apartment and do measurements. The technician looked sicker than I was and was sweating like a pig. However, he did reveal to me the peak usage times which I was able to correlate with times I would experience extreme feelings of un-wellness.

Dr. Yayama

Before moving into this log house and while we were still living in the Kyushu University's staff housing, my wife was calling around Japan trying to find a doctor who did chelation therapy. She had called a doctor in Tokyo who said that we should just go and see a Dr. Yayama in the city of Yamato, Saga Prefecture, as he was the best alternative doctor around. When we finally went to see him, I read the following in his pamphlet: That modern diseases were caused by the following: 1. Heavy Metal Toxicity, 2. Electromagnetic Pollution & Geopathic Stress, 3. Pathogens (viruses, bacteria, fungi, and parasites), 4. Chemical Toxicity, and 5. the Body's Internal State (e.g. including psychological stress) and then noticed all the cell towers along the road on the drive back to Fukuoka.

A Log House in the Saga Mountains

When we started to realize that we were being bombarded by wireless exposures and that this might be behind our decline in health, we quickly started searching for and found a log house in a white zone — an area devoid of wireless signals — in the mountains of Saga Prefecture, (about 30 minutes outside of Fukuoka). We called the owners and asked if we could rent it out for just about three days. They told us that there was no cell phone signal there: Exactly what we wanted. After like the first 24 hours, I experienced a disappearance in I would say 50% of my symptoms. I then knew that this was it. I ended up staying in that log house for four months and I would say recovered during that time about 85-90% of my previous health.

Miraculously, also, Dr. Toshihiko Yayama's Clinic, was conveniently located about 20 to 30 minutes away from this log house.

And via multiple chelation treatment modalities (homeopathy, Chinese Medicine, and IV EDTA, etc.) of chelating the metals out of my body, having all the metal removed from my mouth, and by taking lots of antioxidants, Transfer Factor, and doing Qigong, I was able to recover much of my health and became much better able "tolerate" the EMFs.

Electrosensitivity

However, at the time, whenever I would get into range of a cell phone tower or around people with cell phones, many of these symptoms would start to come back. I could feel an intense pressure in my head, I felt nauseous, I would feel pain in the lymph nodes under my right arm and in my right testicle and groin area. Fortunately, gradually, over the years, these symptoms have diminished with many of them disappearing — though, at the time, it pretty much freaked me out.

The Zero Search Machine

Dr. Yayama, probably the most famous alternative medical doctor in Japan, is quite the amazing person. I would say he is a great genius. He invented a diagnostic tool he calls "Zero Search" which he connects

with a German Rayometer to check frequencies, as they have found that everything has its own signature frequency.

Hence, when I initially went to see him, he was able to pretty much tell me in less than 10 minutes that I had 1. systemic candida, 2. mycoplasma, 3. toxoplasmosis, 4. Epstein Barr Virus, 5. Cytomegalovirus, 6. mercury toxicity, 7. aluminum toxicity, and 8. lead toxicity. Unbeknownst to him at the time, the mycoplasma, Epstein Barr, and Cytomegalovirus had been confirmed by blood tests earlier at Kyushu University Hospital.

My wife (who is Japanese), at the time, wrote to all the Japanese media outlets to get some coverage for our newly discovered problem that those seemingly innocuous waves of wireless radiation were damaging to our health. She received zero replies; they seeming — for (what are now for me) obvious reasons — did not want to touch our story.

EMF Refugee & "Denjiha Nanmin" (電磁波難民)

After four months of living in this log house, we started running out of our savings. I was probably feeling from between 85-90% better but would still start to feel sick when exposed to EMFs. We moved back into our apartment and bought a canopy to sleep under and shielded the windows with special material to block out the EMFs. In early 2006, I started a Japanese Yahoo group in Japanese called "Denjiha Nanmin" (電磁波難民） and its equivalent Yahoo group in English called "EMF Refugee." (We now have almost 1000 members.) I started having people contact me from all over Japan who were having the same problems. We had a meeting at my apartment in Fukuoka. People flew from all over Japan.

Ad Hoc Publications

Around about the same time, I also wrote several papers that were published ad hoc on the Internet: One was called, "Do You Have Microwave Sickness?" (originally published in Feb. 2006) where I wrote, for example

"19. Exposure to microwave radiation has also been shown to effect an abnormal increase in nitric oxide (NO). One theory holds that an abnormal increase in cellular calcium will also lead to an abnormal increase in cellular NO, which in excess produces a damage-producing free radical or oxidant called peroxynitrite."

and the other one "Are Microwaves a Major Causal Factor in Chronic Fatigue Syndrome (CFS) and Myalgic Encephalomyelitis (ME)? (originally published in July 2006). These got quite a bit of fanfare given the fact that I was an associate professor at one of Japan's top universities. Next-up (France) took up the story and there was an article published in the Belgium newspaper LeLibre entitled "Les micro-ondes liées à la fatigue chronique?" or "Are Microwaves Related to Chronic Fatigue?" The Townsend Letter Group even published an article about me in their newsletter in 2009 entitled "Microwaves Role Examined."

Looking for a Place to Live: Kunming, China

At any rate, after going back and forth with a Japanese president of an IT firm who himself developed ES about starting an eco-village for ES people, I eventually decided that the levels of EMF were just too high for me in Japan. I decided to search for another place to live and took a trip around Southeast Asia — Thailand, Myanmar, India, Southwest China, and Laos — looking for a suitable place to live. Upon

traveling to Thailand, I realized that I felt better there EMF-wise than in Japan, and then felt better China than I did in Thailand. I attributed it to the fact that at the time, Japan (if my memory serves me right) was moving into 3G, Thailand was still working on 2G, and China had stricter regulations regarding ambient levels of EMF. I eventually severed my ties with Kyushu University and ended up in the city of Kunming, Yunnan Province in 2006.

It was a fascinating place to live and I started studying Mandarin, worked at a language school and eventually secured a teaching position at Yunnan Normal University, where I worked for a year.

After living there alone for six months, my wife and son joined me.

We had a very interesting time living in Kunming together for a year. Our weekends and breaks were often spent taking trips to other parts of Yunnan Province. Interestingly, a person named Peter Monaghan had contacted me in response to an ad I put on GoKunming (the local community website) selling some stuff who said that his mother was a Doyon and that he was coming to Kunming to teach English at one of its universities. It ended up that his mother was my father's cousin, had grown up in the same town as my father in Quebec (St. Benoit), and that Peter was my second cousin. Small world, eh! We often spent our weekends together either taking trips around the city or to other cities in the vicinity.

Auroville

However, after a year of living in Kunming together, we decided to leave and go live in the intentional community of Auroville, India, which was very progressive with alternative forms of medicine, agriculture, building, education, health, and electromagnetic policy (i.e. there was a rule in place that no cell towers could be built within the city's limits of 20 square kilometers). They do not use pesticides or chemicals on their land, food is organic vegetarian, medicine is mainly Ayurvedic, Chinese, Naturopathic, and Homeopathic, and buildings are Building Biology standard: i.e. a very healthy place to live.

But before doing that we had a nice trip together through Thailand, which I love except for all the chemicals there to which my body reacts. Ah!

Back to Thailand: ITM

Auroville was wonderful, but at the time, we did not have the funds to sustain ourselves in this sustainable community. I needed to go to China to do training with the British Council to become qualified as an IELTS examiner and got stuck in Chiang Mai, Thailand because China would not give me a visa. I ended up doing a Thai Massage Workshop at a school called ITM in Chiang Mai.

Mae Fah Luang University: Chiang Rai

Later I got a job teaching English as a Foreign Language (EFL) at Mae Fah Luang in Chiang Rai, Thailand, about two hours northeast of Chiang Mai.

Allergies Gone Crazy

After living in Thailand for awhile, I started to gradually experience a worsening condition of skin allergies: I think it was a combination of dust, pollen, mold, smoke (from the burning of the fields), pesticides, formaldehyde, and food chemicals. My skin was extremely itchy, red, and irritated. I needed to take sleeping pills to sleep and when I woke up my sheets would be covered with blood from the unconscious scratching that had occurred while I was sleeping.

Escape to Chiang Mai
I had to eventually leave my teaching position and seek help in Chiang Mai. After a month of seeking treatment from all the alternative health practitioners (acupuncturists, chiropractors, naturopaths, and so on) and not getting better, we decided to return to Japan.

Back to Japan: Dr. Sei Takahashi: An Amazing Acupuncturist
However, after a month of daily acupuncture treatments with an amazing acupuncturist,and medical qigong practitioner, Dr. Takahashi Sei, at his clinic Ishindo, not to mention daily far infrared saunas, and the drinking of lots of alkaline water, I was thankfully pretty much back to normal.

Utsunomiya University
Within a month, I had applied for teaching positions at a number of Japanese universities and had several interviews lined up. I applied at Utsunomiya University and received a phone call from the directly after getting home. She wanted to hire me. I accepted and moved to the city of Utsunomiya in March of 2010.

I worked there until March of 2011 when Fukushima happened and we were approximately 100 miles away — too close for comfort.

Fukushima

Escape to Europe

Back to Japan

Chile

A Return to the USA after 25 Years Abroad

The International Institute for Building Biology and Ecology: Electromagnetic Radiation Specialist (EMRS)

Out of Sight and Out of Mind
When something is out of sight, it is also out of mind — and microwaves from cellphones, cellphone towers, and other wireless-radiation emitting devices are invisible, tasteless, odorless, and cannot be sensed with touch. Naturally, it has been difficult for many — even most doctors — to fathom them as being a culprit in the disease process. However, increasingly, people worldwide are starting to wake up to the fact of what is indeed the cause of their previously mysterious symptoms. An increasing number of these people become noticeably ill when exposed to this invisible source of pollution and they are starting to connect the dots. Also, it is becoming known that people with an inordinate amount of metal toxicity seem to be particularly sensitive. When people realize the problem, and come together to find solutions, progress can be made.

Connecting the Dots
After having had this experience, and in line with the growing quantities of ambient electromagnetic pollution in our environments, I began to suspect that the large number of people around me becoming sick with some kind of illness may also have been unwittingly affected by this health-damaging ambient electromagnetic radiation. Just as cellphones were starting to become popular, I remember a student of mine's three-year-old daughter dying of influenza. This was the first time I had ever heard of a little girl

dying of influenza, though apparently it is increasing more common and one has to seriously consider the fact that all this electromagnetic radiation we are being exposed to 24/7 might in fact be weakening our immune systems. It seems that when people catch colds nowadays that it takes them longer to recover — whereas instead of the normal 3-4 days we are now seeing people sick for up to two weeks or longer. We are being fed with the idea that the bugs are becoming stronger and not rather that our immune systems might be becoming weaker.

Since that time, I had the unfortunate fate to have known a number of people who have committed suicide, developed or died of cancer, had their children diagnosed with Autism Spectrum Disorders (ADS) or ADHD, developed brain tumors, been diagnosed with intestinal disorders (Crohn's Disease, Irritable Bowel Syndrome, Colitis), developed vision problems, strokes, and were diagnosed with epilepsy. I have also known women who have had miscarriages due to deformity of the fetus. This has become the norm — but it is not normal. Also, every year, in Japan, the news programs report about an increasing number of people suffering (or dying) from heat stroke in the summer. Something I had never heard when I first went there in 1988. When one looks at the research on how EMFs negatively affect the immune system, the endocrine system, the autonomic nervous system, alter the brain's neurotransmitters, open up the blood-brain-barrier, damage DNA, and create a deluge of free radicals in the body, one can view the causal factors of many of these disease states in a new light.

Public Brainwashed by the Wireless Industry

While the Wireless Industry has had the money to lobby politicians to get the laws they wanted passed, to fund the researchers to get the research results they wanted, and to promote their desired narrative through their media arms, in the past five-or-six-or-seven-or-so years, I have started to notice not only a shift in how the media is starting to change the way it covers this problem, but also in the public's acceptance and acknowledgement that this may in fact be a serious problem, whereas before the media was pumping out — and the public regurgitating — a narrative in which anyone questioning the health and environmental effects of wireless radiation was nothing but a tinfoil-hat-wearing conspiracy-theorist Luddite. There is now an increasing acknowledgement that this wireless might indeed be an actual serious health and environmental quagmire; that it might in fact even be behind unexplained increases in a plethora of health and environmental problems — autism, ADHD, chronic fatigue syndrome, MS, diabetes, Parkinson's, Alzheimer's, epilepsy, not to mention the skyrocketing rates of cancer, plus the disappearance of insects, frogs, other amphibians, and birds —and that we might have to seriously do something about it.

The Simple Truth

Dr. Robert O. Becker's statement 30 years ago in his book The Body Electric, may very well be accepted as the truth by the majority of people alive in my lifetime:

The dangers of electropollution are real and well documented. It changes, often pathologically, every biological system. What we don't know is exactly how serious these changes are, for how many people. The longer we as a society, put off a search for that knowledge, the greater the damage is likely to be and the harder it will be to correct. p. 304

http://electromagneticsafeplanet.com/pauls-story

Additional Resources

Further testimonials from individuals affected in some way by the proliferation of wireless technologies can be found here: https://wearetheevidence.org/harmed-by-wireless/

Of the tens of thousands of peer-reviewed studies that exist confirming the negative biological impacts of radiofrequency radiation, only a very small portion have been included in this publication. Because the science is always changing and new research is always underway, a few links to research databases and pages that contains links to numerous other studies have been included here:

- https://www.emf-portal.org/en/updates/articles?maxAge=60
- https://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=16041996
- https://www.ncbi.nlm.nih.gov/pubmed?cmd=link&linkname=pubmed_pubmed&uid=25475345&log$=relatedarticles&logdbfrom=pmc
- http://www.justproveit.net/studies
- http://stopsmartmeters.org/the-science/
- http://annlouise.com/books/zapped/zapped-resources/
- http://www.truehealthfacts.com/reasearch-news/CellPhonesEMR.html
- https://wirelesseducationaction.wordpress.com/the-reality-wi-fi-in-schools/
- http://smartmeterdangers.org/smart-meter-research/
- http://emfsafetynetwork.org/shortcut-to-science/
- http://www.powerwatch.org.uk/science/studies.asp
- http://wifiinschools.org.uk/30.html
- http://www.safeinschool.org/2011/01/international-warnings-on-wi-fi.html
- http://safetechforschoolsmaryland.blogspot.com/2016/02/teacher-unions-and-parent-teacher.html
- http://stopsmartmeters.org.uk/resources/resources-scientific-studies-into-the-health-effects-of-emr/
- http://c4st.org/electrosensitivity/

Lastly, Major insurance firm, Swiss Re, warns of large losses from "unforeseen consequences" of electromagnetic frequencies:

http://media.swissre.com/documents/SONAR_+Emerging_risk_insights_from_Swiss_Re.pdf

The insurance companies are starting to grasp what the stakes are here; do you?

Conclusion

We don't want to believe that our new toys to which we are so attached and which bring enormous profits could also cause our demise or that of our children. But science is not about belief. Government's responsibility to their citizens should not be either.

— Devra Davis, PhD

If governments did their job correctly and were the responsible entities they were meant to be, electrosmog might never have become a problem. Cell phones would never have made it past the drawing boards, and we'd all be talking during power outages because cordless phones would never have made it off the shelf either. Rather than experiencing the slow connectivity wireless networking offers, every computer in the world could be connected with Ethernet and Fiber Optic cables.

This dream of a safe, hospitable world is still possible. But nobody else is going to make it happen for you. It will require each of us to stand up for our human rights. It took 50 years for the curtain to fall on tobacco; who knows how many decades of lies and millions of causalities will be required before the truth becomes apparent to the mainstream?

Despite the large body of emerging science confirming the negative health implications of pulsed radiofrequency radiation and the existence of electromagnetic hypersensitivity, the majority of the world's population remains in the dark, ignorant or unreceptive of the truth. In a world dominated by science and research, it is quite unfortunate that even well-regarded scientists remain opposed to the truth. Many governments themselves are compromised, lobbied by the very industries they are there to presumably 'regulate'.

Until there is a critical shift in the way technology is used in this world, both wired and wireless, it will be up to the individual to become empowered to make a difference. What little progress has been made so far towards a healthier, safer, more sustainable future, has been made by like-minded activists working towards a healthier future for ourselves and our offspring. In the face of critics, skeptics, tin-foil hat paranoids, and the ever-growing influence of industry, facts will ultimately prevail. If it is when, not if, a critical reorganization of our technological infrastructure occurs that we can pursue its own betterment instead of resenting the ailments that have befallen us.

Regardless of industry pseudoscientific claims, the jury is no longer out. There are tens of thousands of peer-reviewed studies out there confirming the negative health implications of radiofrequency radiation; some of them are contained in this publication. It is not a valid decision to choose to "believe" the science or not. The truth does not go away simply because it is ignored.

If you are still unreceptive of the truth, however forbidding it may be, take some time to look at some more research. Anyone who isn't yet concerned about the perils of wireless technologies hasn't looked at the research carefully enough yet.

If you are receptive and acknowledge the truth, pass it on. Ditch your cell phone and cordless phones and replace them with corded phones. Apart from the physiological impacts of wireless technology, the social and physiological implications of wireless technology are more

visible. An increasing social disconnect among one another is being experienced, namely due to the rise in usage of mobile devices. Those who remain unconvinced of the health implications of mobile devices may appreciate the humanity of the era predating cellular technologies.

Wireless technologies are often likened to tobacco. Their impacts on biological life, after all, are varying but very similar. Despite the ubiquity of tobacco in society even five decades ago, the usage of cigarettes has declined dramatically and constantly since the collapse of industry claims of tobacco's safety in the late twentieth century.

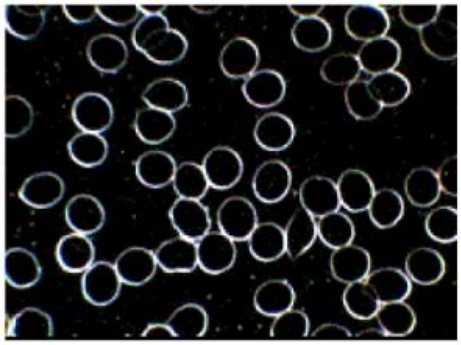
A growing number of scientists agree that wireless proliferation is, and will continue to be, the biggest public health crisis of the twenty-first century, perhaps the biggest health crisis humanity as ever faced. However long it may take for our world to return to a safer state, there is no need to wait for government approval of industry acknowledgement. The technology that will keep us safe is already here; in the form of corded landlines, hardwired Ethernet cables, and fiber-optics. Truly, a return to the dominant technologies of yesteryear is what will pave the way forward in the future.

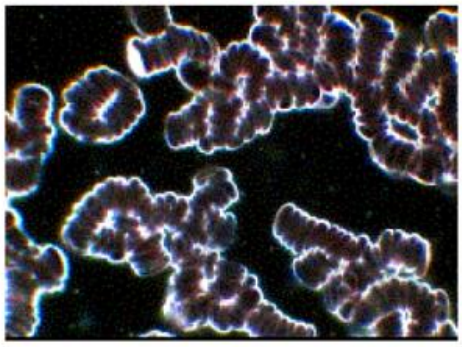
Appendix A: Measuring Radiation

Detecting and measuring radiation is beyond the scope of this text. To measure levels of RF radiation in your home:

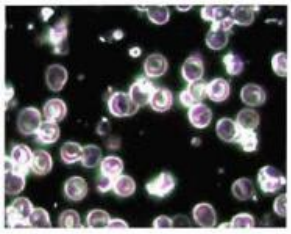
- Purchase an Electrosmog meter. You can buy meters of varying sensitivities at http://stopsmartmeters.org/store
- Aluminum foil shielding is a last resort and can possibly make levels worse. However, because radiofrequency fields do not penetrate metal well, if done right and levels are confirmed with a meter, shielding can significantly reduce your exposure to radiofrequency fields.
- Want to find out if there are any cell towers or antennas radiating near you? Look no farther than Antenna Search and TowerKill!
- You can use Xfinity's Wi-Fi search portal to find out if there are any radiating Wi-Fi hotspots near you.

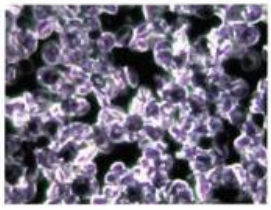
Appendix B: Pictures & Diagrams





Red Blood Cells Before and After a 90-Second Cell Phone Call

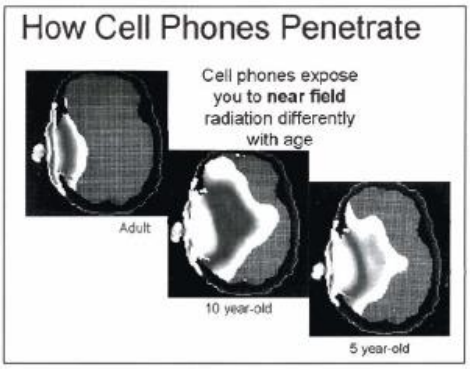


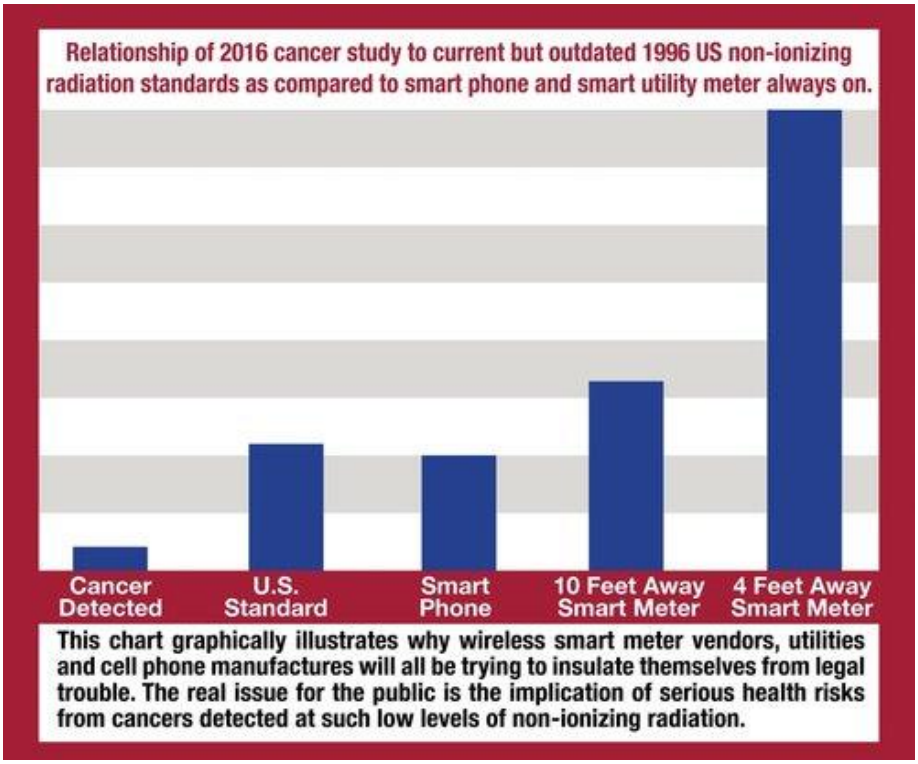


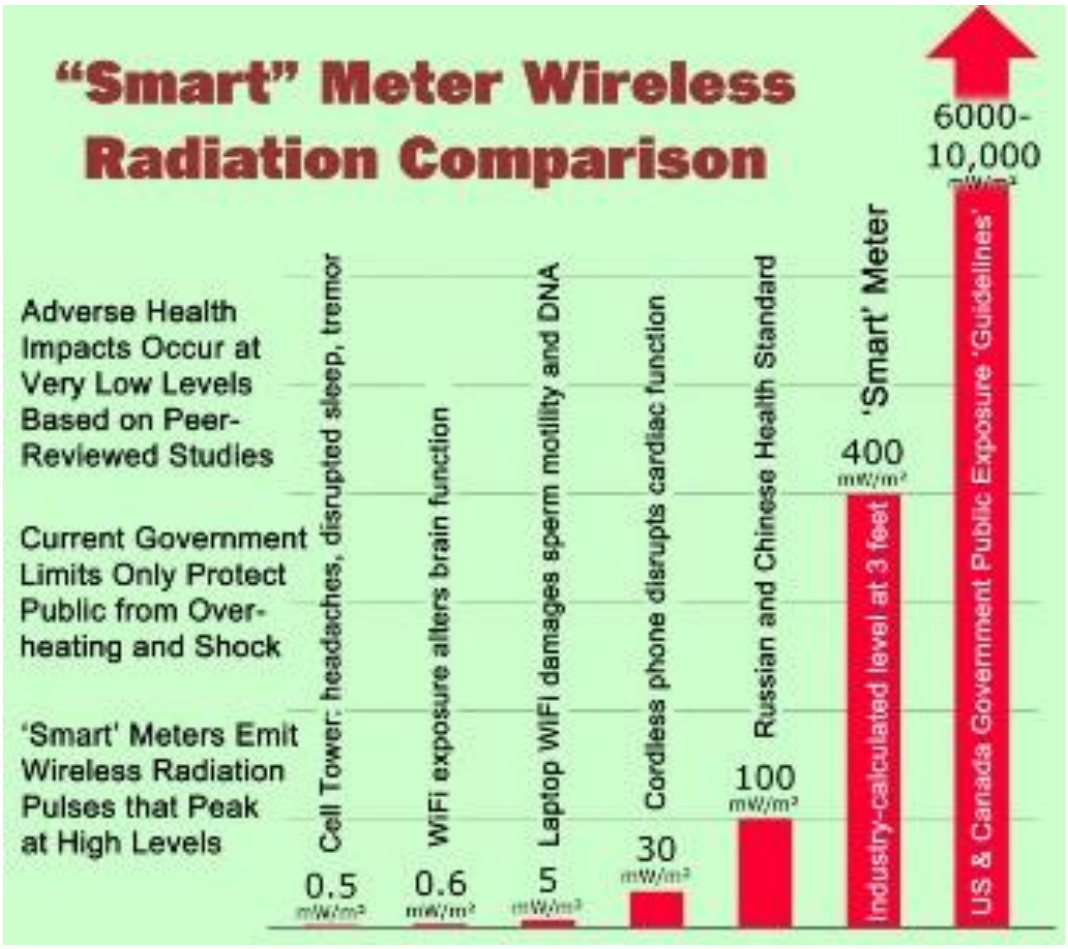
Disrupted red blood cell intercellular communication occurs within minutes of exposure to information carrying radio waves. Red blood cells must be able to sense the location of other blood cells to avoid clumping. Slide at left: prior to cell phone exposure – red cells are functional. Slide at right: after five minutes on a cell phone red cells are clumped and non-functional.

Deformed cows near cell phone towers in Germany are just one example among many animal deformities appearing around the world. Research has also connected the worldwide disappearance of frogs, birds, and insects [most recently bees] with the dramatic increase of electrosmog permeating our planet.

The amount of radiation penetration of a skull for an adult, a 10-year-old child, and a five-year-old child.




Relationship of 2016 cancer study to current but outdated 1996 US non-ionizing radiation standards as compared to smart phone and smart utility meter always on.
Cancer Detected
U.S. Standard
Smart Phone
10 Feet Away Smart Meter
4 Feet Away Smart Meter
This chart graphically illustrates why wireless smart meter vendors, utilities and cell phone manufactures will all be trying to insulate themselves from legal trouble. The real issue for the public is the implication of serious health risks from cancers detected at such low levels of non-ionizing radiation.


"Smart" Meter Wireless Radiation Comparison
Adverse Health Impacts Occur at Very Low Levels Based on Peer-Reviewed Studies
Current Government Limits Only Protect Public from Over-heating and Shock
'Smart' Meters Emit Wireless Radiation Pulses that Peak at High Levels
Cell Tower: headaches, disrupted sleep, tremor
0.5 mW/m²
WiFi exposure alters brain function
0.6 mW/m²
Laptop WiFi damages sperm motility and DNA
5 mW/m²
Cordless phone disrupts cardiac function
30 mW/m²
Russian and Chinese Health Standard
100 mW/m²
'Smart' Meter
400 mW/m²
Industry-calculated level at 3 feet
6000-10,000 mW/m²
US & Canada Government Public Exposure 'Guidelines'

Appendix C: Listservs & Support Groups

The number of refugee camps for electrohypersensitive individuals in the United States and around the world is growing exponentially. You can join the discussion today if you are interested in either planning or joining an EMF free retreat.

You can follow Stop Smart Meters! and Save Landlines on Twitter and subscribe to Stop Smart Meters! Newsletters. You can also find local groups in your area to join in the fight against smart-meters and forced wireless proliferation.

Want to get involved more? Join an organizing Listserv:
Stop Smart Meters (Electric Embers)
Save Landlines (Electric Embers)
EMF Sanctuary (Electric Embers)
Occupy EMF Harm/Housing (Yahoo Groups)
Occupy EMF/MSC Harm (Yahoo Groups)
EMF Refugee (Yahoo Groups)
Living Simply Off Grid (Yahoo Groups)
Small House Society Online (Yahoo Groups)
No-Spray! (Yahoo Groups)

Teleconference Calls

→ Occupy EMF's conference calls held weekly Thursdays at 11:00am Pacific (click here for agenda).

Appendix D: Further Resources

One text can only cover so much material. The following websites, books, and documentaries provide more in-depth analysis of this issue. Excerpts either partially or in full from some of these resources may have been referenced in this text:

WEBSITES

StopSmartMeters.org
SaveLandlines.org
On the Level: Car Free Blog
Environmental Health Trust
Windheim EMF Solutions
International Institute for Building-Biology & Ecology
We Are The Evidence
National Association For Children and Safe Technology
Truth & Facts Never Lie
What Is 5G?
EMF Research
The EI Wellspring
EMFs.com
Understanding EMFs
International Electromagnetic Fields Alliance
Smart Meter Dangers
Smart Grid Awareness
Smart Meter Education Network
Center for Electrosmog Prevention
Citizens for Safe Technology
Electric Sense
Wi-Fi in Schools
Cell Tower Dangers
Electronic Silent Spring
Canadians 4 Safe Technology
Clear Light Ventures
Create Healthy Homes
Cell Phone Danger
EMF Wise
RF/EMF
RF Safe
Radiation Education
EMR Safety
EMF Safety Network
EMF Help Safety
The EMF Experts
Healthy Housing Research Institute
Electrosensitivity
Cell Phone Radiation USA
Show The Fine Print
The BabySafe Project
Electrical Pollution
Freedom Taker

Parents for Safe Technology
Microwave News
Cellular Phone Task Force
Global Union Against Radiation Deployment From Space (GUARDS)
No Cell Towers on Schools
Moving to Learn
Safe Schools IT Alliance
Wireless Education Action
Radiation Refuge
Wired Child
WEEP
Electromagnetic Health
Wi Cancer
Radiation Research Trust
EMF Scientist
Kevin Mottus
Smart & Safe
Dr. Magda Havas, PhD
First Do No Harm blog
Coalition to Stop Smart Meters in BC
Maine Coalition to Stop Smart Meters
Stop Smart Meters Australia
Total EMF Solutions
Wi-Fi in Schools – Australia
Olga Sheean – "Beyond Belief: exposing the deeper truth"
Safer Grid
Electromagnetic Radiation Safety
SPGO EMF Assessment, Consulting and Remediation
Elektrosmog (Electrosmog) – *click Translate → English*
Gary C. Vesperman
Gary Vesperman documents
Wireless Watch Blog
Oscillatorium

BOOKS & FURTHER READING

BioInitiative Report - http://bioinitiative.info/bioInitiativeReport2012.pdf - *1,557 pages*
Overpowered – Martin Blank
Chemical and Electrical Hypersensitivity: A Sufferer's Memoir – Jerry Evans
Disconnect: The Truth About Cell Phone Radiation, What the Industry Has Done to Hide It, and How to Protect Your Family – Devra Davis
The Big Disconnect: Protecting Childhood and Family Relationships in the Digital Age – Catherine Steiner-Adair, EdD.
Reset Your Child's Brain: A Four-Week Plan to End Melt-downs, Raise Grades, and Boost Social Skills by Reversing the Effects of Electronic Screen Time – Victoria Dunckley
An Electronic Silent Spring – Katie Singer
Cell Phones: Invisible Hazards in the Wireless Age: An Insider's Alarming Discoveries about Cancer and Genetic Damage – Dr. George Carlo
Cell Phones and The Dark Deception: Find Out What You're Not Being Told… And Why – Carleigh Cooper
Glow Kids: How Screen Addiction Is Hijacking Our Kids-and How to Break the Trance – Nicholas Kardaras
Zapped: Why Your Cell Phone Shouldn't Be Your Alarm Clock and 1,268 Ways to Outsmart the Hazards of Electronic Pollution – Ann Louise Gittleman
"The Cell Phone Poisoning of America" – Lynn Quiring, RPh, CCN, NMD
"Captured Agency" – Norm Alster, Harvard Ethics
The Body Electric – Dr. Becker
The Effect of Microwaves on the Central Nervous System – W. Bergman – Ford Motor Company, 1965
Microwaving Our Planet: The Environmental Impact of the Wireless Revolution – Arthur Firstenberg, 1997

Olga Sheean's Collection of Public Documents

NO SAFE PLACE – 15 June 2016
https://olgasheean.com/wp-content/uploads/2016/07/NO-SAFE-PLACE-Letter-to-Gregor-Robertson-240716.pdf

HEADS IN THE SAND, PIES IN THE SKY – 7 November 2016
https://olgasheean.com/wp-content/uploads/2016/11/Heads-in-the-sand-pies-in-the-sky-1.pdf

WHO – Setting the standard for a wireless world of harm – 30 January 2017
https://olgasheean.com/wp-content/uploads/2017/02/WHO-setting-the-standard-for-a-wireless-world-of-harm.pdf

DOCUMENTARIES

Take Back Your Power – This documentary highlights the negative impacts of smart-meters to our health and the environment. *While* Take Back Your Power *documents smart-meter problems well, many of the solutions proposed are dubious ones, and Josh del Sol believes climate change is not caused by humans, a viewpoint we believe is dangerous and ignorant.*
Public Exposure: DNA, Democracy and the Wireless Revolution – When do we draw the line?
Offline is the New Luxury – Where are the "white spots" on the map? Are there any sanctuaries left in a world full of wireless?

Resonance: Beings of Frequency – This sensational documentary reveals the harm of existing in a world of man-made wireless frequencies.
Full Signal – With over 3.5 billion cell phone users and thousands of cell towers popping up across the globe, people are starting to feel the effects.
"Wi-fried" on ABC 2016 – 2016, 30 mins.
Generation Zapped – We are getting ZAPPED by wireless technology.
Mobilize: A Film on Cell Phone Radiation – The long term effects from cell phone radiation are investigated.
Is Your Cell Phone Killing You? – 2011, 45 mins.
Beyond Coincidence – The Perils of Electrical Pollution, Part 1 – 2011, 11 mins.
Beyond Coincidence – The Perils of Electrical Pollution, Part 2 – 2011, 8 mins.
Grounded: Could It Happen to You? – 2013, 74 mins.
Microwaves, Science, and Lies – 2014, 92 mins.
Lo and Behold: Reveries of the Connected World – 2016, 98 mins.
Invisible Danger – 2016, 172 mins.

https://wirelessaction.wordpress.com

UNIVERSITY AT ALBANY
State University of New York

Institute for Health and the Environment
WHO Collaborating Center in Environmental Health

3 February 2017

Kentucky Public Service Commission
P.O. Box 615
211 Sower Boulevard
Frankfort, Kentucky 40602-0615

Re: Case files 2012-00428, 2016-00370, 2016-00187, 2016-00152 and all other Utility Company Case Files regarding Wireless Utility Meters (ie., AMI, AMR, AMS, ERT, Wireless, Smart Meters, etc.)

Dear Kentucky Public Service Commission, All Electric, Gas and Water Utility Companies, President, Agents, Officers, Employees, Contractors and Interested Parties:

We, the undersigned, are scientists and health professionals who together have co-authored many peer-reviewed studies on the health effects of radiofrequency radiation (RFR). We are aware that the Kentucky Public Service Commission is considering a proposed smart meter opt-out fee from Duke Energy. Smart meters, along with other wireless devices, have created significant public health problems caused by the radiofrequency radiation (RFR) they produce, and awareness and reported problems continue to grow. With Duke Energy being America's largest utility provider and, consequently, having the largest potential smart meter implementation reach, it is imperative that the Kentucky Public Service Commission be fully aware of the harm that RFR can cause and allow utility customers to opt out of smart meter installation with no penalty.

The majority of the scientific literature related to RFR stems from cell phone studies. There is strong evidence that people who use a cell phone held directly to their ear for more than ten years are at significantly increased risk of developing gliomas of the brain and acoustic neuromas of the auditory nerve. There is also evidence that the risk of developing these cancers is greater in younger than older people. The May 2016 report from the US National Toxicology Program showing that rats exposed to cell phone radiation for nine hours per day over their life-span develop gliomas of the brain and Schwannoma of the heart (the same kind of cancer as acoustic neuroma) adds proof to the conclusions from the human health studies that radiofrequency radiation increases risk of cancer.

East Campus, 5 University Place, Room A217, Rensselaer, NY 12144-3429
PH: 518-525-2660 FX: 518-525-2665
www.albany.edu/ihe

Smart meters and cell phones occupy similar frequency bands of the electromagnetic spectrum, meaning that cell phone research directly applies to smart meter RFR. Smart meter RFR consists of frequent, very intense but very brief pulses throughout the day. Because smart meter exposure over a 24 hour period can be very prolonged (pulses can average 9,600 times a day), and because there is building evidence that the sharp, high intensity pulses are particularly harmful, the cell phone study findings are applicable when discussing adverse health impacts from smart meters.

While the strongest evidence for hazards coming from RFR is for cancer, there is a growing body of evidence that some people develop a condition called electro-hypersensitivity (EHS). These individuals respond to being in the presence of RFR with a variety of symptoms, including headache, fatigue, memory loss, ringing in the ears, “brain fog” and burning, tingling and itchy skin. Some reports indicate that up to three percent of the population may develop these symptoms, and that exposure to smart meters is a trigger for development of EHS.

In short:

- Smart meters operate with much more frequent pulses than do cell phones, increasing the potential for adverse health impacts.
- Smart meter pulses can average 9,600 times a day, and up to 190,000 signals a day. Cell phones only pulse when they are on.
- Cell phone RFR is concentrated, affecting the head or the area where the phone stored, whereas smart meter RFR affects the entire body.
- An individual can choose whether or not to use a cell phone and for what period of time. When smart meters are placed on a home the occupants have no option but to be continuously exposed to RFR.

The Public Service Commission should not be relying on industry representatives for assistance, due to their obvious conflict of interest. Too often they rely on biased research and hold opinions that are not consistent with medical evidence. The symptoms and illnesses experienced from wireless utility meters are related to length and accumulation of exposure and therefore not everyone will exhibit symptoms immediately. In addition, as with many other diseases, not everyone is equally susceptible. There are a number of double-blind studies which clearly show that some people with EHS will develop symptoms when exposure to RFR is studied in a double blinded experimental protocol, in which the subject do not know whether or not the RFR is being applied. These individual are not suffering from a psychosomatic disease, but rather one that is induced by the exposure to RFR. Public health agencies that label these symptoms as being only psychosomatic are ignoring this evidence and are not working to ensure fair treatment of and protection of the public.

The adverse health impacts of low intensity RFR are real, significant and for some people debilitating. We want to stress three fundamentals as your agency proceeds to consider a smart meter opt-out:

- The Federal Communication Commission’s safety standards do not apply to low intensity RFR.
- There is no safe level of exposure established for RFR.
- People around the world are suffering from low intensity RFR exposure, being at increased risk of developing both cancer and EHS.

Citizens rely on their government agencies for protection from harm. Accordingly, we urge the Kentucky Public Service Commission to reject any fees or tariffs associated with smart meter opt-out and allow citizens to opt out without penalty.

Thank you for your attention and consideration. What you do in this instance affects the lives of many in Kentucky and beyond.

Yours sincerely,

David O. Carpenter, M.D.
Director, Institute for Health and the Environment
University at Albany
Rensselaer, NY 12144

Dr. Lennart Hardell, MD, PhD
Professor
Department of Oncology, University Hospital
Orebro, Sweden

Dr. Magda Havas, BSc, PhD
Environmental & Resource Studies
Trent University
Canada

http://www.myfoxdetroit.com/story/25265744/foxe-report-smart-meter-concerns

FOXe report: Smart meter concerns

- Posted: Apr 16, 2014 4:32 PM EDT Updated: Apr 17, 2014 10:53 AM EDT

By Robin Schwartz, Fox 2 News - email

Smart meters have been installed in 1.5 million homes across Michigan.
About 1,900 people have chosen to get an opt-out meter, in which the radio is turned off.
An engineer tests the radio frequences coming from a smart meter.
(WJBK) - DTE Energy crews have installed smart meters at 1.5 million homes across Michigan. The new meters are an advancement in technology and can be read remotely by radio signals, but some homeowners say the meters are intrusive and dangerous.

For example, a fire in Pennsylvania is believed to have started when a smart meter exploded. Some homeowners fear the technology will be used for spying by tracking your energy use, even being able to pinpoint when you're not home. National news reports have indicated that is possible.

Others say the meters also cause health problems.

Jeanette Wagner says a smart meter on her previous house in Kentucky left her temporarily paralyzed. She's since moved to Michigan and lives in a hotel.

"I cannot find a house that doesn't have a smart meter on it, so I don't feel safe," she tells FOX 2's Robin Schwartz.

Leslie Panzica-Glapa says her son, Drew, got sick from the smart meter. He has diabetes and she says his blood sugar levels spiked when the meter went in. She says she also experienced insomnia and terrible headaches.

Schwartz took all the concerns to the General Manager of DTE's Advanced Meter Program, Bob Sitkauskas.

"We've got 10,000 employees, two million customers. We're not going to install something that we feel is unsafe," he says. He adds that he uses a smart meter in his own home.

DTE adds it would never sell the homeowner's readings, which could lead to the aforementioned spying.

An engineer came to Schwartz's home to test the radio frequencies coming from her smart meter. She was told the amount is less than 1 percent of the maximum exposure allowed by federal guidelines. DTE says research proves the smart meters are not a health concern.

Still, others choose to do their own research.

"The research being handed to us by utility companies is going to be skewed. They can get away with telling you their research shows no health dangers, but it's called "interpretive difference," says Wagner.

Panzica-Glapa chose to remove the meter from her home after her and her son experienced those various ailments. DTE has since threatened a lawsuit.

DTE does, however, have a program that gives customers an option.

Homeowners who don't want a smart meter can opt out, and so far about 1,900 people have. For a fee they can get an opt-out meter, which is the same meter with the radio turned off.

Participating in the opt-out program costs about 70 dollars, plus another $9.80 a month.

Some say the opt-out meter is just as bad, though, because it creates so-called "dirty electricity."

An appeal is pending for DTE to allow people with health problems to keep old analog meters, instead of the opt-out meters. Some are still fighting to get smart meters banned altogether.

If you are interested in the opt-out program, call 1-800-477-4747.

JSI **Center for Environmental Health Studies** (617) 482-9485
44 Farnsworth Street, Boston, MA 02210 http://www.jsi.com

Leukemia and Exposure to Ionizing Radiation

Summary: Strong evidence has been recorded of a possible connection between forms of leukemia and exposure to ionizing radiation. This evidence is based upon studies conducted at Los Alamos National Laboratory, studies of nuclear workers at other sites, and others exposed to ionizing radiation. These findings are consistent with the National Research Council's determination that radiation can cause acute leukemia and chronic myeloid leukemia. Leukemia (except chronic lymphocytic leukemia) is designated as a "specified" cancer under the Energy Employees Occupational Illness Compensation Program Act. Historically, incidence of leukemia has been very high for Los Alamos County while mortality has been in the lowest third of New Mexico counties. Incidence and mortality due to leukemia in Rio Arriba County has been roughly comparable to other NM counties. Incidence means new cases of cancer, while mortality means deaths due to cancer.

What is Leukemia?

When leukemia develops, the body produces large numbers of abnormal blood cells. In most types of leukemia, the abnormal cells are white blood cells. There are several types of leukemia. They are grouped in two ways. One way is by how quickly the disease develops and gets worse. The other way is by the type of blood cell that is affected. Leukemia is either acute or chronic. In acute leukemia, the abnormal blood cells remain very immature and cannot carry out their normal functions. In chronic leukemia, some immature cells are present, but in general, these cells are more mature and can carry out some of their normal functions. Leukemia can arise in either of the two main types of white blood cells. When leukemia affects lymphoid cells, it is called lymphocytic leukemia. When myeloid cells are affected, the disease is called myeloid or myelogenous leukemia.

These are the most common types of leukemia:

- **Acute lymphocytic leukemia** (ALL) is the most common type of leukemia in young children. This disease also affects adults, especially those age 65 and older.
- **Acute myeloid leukemia** (AML) occurs in both adults and children. This type of leukemia is sometimes called acute nonlymphocytic leukemia (ANLL).
- **Chronic lymphocytic leukemia** (CLL) most often affects adults over the age of 55. It sometimes occurs in younger adults, but it almost never affects children.
- **Chronic myeloid leukemia** (CML) occurs mainly in adults. A very small number of children also develop this disease.

There are also other less common type of chronic leukemia. (National Cancer Institute)

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* *Findings were statistically significant (strong evidence)*

\+ *Evidence of a dose-response relationship (strongest evidence)*

Findings of Human Health Research Studies

Human health research studies compare the patterns of disease among groups of people with different amounts of exposure to a suspected risk factor. Below are results reported from such studies of leukemia among people exposed to ionizing radiation.

These studies found increases and possible increases in leukemia among certain groups of exposed individuals, in some cases followed over time. Statistically significant is a term used to mean that the connection between the health outcome and the exposure was strong enough that it was unlikely to be due to chance. An asterisk (*) was placed by statistically significant findings. The research included incidence studies, which look at new cases of cancer. Incidence studies can track health more quickly and accurately than mortality studies of deaths due to cancer. Adding to the strength of the findings is that increasing rates of leukemia were observed with higher doses in some studies.

Studies of Los Alamos National Laboratory (LANL) Workers

Research conducted of LANL workers provides the most direct evidence about possible relationships between a health problem and workplace exposures at LANL.

- **Mortality Study up to 1991:** Increasing rates of death due to lymphocytic leukemia were found with increasing doses of external radiation, assuming a latent period of two years. *+ However, all four of the cases were chronic lymphocytic leukemia (CLL) which is not thought to be caused by ionizing radiation. [21]

- **Survivors of Accidents:** Two of the security guards who were present at early criticality accidents in 1945 and 1946 developed fatal acute lymphocytic leukemia 20 to 30 years later.[55]

Studies of Other Nuclear Workers in the United States

The next most relevant evidence comes from studies of workers in similar occupations with the same types of exposures. Listed below are studies that looked at leukemia and workplace exposures among nuclear workers in other parts of the United States.

- **Fernald, Ohio:** Possible increase in deaths due to leukemia (and all blood and lymph cancers) were observed in a study of 4,014 uranium processing workers employed between 1951 and 1989, followed through 1989. [1]

- **Hanford, Washington:** A possible increase in deaths due to all blood and lymph cancers were observed in a study of 44,100 workers who were employed between 1944 and 1978. [52] A possible increase in deaths due to myeloid leukemia was observed in 35,000 men employed at Hanford between 1944 and 1972. [51]

---

* *Findings were statistically significant (strong evidence)*

+ *Evidence of a dose-response relationship (strongest evidence)*

- **Mallinckrodt, St. Louis, Missouri:** A possible increase in leukemia deaths was observed in a study of 2,514 males who were employed between 1942 and 1966, and then followed through 1993. [2]

- **Mound, Ohio:** Increase in leukemia deaths (and blood and lymph cancers) was found in a study of 3,229 males who were monitored for external radiation between 1947 and 1949, assuming a 10-year latent period (time after exposure for the disease to develop). [56 *+]

- **Oak Ridge:** A possible increase in leukemia deaths was observed in a study of 8,375 males employed at least 30 days between 1943 and 1972, and then followed through 1977. Possible increasing rates of death were seen with increasing doses of external radiation, assuming a latent period of 10 years. [50 +] For each rem (a measure of radiation dose) of exposure to external radiation, there was a 6-9% increase in the risk of leukemia. When the follow up period was extended through 1984, there was an increase in leukemia deaths in workers monitored for internal contamination. [57 *]

- **Pantex:** A possible increase in deaths due to all blood and lymph cancers was observed in a study of 3,564 males who were employed between 1951 and 1978, and then followed through 1978. [58]

- **Pooled Analysis of Nuclear Worker Studies:** For all blood and lymph cancers combined, a 20% increased risk at 1-5 rem (a measure of radiation dose) of exposure and a doubling of risk at more than 5 rem of external radiation was found across studies. [59]

- **Rocketdyne/Atomics International:** Increasing rates of death due to all blood and lymph cancers with increasing doses of external and internal radiation were found in a study of workers who were employed between 1950 and 1993, and then followed through 1995. [*+] The largest effect was seen with a latent period of 15 to 20 years. The researchers who performed the study were "somewhat surprised" because the levels of internal radiation were low. [25] A possible increase in leukemia deaths was observed in workers monitored for external and internal radiation. [27]

- **Rocky Flats:** An increase in deaths due to all blood and lymph cancers was found in a study of 5,412 males who were employed for at least two years between 1952 and 1979 who had plutonium body burdens of at least 2 nanocuries (a measure of radiation exposure). The analysis assumed a latency period of five years following exposure for the disease to develop. [*] Possible increasing rates of death due to blood and lymph cancers were observed with increasing body burdens of plutonium or external radiation dose, assuming a latent period of two years. [+] The authors considered this "suggestive" of dose-response trends. [28]

- **Savannah River Site**: An increase in deaths to leukemia (and all blood and lymph cancers) was found in hourly workers hired before 1955, and employed for 5 to 15 years. [*]

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* *Findings were statistically significant (strong evidence)*

+ *Evidence of a dose-response relationship (strongest evidence)*

All blood and lymph cancers were also increased in white males employed before 1955. * Possible increases were observed in other groups. [44, 60]

- **West Chicago (Kerr-McGee) Thorium Plant:** Possible increase in deaths due to leukemia and aleukemia were observed in a study of 1,352 men who were employed between 1940 and 1954, and then followed through 1975. [45]

- **Women at 10 DOE Sites**: An increase in deaths due to leukemia (excluding CLL) was found in a study of 65,984 women employed between start-up and 1980 at 10 DOE facilities. [37 *]

Studies of Other Nuclear Workers World-Wide

Below are studies of nuclear workers outside of the United States that looked at leukemia in connection with radiation exposures.

- **Canadian Radiation Workers:** A 5.9% increase in the incidence of leukemia was found per 100 rem (a measure of radiation dose) in a study of 191,300 workers employed between 1951 and 1988. [47 *+]

- **Nuclear Workers in 3 Countries:** An increase in rates of death due to all leukemias (except CLL) was found in a study of 95,673 workers employed for at least six months and monitored for radiation. [40 *+]

- **3 Nuclear Workforces in the U.K.:** Increasing rates of death due to all blood and lymph cancers was found with increasing time since first monitored for plutonium in a study of 12,498 workers.[*+] Increasing rates of leukemia deaths was found with increasing whole body dose in a study of 75,211 workers who were employed between 1946 and 1986, and then followed through 1988. An increase in leukemia deaths (except CLL) was found in workers monitored for any radionuclide (This study assumed a latency period of 0 or 10 years). [29 *+]

- **Registry of Nuclear Workers in the U.K.:** Increasing rates of leukemia deaths (except CLL) were found with increasing doses of external radiation in a study of 95,217 workers, who were followed through 1988. [5]

- **Sellafield, England:** Increasing rates of leukemia deaths were found with increasing doses of external radiation in a study of 10,382 workers who were employed between 1947 and 1975, and then followed through 1992, assuming a latent period (time following exposure for disease to develop) of 2 years.[*+] Increasing incidence of leukemia was found with increasing combined dose of plutonium and external radiation in a study of 5,203 workers. [3 *+]

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* *Findings were statistically significant (strong evidence)*

+ *Evidence of a dose-response relationship (strongest evidence)*

Studies of Other Ionizing Radiation Exposures

Studies among other groups of people who were not nuclear workers can also be significant as evidence of possible increases in leukemia among those who have been exposed to ionizing radiation. Most other research has been conducted of people exposed to atomic bombs.

- **Atomic Bomb Survivors:** Increasing leukemia deaths were observed with increasing doses of radiation in a study of 86,572 A-bomb survivors.*+ Most of the deaths occurred within the first 15 years following exposure.[8] Children under age 15 are more susceptible.[38]

Is Leukemia Radiation-Sensitive?

- **Yes.** The National Research Council's BEIR V committee performed a detailed analysis of the risks of leukemia from radiation exposures. Among their conclusions are that radiation causes acute leukemia and chronic myeloid leukemia.[9]

The National Research Council advises the U.S. government on scientific matters. Their Committee on Biological Effects of Exposure to Ionizing Radiations (BEIR) V reviewed sensitivity of parts of the body to radiation. Their findings are based mostly on studies of cancer among atomic bomb survivors, as well as on some of the available information on the biology of the body, animal studies, and other evidence. The greatest risk is at high exposure levels.

Is Leukemia a "Specified" Cancer Under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA)?

- **Yes.** Leukemia is a "specified" cancer under the EEOIC Act consideration of Special Exposure Cohorts, except for CLL.

Policy makers have identified certain types of cancer among energy employees at nuclear facilities, including those employed at Los Alamos National Laboratory, as being potentially related to occupational exposures under the EEOICPA.

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* *Findings were statistically significant (strong evidence)*

\+ *Evidence of a dose-response relationship (strongest evidence)*

What Are Other Risk Factors Associated with Leukemia?

In considering the cancer risk from exposure to ionizing radiation at work, it is important to understand other risk factors. Below is a list of other possible risk factors for leukemia.

- **Electromagnetic fields.** Some research suggests that exposure to electromagnetic fields is a possible risk factor for leukemia. (Electromagnetic fields are a type of low-energy radiation that comes from power lines and electric appliances.)
- **Genetics.** Certain genetic conditions can increase the risk for leukemia. One such condition is Down's syndrome; children born with this syndrome are more likely to get leukemia than other children.
- **Certain Chemical exposure.** Workers exposed to certain chemicals over a long period of time are at higher risk for leukemia. Benzene is one of these chemicals.
- **Certain cancer drugs.** Some of the drugs used to treat other types of cancer may increase a person's risk of getting leukemia. However, this risk is very small when compared with the benefits of chemotherapy.
- **Viruses.** Scientists have identified a virus that seems to increase the risk for one very uncommon type of leukemia. However, this virus has no known connection with common forms of leukemia. (National Cancer Institute)
- A "weak relationship" has been observed between myeloid leukemia and smoking in men. But not for women or for other types of leukemia. [41]

These factors may add to any risk due to workplace exposure to ionizing radiation. Leukemia occurs in males more often than in females and in white people more often than in black people.

Rates of Leukemia in Exposed Counties

Los Alamos County

There have been very high rates of leukemia incidence reported in Los Alamos County; yet relatively low rates of cancer mortality. In the 1950's and 1960's, all blood and lymph cancers may have been increased in males in the county, due to occupational exposures during the early years of the nuclear complex. [61] In recent years, about two to three case have occurred annually. [13, 14] Los Alamos County ranked:

- Ranked second highest in incidence of leukemia and
- 21st in mortality among the 33 counties in New Mexico from 1970 to 1996. [33]

Rio Arriba County

There have been moderate rates of leukemia reported in Rio Arriba County for both cancer incidence and mortality. Rio Arriba County:

- Ranked 16th in incidence and
- 12th in mortality among the 33 counties in New Mexico from 1970 to 1996. [33]

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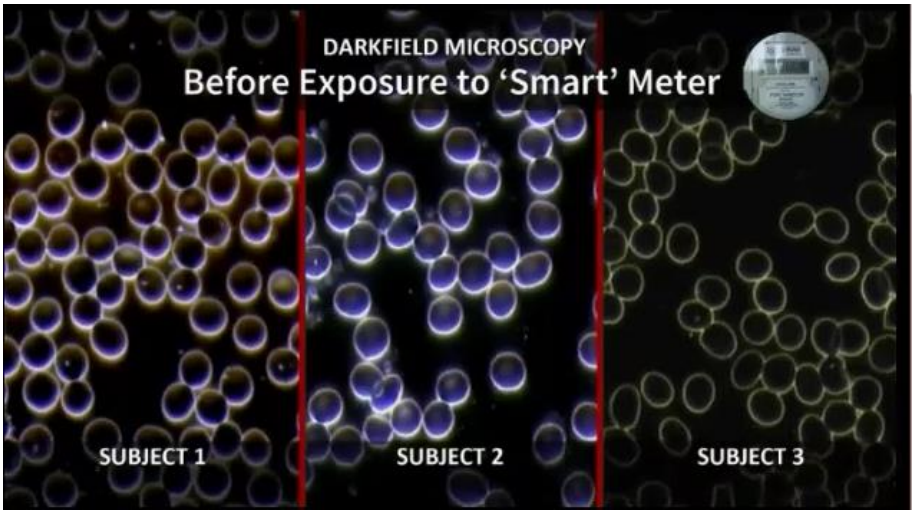
* *Findings were statistically significant (strong evidence)*

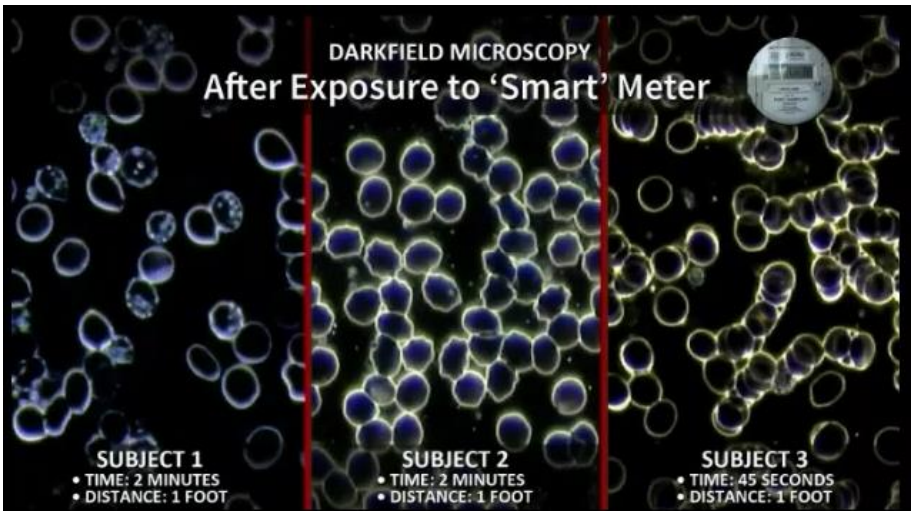
\+ *Evidence of a dose-response relationship (strongest evidence)*

Live Blood Analysis – Observable Effects of Radiofrequency Radiation from Smart Meters

From StopSmartMeters.org.uk

This clip from the film Take Back Your Power shows observable effects of the RF/MW radiation from a Smart Meter on human blood cells using dark-field microscopy.





More than 5,000 studies now show RF/MW radiation to be harmful to human biology, animals and plants. Acute and chronic exposure to RF (radio-frequency) and MW (microwave) radiation can, even at very low power-densities, lead to not only the negative health effects shown in this picture, but calcium ion damage in cells, endothelial cell dysfunction, nitric oxide depletion, oxidative stress, melatonin disruption, blood-brain-barrier leakage, DNA damage, sperm damage and more.

Glucose metabolism changes within the brain are observable after just minutes of cell phone use.

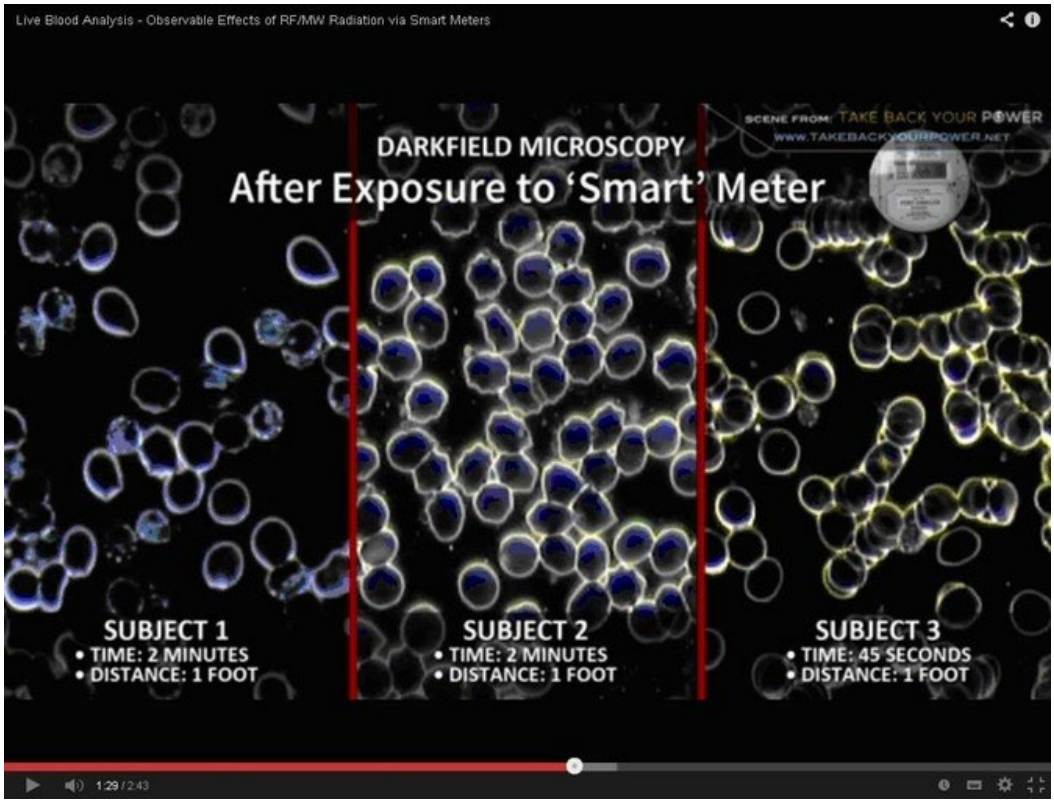
The mechanisms for damage from non-thermal, non-ionizing radiation exposure are now becoming clear.

Unfortunately, so-called "safety" thresholds maintained in the UK are woefully out of date and obsolete, permitting a deluge of highly-profitable, RF-emitting technologies to be introduced into our lives. Whilst

attempts by campaigners in every country are being made to stem and reverse the tide of these environmental toxins, you can take positive action to protect yourself and your family by limiting your own exposure to RF and MW-emitting devices, such as Smart Meters, cell phones, WiFi routers and devices, wireless baby monitors, wireless alarm systems, wireless games consoles, etc.

http://stopsmartmeters.org.uk/live-blood-analysis-observable-effects-of-rfmw-radiation-from-smart-meter/

Live Blood Analysis – Observable Effects of RF/MW Radiation from 'Smart' Meter



Live Blood Analysis – Observable Effects of RF/MW Radiation from 'Smart' Meter

The following clip (https://www.youtube.com/watch?v=y4JDEspdx58)
is an excerpt from upcoming documentary, Take Back Your Power – a critical investigation of the Smart Metering phenomenon and Smart Grid. It shows observable effects of the RF/MW radiation from a Smart Meter on human blood cells using dark-field microscopy.
Please watch and and take action to share this information as widely as possible.
More than 5,000 studies now show RF/MW radiation to be harmful to human biology, animals and plants. Acute and chronic exposure to RF (radio-frequency) and MW (microwave) radiation can, even at very low power-densities, lead to not only the negative health effects shown in this video, but calcium ion damage in cells, endothelial cell dysfunction, nitric oxide depletion, oxidative stress, melatonin disruption, blood-brain-barrier leakage, DNA damage, sperm damage and more.
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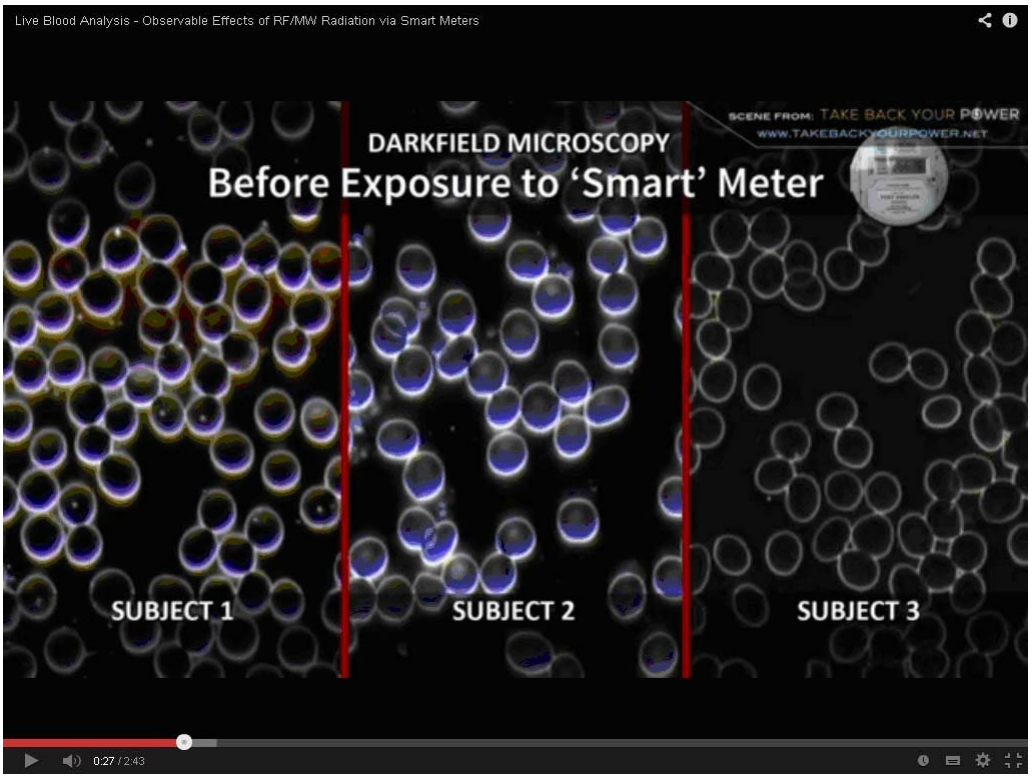
The mechanisms for damage from non-thermal, non-ionising radiation exposure are now becoming clear. Unfortunately, so-called “safety” thresholds maintained in the UK are woefully out of date and obsolete, permitting a deluge of highly-profitable, RF-emitting technologies to be introduced into our lives. Whilst attempts by campaigners in every country are being made to stem and reverse the tide of these environmental toxins, you can take positive action to protect yourself and your family by limiting your own exposure to RF and MW-emitting devices, such as Smart Meters, cell phones, WiFi routers and devices, wireless baby monitors, wireless alarm systems, wireless games consoles, etc.
For more information on Smart Meters, visit www.StopSmartMeters.org.uk. To watch the Take Back Your Power documentary, from 5 September 2013, visit www.StopSmartMeters.org.uk/film
You have the lawful right to refuse a Smart Meter. www.DontSmartMeter.me
Please alert your neighbours, friends and families to this important information.



Exp Oncol. 2011 Jun;33(2):62-70.

Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems.

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Author information

Abstract

In this review we discuss alarming epidemiological and experimental data on possible carcinogenic effects of long term exposure to low intensity microwave (MW) radiation. Recently, a number of reports revealed that under certain conditions the irradiation by low intensity MW can substantially induce cancer progression in humans and in animal models. The carcinogenic effect of MW irradiation is typically manifested after long term (up to 10 years and more) exposure. Nevertheless, even a year of operation of a powerful base transmitting station for mobile communication reportedly resulted in a dramatic increase of cancer incidence among population living nearby. In addition, model studies in rodents unveiled a significant increase in carcinogenesis after 17-24 months of MW exposure both in tumor-prone and intact animals. To that, such metabolic changes, as overproduction of reactive oxygen species, 8-hydroxi-2-deoxyguanosine formation, or ornithine decarboxylase activation under exposure to low intensity MW confirm a stress impact of this factor on living cells. We also address the issue of standards for assessment of biological effects of irradiation. It is now becoming increasingly evident that assessment of biological effects of non-ionizing radiation based on physical (thermal) approach used in recommendations of current regulatory bodies, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines, requires urgent reevaluation. We conclude that recent data strongly point to the need for re-elaboration of the current safety limits for non-ionizing radiation using recently obtained knowledge. We also emphasize that the everyday exposure of both occupational and general public to MW radiation should be regulated based on a precautionary principles which imply maximum restriction of excessive exposure.

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LONG-TERM EXPOSURE TO MICROWAVE RADIATION PROVOKES CANCER GROWTH: EVIDENCES FROM RADARS AND MOBILE COMMUNICATION SYSTEMS

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Summary. In this review we discuss alarming epidemiological and experimental data on possible carcinogenic effects of long term exposure to low intensity microwave (MW) radiation. Recently, a number of reports revealed that under certain conditions the irradiation by low intensity MW can substantially induce cancer progression in humans and in animal models. The carcinogenic effect of MW irradiation is typically manifested after long term (up to 10 years and more) exposure. Nevertheless, even a year of operation of a powerful base transmitting station for mobile communication reportedly resulted in a dramatic increase of cancer incidence among population living nearby. In addition, model studies in rodents unveiled a significant increase in carcinogenesis after 17-24 months of MW exposure both in tumor-prone and intact animals. To that, such metabolic changes, as overproduction of reactive oxygen species, 8-hydroxi-2-deoxyguanosine formation, or ornithine decarboxylase activation under exposure to low intensity MW confirm a stress impact of this factor on living cells. We also address the issue of standards for assessment of biological effects of irradiation. It is now becoming increasingly evident that assessment of biological effects of non-ionizing radiation based on physical (thermal) approach used in recommendations of current regulatory bodies, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines, requires urgent reevaluation. We conclude that recent data strongly point to the need for re-elaboration of the current safety limits for non-ionizing radiation using recently obtained knowledge. We also emphasize that the everyday exposure of both occupational and general public to MW radiation should be regulated based on a precautionary principles which imply maximum restriction of excessive exposure.

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Abbreviations used: 8-OH-dG — 8-hydroxi-2-deoxyguanosine; EGF — epidermal growth factor; EMF — electromagnetic field; EMR — electromagnetic radiation; ERK — extracellular-signal-regulated kinase; GSM — Global System for Mobile communication; ICNIRP — International Commission on Non-Ionizing Radiation Protection; MW — microwaves; NHL — Non-Hodgkin lymphoma; ODC — ornithine decarboxylase; OER — observed expected ratio; OR — odds ratio; ROS — reactive oxygen species; SAR — specific absorption rate; SIR — standardized incidence ratio; SMR — standardized mortality ratio; WHO — the World Health Organization.

INTRODUCTION

Electromagnetic radiation (EMR) became one of the most significant and fastest growing environmental factors due to intensive development of communication technologies during the last decades. Currently, according to expert estimations, the level of electromagnetic radiation from artificial sources exceeds the level of natural electromagnetic fields by thousand folds. The active development of mobile communication technologies over the world will only raise this level further. In this connection the problem of possible adverse effects of anthropogenic EMR on human health and particularly strictest assessment of possible carcinogenic effects of EMR is extremely important.

In August 2007 an international working group of renowned scientists and public health experts released a report on electromagnetic fields (EMF) and human health [1]. It raised a serious concern about safety limits for public electromagnetic irradiation from power lines, cell phones, radars, and other sources of EMF exposure in daily life. The authors concluded that the existing public safety limits were inadequate to protect public health. Moreover, very recently a vast number of new extremely important studies in this field have been published. Importantly, nowadays the problem is discussed on highest political level over the world. It appears that the most sound political document in Europe is a European Parliament Resolution from April 2, 2009 (*http://www.europarl.europa.eu*), where the direct appeals to activate the research and business strategy for effective solving of the problem over the member states were indicated.

In this review we would like to analyze the results of studies on specific biological effects of microwaves (MW), both epidemiological and experimental that deal with cancer promotion by long term low intensity microwave irradiation of human/animal beings. We will concentrate on unequivocal studies and will not analyze ambiguous data. For additional analysis of microwave risks we can recommend recently published reviews [2—10].

MICROWAVES OF RADARS AND MOBILE COMMUNICATION SYSTEMS

Microwaves are non-ionizing electromagnetic radiation. That means MW is a type of electromagnetic radiation which does not carry enough energy for ionization of atoms and molecules under normal conditions and unlike the ionizing radiation this kind of radiation generally has not enough energy for breaking the intermolecular bonds or for breakaway of electrons from atoms or molecules. MW comprise a part of radiofrequency range. Radiofrequency radiation (RF) refers to electromagnetic waves with a rate of oscillation of electromagnetic fields in the range from 30 kHz to 300 GHz. As any other electromagnetic waves, the radio waves are pulses of electric and magnetic fields. These fields regenerate each other as they move through the space at the speed of light. MW have frequencies from 300 MHz to 300 GHz. As MW have the highest frequency among other RF, it carries the highest energy and produce most thermal effect upon interaction with the matter.

The main sources of radiofrequency radiation during a long period in previous century were broadcasting systems. In some cases, for example, in military and aviation the most powerful local sources of radiofrequency radiation were and still are radars (RAdio Detection And Ranging). However, the situation changed dramatically for general population during recent decades; and currently the most prevailing sources of RF in nearest human environment are mobile communication systems. It is important that both radars and systems for mobile communication use the same microwave part of radiofrequency spectrum.

Radar systems are type of powerful sources of pulsed MW which generally effect only certain groups of military or service staff or population living nearby. Radars are detection systems which use MW to determine both moving and fixed objects like aircraft, ships, missiles, etc. Depending on the tasks they use different frequencies of MW, from 1GHz to 12 GHz.

Mobile communication systems are undoubtedly the most source of MW in human environment over the world nowadays. Starting from the first commercial mobile phone networks in Japan, Europe and USA since 1979—1983 the number of active users of mobile telephony increased globally to over five billion. In developed countries the number of cellular phone users today is over the point of saturation. It means that many people use more than one cell phone. The initial age of youngest users of cell phone is estimated as three years old [5].

Mobile communication technology utilizes MW for connection of cell phones and base transmitting stations. Phone refers to as mobile because it is free from wire connection and it refers to as cellular/cell because technology utilizes cellular network principle. All area is covered by many base transmitting stations, each station operates in one cell (part of area) and cell phone automatically changes the station when moves from one cell to another. In GSM (Global System for Mobile communication) standard, which covers about 80% of all services over the world the frequencies of electromagnetic waves used are about 850; 900; 1850; or 1900 MHz, which belongs to the microwave range. The useful information (sounds or images) is transferred by modulation of electromagnetic wave frequency. In GSM standard TDMA (Time Division Multiple Access) principle is realized. This means a part-time access of each consumer to the logical channel with frequency of channel rotation about 217 Hz. Thus, both base transmitting stations and cell phones emit MW modulated according to the digital standard.

SAFETY LIMITS FOR MICROWAVE RADIATION

The main international recommendations on safety levels of non-ionizing electromagnetic radiation is *Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)* of International Commission on Non-Ionizing Radiation Protection [11]. The document gives recommended safety limits in all ranges of EMR both for occupational and general public exposure. “Basis for limitation exposure” is dramatically important for understanding the imperfection of this document. Accordingly, the document directly states that “Induction of cancer from long-term EMF exposure was not considered to be established, and so these guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures resulting from absorption of energy during exposure to EMF.” However, the basic assumption of that is questioned nowadays by numerous data sources.

According to that document a few parameters of EMR energy are recommended to be restricted. Among them the two parameters are used the most often: 1) Specific Absorption Rate (SAR) in W/kg, which indicates the EMR energy absorbed per mass unit of human tissue per second; and 2) power density or intensity of incident radiation in W/m2 (or μW/ cm2) which indicates the amount of electromagnetic energy which falls on a unit of surface (under the right angle) per second. SAR safety limit for general public exposure indicated in Guidelines as 2 W/kg (for head and trunk) for the microwave range. To that, this limit is accepted by industry as mandatory for every commercial cell phone over the world, and real value of SAR of each cell phone model must be indicated in technical specification of the model. Unfortunately, SAR is rather sophisticated index for measurement. Moreover, only models of adult human head are currently used by industry for calculation of SAR, while real SAR values depend on a geometry and structure of tissues and, for example, was shown to be much higher for a child head than for the adult one [12—14].

Power density, or intensity of radiation, is much more direct and simple index as compared to SAR, although it does not estimate the specificity of interaction of EMR and the matter. Occupational exposure limits in microwave range according to ICNIRP are 10–50 W/ m2. Public exposure limits for microwaves according to ICNIRP recommendation were set to 2–10 W/m2 (or 200—1000 μW/cm2) depending on frequency. For example, for GSM—900 MHz standard ICNIRP safety limit will be calculated as 450 μW/cm2 [11].

It is important to note that ICNIRP recommendations have no legal validity, as it is only a recommendation. Each country has their own national legislation in the field of electromagnetic safety, and national limits are rather different in different countries. **Some countries such as the USA and Germany conformed national EMR limits to ICNIRP recommendation. Other countries have much tougher national limits as compared with ICNIRP guidelines.** For example, for GSM-900 MHz standard MW safety limits are: in Italy, Russia and China — 10 μW/cm2, in Switzerland — 4 μW/cm2, in Ukraine — 2.5 μW/cm2 [1]. As we can see, some countries, including Ukraine, have extremely strict national safety limits. Such national positions are explained first of all by long-term national research traditions in a field of electromagnetic biology, and on experience in studying the non-thermal biological effects of this kind of radiation. On the other hand, some countries like Switzerland follow a strict precautionary principle (Better protect than sorry).

RADAR RADIATION AND CANCER PROMOTION

Substantial military and occupational data indicate a significant effect of pulse microwaves on cancer development and other pathological conditions in human. Accordingly, a statistically significant increase in immature red blood cells among workers exposed to a radar was reported [15]. In addition, radar-exposed workers had significantly lower levels of leukocytes and thrombocytes than workers distant from MW sources.

Among Polish soldiers (128 thousand personnel subjects aged from 20 to 59 years), soldiers of 20—29 years old exposed to radar microwaves during 1970—1979 had cancer incidence rates 5.5 folds higher than non-exposed soldiers [16]. The greatest rise of cancer cases was detected in blood-forming organs and lymphatic tissues: by 13.9 folds for chronic myelocytic leukemia and 8.6 folds for myeloblastic leukemia. The level of mortality among all exposed personnel was significantly higher than in unexposed: for colorectal cancer (observed-expected ratio, OER 3.2; 95 %), for cancer of esophagus and stomach (OER 3.2; 95 %), cancer of blood-forming system and lymphatic tissues (OER 6.3; 95 %) [17].

Almost two times more cases of cancer were indicated in the high-exposed American naval personnel served during the Korean War (1950—1954) as compared with the low-exposed subjects among 40 thousands of personnel [18]. Death rates for aviation electronic technicians, the group with the highest exposure rate, were significantly higher than those for the other personnel during the following years up to 1974 [15].

A very substantial increase in cancer incidence was also detected in commercial airline pilots. Thus, the standardized incidence ratio (SIR) for malignant melanoma cases was 10.2; 95.5 % for pilots of commercial airlines in Iceland [19]. Significantly increased risks of acute myeloid leukemia (SIR 5.1), skin cancer, excluding melanoma (SIR 3.0) and total cancer (SIR 1.2) were observed also among Danish male jet pilots [20]. These data have been explained as a result of excess cosmic ionizing radiation or even excessive sun radiation during a leisure time. However, analysis of brain cancers among US Air Force personnel has revealed that non-ionizing radiation and particularly MW had significant effect on cancer development (odds ratio, OR 1.38; 95%), whereas ionizing radiation had negative association with cancer cases (OR 0.58; 95 %) [21]. To that, standardizing mortality ratio (SMR) for brain tumors was 2.1; 95 % among German male cockpit crew members (6,017 people) [22]. Cancer risk was significantly raised (risk ratio 2.2; 95%) among cockpit crew members employed for 30 years as compared to those employed for less than 10 years. In addition, Non-Hodgkin's lymphoma (NHL) was also increased (SMR 4.2; 95%) among male cabin crew members (20,757 people). Importantly, any increase in cancers associated with ionizing (cosmic) radiation was not detected in this cohort study.

In another report, six incident cases of testicular cancer occurred within a cohort of 340 police officers between 1979 and 1991 in Seattle, Washington, observed/expected ratio was 6.9; $p<0.001$ [23]. Occupational use of hand-held radar was the only shared risk factor among all six officers, and all had a routine habit of keeping the radar

gun directly in close proximity to their testicles. Similarly, in Ontario, Canada risk assessment among police officers exposed to radar devices for speed measurement (1,596 females and 20,601 males) revealed an increased risk among men for testicular cancer (SIR 1.3) and for melanoma (SIR 1.45; 95 %) [24].

In another study, eighty seven persons working with radars (and 150 matched control) were divided into risk groups according to frequencies of MW (200 KHz to 26 GHz) and power density (8 μW/cm2 to 300 μW/cm2) [15]. Three specific radiation cataracts in persons working with extremely high MW exposure were identified. Lens changes were associated with level of exposure in different risk groups.

Other occupational studies revealed the highest risk ratio (2.6) for acute myelogenous leukemia in radio and radar operators among all occupational groups studied [25]. In addition, excessive risk for breast cancer was detected (SIR 1.5) among Norwegian female radio and telegraph operators (2,619 women) with potential exposure to radio frequency (405 kHz — 25 MHz) [26].

RADIATION FROM MOBILE COMMUNICATION SYSTEMS AND CANCER PROMOTION

Cell phones. A significant increase of risk of particular brain tumors in long-term (10 years or more) users of cell phones and cordless phones has been detected in series of epidemiological studies of Swedish oncologist Prof. L. Hardell with colleagues [27–33]. It is important that for a short-term use of cell phones similar effects were absent or less evident [4].

The risk of development of high-grade glioma has increased in more than 3 times (OR 3.1; 95 %) for bilateral users of cell phones and in more than 5 times (OR 5.4; 95%) for ipsilateral users after 10 years of using [34].

The risk of development of acoustic neuroma for bilateral users of cell phones was OR 2.9; 95% and OR 3.5; 95 % for ipsilateral users after 10 years of using [29].

Notably, the highest risk of brain tumors has been detected in the youngest users of cell phones (20—29-yr) among all analyzed age groups (20—80 years old), with OR 5.91; 95% for ipsilateral use of cell phones. The highest risk was associated with more than 5-year using period in the 20—29-yr age group for analog cell phones (OR 8.17; 95%) [28].

International multiyear Interphone project conducted under the management of the World Health Organization and substantially supported by industry, was an interview-based case-control study with 2708 glioma and 2409 meningioma cases and matched controls, conducted in 13 countries using a common protocol [35]. The results of study were rather controversial. For example, **authors were forced to declare "a reduced odds ratio related to ever having been a regular mobile phone users was seen for glioma (OR 0.81; 95 %) and meningioma (OR 0.79; 95 %), possibly reflecting participation bias or other methodological limitations."** However, significantly increased risks of tumors development in "heavy" users of cell phones (with more than 1640 hours of using during less than four years) have been revealed in this study: for meningioma OR 4.8; 95 %, for glioma OR 3.77; 95% as compared with the matched controls [35]. One thousand and six hundred forty hours per four years means about one hour per day of a cell phone use. In this connection we can point to our data [36] that indicates amount of time which Ukrainian students (like students in other countries?) spend talking via cell phones every day. Our findings indicated that more than a half of them spend over one hour per day, and more than a quarter of them spend over two hours per day talking via cell phones every day.

Parotid gland, like a human brain, is another potential target for cell phone MW radiation during cell phone talks without hands-free devices. Thus, a study done by an Israeli team has indicated an association between a cell phone use and parotid gland tumors [37]. This study comprised 402 benign and 58 malignant cases of parotid gland tumors diagnosed in Israelis at age over 18 years in 2001—2003. The risk of parotid malignant tumors in intensive users of cell phones (for users with more than 5,479 hours of a use during less than five years) were OR 2.26; 95%. Recently new data have been published that totally a 4-fold increase of parotid malignant tumors in Israel during 1970—2006 took place, whereas other salivary glands tumors had been almost on a stable level during that period of time [38]. Previously, a Finnish study has revealed the OR 5.0; 95% for salivary gland cancer among all Finland digital cell phone subscribers compared with control population after one-two years of a cell phone use [39].

The odds ratio for Non-Hodgkin's lymphoma of T-cell, cutaneous and leukemia types has been found for analogue-cell-phone users as 3.4; 95%; for digital-phone users 6.1; 95 %; and for cordless-phone users 5.5; 95% by L. Hardell group [40]. An American study indicated OR 1.6; 95 % for NHL in users of cell phones with a period of use over eight years [41].

Uveal melanoma (in analysis of 118 cases with uveal melanoma and 475 controls in Germany) has been indicated to have odds ratio 4.2; 95% for people probable/certain exposed to cell phone radiation [42].

Testicular cancer (seminoma) risk had odds ratio 1.8; 95% for men keeping a cell phone during "stand by" in ipsilateral trousers pocket [43]. The results have been based on 542 cases of seminoma in Sweden.

Base transmitting stations. During the last decades more than one and half million base transmitting stations for mobile communication have been installed over the world. However, the World Health Organization suggested a priority to study effects mainly of cell phones, while discouraging studies on the effects of transmitting stations (with an exception of years 2003—2006 when WHO recommended studies of possible effects of radiation of transmitting stations as well) [44]. This is probably the main reason why only a few publications on this particular problem can be found to date [45—49].

The comparison of cancer cases among people living up to 400 m from base transmitting station and people living further than 400 m from station during 1994—2004 was carried out in Germany [48]. A total increase of cancer cases among people living nearby to transmitting station over the control population was 1.26 times during the first five-year period (1994—1998), and 3.11 times during the second five-year period (1999—2004) of operation of the station. Particularly, in the second period the increase of cancer cases was statistically significant both as compared with the population from more distant area and with the expected background incidence.

Population (n=622) living in the area nearby (up to 350 m) the cell phone base transmitting station (850 MHz, 1500 watt of full power) during one year of operation and matched individuals (n=1222) from other area have been compared In Israel [47]. There were 4.15 times more cases of cancer in transmitted station area than in the rest of a city. Relative cancer rates for females were 10.5 for close to station area, 0.6 for control area and 1 for the whole town. Cancer incidence of women in close to base station area was significantly higher ($p<0.0001$) as compared with the control area and the whole city. Keeping in mind that very significant increase in a number of cancer cases took place during only one year period, the authors of the study suggested that MW could provoke latent cases of cancer in inhabitants of the area nearby transmitting station.

French and Spanish researchers also revealed that inhabitants living near base station for mobile communication (up to 300 m) developed significantly higher rates of many subjective symptoms of health

like headache, fatigue, sleep disorder, depression as compared with the matched control from distant area [49, 50].

RODENT MODEL Of CANCER PROMOTION BY MICROWAVES

A highly representative research has been carried out at the University of Washington, Seattle commissioned by US Air Force [51]. The experimental rats (100 animals) were exposed during 24 months at 21.5 hours per day to 2,450-MHz http://canadapharmacy-drugnorx.com/ pulsed microwaves at 800 pps with a 10 μs pulse width. The pulsed microwaves were square-wave modulated at 8 Hz. An average SAR was 0.4 W/kg for a 200-g rat. It was a model of long-term irradiation of Air Force pilots to pulsed microwaves of radar systems. Totally 155 indexes of metabolisms were checked out during the study. As a result, the most expressive effect of long-term MW irradiation of animals was a dramatic increase in a level of cancer cases. In total, 3.6 folds more cancer cases were detected in irradiated animals than in matched control. Lymphoma cases were diagnosed in the irradiated animals 4.5 times more often than in the control group. In addition, benign tumors of adrenal were detected seven folds more often in the irradiated animals than in the control.

In the next study under US Air Force contract, 200 female C3H/HeJ mice were exposed for 21 months (22 h/day, 7 days/week) to a horizontally polarized 435 MHz pulse-wave (1.0 ps pulse width, 1.0 kHz pulse rate) RF radiation environment with an incident power density of 1.0 mW/cm2 (SAR 0.32 W/kg), while 200 mice were sham-exposed [52]. Although under the conditions of this study, an exposure of mice prone to mammary tumors did not affect the incidence of mammary tumors, when compared with the controls, some other tumor cases increased markedly. For example, bilateral cases of ovary epithelial stromal tumor raised by five folds; multiple cases of hepatocellular carcinoma, raised 3 folds, and adrenal gland tumor cases (total) raised 1.63 folds.

In the third published study of this series [53] the same prone-mammary tumor mice were irradiated during 20 months to continuous wave 2450 MHz MW radiation with SAR from 0.3 to 1 W/kg (20 h/day, 7 days/week). A hundred mice were exposed, while 100 mice were used as sham-exposed. As a result, the exposed mice had higher level of mammary tumors (1.27 folds), and higher total level of all types of tumor (1.38 folds) as compared with sham-exposed; the difference between groups was statistically insignificant. Meanwhile, multiple mammary tumor cases occurred in exposed mice twice more frequently than in sham exposed.

In other study mice with high incidence of spontaneous breast cancer and mice treated with 3,4-benzopyrene (BP) were irradiated to continuous wave 2,450 MHz microwaves in an anechoic chamber at 5 or 15 mW/cm2 (2 hours daily, 6 sessions per week, 3 months) [54]. Irradiation with MW at either 5 or 15 mW/cm2 resulted in acceleration of development of BP-induced skin cancer. Microwaves-exposed mice with high incidence of spontaneous breast cancer developed breast tumors earlier than control. Authors indicated that the promotion of cancer development and lowering of natural antineoplastic resistance was similar in mice exposed to MW at 5 mW/cm2 and chronically stressed by confinement, but level of cancer cases in animals exposed to 15 mW/cm2 was significantly higher as compared to chronically stressed by confinement control.

And in well-known study of M. Ripacholi *et al.* (1997)transgenic mice moderately predisposed to develop lymphoma spontaneously have been used for exposure to MW of 900 MHz, with pulse repetition frequency of 217 Hz, incident power densities of 2.6—13 W/m2, and average SAR of 0.13—1.4 W/kg [55]. One group of mice (101 females) has been exposed for two 30-min periods per day during 18 months. Another group of mice (100 females) has been a sham-exposed control. Lymphoma risk was significantly higher, more than twice, in the exposed mice than in the matched control (OR 2.4; 95 %). In particular, follicular lymphoma was the major contributor to the increased tumor incidence.

MICROWAVES AND CELL METABOLISM

Free radical species, including reactive oxygen species (ROS), is an intrinsic feature of cell metabolism [56–58]. But disturbance of redox balance, uncontrolled activation of free radical processes, overproduction of ROS and/or suppression of antioxidant defense in cell often are the important signals of some hazardous changes in cell metabolism [59, 60]. That is why data indicated oxidative effect of some factor is extremely important in risk-assessment research.

A significant increase of ROS and nitrogen oxide generation in cells under non-thermal intensities of MW has been detected both *in vivo* [61—67] and *in vitro* [68—72]. Possibilities of mitochondrial and membrane NADH oxidase dependent ways of ROS generation in exposed cells have been suggested [71, 72]. Accordingly, it was found that the first step in MW (875 MHz, 0.07 mW/cm2) interaction with model cells (Rat1 and HeLa) was mediated in the plasma membrane by NADH oxidase, which can rapidly (during the minutes) generate ROS [72]. ROS directly stimulate matrix metalloproteinases and allow them to cleave and release heparin-binding epidermal growth factor (EGF). This secreted factor activates the EGF receptor, which in turn activates the extracellular-signal-regulated kinase (ERK) cascade and thereby induces transcription and other cellular pathways. On the other hand, on the model of purified human spermatozoa exposed to MW (1.8 GHz, SAR from 0.4 W/kg to 27.5 W/kg) a significant overproduction of ROS in mitochondria was detected, along with a significant reduction in motility and vitality of spermatozoa [71]. All observed effects were significantly correlated with SAR levels, suggesting that significant effects of MW exposure occurred under non-thermal levels of MW.

Therefore, MW can induce cellular oxidative stress, which in turn can cause cancer stimulation [57, 59]. To that, it is known nowadays that in addition to damage via oxidative stress, ROS in cells can play a role of a secondary messenger for certain intracellular signaling cascades which can induce oncogenic transformation [60].

DNA damage in cells exposed to low-intensive microwaves both *in vivo* and *in vitro* was demonstrated during the last years in more than 50 independent studies [73]. The most often method used for detection of DNA damage after the MW exposure was alkaline Comet Assay. A statistically significant increase of both single strand and/or double strand breaks of DNA has been detected in humans [74, 75], animal models [76—79] and cell cultures [76, 80—83] exposed to low intensity microwaves.

Recently, an oxygen damage of DNA in human spermatozoa through formation of 8-hydroxi-2-deoxyguanosine (8-OH-dG) under non-thermal microwaves irradiation *in vitro* has been demonstrated [71].

Consequently, as DNA mutation is a critical step in carcinogenesis and increased level of 8-OH-dG takes place in many tumors [60], the possibility of MW to initiate oxidative damage of DNA is extremely dangerous signal for risk-assessment studies.

Ornithine decarboxylase (ODC) significantly changes its activity under conditions of non-thermal microwave exposure [84—88]. It was one of the first markers of carcinogenesis revealed to be activated under the low intensity microwaves exposure. ODC is involved in processes of cell growth and differentiation, and its activity is raised in tumor cells. Although overexpression of ODC is not sufficient for transformation of normal cells into tumorigenic ones, an increased activity of the enzyme was shown to promote the development of tumors from pre-tumor cells [89].

DISCUSSION AND CONCLUSIONS

In this review we presented evidences for carcinogenic effects of low intensity microwaves. Both epidemiological and experimental data led us to a conclusion that at least under certain conditions the exposure to long term low intensity MW can lead to tumorigenesis. Supporting evidences come from statistically significant epidemiological data based either on long-term analysis, e.g., on mortality of US Navy personnel in 20 years after expose during the Korean War [15], or on relatively short, one year exposure, e.g., by base transmitting station for mobile communication in Israel [47]. In the latter case we fully agree with the authors that MW exposure most likely results in acceleration of pre-existed cancer development. It is of note here that the same conclusion was drawn in epidemiological research on fast increase cancer incidence among adult population in Colorado exposed to extremely low frequency radiation [90].

The main shortcoming of the most epidemiological data, both in military studies and in mobile communication risk assessment, is a lack of a strict dose measurement of exposure. We strongly suggest that in the forthcoming epidemiological studies the correct measurement of intensity and dosage of exposure should be obligatory. The example of a large-scale epidemiological research employing personal MW dosimeters can be found in recent studies in Germany [91—94]. On the other hand, we also realize that the levels of the MW exposure in contemporary epidemiological studies, at least in those which deal with mobile communication systems, were within the official “safety limits” set by appropriate national standards and ICNIRP recommendations. Therefore, taking into account the reviewed data, we conclude that the relatively long-term (e.g., 10 years) exposure to microwaves emitted from mobile communication devices operating within “safety limits” set by current regulating bodies can be considered as a potential factor for promotion of cancer growth. Indeed, in the most studies on rodents the intensity of MW exposure was appropriately measured, and in majority of them the MW intensity was below ICNIRP safety limits. Nevertheless, majority of these studies to a greater or lesser extent demonstrated obvious carcinogenic effects after long term exposure (up to 24 months). This further emphasizes that at least under certain conditions the exposure to both pulsed and continuous MW with intensities below the current official “safety limits” can indeed promote cancer development.

In addition, experimental evidences of involvement of typical markers of carcinogenesis like overproduction of reactive oxygen species or formation of 8-OH-dG under conditions of MW exposure further indicate potential danger of this type of radiation for human health. It is important to emphasize here that experimental data, especially obtained in studies *in vitro* often reveal significant biological effects even after short-term (e.g., only a few minutes) [72] and/or extremely weak intensity of exposure to MW (by several orders of magnitude lower than in ICNIRP recommendations) [95]. Taking these data into account we strongly suggest that currently used “thermal” assessment of potential hazards of MW exposure is far from being appropriate and safe.

Taken together, we state here that nowadays there is enough convincing data to appropriately assert that the long-term exposure to low intensity electromagnetic microwaves can indeed promote cancer development. To that, the official recommendations by ICNIRP and safety limits set by many national regulatory bodies for technical devices emitting microwave radiation, first of all for mobile communication systems, must be re-assessed according to the recent alarming data; and additional studies for unprejudiced risk assessment must be carried out. At present, we strongly suggest for a wide implementation of precautionary principle for everyday microwave exposure that implies maximum restriction of excessive exposure.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Low doses of radiation used in medical imaging lead to mutations in cell cultures

Discovery that radiation creates breaks that allow in foreign DNA must be confirmed in animal studies

Date: January 16, 2020
Source: PLOS
Summary: Common medical imaging procedures use low doses of radiation that are believed to be safe. A new study, however, finds that in human cell cultures, these doses create breaks that allow extra bits of DNA to integrate into the chromosome.

Common medical imaging procedures use low doses of radiation that are believed to be safe. A new study, however, finds that in human cell cultures, these doses create breaks that allow extra bits of DNA to integrate into the chromosome. Roland Kanaar and Alex Zelensky of Erasmus University Medical Center and Oncode Institute and colleagues report these new findings in a study published 16th January in *PLOS Genetics*.

Scientists have long known that exposing cells to high doses of ionizing radiation generates mutations by creating double-strand breaks that let in external segments of DNA. These extraneous fragments of DNA can occur in the nucleus, left over from natural processes, such as genomic DNA repair and viral infections. In the new study, researchers investigated whether low doses of ionizing radiation have damaging side effects by irradiating human and mouse cells grown in the lab. When they counted the cells that had taken up foreign DNA, they found that low doses of radiation, in the upper range of common diagnostic procedures, create mutations through inserted DNA even more efficiently than the much larger doses studied previously.

While the new results in cell cultures are potentially concerning, the study's authors stress that translating radiation's effects on lab-grown cell cultures to effects in the body is premature. Future experiments using animal models will be necessary to determine the full effects of low-dose radiation, and whether its use in medical imaging has an impact on patient health. If the same phenomenon does occur inside the body, then doctors may need to take into account levels of extraneous DNA, such those resulting from a long-term viral infection, when assessing a patient's risk from a procedure that requires radiation.

"Most molecular radiobiological research is focused on high doses of ionizing radiation relevant to cancer treatment, while effects of physiologically relevant doses of radiation on the cell are notoriously difficult to study at the molecular level," said author Roland Kanaar. "Our discovery that mutagenic insertion of foreign DNA into cell's genome is remarkably responsive to doses encountered during diagnostic, rather than therapeutic, procedures provides a new simple and sensitive tool to study their consequences and revealed surprising molecular genetic details of how cells cope with natural amounts of DNA damage."

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Electromagnetic Hypersensitivity: Biological Effects of Dirty Electricity with Emphasis on Diabetes and Multiple Sclerosis

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Dirty electricity is a ubiquitous pollutant. It flows along wires and radiates from them and involves both extremely low frequency electromagnetic fields and radio frequency radiation. Until recently, dirty electricity has been largely ignored by the scientific community. Recent inventions of metering and filter equipment provide scientists with the tools to measure and reduce dirty electricity on electrical wires. Several case studies and anecdotal reports are presented. Graham/Stetzer (GS) filters have been installed in schools with sick building syndrome and both staff and students reported improved health and more energy. The number of students needing inhalers for asthma was reduced in one school and student behavior associated with ADD/ADHD improved in another school. Blood sugar levels for some diabetics respond to the amount of dirty electricity in their environment. Type 1 diabetics require less insulin and Type 2 diabetics have lower blood sugar levels in an electromagnetically clean environment. Individuals diagnosed with multiple sclerosis have better balance and fewer tremors. Those requiring a cane walked unassisted within a few days to weeks after GS filters were installed in their home. Several disorders, including asthma, ADD/ADHD, diabetes, multiple sclerosis, chronic fatigue, fibromyalgia, are increasing at an alarming rate, as is electromagnetic pollution in the form of dirty electricity, ground current, and radio frequency radiation from wireless devices. The connection between electromagnetic pollution and these disorders needs to be investigated and the percentage of people sensitive to this form of energy needs to be determined.

Keywords Diabetes; Dirty electricity; Electromagnetic hypersensitivity; Multiple sclerosis; Power quality; Radio frequency.

Introduction

Most of the research on the biological effects of nonionizing radiation is done at one of two frequency ranges: extremely low frequency (ELF) associated with electricity (50/60 Hz) and radio frequency (RF) associated with wireless telecommunication

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devices (800 MHz to 2.5 GHz range). An intermediate frequency range, at the low end of the RF spectrum (kHz), flows along and radiates from wires (dirty electricity) and thus has characteristics of the two major types of electromagnetic pollution mentioned above. Scientists doing research on the biological effects of power line frequencies seldom measure this frequency range and thus ignore the effects it might have on health.

Recent advances in filtering technology (Graham/Stetzer or GS filters) and measuring equipment (microsurge meter) enable scientists to test for dirty electricity and to reduce it on indoor wires. In this article, case studies are presented of individuals who have benefited after the dirty electricity in their environment was reduced. This technology provides scientists with the tools to monitor, reduce, and experiment with a frequency range that, until now, has been largely ignored and it may help those who suffer from symptoms of electromagnetic hypersensitivity (EHS).

Dirty Electricity

Poor power quality, also known as dirty electricity, has been a concern for the electric utility for decades. Dirty electricity refers to electromagnetic energy that flows along a conductor and deviates from a pure 60-Hz sine wave (Figure 1). It has both harmonic and non harmonic (transient) components and emerged as a problem in the late 1970s with the increasing use of electronic devices that produce nonlinear loads. Karl Stahlkopf, a vice president of the Electric Power Research Institute (EPRI), estimates that dirty power costs U.S. industry between $4 and $6 billion a year, and that it is likely to get worse before it can be mitigated. EPRI expects that 70% of all electricity produced within the U.S. will flow through electronic devices by 2002, compared with 30% in 1999 (Fortune, 1999).

Dirty electricity is ubiquitous. It is generated by electronic equipment such as computers, plasma televisions, energy efficient appliances, dimmer switches, as

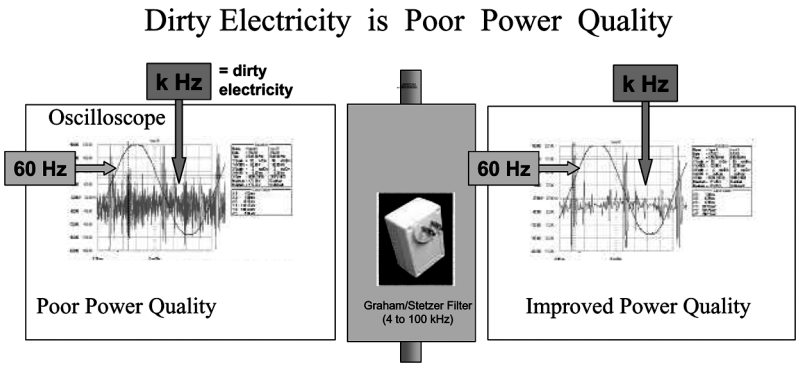

Figure 1. Visual display of dirty electricity (kHz range) and 60 Hz power frequency without (left) and with (right) Graham/Stetzer filters. A 2-channel Fluke 199 Scopemeter was attached to a ubiquitous filter to separate the 60 Hz frequency from the dirty electricity (Graham, 2000). The improved power quality has fewer spikes and smaller amplitude for the high frequency transients. The GS filters have no effect on the 60 Hz sine wave.

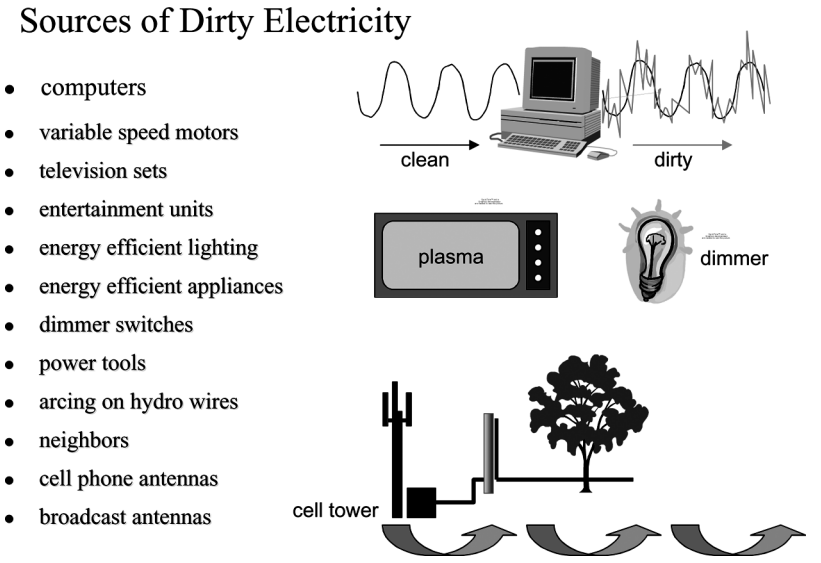

Figure 2. Sources of dirty electricity include electronic equipment and appliances, arcing on wires, and unfiltered cell phone and broadcast frequencies from nearby antennas.

well as arcing on electrical conductors caused by loose wires or contact with trees (Figure 2). Dirty electricity is thus produced within buildings but can also enter buildings from neighbors who share the same transformer. Mobile or broadcast antennas, if not properly filtered, can also contribute to high frequencies on electrical wires in nearby buildings.

The IEEE 519-1992 recommends installing filters to control harmonic distortions on power lines. With 5 kV and higher voltage distribution lines the IEEE identifies voltage notching, which produces both harmonic and nonharmonic frequencies in the radio frequency (RF) range and, as such, can introduce harmful effects associated with spurious RF. Industry uses large capacitors to protect sensitive equipment from power surges, especially in production line work, where malfunctions and down time are costly. Until now filters have not been available for in home use.

Professor Martin Graham from UC Berkeley and power quality expert, Dave Stetzer, President of Stetzer Electric in Wisconsin, have designed a filter that can be used inside buildings to clean the power that enters the building as well as the dirty electricity generated within the building. The Graham/Stetzer (GS) filter is a compact unit that plugs into an electrical outlet (Figure 3). It contains an electrical capacitor that shorts-out the high frequency transients on the circuit and is most effective when placed close to the appliance generating the dirty electricity. The GS filter has optimum filtering capacity between 4 and 100 kHz (Graham, 2000, 2002).

In Russia, the safety guidelines for electric and magnetic field exposure are frequency specific. For frequencies between 5 Hz and 2 kHz, the guideline is 25 V/m for electric fields and 0.25 μT (2.5 mG) for magnetic fields. For frequencies between 2 and 400 kHz, the guidelines are lower by a factor of 10. Since energy is proportional to frequency, the energy is 1,000 times higher at 60 kHz than it is at 60 Hz.

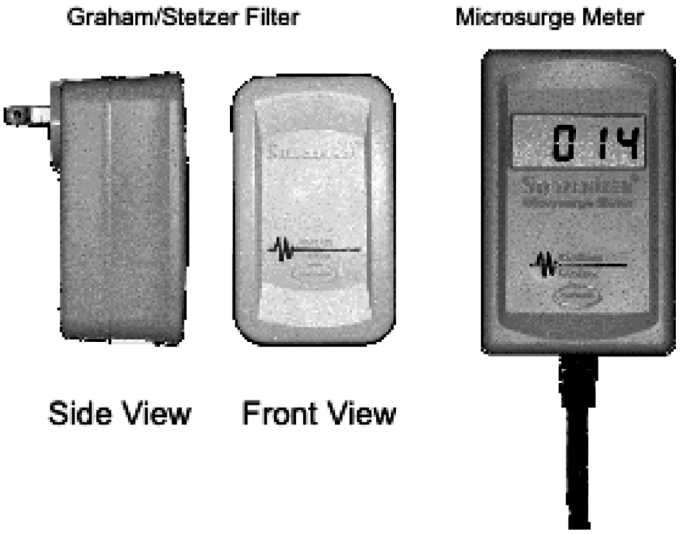

Figure 3. Equipment used to reduce and monitor dirty electricity inside buildings: the Graham/Stetzer filter and the microsurge meter.

The microsurge meter (Figure 3), also designed by Graham and Stetzer, measures the energy associated with dirty electricity in GS units with a range from 1 to 1999 and an accuracy of ±5% (Graham, 2003). The Health Department of the Republic of Kazakhstan (2003) has stated that any reading on the microsurge meter exceeding 50 is unacceptable and steps must be taken to lower such readings. Experience with this meter suggests that values below 30 GS units are undesirable and that extremely sensitive individuals may not see any benefits until the values are at or below 20 GS units. In some extremely dirty environments it is not possible to achieve such low values.

In the following, a number of case studies are presented.

Case Studies

GS filters have been placed in homes, offices, and schools. People report having better sleep, more energy, and less pain. They document cognitive improvements in memory and concentration. Symptoms of radio wave sickness or electrical hypersensitivity (Table 1) are often reduced or eliminated in the filtered environment.

GS filters placed in one Wisconsin school that had sick building syndrome, significantly improved power quality. Shortly after the filters were installed, the health and energy level of staff and students began to improve. According to the District Nurse, of the 37 students in the school who used inhalers on a daily basis, only 3 required inhalers and only for exercise-induced asthma after the filters were in place (Sbraggia, 2002).

GS filters were placed in a Toronto school and approximately 50% of the teachers documented improvements in energy, performance, mood, and/or health in a single blind study (Havas et al., 2004). Student behavior, especially at the elementary level, also improved. The symptoms that changed were ones we associate

Table 1
Symptoms of radio wave sickness first documented among radar workers during the Second World War resemble those now associated with electromagnetic hypersensitivity

Symptoms of radio wave sickness* (Firstenberg, 2001)
Neurological: Headaches, dizziness, nausea, difficulty concentrating, memory loss, irritability, depression, anxiety, insomnia, fatigue, weakness, tremors, muscle spasms, numbness, tingling, altered reflexes, muscle and joint paint, leg/foot pain, "flu-like" symptoms, fever. More severe reactions can include seizures, paralysis, psychosis, and stroke.
Cardiac: Palpitations, arrhythmias, pain or pressure in the chest, low or high blood pressure, slow or fast heart rate, shortness of breath.
Respiratory: Sinusitis, bronchitis, pneumonia, asthma.
Dermatological: Skin rash, itching, burning, facial flushing.
Ophthalmologic: Pain or burning in the eyes, pressure in/behind the eyes, deteriorating vision, floaters, cataracts.
Others: Digestive problems, abdominal pain, enlarged thyroid, testicular/ovarian pain, dryness of lips, tongue, mouth, eyes, great thirst, dehydration, nosebleeds, internal bleeding, altered sugar metabolism, immune abnormalities, redistribution of metals within the body, hair loss, pain in the teeth, deteriorating fillings, impaired sense of smell, ringing in the ears.

**Note:* These symptoms resemble symptoms associated with electrical hypersensitivity.

with attention deficit disorder (ADD) and attention deficit hyperactivity disorder (ADHD). This begs the question, "How much of the increase in ADD/ADHD among young people is due to electromagnetic pollution and poor electromagnetic hygiene?"

People with situational tinnitus (ringing in the ears that is present only in certain environments, often where RF is present) have documented improvements as well after the filters were installed in their home, as have those individuals who are otherwise healthy (Havas and Stetzer, 2004). Two diseases we seldom associate with electromagnetic hypersensitivity are diabetes and multiple sclerosis (MS). What follows are case studies that document the response to dirty electricity of diabetics and those with MS.

Diabetes

Two case studies are presented. (1) A 51-year old male with Type 2 diabetes who does not take medication and (2) an 80-year old female with Type 1 diabetes who takes insulin twice a day. A 51-year old male with Type 2 diabetes monitored dirty electricity in his environment and his blood sugar levels randomly throughout the day for approximately one month in 2003. The microsurge meter was not yet available to measure dirty electricity so he used a Protek 506 Digital Multimeter and measured the peak-to-peak voltage. His blood sugar levels were positively correlated with the amount of dirty electricity in his environment (Figure 4). One day he was

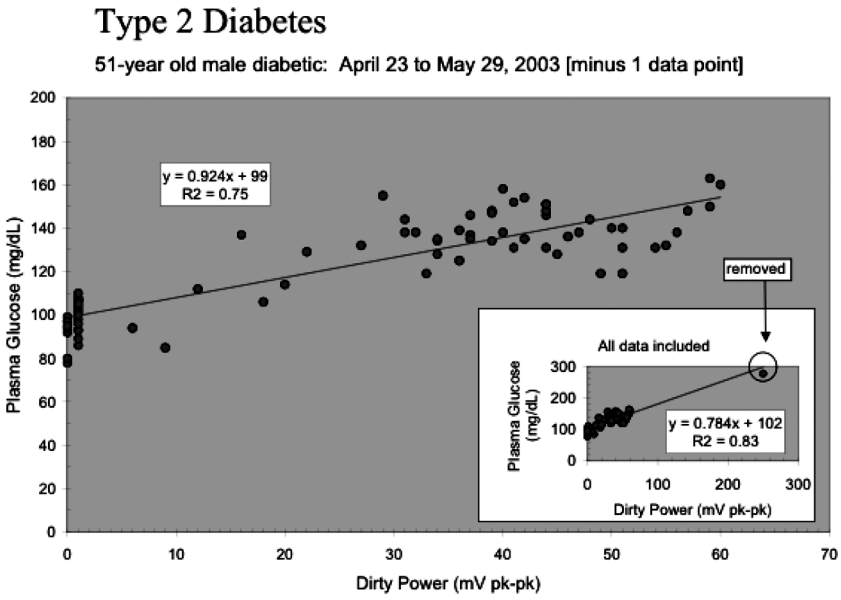

Figure 4. Fifty-one year old male with Type 2 diabetes. His plasma glucose levels correlate with the dirty electricity in his environment. Insert shows exposure on one day to a very high level of dirty electricity and this is reflected in elevated blood sugar.

exposed to very high levels of dirty electricity and this was reflected in exceptionally high levels of blood sugar. He noticed that his blood sugar levels remained low when he was in his truck away from power lines and antennas and when he was in a wilderness setting. In an electromagnetically dirty environment his blood sugar levels would increase within minutes.

An 80-year old female with Type 1 diabetes, who monitors her blood sugar twice daily—once in the morning upon awakening (fasting plasma glucose) and once in the evening before supper—had her home in Arizona filtered by an electrician. He was able to reduce the dirty electricity in her home from an average of 800 GS units to 13 GS units. As soon as the dirty electricity in her home was reduced, her blood sugar began to drop. Her average fasting plasma glucose levels without the filters was 171 mg/dL and this dropped to an average of 119 with the filters (Figure 5). During this period her insulin injections were reduced from a daily average of 36 units to 9 units.

Her evening plasma glucose did not change after the filters were installed in her home but they did change on days she spent away from home. Levels were particularly high after spending time in a casino. Casinos are likely to have high levels of dirty electricity but stress may also have contributed to higher levels of blood sugar (Hinkle and Wolf, 1950).

Multiple Sclerosis

One teacher in the Wisconsin school that was filtered had been diagnosed with multiple sclerosis (MS). She was extremely tired, had double vision, had cognitive

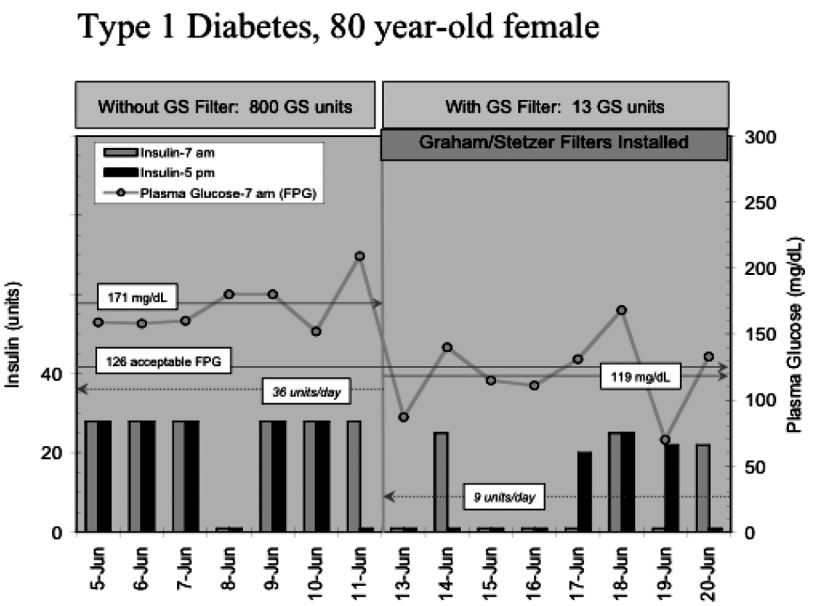

Figure 5. Eighty-year old female with Type 1 diabetes, who takes insulin twice daily. Fasting plasma glucose levels and insulin injections with and without Graham/Stetzer filters are shown.

difficulties and could not remember the names of the students in her 4th grade class. Her health would improve during the summer but her symptoms returned in September. She assumed her problems were mold-related but her symptoms did not improve after the mold was removed from the school. Once the school was filtered her symptoms disappeared. Similar stories prompted studies with people who had MS.

Havas began to work with people diagnosed with MS, who had difficulty walking and who used canes or walkers. The first person she worked with noticed improvements within 24 h. At that stage Havas assumed this was a powerful placebo effect but the subject's symptoms continued to improve weekly and regressed only during wet weather, which had always been a problem for this subject. Several other people with MS were able to walk unassisted after a few days to weeks with the GS filters and Havas began to videotape those who gave her permission to do so.

One of those individuals is a 27-year old male who had been diagnosed with primary progressive MS two years earlier. He walked with a cane or did "wall walking" at home (holding onto the wall or furniture for balance). He had tremors, was exceptionally tired, and was beginning to have difficulty swallowing. Three days after 16 GS filters were placed in his home his symptoms began to disappear. The dirty electricity in his home was reduced from 135–410 GS units to 32–38 GS units. He assumed his body was recovering spontaneously but he had been diagnosed with progressive MS and not relapsing/remitting MS, so spontaneous recovery was unlikely in his case.

A week after the filters were installed in his home he had enough energy to go shopping with his father. He did not take his cane because he had not needed it, but

Figure 6. Video-clip of 27-year old male with primary progressive multiple sclerosis, diagnosed two years earlier. In the video on left (without Graham/Stetzer filters), he walks slowly and is hesitant. In the video on the right (two weeks after Graham/Stetzer filters were installed in his home), he walks with confidence and is well coordinated.

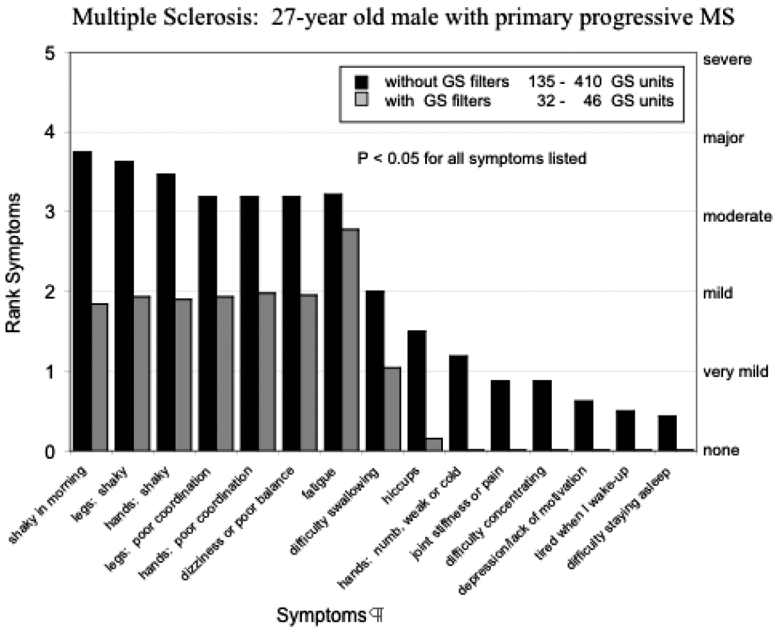

Figure 7. Symptoms of 27-year old male with primary progressive multiple sclerosis with and without Graham/Stetzer filters in his home.

after a couple of hours in the store his symptoms reappeared and he had difficulty walking to the car. His tremors began to subside three hours after arriving home. This experience has been repeated on several occasions and he now knows that if he goes into an environment with dirty electricity his MS symptoms reappear.

Figure 6 is taken from a video before the filters were installed in his home and two weeks later. Prior to the filters his walk was stilted and slow. He staggered and resembled the gait of someone who was intoxicated. Two weeks after the filters were installed his walk was normal with no signs of MS. During this period he began to put on weight, was sleeping better, and had fewer tremors and more energy (Figure 7).

Some other observations that are notable is that his mother had been suffering from hot flashes at night associated with menopause and these came to an end after the filters were installed and his father experienced several episodes of vertigo weekly and these became less frequent.

Conclusions

These case studies and anecdotal reports suggest that dirty electricity is biologically active. Once dirty electricity is reduced, people's health improves. For some it is reflected in more normal blood sugar levels, for others symptoms of MS are reduced, and for still others tinnitus disappears and behavior resembling ADD/ADHD improves. Since dirty electricity is becoming ubiquitous large fractions of the population are being exposed to this pollutant and some are being adversely affected.

Diabetes, multiple sclerosis, ADD/ADHD, asthma chronic fatigue, and fibromyalgia are all increasing in the population and the reasons for this increase are poorly understood. Dirty electricity may be one of the contributors to these illnesses.

According to Philips and Philips (2006) 3% of the population has electromagnetic hypersensitivity (EHS) and 35% have symptoms of EHS. If these percentages apply to diabetics then as many as 5–60 million diabetics worldwide may be responding to the poor power quality in their environment (Wild et al., 2004). Evidence from laboratory studies documents that insulin release and insulin-binding capacity to receptors cells is reduced by electromagnetic fields (Li et al., 2005; Sakurai et al., 2004). It is further known that stress increases blood sugar levels in diabetics and that exposure to electromagnetic energy induces stress proteins at various frequencies (Blank and Goodman, 2004; Hinkle and Wolf, 1950).

Dirty electricity can now be monitored with meters and reduced with filters, providing scientists with the tools needed for research. What is presented here is a handful of studies, many preliminary, with dramatic results. This area warrants further investigation to determine the mechanisms involved and the percentage of the population affected.

Conflict of Interest

Please note that the author has no vested interest, financial or otherwise, in the commercial devices discussed in this article.

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https://www.intellihub.com/mainstream-media-admits-smart-meters-spying-devices/

Mainstream media admits smart meters are spying devices

By JGVibes -
02.24.2014 @2:28 AM EST

Mainstream media finally recognizes the smart meter dangers that "conspiracy theorists" have warned of for years

By John Vibes

(INTELLIHUB) — For years researchers and activists have been warning about the health and privacy dangers involved with smart meters. As usual, the mainstream media ridiculed these warnings and insisted that smart meters were harmless. However, now it is becoming common knowledge that these smart meters can be used to spy on innocent people, and even the mainstream media is starting to catching on.

Shockingly, news organizations like NBC are even picking this story up, in a recent article for NBC News, Matt Liebowitz writes:

Researchers examining the privacy implications of smart-meter technology found that one German provider's devices contained vulnerabilities that allowed them to snoop on unencrypted data to determine whether or not the homeowners were home.

After signing up with the German smart-meter firm Discovergy, the researchers detected that the company's devices transmitted unencrypted data from the home devices back to the company's servers over an insecure link. The researchers, Dario Carluccio and Stephan Brinkhaus, intercepted the supposedly confidential and sensitive information, and, based on the fingerprint of power usage, were able to tell not only whether or not the homeowners were home, away or even sleeping, but also what movie they were watching on TV.

Smart meters are just one piece of the national surveillance puzzle that has been growing in recent decades.

"Over the last several years, traffic-centric surveillance applications were the most prolific," said Eric Ackermann, sales manager for enterprise solutions and services at Siemens Industry in California's Orange County. *"In the last two years, a vast majority of the demand has come from city water/utility, parks/recreation, police and public works."*

Just last week we reported that many researchers who were labeled as "conspiracy theorists" were vindicated by the mainstream media in regards to weather control, when a mainstream scientist discussed the deep history of government weather modification on nationwide television. As the truth of our reality becomes more undeniable, the mainstream will continue to admit things that they once ridiculed.

Writer Bio:

John Vibes is an investigative journalist, staff writer and editor for Intellihub News where this article originally appeared. He is also the author of an 87 chapter e-book entitled "Alchemy of this Modern Renaissance" and is an artist with an established record label. You can find him on his Facebook.

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Cutaneous mast cells are altered in normal healthy volunteers sitting in front of ordinary TVs/PCs – results from open-field provocation experiments

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Background: Considerable controversy has surrounded the question of possible biological responses to electromagnetic fields (EMFs) generated from visual display terminals (VDTs), such as personal computers (PCs) and ordinary television sets (TVs). The cellular and molecular mechanisms for such potential harmful health hazards have not yet been understood, although clues from the literature include mast cells and histamine. The aim of this study was therefore to investigate possible biological mast cell responses to TV/PC screens.
Methods: Using the indirect immunofluorescence technique, we studied the presence of histamine-containing mast cells in the dermis of healthy volunteers. Cutaneous biopsies taken before and after exposure to ordinary TV/PC screens for 2 or 4 h were investigated in 13 healthy subjects.
Results: Our present *in vivo* study indicates that normal cutaneous mast cells could be altered by exposure from ordinary TV/PC screens. To our great surprise, we found the number of mast cells in the papillary and reticular dermis to increase, to varying degrees, in 5 out the 13 subjects after such an exposure. A migration of mast cells towards the uppermost dermis appeared as the most important event. Thus, the normally upper "empty zone" of the dermis disappeared, and instead, a higher density of mast cells were found in this zone. These cells also seemed to have a tendency to increase in number towards the epidermal-dermal junctional zone and some of them lost their granular content and the cytoplasm shrunk (=degranulation). These findings could only be seen in the exposed skin. Two of the 13 cases instead showed a decrease in mast cell number, but the shift in mast cells towards the upper dermis was still visible. Twenty-four h after the provocation, the cellular number and location were normalized in all subjects.
Conclusions: By definition, normal healthy volunteers are assumed not to react to a TV/PC screen provocation. To our great surprise, this proved not to be true. The present results might lay a foundation to understand the underlying cause of so-called "screen dermatitis" with special reference to mast cells. However, blind or double-blind experiments using patients ought to be further investigated in order to find out the exact cause for the observed changes. Such causes include the effects of surrounding airborne chemicals, stress factors, etc.

Johansson O, Gangi S, Liang Y, Yoshimura K, Jing C, Liu P-Y. Cutaneous mast cells are altered in normal healthy volunteers sitting in front of ordinary TVs/PCs – results from open-field provocation experiments.
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It has previously been assumed that three visual display terminal (VDT)-dependent factors potentially might affect human health: radiation, ergonomics, and stress factors.[1]

The X-ray radiation emitted from the VDT screen was, however, found to be far below accepted risk levels, even under "worst case" conditions, and has not been considered to be associated with any adverse health effects.[1] Considerable controversy has surrounded the question of possible biological responses to low- or high-frequency electromagnetic fields (EMFs). The mechanisms of any harmful health events, such as in so-called "screen dermatitis", have not been understood. Psychological stress factors are believed to be involved in the development of so-called "screen-induced symptoms".[2] Animal experiments have shown disturbances in endogenous opioid systems, with secondary effects on cholinergic systems, after exposure to low-frequency EMFs.[3] Pulsed EMFs imposed on developing chick embryos resulted in an increase in the frequency of abnormal developments.[4] Mammalian cell lines have been shown to respond to extremely low-frequency EMFs with an increase in the activity of a proliferation-regulating enzyme,[5] and stimulation of the calcium influx;[6] furthermore, EMFs could promote peripheral nerve regeneration both *in vivo* and *in vitro*.[7–12] All obtained data thus indicates that EMFs can directly affect biological systems through different, but yet, unclear pathways, including both physiological and biochemical ones.

Most recently, some interesting studies have been published, e.g. Henshaw et al.[13] revealed an enhanced deposition of radon (^{222}Rn) daughter nuclei (^{214}Po; ^{218}Po) in the vicinity of everyday sources of power-frequency EMFs in normal domestic room air. Since countries such as Sweden and the United Kingdom are very rich in ground-based radon as well as radon exposure from building materials, one may ask whether devices like VDTs are true α-emitters?

In this context one has to also mention the findings of Lai & Singh,[14] who investigated the effects of acute (2-h) exposure to pulsed (2 μs pulse width, 500 pulses/s) or continuous-wave 2,450 MHz radiofrequency electromagnetic radiation on DNA strand breaks in the brain cells of rats. An increase in both types of such DNA strand breaks was observed after exposure to either the pulsed or continuous-wave radiation. Again, it is natural to ask what happens with humans using high-frequency devices such as TVs/PCs, mobile telephones, light tubes, etc.?

It has been known for several years that mast cells can be involved in many physiological and pathological reactions in inflammation, allergy, urticaria, psoriasis, itch sensations and pain.[15–17] Cutaneous mast cells are involved in both type I and IV hypersensitivity reactions. In another case-control study (Johansson & Liu, unpublished data), the results in human skin clearly showed that cutaneous mast cells differed both in quantity, quality and distribution pattern in so-called "screen dermatitis" patients as compared to normal healthy volunteers.

Using the same approach in this study, we employed conventional PCs and household TVs as provocation tools to conduct an *in vivo* study on human normal healthy volunteers. The aim of this study was to investigate possible biological mast cell responses to TV/PC screens. By definition, normal healthy volunteers are assumed not to react to such a provocation. To our great surprise, this proved not to be true.

Material and methods

Subjects

Thirteen healthy volunteers (7 male and 6 female, aged 19–34 years old, average 25.7) were selected as the subjects in the study, which was approved by the Committee of Ethics at the Karolinska Hospital. All subjects had no history of dermatoses, allergic diseases or other somatic diseases, and they were all non-smokers.

Test parameters

An ordinary laboratory room without windows was used for the provocation experiment. The room was equipped with 5 conventional PCs (attached to their monitors), 2 ordinary household TVs and 1 portable TV. The temperature in the room was 23–24 °C, and the electric and magnetic fields had a strength of 85 V/m, 35 nA and 310 μT/s in the TVs/PCs "OFF"-position, and a strength of 250–500 V/m, 100 nA and >10,000 μT/s in the TVs/PCs "ON"-position,

as measured at the biopsy spot with a Friman Instrument MF-4 (size of measuring plate: 21.5 mm×65.5 mm; 1 m^2 coil (MF-3) and an RC nT-converting filter (no. 169; Friman Datakonsult AB, Stockholm, Sweden). The subjects were seated at a distance of 40 cm from the TVs/PCs with their backs facing the front of the TVs/PCs. The whole provocation lasted 2 or 4 h. Biopsies from the challenged area were taken in pairs at anatomically symmetric sites right before, immediately after the provocation and at 2, 4 or 24 h after the provocation.

Preparation of tissues

Routine punch (Kai Industries, Japan) biopsies (3 or 4 mm in diameter), including epidermis and dermis, were taken under local anaesthesia (Xylocaine, Astra, Sweden). The biopsies were fixed in 4% carbodiimide (1-ethyl-3–3-dimethylaminopropyl-carbodiimide (Sigma, St. Louis, MO, USA) diluted in phosphate buffer (pH 7.4)) for 2 h at 4 °C.[18] The tissue was then rinsed for at least 24 h in 0.1 M Sörensen's buffer containing 10% sucrose, 0.01% NaN_3 and 0.02% Bacitracin and then sectioned on a Microm cryostat to yield 14-µm-thick sections, thawed onto gelatine-coated slides and processed for indirect immunohistochemistry.

Immunohistochemistry

The indirect immunofluorescence technique was employed.[18,19] The sections were kept in an humid atmosphere, incubated with the primary rabbit histamine antiserum (1:2,000; Milab AB, Malmö, Sweden) overnight at 4 °C, rinsed in phosphate-buffered saline (PBS), incubated for 30 min at 37 °C in rhodamine (TRITC)-conjugated goat anti-rabbit IgG (1:80; Boehringer-Mannheim, Mannheim, Germany), rinsed and mounted. All antisera were diluted in PBS containing 0.3% Triton X-100.

The control of the antiserum specificity was performed by pre-absorption with histamine dihydrochloride (0.1 mM; Sigma). In addition, it has been verified by the manufacturer that the antiserum does not cross-react with norepinephrine, serotonin, vasoactive intestinal polypeptide, glucagon or histidine. To test for any possible non-specific binding of the primary antiserum to Fc receptors in the tissue, a normal rabbit serum (1:100) was used instead of the primary antibody. To control for any possible non-specific reactions of the secondary antiserum, PBS was used on certain sections instead of the primary antibody. Other sections were directly only incubated with the secondary antibody. For observation and photography a Nikon Microphot-FXA fluorescence microscope was used. The results were collected from two independent observers.

Results

First, it should be noted that no cutaneous and/or somatic objective or subjective symptoms at all were induced in or reported by the tested volunteers during and after the provocation. This is fully in accordance with the assumption that normal healthy volunteers should not react to the TV/PC provocation situation at all.

The histamine immunoreactivity was only found in cells of the dermis. The immunoreactive cells observed in this study are considered to be mast cells based on their localization, number and cellular morphology, e.g., size and arrangement of granules according to our previous investigations.[18,19] They were seen around dermal appendages such as hair follicles, sebaceous glands, sweat glands and blood vessels, and they all had a similar morphology. Although mast cells were frequently found close to small capillaries and large blood vessels, they were never actually pres-

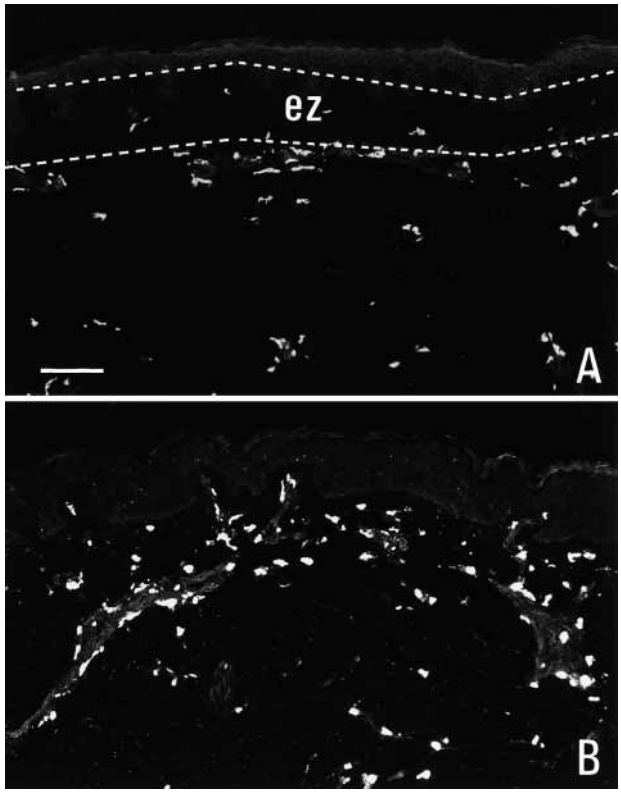

Fig. 1. The distributional alteration of cutaneous mast cells due to the provocation. A) An unexposed biopsy illustrates the relatively empty zone (ez) below the epidermal-dermal junction, where only single cells are seen. Further below this empty zone, mast cells are found in their highest density and gradually decrease towards the deeper dermis. B) In an exposed skin, a cellular migration upwards to the uppermost dermis was induced after exposure, i.e. the normally empty zone disappeared, and, instead, a high density of mast cells is observed in this zone. Bar in A=50 µm. The magnification in A=B.

ent in the vascular wall. The immunolabelling was found exclusively in the cytoplasm of the cells, leaving the ovoid single spherical or oblate spherical nucleus unlabelled, generally displaced to one side of the cells and along the long axis of cell (Fig. 1A). All the positive cells appeared prominently granular and most of them were elongated with cytoplasmic extensions while others were flat or dendritic when examined under high magnification.

In all unexposed biopsies, a relatively empty zone could be seen, which was approximately 100–200 μm wide below the epidermal-dermal junctional zone running parallel to that border (Fig. 1). One could hardly see any mast cells in that zone. This is consistent with our previous results in normal facial skin (Johansson & Liu, unpublished data). Further below the empty zone, mast cells were found in their highest density and gradually decreased towards the deeper dermis.

The main experimental results registered after exposure to the TVs/PCs are shown in Table 1. To our great surprise, the numerical density of mast cells increased in 5 out of the 13 subjects in the papillary dermis and reticular dermis as a response to the provocation; however, the cellular volume seemingly remained unchanged in most cases. Two out of 13 also increased the fluorescence intensity of their histamine granules. Above all, a cellular migration appeared as the most important event in the provocation experiment, i.e. the normally empty zone disappeared, and instead a high density of mast cells was observed in this zone. These cells also seemed to have a tendency to move towards the epidermis and some of them lost their granular content and their cytoplasm shrinked (pointing to a possible degranulation) (Fig. 2).

In contrast to the results mentioned above, two cases showed a numerical mast cell decrease, but the upward movement was still visible. In addition, in one case, the processes of mast cells were found to be

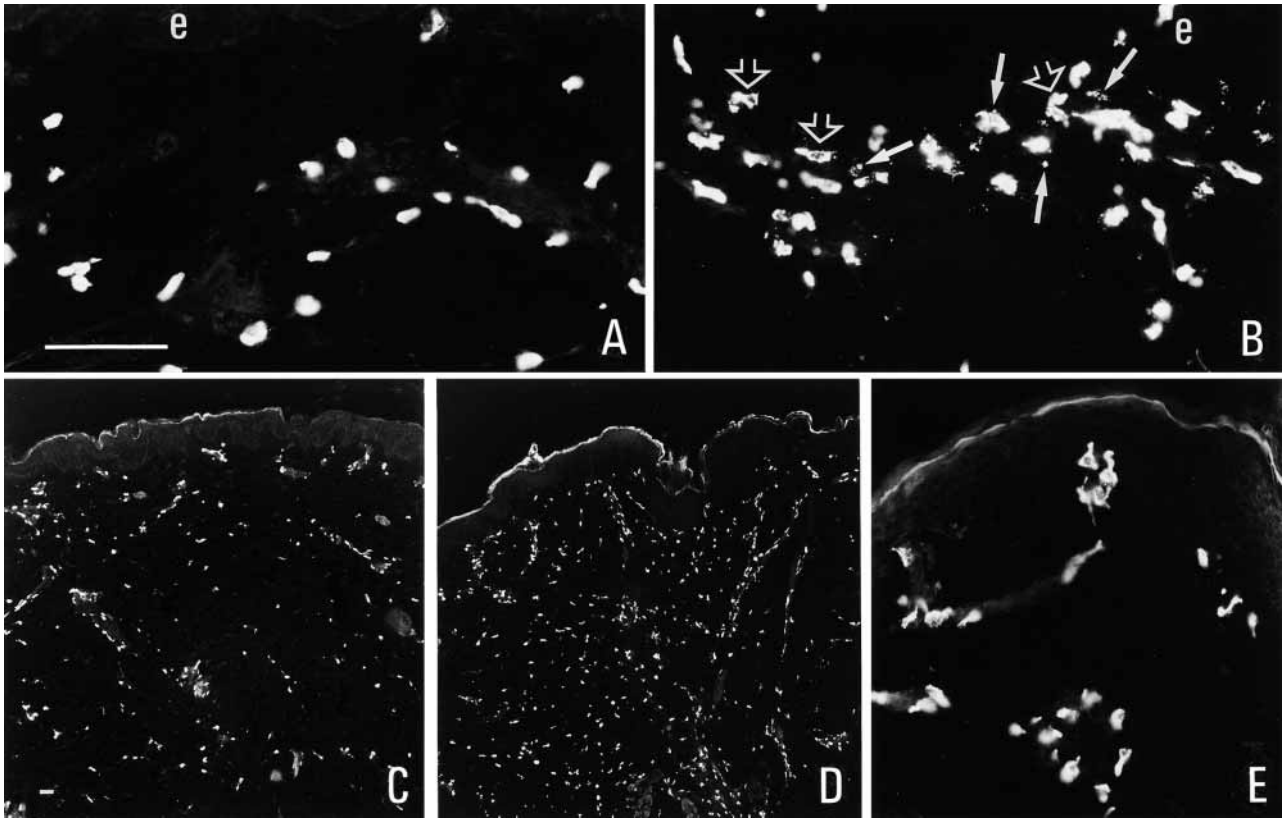

Fig. 2. A typical cutaneous response to TV/PC provocation. Note that biopsies A & C and B & D, respectively, came separately from the same subject. In A, the unexposed biopsy shows the morphology of normal status mast cells. In B, a biopsy from after 4 h of exposure, it is shown that these cells close to the epidermis have degranulated and that their cytoplasm has shrinked. Open arrows point to shrinked mast cells; solid arrows point to discharged histamine granules from mast cells. e=epidermis. C and D are low-power micrographs clearly demonstrating that compared to before (C), after 4-h exposure (D) the number of mast cells has increased and an upward movement of these mast cells has appeared. In E, one case showed an odd morphology of mast cells as a response to the provocation; the processes became more numerous as well as larger, especially in cells that were situated closer to the epidermis. Bars in A and C=50 μm. The magnification in A=B=E, and in C=D.

Table 1. The protocols of cutaneous mast cell variation after 2 or 4 h screen provocation compared with unexposed biopsies

Subject	2 or 4 hours after provocation				After a 24-h delay			
	No.	CV	GI	McM	No.	CV	GI	McM
1.	↑↑	–	-	3+	–	–	–	0
2.	↑↑	↑	–	1+	–	–	–	0
3.	↑↑	–	–	1+	–	–	–	0
4.	↓	–	–	1+	–	–	–	0
5.	–	–	–	1+	–	–	–	0
6.	–	–	↑	0	–	–	–	0
7.	–	↑	–	0	–	–	–	0
8.	–	–	–	0	–	–	–	0
9.	–	↑	↑	2+	–	–	–	1+
10.	↓	–	–	1+	–	–	–	0
11.	↑↑	–	–	1+	–	–	–	1+
12.	–	–	–	0	–	–	–	0
13.	↑↑↑	–	–	2+	↑	–	–	0

–=no change; ↑=increase; ↓=decrease; 0=not present; +=was induced to a mild (1+), medium (2+) or strong (3+) degree; CV=cellular volume; GI=granular intensity; McM=mast cell migration into the uppermost dermis

more numerous as well as larger, especially in cells that were situated closer to the epidermis, as a response to the provocation (Fig. 2E). The morphology of the cutaneous capillaries, sebaceous glands as well as hair follicles always remained unchanged. Finally, it should be noted that 24 h later, all of the subjects with changes reported above revealed a normal pattern.

There was no significant difference between biopsies that were taken instantly after exposure or after 2 or 4 h post-provocation delay. Furthermore, no differences could be seen if the provocation time was 2 or 4 h.

Discussion

Mast cells are effectors of IgE-mediated immune reactions because they have high-affinity receptors for the Fc-portion of IgE.[20] Their ability of rapid response to allergens or poison stimuli may be considered as a first line of defence in protecting the skin from being infiltrated by micro-organisms and other potentially harmful agents. They contain and release, after activation, a wide array of pro-inflammatory mediators affecting structures and cells, and conversely their differentiation and function are affected by their environment.

Histamine is synthesized in mast cells from histidine and is stored within the mast cell secretory granules by forming a complex with the glycosaminoglycan side chains of heparin. In mammalian connective tissue, including the skin, mast cells have generally been regarded as the major source of histamine.[21] It has been found that there were statistically significant correlations between the mast cell number and histamine content.[19,21–24] Therefore, most of the histamine immunoreactivity cells are equal to classical mast cells.

In the present study, we found a special distribution in the papillary dermis, i.e. an empty zone could easily be identified, like in the face (Johansson & Liu, unpublished data), which has not been reported in the back before. This zone may be considered as a 'buffer' zone for immune reactions; once an antigenic substance or stimulus intrude into this area, immunocytes (as well as mast cells) migrate into this zone to participate in the immunological response.

Apart from the fact that mast cells could be provoked to increase their infiltration in the dermis, another prominent finding in this investigation is, of course, the upward migration. It could be induced in most cases (9 out of 13; see Table 1), although two cases showed a decrease of mast cell number. In this context, it may be noted that Donnellan et al.[25] have shown clear-cut effects on a mast cell analogue, RBL-2H3, of EMFs at 835 MHz. The rate of DNA synthesis and cell replication increased, the actin distribution and cell morphology became altered, and the amount of β-hexosaminidase released in response to a calcium ionophore was significantly enhanced, in comparison to unexposed cultures. There were no effects seen on the levels of cytoskeletal protein synthesis or β-actin mRNA. However, the amount of Ras in the membrane fraction of exposed cells increased. The morphological changes persisted following subculture for at least 7 days in the absence of further exposure.[25] This work has now also been extended to yet another mast cell line, namely the HMC-1, and at 864.3 MHz.[26] In their study, the authors reported effects on the localization of the protein kinase C, and expression of 3/588 genes screened. The affected genes included the proto-oncogene c-kit, the transcription factor nucleoside diphosphate kinase B and the apoptosis-associated gene DAD-1. In addition, stress response genes were variably upregulated. No significant effect on cellular morphology or on F-actin distribution was detected. The conclusion of the publication[26] was that the low-power microwave exposure used may act on the HMC-1 cells by altering gene expression via a mechanism involving activation of protein kinase C, and at temperatures (=26.5 °C) well below those known to induce heat-shock responses.

The recent finding that small magnetic particles of magnetite (Fe_3O_4) are present in various biological tissues opens the arena for new speculations on interaction mechanisms.[27] A cluster of cells, denoted magnetocytes or Jurkat cells (a human leukemic T-cell line)[27] and bacteria *Magnetospirillum magnetotacticum* have been reported to contain magnetite, and low-frequency magnetic fields have been shown to increase inositol 1,4,5-triphosphate levels in the Jurkat cell line.[28] Earlier reports from the same group have shown that when a weak 50-Hz magnetic field was applied, the Jurkat cells responded with intracellular

calcium oscillations.[29] The results suggested that the magnetic fields interfered with the signal transduction, although neither target molecules nor molecular mechanisms are at present known. Perhaps some cutaneous mast cells also may contain magnetite and such cells may be involved in possible interactions of environmental EMFs and skin. When there exists an EMF, they might migrate toward the magnetic source, i.e., towards the epidermis, to degranulate their histamine content. Since this effect only happens at the cellular level, it may not be strong enough to immediately cause cutaneous objective/subjective symptoms of long-lasting nature. Support for this idea may be given by the observation that, even if a subject had cellular changes directly after the provocation, 24 hours later they had become normal again (cf. Table 1). But, repeated chronic exposure to magnetic fields may be able to cause symptoms such as itch, smarting, redness, papules, etc.[30] This is correspondent to the fact that mostly when the so-called "screen dermatitis" patients leave their VDT work, the symptoms are relieved or, more or less, disappear.

In conclusion, although the subjects in the present investigation did not report any cutaneous and/or somatic objective or subjective symptoms during as well as after the provocation, 7 out of 13 still had profound cellular changes in their dermal mast cell population. This would mean that normal human skin very well could biologically react to external EMFs generated from TVs/PCs. What this would imply for the whole human being could only, at this stage, be guessed at. Since the subjects did not verbally complain it is not likely that psychological and/or psychosomatic events have taken place, rather the cellular changes point to a UV, microwave, or other high-frequency radiation emitted by the TVs/PCs. The assumption that normal healthy volunteers should not react at all to the TV/PC provocation situation thus proved to be wrong. And, maybe the observed cellular changes are actually just plain radiation damages?

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Review

Mechanisms of Radiation Toxicity in Transformed and Non-Transformed Cells

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Abstract: Radiation damage to biological systems is determined by the type of radiation, the total dosage of exposure, the dose rate, and the region of the body exposed. Three modes of cell death—necrosis, apoptosis, and autophagy—as well as accelerated senescence have been demonstrated to occur *in vitro* and *in vivo* in response to radiation in cancer cells as well as in normal cells. The basis for cellular selection for each mode depends on various factors including the specific cell type involved, the dose of radiation absorbed by the cell, and whether it is proliferating and/or transformed. Here we review the signaling mechanisms activated by radiation for the induction of toxicity in transformed and normal cells. Understanding the molecular mechanisms of radiation toxicity is critical for the development of radiation countermeasures as well as for the improvement of clinical radiation in cancer treatment.

Keywords: ionizing radiation; apoptosis; necrosis; senescence; autophagy; cancer; primary cell

1. Introduction

In Germany, 1895, Wilhelm Conrad Röntgen observed that invisible rays generated in a vacuum tube induced fluorescence from a barium platinocyanide-coated plate. He found that the rays could differentially penetrate objects of differing densities, and Röntgen generated the first radiographic

images of bones. Later that same year, he reported his discovery in which he called these images X-rays, and later was awarded the Nobel Prize for Physics in 1901 [1,2]. Based on these findings, Antoine Henri Becquerel began investigations to determine whether other forms of naturally occurring phosphorescence were related to X-rays; in 1896 Becquerel discovered spontaneous radioactive properties of uranium ore, for which he too was awarded the Nobel Prize for Physics in 1903 [3]. Investigations conducted by Marie Curie on radioactive substances and their properties led to the discoveries of polonium and radium, which resulted in the receipt of Nobel Prizes in Physics in 1903 (shared with Becquerel and Pierre Curie) and in Chemistry 1911 [4]. The application of radiation has advanced the fields of medicine, biology, physics, astronomy, materials science, engineering. Indeed, the full extent of radiation application is still waiting to be realized.

Despite the many practical uses of ionizing radiation (IR), exposure to high levels of radiation has lethal consequences. The medical effects of radiation exposure have been classified into Acute Radiation Syndrome (ARS) and the Delayed Effects of Acute Radiation Exposure (DEARE). ARS consists in a constellation of health effects ensuing from an exposure of the total body or a significant area of the body to a relatively high dose (>2–5 Gy) delivered at a relatively high dose rate [5]. ARS is usually divided into three types of syndromes, based on the radiosensitivity of the organs/tissues involved: the Hematopoietic Syndrome (occurring after exposure to 0.7–10 Gy), the Gastrointestinal Syndrome (usually greater than 10 Gy), and the Cardiovascular/Central Nervous System Syndrome (>50 Gy) [5,6]. DEARE, on the other hand, consists of syndromes occurring months or years following radiation exposure which include: prolonged gastrointestinal effects, delayed immune reconstitution, delayed skin injury, renal failure, and radiation-induced lung injury [7]. Damage to normal tissue is often a limiting factor for the clinical use of radiation for cancer eradication; all forms of cell death as well as accelerated senescence have been linked to delayed cycles of inflammation, tissue dysfunction, atrophy, and/or fibrotic remodeling [8–12]. While there has been an exponentially growing number of studies attempting to explain the mechanisms of radiation toxicity over the years, there are only a limited number agents approved by the Food and Drug Administration as countermeasures for prevention, mitigation, or treatment of ARS or DEARE [13].

2. Ionizing Radiation-Induced Damage to Biological Molecules

Ionizing radiation (IR) generates both direct and indirect damage to biological molecules. In high linear energy transfer (LET) radiation, such as neutrons and alpha particles, most of the cellular damage results from the direct ionization of cellular macromolecules including DNA, RNA, lipids, and proteins [14]. In contrast, low LET radiation, such as X-rays and gamma rays, indirect damage to biological macromolecules occurs following the generation of reactive oxygen species (ROS) [14]. ROS, especially superoxide and hydroxide radicals from the radiolysis of intracellular H_2O, can have many effects, including the oxidation of biological macromolecules and activation of intracellular signaling pathways [14–18].

A widely accepted dogma in the field of radiation biology is that DNA is the most important molecular target of radiation because of its critical role in cell replication and proliferation [19]. Both single-stranded DNA breaks (SSB) and double-stranded DNA breaks (DSB), along with nucleotide mutations, occur during IR exposure and lead to cell death or mutagenesis if not properly

repaired [20,21]. DSB have more lethal consequences than SSB, as noted in low LET radiation when DSB are induced in a relatively large fraction of cells [20]. Overall, radiation-induced DNA damage is believed to activate a variety of signaling pathways leading to cell death as well as accelerated senescence.

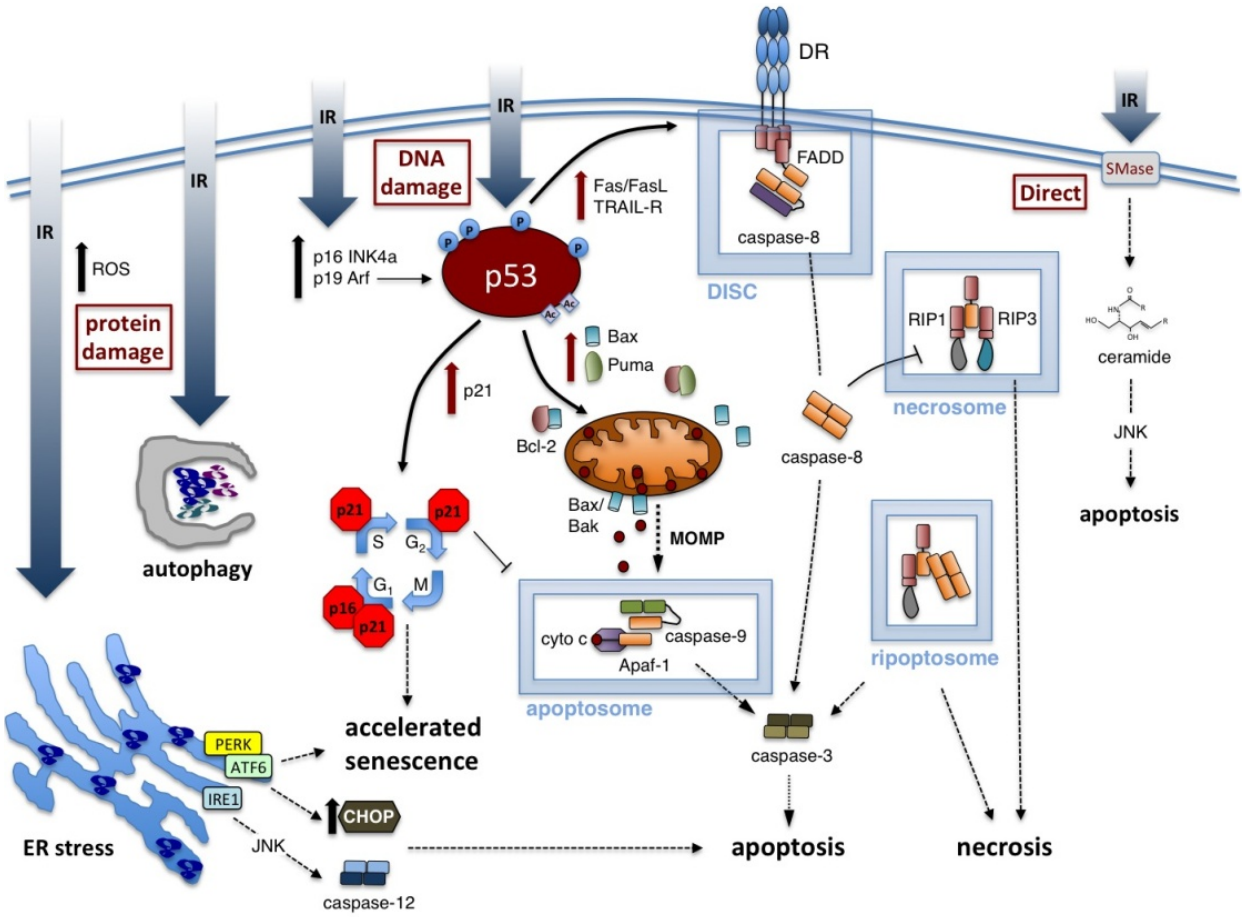
Recent investigations have challenged the classical DNA-centric view of radiation injury by demonstrating that proteins are also critical radiation targets that influence cell death mechanisms. In some cases, radiation-induced death by protein damage is proposed to be a consequence of reduced DNA repair fidelity, indirectly decreasing cell viability [22]. In prokaryotes, Qui *et al.* [23] suggested that protein damage underlies the radiosensitivity of *Shewanella oneidensis* while Daly *et al.* [24] proposed that the extreme radioresistance of *Deinococcus radiodurans* has been attributed to the reduction of protein oxidation by a variety of protective mechanisms. *Bdelloid* rotifers also display resistance to radiation damage due to decreased protein oxidation [25]. Studies using cultured mammalian cells have also provided evidence for protein oxidation in the activation of pro-apoptotic signaling downstream of radiation damage [26,27]. However, a direct comparison has not yet been made for the contribution of protein damage *versus* DNA damage for overall cellular toxicity.

3. Ionizing Radiation-Induced Cell Toxicities

The molecular mechanisms of radiation-induced cellular injury depend on a number of factors including radiation dosage, the cell type, and the transformed status of the cell [21,28,29]. As suggested by the manifestation of acute and delayed radiation syndromes, specific tissues and organ systems have differential radio-sensitivity. In several cases, the vulnerability of tissues to radiation injury is predicted by the Law of Bergonie and Trebondeau which states that radiation is generally more damaging in rapidly dividing cells and in undifferentiated cells [28,30]. For example, untransformed epithelial cells of the gastrointestinal tract and progenitor cells of the hematopoietic system, which have rapid turnover rates, are generally more radiosensitive than the non-dividing neurons of the central nervous system. This differential proliferative capacity corresponds to the induction of Hematopoietic Syndrome at lower radiation exposures (0.7–10 Gy) compared to doses required for inducing Central Nervous System Syndrome (>50 Gy).

Unrepaired DNA damage can lead to mutations, genomic instability, and cell death. Cells have evolved complex systems for the repair of single- and double-stranded DNA breaks [31]. It has been demonstrated that normal (non-transformed, non-immortalized cells) can repair as many as 70 DSB/cell within 24 h of radiation exposure [32]. Different DNA repair mechanisms are thought to be activated during specific phases of the cell cycle [28,33]. DSB can be repaired via a homologous recombination-dependent mechanism during the G2/M phases of the cell cycle, whereas non-homologous end joining mechanisms are believed to be active during G1/G0. In contrast, DNA repair is relatively inefficient during the S phase of the cell cycle [28]. Importantly, the duration for activity of a particular DNA repair mechanism depends upon the time that the cell remains in a particular phase of the cycle [28]. Therefore, cells that move rapidly through the cell cycle have less time to repair their DNA than cells that are paused during a cycle in which a particular DNA repair mechanism is activated.

Figure 1. Molecular responses to ionizing radiation (IR) in exposed cells. Depending on dose and radiosensitivity of the exposed cell, IR may induce cell death (through apoptosis or necrosis) or trigger accelerated senescence. Increased expression of p53, coupled to various post-translational modifications (e.g., phosphorylation (P), acetylation (Ac)), is a critical step in mediating the cellular response to IR-induced DNA damage. Accelerated senescence can result from p53-dependent induction of p21/waf1 or upregulation of other cell cycle inhibitory proteins (e.g., p16 INK4a). p53 activation also triggers *de novo* synthesis of pro-apoptotic molecules that mediate intrinsic (e.g., Bax, Puma) or extrinsic (e.g., Fas) apoptotic cell death (red arrows, p53-dependent). Intrinsic apoptosis is governed by Bcl-2 family proteins that regulate mitochondrial outer membrane permeabilization (MOMP), whereas extrinsic apoptosis is signaled through dedicated death receptors (DRs) such as Fas. Both forms of apoptosis rely on the assembly of large multiprotein platforms, including the apoptosome and death-inducing signaling complex (DISC), which facilitate caspase activation through recruitment, dimerization and autocatalytic cleavage. Separate protein complexes containing RIP-1 and/or RIP-3 (e.g., necrosome) can trigger programmed necrosis under certain conditions (e.g., caspase-8 inhibition). IR can also elicit ER stress and autophagy in response to the accumulation of oxidized or misfolded proteins, which may in turn induce apoptosis. Finally, apoptosis may also be triggered by increased ceramide levels, generated through direct IR-induced activation of sphingomyelinases (SMases) in the plasma membrane.



Our current understanding of the mechanisms of ionizing radiation-induced cell death comes from studies that are mostly conducted on immortalized cancer cell lines that do not represent the biological status of non-immortalized, non-transformed normal cells [29]. Although cancer cells proliferate more quickly than normal cells, leaving their DNA more susceptible to unrepaired damage, these cells often contain multiple mutations resulting in constitutive activation of mechanisms for DNA repair or allowing them to survive following damage that would render normal cells unviable [34].

Radiation exposure to cells has been demonstrated to result in a variety of mechanisms of cell death, including necrosis, apoptosis, or autophagy (see Figure 1) [35]. Additionally, radiation may induce accelerated cellular senescence, a state in which the cell remains viable but with altered functions, and which is no longer competent for proliferation [36]. In some cases, it has been demonstrated that increasing IR dosages shift the cellular response from senescence to apoptosis and/or autophagy, with higher doses leading to necrosis [27]. However, there is no absolute response of all cells to a given dose of radiation exposure. Some cell types rapidly undergo apoptosis in response to the same level of radiation that induces senescence in another cell type (e.g., primary human hematopoietic $CD34^+$ cells undergo apoptosis whereas pulmonary artery endothelial cells primarily undergo accelerated senescence) [27,37]. The selection process resulting in a specific mode of cell death or senescence has not been clearly defined, but research indicates that it is affected by the radiation dose, the dose rate, and multiple aspects of the cellular context [31,32,34,38,39].

3.1. Radiation-Induced Apoptosis

Apoptosis, or programmed cell death, is an evolutionarily conserved and highly regulated form of cell death required for the removal of extraneous, damaged, infected, or transformed cells from normal tissues [40]. Apoptosis is characterized by chromatin condensation, DNA fragmentation, cell shrinkage, and ultimately disintegration of the cell into membrane-bound particles [41,42]. These apoptotic "blebs" are rapidly removed by phagocytic cells *in vivo* to prevent cell death-associated inflammation. Two principal apoptotic pathways are widely recognized—extrinsic apoptosis and intrinsic apoptosis. The extrinsic pathway is activated by extracellular signals transduced by transmembrane "death receptors". In contrast, the intrinsic pathway is initiated by signaling pathways from inside the cell that govern mitochondrial integrity. The use of either of these pathways depends on the nature and origin of the death signal [43,44]. Each apoptotic pathway regulates the activation of specific initiator caspases, a family of cysteine-aspartic proteases required for apoptotic cell death signaling [45]. The two apoptotic pathways eventually converge with the activation of central activator caspases (e.g., caspase-3, -6, and -7) required for proteolytic processing of key cellular proteins as well as DNA fragmentation [45].

Many cancer cells, including lung, prostate, immortalized keratinocytes, and colon cancer cells, commit to apoptotic cell death when exposed to radiation ranging from 1 to 20 Gy [31,46–49]. Low doses of radiation (10–200 cGy) have been demonstrated to induce apoptosis in human skin organotypic culture and murine epidermal cells [50]. In response to low to moderate doses of radiation ($\leq$32 Gy), neurons also undergo apoptosis *in vitro* [11]. In contrast, some non-transformed, non-immortalized cells, such as smooth muscle cells and pulmonary artery endothelial cells, display apoptotic responses only when exposed to higher doses of radiation (>20 Gy) [27,51]. One important

characteristic of apoptosis that it is generally non-inflammatory, with reduced effects on neighboring cells compared to other modes of cell death [52]. However, tumor cell apoptosis has been linked to the induction of increased tumor cell growth in some studies [53]. The mechanisms of apoptotic cell death induced by IR are further described below.

3.1.1. Intrinsic Apoptosis Induced by IR

Because IR is known to cause DNA damage that can initiate a variety of intracellular signaling, the intrinsic pathway has been inferred to be the primary apoptotic mechanism mediating IR-induced apoptosis. Intrinsic apoptosis, also referred to as the mitochondrial pathway, is characterized by mitochondrial outer membrane permeabilization (MOMP) and cytochrome c release [54,55]. Cytosolic cytochrome c interacts with apoptotic protease activating factor 1 (Apaf1) and procaspase-9, forming the apoptosome [43,56]. The primary function of the apoptosome is to activate the initiator caspase-9, which triggers a cascade of caspase activation beginning with the executioner caspase 3 [56,57].

Intrinsic apoptosis is initiated by signaling pathways activated in response to DNA damage [6,31]. DNA breaks are initially sensed by several groups of proteins including: the mediator of DNA damage checkpoint protein 1 (Chk1); p53 binding protein 1 (53BP1); DNA-dependent protein kinase (DNA-PK); the protein complex meiotic recombination 11 homolog 1, Rad50 protein, and nibrin (Mre11/Rad50/NBS1, MRN); and the protein complex Rad9, Rad1, and Hus1 (Rad9/Rad1/Hus1, 9-1-1) [31,33]. Binding of MRN and 9-1-1 to DNA leads to the activation of a number of kinases that amplify the DNA damage response, including the Ataxia telangiectasia mutated protein (ATM) kinase and the ATM and Rad3-related (ATR) kinase [31,35,58]. DNA-PK, ATM and ATR phosphorylate the tumor-suppressor protein p53, the critical mediator of DNA damage-induced intrinsic apoptosis [35,39,57,59–61].

p53 is referred to as the "guardian of the genome" because of its role in maintaining chromosomal stability and determining the fate of the cell following DNA damage: either survival with temporary cell cycle arrest (during which damaged DNA is repaired) or apoptotic cell death [33,44,62]. Expression of p53 protein increases immediately following DNA damage. This increase in p53 protein levels has been shown to be proportional to the extent of DNA damage in a cell, and the kinetics of p53 regulation vary with different types of radiation [63]. Specific posttranslational modifications of p53 (phosphorylation and acetylation) stabilize the protein and activate its functions as a transcription factor as well as modulate its association with other proteins [64]. For example, CREB (cAMP response element-binding) binding protein (CBP)/p300 and the p300-CBP-associated factor (PCAF) acetylate p53, protecting it from ubiquitination and degradation [64]. Acetylation and phosphorylation are also required for p53 transcriptional activity and changes in protein-protein interactions [65,66]. Depending upon the extent and nature of p53 activation, divergent pathways may be activated [63].

p53 dictates apoptosis sensitivity in part through the regulation of levels and functions of pro-apoptotic and anti-apoptotic proteins of the B-cell lymphoma 2 (Bcl-2) protein family [67]. The anti-apoptotic members of the Bcl-2 family protect the mitochondria from MOMP and cytochrome c release, primarily by binding to and neutralizing Bax and Bak (two pro-apoptotic members of the Bcl-2 family), which directly facilitate mitochondrial permeabilization. There are three primary effects of p53 on this system: 1) Increased expression of pro-apoptotic Bcl-2 family proteins; 2) disruption of

the binding between pro- and anti-apoptotic Bcl-2 family proteins; and 3) induction of pro-apoptotic Bcl-2 protein oligomerization. p53 nuclear localization and transcriptional activation leads to increased gene expression of pro-apoptotic Bcl-2 family proteins such as Bax and Puma [68–72]. Furthermore, p53 in the cytoplasm can localize to the mitochondria, where it inhibits the association between anti-apoptotic proteins Bcl-2 and Bcl-x_L with the pro-apoptotic Bax and Bak proteins [35,59,73]. Note that in contrast with its function in the activation of mitochondrial apoptosis, p53 is not localized to the mitochondria during the induction of cell cycle arrest [67]. A combination of release of Bax from Bcl-2-protein binding as well as direct interactions with p53 lead to the oligomerization of Bax and Bak, which then form channels in the mitochondrial membrane inducing MOMP, cytochrome c release, and subsequent apoptosome formation [43,56,74].

The expression level and mutational status of p53 can affect the cellular decision to undergo apoptosis. Studies have indicated that tissues sensitive to radiation-induced apoptosis (spleen, thymus, and testis) display more rapid increases in p53 proteins compared with radioresistant tissues (liver and kidney) [67]. Additionally, cancer cells may evade radiation-induced apoptosis by suppression of p53 expression, or by gaining mutations in p53 that nullify its pro-apoptotic activity [75]. Indeed, over 50% of all human tumors harbor mutations or deletions in the *TP53* gene [76]. Thymocytes lacking p53 were shown to be more resistant to apoptosis induced by DNA DSB than those having wild-type p53 [77,78]. Overexpression of wild-type p53 increases apoptosis in p53-deficient leukemic and colon tumor-derived cell lines [79,80]. A number of agents that increase p53 levels are currently being utilized to increase apoptosis sensitivity of tumor cells to radiation therapy [67].

Independently of p53 function, the sphingomyelin pathway also mediates radiation-induced apoptosis through ceramide generation. Ceramide is an important second messenger molecule for regulating stress responses, including apoptosis induction [81]. For example, IR exposure in endothelial cells has been shown to activate sphingomyelinases (SMases) that hydrolyze sphingomyelin in the plasma membrane to generate ceramide. In fact, mouse embryonic fibroblasts (MEFs) from acid SMase knockout mice are completely resistant to radiation-induced apoptosis [82]. Ceramide appears to engage multiple modes of apoptotic signaling (e.g., JNK activation, PI-3K inactivation, *etc.*) that ultimately require MOMP, even when the death receptor CD95/FAS is implicated [81]. Ceramide can also stimulate BAX integration into the mitochondrial outer membrane to directly facilitate MOMP [83]. Although more studies are needed, pharmacological manipulation of ceramide may represent an attractive and relatively accessible strategy for modulating cellular responses to IR.

3.1.2. Extrinsic Apoptosis Induced by IR

In contrast with the intrinsic apoptotic pathway, the extrinsic pathway of apoptosis is initiated by extracellular activation of transmembrane "death" receptors (DRs)—CD95/Fas, tumor necrosis factor receptor 1 (TNF-R1), and tumor necrosis factor-related apoptosis-inducing ligand (TRAIL) receptors DR4 and DR5—by their corresponding ligands [43,44]. These DRs contain conserved intracellular "death domains" which, upon ligand binding, cluster and nucleate the death-inducing signaling complex DISC containing the adapter protein Fas-associated death domain (FADD) protein and procaspase-8 and -10 [44,62]. Caspase-8 is the main initiator caspase of the extrinsic apoptotic

pathway, equivalent to caspase-9 in the intrinsic pathway. Similar to caspase-9 in the apoptosome, procaspase-8 undergoes autocatalytic cleavage within the DISC, and the active form of caspase-8 directly cleaves and activates the executioner caspases-3 and -7 [84].

In vivo studies have demonstrated that mice deficient in extrinsic apoptosis signaling have reduced apoptosis in response to radiation in a tissue-specific manner. In response to IR, *DR5* knockout mice show reduced apoptosis in the thymus, spleen, Peyer's patches, and the white matter of the brain, with normal levels of apoptosis in the ileum, colon, and stomach [85,86]. IR also causes caspase-8-mediated apoptosis in Jurkat T cells, glioma cells, and some breast cancer and human lymphoma cell lines [87–90]. However, in a number of instances, the activation of both intrinsic and extrinsic apoptosis has been observed simultaneously. Some cancer cells exhibit both extrinsic and intrinsic apoptosis in response to IR [91]. Our laboratory also recently demonstrated that in normal lung endothelial cells caspase-8 is activated by IR concurrent with the activation of caspase-9 [27]. The distinction between intrinsic and extrinsic apoptosis can become blurred, since the effector caspases 3 and 7, which are activated during both intrinsic and extrinsic apoptosis, can feedback to regulate mitochondrial events, such as Bax translocation and cytochrome c release [92].

Several mechanisms have been proposed for the regulation of the extrinsic apoptotic pathway by IR. In some tissues, the regulation of DRs following DNA damage may proceed through the activation of p53 transcriptional activity [31,85]. p53 has been demonstrated to upregulate TRAIL receptors and CD95/Fas, as well as the Fas ligand [85,93]. However, in some tissues, such as the thymus and colon, the regulation of death receptors was shown to be p53-independent [94,95].

Interestingly, the specific inhibition of extrinsic apoptosis is a common mechanism for cancer cell evasion of cell death signals. For example, various isoforms of cellular FLICE inhibitory protein (cFLIP) contribute to DR-induced apoptosis resistance by interfering with caspase-8 activation at the DISC [96]. Therapeutic strategies for targeting cFLIP to lower the threshold for DR-induced apoptosis are generating considerable interest for cancer therapy [97]. Inhibitor of apoptosis proteins (IAPs) also modulate apoptosis and necrosis sensitivity through their ubiquitin ligase activity (e.g., c-IAP1/2) or by directly inhibiting certain caspases (e.g., XIAP) [98]. Apoptosis repressor with caspase recruitment domain (ARC) also functions to suppress both intrinsic and extrinsic apoptosis through multiple mechanisms, including the inhibition of caspase activation, the inhibition of association of DRs with downstream signaling molecules, and through direct inhibition of Bax [99]. Like IAPs, ARC has been found to be overexpressed in a variety of cancer cells, including glioblastoma, melanoma, and lymphoma cells, and in cancers from pancreas, colon, breast, lung, cervix and prostate [100]. Paradoxically, the overexpression of anti-apoptotic Bcl-2 proteins can also protect cancer cells from extrinsic apoptosis, when MOMP and caspase-9 activation are required to amplify the DR-induced caspase cascade [101–103]. Additional mechanisms have been identified for cancer cell evasion of the extrinsic pathway, including downregulation of DRs and the suppression or mutation of proteins required for death receptor signaling [104–107]. Not surprisingly, proteins regulating extrinsic apoptosis have become therapeutic targets for improving the efficacy of both clinical radiation and chemotherapy in resistant cancer cells [102,107–109].

3.1.3. ER Stress and Activation of Apoptosis by IR

DNA damage is a critical target for IR-induced cell toxicity, but increasing evidence indicates that protein damage also contributes significantly to cell death in some organisms [23–25]. In eukaryotic cells, the endoplasmic reticulum (ER) serves as a sensor of cellular homeostasis, being the site for protein folding and maturation for secretory and membrane proteins [110]. Specifically, the ER initiates signaling in response to damaged proteins. An accumulating body of evidence implicates oxidized, damaged proteins as triggers of the ER stress pathway (also known as unfolded protein response, UPR) [111,112]. A critical increase in the level of unfolded proteins is detected by the ER. The ER stress response pathway is designed to transiently halt new protein synthesis and increase the expression of chaperones to promote protein folding as well as to induce the ER-associated degradation (ERAD) system to remove terminally damaged proteins from the ER for proteasome-dependent degradation [110]. Failure to eliminate the damaged/unfolded proteins from the ER can ultimately result in apoptosis or accelerated senescence [110,113,114]. Protein unfolding may typically activate three ER-localized sensors: (1) the RNA-like endoplasmic reticulum kinase (PERK); (2) the activating transcription factor 6 (ATF6); and (3) the inositol-requiring enzyme 1 (IRE1) [112]. PERK, ATF6 and IRE1 are bound in the ER lumen and held in an inactive state by the chaperone glucose-regulated protein 78 (GRP78). Release of these proteins from GRP78 is believed to be the initiating event in UPR [115].

PERK, a transmembrane protein resident of the ER, phosphorylates the eukaryotic initiation factor 2 alpha (eIF2α), leading to the inhibition of protein synthesis to reduce the traffic of newly-synthesized, unfolded polypeptides to the ER [116,117]. Although eIF2α phosphorylation inhibits most protein synthesis, phosphorylated eIF2α specifically enhances some translation, including the translation of the ATF4 transcription factor that can induce the expression of other genes involved in the UPR, such as chaperones, amino acid transporters, and antioxidant proteins [110].

Activation of the ATF6 transcription factor by UPR allows nuclear translocation of the factor to increase the expression of several target genes, including chaperones GRP78 and GRP94, and the transcription factor X-box-binding protein 1 (XBP1). Interestingly, XBP1 mRNA requires further processing by IRE1, suggesting that signaling cross-talk tightly regulates the ER stress pathways (see below) [110]. In some cell types ATF6 also regulates acute inflammatory response genes during ER stress, which can lead to systemic effects [118].

IRE1 is a Ser/Thr protein kinase and endoribonuclease. IRE1 cleaves a number of mRNAs including mRNAs targeted for the ER as well as the 28S ribosomal subunit; both of these events are likely involved in the reduction of protein synthesis [110]. IRE1 also initiates unconventional splicing of XBP1 mRNA in the cytoplasm, allowing XBP1 to be translated in its active form. The active form of XBP1 protein is then translocated to the nucleus where it binds to the ER stress response element (ERSE) found in the promoters of target genes, resulting in the subsequent increased expression of other chaperones, transcription factors, ER associated protein degradation components, and proteins involved in the secretory pathway [119].

In a later stage of ER stress, if protein unfolding is resolved, both eIF2α and ATF6 up-regulate the C/EBP homologous protein transcription factor (CHOP) [112,120]. CHOP targets expression of the growth arrest and DNA damage-inducible protein 34 (GADD34), a phosphatase that dephosphorylates

eIF2α to restore protein translation [112]. However, if the levels of unfolded proteins have not been reduced, the activation of eIF2α by CHOP can induce further ER stress [110]. Data indicate that CHOP, c-Jun NH_2-terminal kinase (JNK), and caspase activation are all involved in ER stress-induced apoptosis [110]. During ER stress, IRE1 can recruit TRAF2 to the plasma membrane, which leads to the activation of the JNK pathway and subsequent cell death via caspase-12 activation [121]. Other studies demonstrated that JNK activation downstream of ER stress leads to Bax activation, MOMP, and activation of caspase 3 [122].

Studies indicate that ROS and ROS-generating substances induce ER stress leading to cell death [113,123–126]. Radiation has also been shown to elicit the induction of ER stress in immortalized cell lines and in normal endothelial cells [27,127]. Our laboratory recently demonstrated that in primary lung endothelial cells IR-induced ER stress contributes to apoptosis but not to accelerated senescence [27]. Inhibition of ER stress by salubrinal reduced levels of caspase-3 activation but not levels of p21/waf upregulation in response to IR. Blockade of ER stress and JNK activation during IR exposure also inhibits MOMP and caspase activation via the intrinsic apoptosis pathway in some transformed cell types [122]. Methodologies for increasing IR-induced ER stress are currently a topic for cancer therapeutic research [128–130].

3.2. Radiation-Induced Necrosis

In contrast to apoptosis, necrosis is traditionally viewed as a passive process, characterized by the early rupture of the plasma membrane, dilatation of cytoplasmic organelles, and uncontrolled release of cytoplasmic contents [131,132]. Necrosis typically results from a higher magnitude of stress relative to either apoptosis or cellular senescence [31,131,133], and radiation-induced necrosis has been demonstrated *in vitro* and *in vivo* [134–137]. For example, high radiation exposures (≥ 32–50 Gy) were demonstrated to induce necrosis in neurons and in p53-deficient human leukemia cells in cell culture [11,138]. However, lower doses of gamma radiation (0.5 Gy) were shown to cause necrosis in the immortalized human keratinocyte cell line HaCaT [137]. In contrast to apoptosis, necrosis (including radiation-induced necrosis) is associated with increased inflammation of the surrounding normal tissue [8,139].

In contrast to necrosis induced by severe physiochemical stress, recent research has focused on programmed necrosis or necroptosis [140]. This dedicated signaling pathway is often triggered by traditional apoptotic stimuli (e.g., TNF, FasL, TRAIL) when caspase-8 activity is inhibited by deletion or binding to cFLIP and/or viral inhibitors such as CrmA or vICA, permitting the formation of "necrosome" protein complexes containing receptor interacting proteins 1 and 3 (RIP1/RIP3). Deubiquitination of RIP1 allows it to interact with the death domain of FADD, promoting recruitment and mutual phosphorylation of RIP1 and RIP3 and downstream necroptotic signaling preferentially through the mitochondrial permeability transition complex [141,142]. In response to genotoxic stress, a similar "ripoptosome" containing FADD, caspase-8 and RIP1 can assemble and mediate either apoptosis or necroptosis, independent of DRs or mitochondrial signaling [143]. In both scenarios, necroptosis is specifically blocked by the RIP1 kinase inhibitor necrostatin-1 [144]. To date, a single study has demonstrated that necroptosis involving RIP1 contributes to IR-induced cell death in irradiated anaplastic thyroid and adrenocortical cancers [145]. IR-induced cell death was blocked in

those tumors by necrostatin-1 treatment, suggesting strategies to promote RIP1 activation may help to radiosensitize certain cells. However, such a strategy must weigh the risks and benefits of promoting the associated release of highly immunogenic molecules known as "danger-associated molecular patterns" (DAMPs) from necrotic cells [140]. Enhanced inflammation triggered by necroptosis may augment anti-tumor immune responses, but ultimately provoke unintended damage to healthy tissues.

3.3. Radiation-Induced Autophagy

Autophagic cell death is a nonapoptotic (caspase-independent), highly evolutionarily conserved mechanism of programmed cell death, characterized by the catabolism of cellular constituents by the cell's own intracellular enzymes [146]. Under normal conditions, microautophagy and chaperone-mediated autophagy allow the limited breakdown of abnormal proteins, cellular debris, or damaged organelles to maintain cellular homeostasis and/or as a means to recycle biological components [146]. Under extreme conditions—including nutrient starvation, oxidative or genotoxic stress, protein aggregation, or extreme organelle damage—autophagy, also called macroautophagy, can result in cell death [147]. Autophagy is recognized as an independent mechanism of programmed cell death, but there is significant cross-talk between pathways activated for autophagy and apoptosis [147].

In mechanistic studies of micro- and macro-autophagy, the nucleation of the double-membraned autophagosome vesicle was demonstrated to require the formation of two key complexes, one comprised of multiple autophagy-related gene (Atg) proteins and the other containing microtubule-associated protein 1 light-chain subunit 3 (LC3) [146,147]. Nucleation of the phagophore can be initiated by the activation of phosphoinositide-3-kinase (PI3K), by mitochondrial activation of the extracellular regulatory kinase (ERK), or by the activation of c-Jun *N*-terminal kinase (JNK) [146]. The phagophore elongates through the incorporation of proteins and lipids to encapsulate the designated cargo. This process is mediated by two ubiquitin-like systems involving a number of Atg proteins and LC3 [147]; although not completely defined, phagophore elongation is hypothesized to involve soluble *N*-ethylmaleimide-sensitive factor attachment protein receptor (SNARE) proteins and endosomal trafficking proteins [146]. Once the autophagosome has matured and is sealed, it fuses with the lysosome to form the autophagolysosome, in which the cargo is degraded. The process of autophagy involves complex regulation by protein sensors of nutrient levels and metabolism, by ER stress pathways, by mitochondrial stress pathways, and by oxidative and nitrative signaling [146].

Because autophagy pathways can function to remove damaged cellular components and serve as a mechanism for programmed cell death, autophagic pathways can paradoxically allow either increased survival or cell death in response to IR depending upon the cellular context [147–149]. IR has been demonstrated to induce microautophagy or macroautophagy in a variety of cancer cells, including breast, colon, lung, esophageal, and prostate cancer cells [129,130,150,151]. Interestingly, key proteins regulating autophagy were shown to be significantly decreased in normal lung tissue *in vivo* 24 h following 6 Gy exposure, suggesting a specific and severe dysregulation of autophagy in this tissue following IR. This effect was not observed in kidney or liver tissue following identical radiation exposures [152].

Several studies have shown that in some cases, agents that increase microautophagy result in improved cellular survival from IR, possibly due to the increased clearance of damaged macromolecules that would otherwise trigger cell death. The PI3K/Akt pathway is a pro-survival pathway in normal and cancer cells, and it was hypothesized that the inhibition of PI3K/Akt in conjunction with IR would increase apoptosis. Paradoxically, the use of inhibitors of the PI3K/Akt pathway (such as Ly294002 and PI-103) actually increased survival in cancer cells exposed to IR through the microautophagy [153]. Chloroquine and bafilomycin A1, both weak bases, raise the pH of the lysosome, and block the fusion of the phagosome with the lysosome, inhibiting late stages of autophagy. In contrast, 3-methyladenine (3-MA) inhibits early autophagy by interfering with the formation of a phagophore initiation complex [146]. Inhibition of autophagy with chloroquine, balfilomycin A1, or 3-MA increased cancer cell death in response to IR, including that of cancer stem cells, via increased apoptosis triggered by the accumulation of autophagosomes [153].

In contrast with these studies, induced autophagy in some cancers results in sensitization to IR. Activation of autophagy abrogated radiation resistance of glioblastoma cells and lung cancer cells to IR [154,155]. Additionally, the zinc ionophore PCI-5002 was demonstrated to radiosensitize lung cancer cells by inducing autophagic cell death [150]. Agents for the sensitization of cancer cells to radiation-induced autophagy are currently being investigated for improving tumor responses to clinical radiation [156,157].

3.4. Radiation-Induced Accelerated Senescence

The concept of cellular senescence was first introduced as early as the 1960s by Hayflick and Moorhead who demonstrated that nontransformed, nonimmortalized cells were capable of a finite number of passages before they lost their ability to replicate *in vitro*; this phenomenon is known as the "Hayflick limit" [158,159]. In contrast with growth-arrested quiescent cells that may resume proliferation in response to physiological stimuli, the growth arrest of senescent cells is essentially irreversible [160]. Various stress stimuli have been shown to induce cellular senescence, including oxidative stress, DNA damaging agents such as IR and chemotherapy, and sustained signaling by certain cytokines such as interferon-alpha and transforming growth factor-β (TGF-β) [161,162]. Senescence can also be induced by oncogenic gene activation, and thus the senescence pathway may provide a mechanism by which cells avoid neoplastic transformation [162,163]. Much of our understanding regarding the activity of senescent cells is derived from cell culture studies, but the importance of senescence *in vivo* is increasingly being recognized. The accumulation of senescent cells in older tissues and in tissues following IR or chemotherapy may account for some age-associated and IR- or chemotherapy-induced pathologies [36,162,164].

Senescent cells display a wide variety of alterations in gene expression, including: (1) aberrant expression of cell cycle regulatory proteins, contributing to the inability to progress through the cell cycle; (2) upregulation of anti-apoptotic proteins; and (3) robust expression of mRNAs for secreted proteins includes inflammatory cytokines, growth factors, and proteases, resulting in a condition termed the "secretory phenotype" [36,164]. In culture, senescent cells have a notably altered morphology, and may assume a "fried egg"-like appearance, with altered cytoskeletal organization and changes in cell-cell contacts. Senescence in many cells has been demonstrated to correlate with

increased expression of a form of β-galactosidase, termed senescence-associated β-galactosidase (SA-β-gal), which has become a recognized marker for senescence [165]. Two primary DNA damage-induced signaling pathways have been demonstrated to lead to cell cycle arrest associated with senescence: the p53/p21waf1 pathway, and the p16 inhibitor of cyclin dependent protein kinase 4(p16INK4a)/retinoblastoma protein (Rb) pathway [166].

Paradoxically, both accelerated senescence and apoptosis can involve stabilization and activation of the p53 protein [163]. Studies indicate that the mechanism of divergent signaling by p53 for differential activation of cell cycle arrest or cell death is not completely understood [167]. Stabilization of p53 in senescence is believed to occur in part by its acetylation as the result of ATM activation and the inactivation of NAD-dependent deacetylase sirtuin-1 (SIRT1), a deacetylase of p53 [168,169]. In contrast with apoptosis, which requires p53 regulation of apoptotic gene proteins, a critical step in p53-induced senescence is the transcriptional activation of p21/waf1. p21/waf1, a cyclin dependent kinase inhibitor 1, inhibits cyclin-dependent kinases (Cdks) including Cdk2 and 4/6; the specific phase of the cell cycle inhibited by p21 may be cell type-dependent, and blockade in G_1, G_2, or S-phase have been reported following DNA damage [161,167,170–173]. p21/waf also protects the cell from undergoing apoptosis following DNA damage [167,174]. The initiation of apoptosis often requires an active cell cycle, which is effectively blocked by expression of p21 [175,176]; additionally p21 can interfere with apoptotic signaling by through direct interactions with pro-apoptotic proteins, thus providing a second mechanism for the generation of cell cycle arrest instead of cell death [174,177,178]. Recently the E2F-associated phosphoprotein (EAPP) was demonstrated to be upregulated in response to DNA damage and to independently increase p21/waf1 transcription; EAPP was also shown to inhibit DNA damage-induced apoptosis in a p21/waf1-dependent manner [174].

A second pathway for DNA damage-induced cellular senescence involves regulation of p16INK4a and Rb [166,169]. IR was demonstrated to increase cellular levels of p16INK4a and the alternative reading frame protein of INK4a (p19Arf), an inhibitor of the p53 inhibitor mouse double minute 2 homolog (Mdm2) [179,180]. These two proteins act together to stop cell cycle progression. p16 INK4a is a cyclin dependent kinase inhibitor; by inhibiting Cdk kinases p16INK4a prevents the phosphorylation and inactivation of the tumor suppressor protein Rb [181]. The primary cell cycle-inhibitory activity of Rb appears to involve its interaction with the members of E2F family of transcription factors. E2F proteins regulate a number of genes involved in the progression through the cell cycle, and Rb binds to E2F proteins, sequestering them in the cytoplasm and inhibiting their transcriptional activity [181]. As its name indicates, p19Arf is transcribed from an alternative reading frame at the same locus as p16INK4a [181,182]. p19Arf is known to inhibit the cell cycle through several mechanisms, including activation of p53 and binding to and inhibition of the ribosomal chaperone nucleophosmin/B23 (NPM) [182,183].

Recent studies suggest that accelerated senescence is a state of continuous cell proliferative signaling in the presence of a cell cycle blockade [184–187]. At the center of this scheme is the mammalian target of rapamycin (mTOR), which acts as a hub for many of the signaling pathways involved in cell growth, proliferation and homeostasis [188]. mTOR inhibition by rapamycin attenuates the increase in senescence-associated β-galactosidase activity in several models of cellular senescence [184–187]. Indeed, rapapmycin is a well-established inducer of autophagy, which may directly impede accelerated senescence. Furthermore, a recent study by Iglesias-Bartolome

demonstrated that rapamycin blocks radiation-induced epithelial stem cell senescence via p16/ink4a and substantially reduces subsequent mucositis in a murine model of head/neck radiation injury [12]. This study also provides evidence that mTOR activation is critical for IR-induced accelerated senescence.

Exposure to IR has been shown to cause some levels of accelerated senescence in almost all types of cells, whether transformed, immortalized or normal cells [27]. It appears that accelerated senescence is the default response of some cell types to IR where accelerated senescence occurs at lower doses than those required for the induction of apoptosis or necrosis in same cells [27]. A variety of cancer cell types contain mutations to avoid cellular senescence. Mutations in Rb, p53, and p16 have been demonstrated to lead to continued proliferation in the presence of DNA damage or oxidative stress, and ectopic expression of these proteins can induce spontaneous senescence [181,189,190]. Furthermore, the p16INK4a pathway appears to be a back-up mechanism for the p53/p21waf1 pathway as p53-deficient fibroblasts exposed to IR to induce senescence accumulate p16INK4a, but not p21 [190].

3.5. Radiation Effects in Bystander Cells

For many years, a dogma in radiation biology posited that manifestation of biological effects of IR is solely due to direct actions on irradiated cells. This classical target theory asserts that cellular damage is due to the deposition of energy for the ionization of biological macromolecules and/or the interactions of generated reactive oxygen species with biological molecules [191]. However, an accumulating body of evidence has established non-targeted (bystander) effects as a *bona fide* response to IR exposure [191–193]. The radiation bystander effect is broadly defined as the induction of biological effects in cells that do not directly absorb radiation including cells that are in close proximity to irradiated cells or, in the case of partial body irradiation, cells in distant organs [193,194]. The significance of the radiation bystander effect is increasingly appreciated as a long-term side effect of radiation exposure. Research indicates that the bystander effect of radiation can be positive or negative [194]. Similar to findings regarding the direct effects of radiation, the bystander effects of radiation are dependent upon the LET, dose rate, total dose and specific radiosensitivity of the cells [194]. The negative effects of radiation on bystander cells include accelerated senescence, necrosis, and apoptosis, each contributing to decreased clonogenicity [195,196]. In contrast, radiation can induce increased proliferation of tumor cells in some settings [194].

Early evidence for the bystander phenomenon originated from experiments utilizing cell culture medium transfer from irradiated cells to non-irradiated cells or the co-culture of irradiated cells with non-irradiated cells [196,197]. Cell culture studies have demonstrated that bystander cells can accumulate DNA damage following exposure to signals from irradiated cells, as evidenced by the development of micronucleus formation, DSB, and sister chromatid exchanges [195,196,198–201]. DNA effects were demonstrated in non-transformed, non-immortalized bystander cells as well as in some transformed cell types [195,196,201]. Research has revealed potential roles for direct cell-cell communication through gap junctions between irradiated cells and bystander cells, as well as the release of soluble factors from irradiated cells to induce bystander effects. A range of extracellular molecules released from irradiated cells has been implicated in bystander effects, including ROS and a

variety of secreted factors such as transforming growth factor-β1 (TGF-β1), tumor necrosis factor-α, and/or cyclooxygenase-2 [193].

Paradoxically, although radiation often has lethal effects on many types of bystander cells, some cells exhibit increased growth as an indirect effect of radiation [194]. Increased proliferation has been observed in normal liver epithelial cells and non-transformed fibroblasts, as well as in several transformed cells [53,202]. Proliferation in bystander cells has been linked to the release of soluble factors into the medium [53,194]. Nitric oxide and TGF-β1 have been identified as potential agents mediating bystander proliferation in some non-transformed cells [203,204]. Another recent study of the effects of radiation-induced tumor cell apoptosis on overall tumor proliferation identified the release of prostaglandin E2 as a proliferative factor [53]. The phenomenon linking tumor cell apoptosis induction to out-of-field tumor cell proliferation has been termed a "Phoenix Rising" pathway [53]. DNA alterations combined with the proliferative effects in bystander cells may together be responsible for the nonlinear threshold model for radiation-induced carcinogenesis [194].

Studies of animal models have attempted to identify bystander effects and mechanisms *in vivo* [194]. Partial lung irradiation in rats demonstrated that regions of the lung outside of the radiation field exhibited DNA damage, albeit at lower levels than areas of the lung exposed to direct irradiation [10,205]. However, the DNA damage in out-of-field areas of the lung was attributed to the generation of ROS by activated inflammatory cells, and the damage could be suppressed by superoxide dismutase or ROS scavengers [10,197]. In mice exposed to unilateral X-irradiation, DNA damage was demonstrated in skin tissue more than 1 cm outside of the radiation field [206]. However, in radiation skin injury, excessive delayed tissue damage can be attributed to the activation of resident mast cells and other inflammatory cells [207]. Thus, the interpretation of *in vivo* out-of-field radiation effects may be complicated by radiation-induced inflammation that can induce tissue damage independently from bystander mechanisms.

4. Conclusions

Radiation-induced toxicity in mammalian cells involves various modes of cell death including apoptosis, necrosis, and autophagy, as well as accelerated senescence. Complex signaling events are induced in these modes of cell death and the cellular response is likely dependent upon the radiation exposure as well as the myriad aspects of the cellular context. The precise mechanisms for the biological selection of a specific mode of cell death following IR exposure have not been unequivocally established. Additionally, the mechanism(s) by which radiation induces death in cells directly affected by radiation are likely different from the mechanism(s) by which bystander cells undergo cell death. Knowledge of the mechanisms for radiation-induced damage in the context of cell death modes may provide insights into the development of more effective therapeutic countermeasures and interventions for the mitigation of radiation associated pathologies.

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Conflict of Interest

The authors declare no conflict of interest.

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Merrymeeting News

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The Newsletter of Friends of Merrymeeting Bay • PO Box 233 • Richmond Maine 04357 • 207-666-1118 • www.fomb.org

Friends of Merrymeeting Bay (FOMB) is a 501(c)(3) non-profit organization. Our mission is to preserve, protect, and improve the unique ecosystems of the Bay through:

Education

Conservation & Stewardship

Research & Advocacy

Member Events

Support comes from members' tax-deductible donations and gifts.

Merrymeeting News is published seasonally and is sent to FOMB members and other friends of the Bay.

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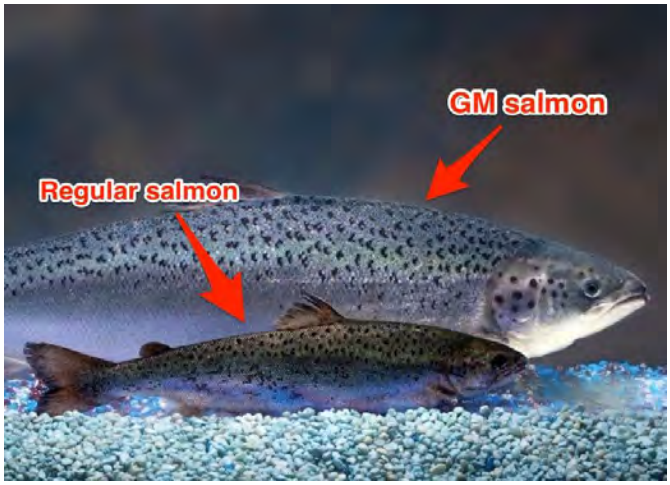
Lawsuit Challenges FDA's Approval of Genetically Engineered Salmon

Coalition of Fishing, Consumer, and Environmental Groups Say First-ever Approval of Laboratory-Created Food Animal Violated Laws and Ignored Risks to Wild Salmon and Fishing Communities

SAN FRANCISCO, CA 3/30/2016 - Friends of Merrymeeting Bay joined with a broad coalition of environmental, consumer, and commercial and recreational fishing organizations in suing the U.S. Food and Drug Administration (FDA for approving the first-ever genetically engineered (GE) food animal, an Atlantic salmon engineered to grow quickly. The man-made salmon was created by AquaBounty Technologies, Inc. with DNA from three fish: Atlantic salmon, Pacific king salmon, and Arctic ocean eelpout. This marks the first time any government in the world has approved a GE animal for commercial sale and consumption.

The plaintiff coalition, jointly represented by legal counsel from Center for Food Safety and Earthjustice, includes Pacific Coast Federation of Fishermen's Associations, Institute for Fisheries Resources, Golden Gate Salmon Association, Kennebec Reborn, Friends of Merrymeeting Bay, Ecology Action Centre, Food & Water Watch, Center for Biological Diversity, Friends of the Earth, Cascadia Wildlands, and Center for Food Safety.

In approving the GE salmon, FDA determined it would not require labeling of the GE fish to let consumers know what they are buying; which led Congress to call for labeling in the 2016 omnibus spending bill. FDA's approval also ignored comments from nearly 2 million people opposed to the approval because the agency failed to analyze and prevent the risks to wild salmon and the environment, as well as fishing communities, including the risk that GE salmon could escape and threaten endangered wild salmon stocks.



AquaBounty's GE salmon will undertake a 5,000-mile journey to reach U.S. supermarkets. The company plans to produce the GE salmon eggs on Prince Edward Island, Canada. The GE salmon will then be grown to market-size in a facility in Panama, processed into fillets, and shipped to the U.S. for sale. That complicated scheme is only for the initial approval, however. AquaBounty has publicly announced plans to ultimately grow its GE fish in the U.S. rather than Panama, and sell it around the world. Despite this, FDA's approval only considered the current plans for the far-flung facilities in Canada and Panama, leaving the risk of escape and contamination of U.S. salmon runs unstudied.

The lawsuit challenges FDA's claim that it has authority to approve and regulate GE animals as "animal drugs" under the 1938 Federal Food, Drug, and Cosmetic Act. Those provisions were meant to ensure the safety of veterinary drugs administered to treat disease in livestock and

Frankenfish (continued)

were not intended to address entirely new GE animals that can pass along their altered genes to the next generation. The approval of GE salmon opens the door to other genetically engineered fish and shellfish, as well as chickens, cows, sheep, goats, rabbits and pigs that are reportedly in development.

"FDA's decision is as unlawful as it is irresponsible," said George Kimbrell, senior attorney for Center for Food Safety and co-counsel for the plaintiffs. "This case is about protecting our fisheries and ocean ecosystems from the foreseeable harms of the first-ever GE fish, harms FDA refused to even consider, let alone prevent. But it's also about the future of our food: FDA should not, and cannot, responsibly regulate this GE animal, nor any future GE animals, by treating them as drugs under a 1938 law."

The lawsuit also highlights FDA's failure to protect the environment and consult wildlife agencies in its review process, as required by federal law. U.S. Atlantic salmon, and many populations of Pacific salmon, are protected by the Endangered Species Act and in danger of extinction. Salmon is a keystone species and unique runs have been treasured by residents for thousands of years. Diverse salmon runs today sustain thousands of American fishing families, and are highly valued in domestic markets as a healthy, domestic, "green" food.

When GE salmon escape or are accidentally released into the environment, the new species could threaten wild populations by mating with endangered salmon species, out-competing them for scarce resources and habitat, and/or introducing new diseases. Studies have shown that there is a high risk for GE organisms to escape into the natural environment, and that GE salmon can crossbreed with native fish. Transgenic contamination has become common in the GE plant context, where contamination episodes have cost U.S. farmers billions of dollars over the past decade. In wild organisms like fish, it could be even more damaging.

"There's never been a farmed salmon that hasn't eventually escaped into the natural environment. Why should we believe that long term, these frankenfish won't be the same?" asked Golden Gate Salmon Association Executive Director John McManus.

The world's preeminent experts on GE fish and risk assessment, as well as biologists at U.S. wildlife agencies charged with protecting fish and wildlife heavily criticized the FDA decision for failing to evaluate these impacts. FDA ignored their concerns in the final approval.

Thoughts from Andrew Kimbrell

Excerpted from an address entitled: Salmon Economics (and other lessons).
23rd ANNUAL E. F. SCHUMACHER LECTURES, October, 2003, Stockbridge, MA

It was early September, and I was standing at the mouth of the Tsiu River on central Alaska's little explored Lost Coast. It was about an hour into the incoming tide, and the water was just above my waist. I was midway in the fifty-foot-wide entrance to the river and could see the waves breaking in front of me with their rhythmic wakes swelling against and around me. The sleek bodies of the silver salmon were everywhere, filling the incoming waves. These beautiful and powerful spawning cohos were rushing en masse into the Tsiu, riding the tide on their last, determined journey.

I stood with legs wide, arms outstretched in the waves, watching and feeling the urgent swell of life coming from the sea to spawn in these chilled waters, which were rushing and tumbling from the melting Bering Glacier eight miles upstream. As the cohos pushed upstream through the narrow inlet, they brushed my thighs and torso, touched my arms and hands. I found myself laughing in surprise and awe.

That day began my multi-year tutelage under the cohos. Over time I have learned many lessons from these beloved wilderness teachers, and just as their return each year keeps a promise, so the promise of ever new lessons is also kept.

Thoughts (continued)

When the Pacific salmon return to the rivers of their birth, they carry in their bodies a number of nutrients, including nitrogen and phosphorous garnered from their ocean sojourn. In fact, isotopic analyses indicate that riverside vegetation near spawning streams receives 22 to 24 percent of its nitrogen—the nutrient that most commonly encourages plant growth—from salmon. As a result, trees on the banks of salmon-stocked rivers grow more than three times faster than their counterparts along a salmon-free river. Alongside spawning streams Sitka spruce (Picea sitchensis) have been found to take eighty-six years instead of the usual three hundred to reach 50 cm. in thickness. Research also shows that at least one-fifth of the nitrogen in the needles of Sitka spruce trees and other plants near spawning sites comes from the ocean via Pacific salmon carcasses. These same trees that have been fertilized by the carcasses enhance the quality of breeding and rearing habitats for the fish by providing shade, sediment and nutrient filtration, and large woody debris.

In more recent years a variety of companies and scientists intensified their efforts to ratchet up the natural salmon growth rates in hopes of maximizing the profitability of aquaculture. With much experimentation it was discovered that salmon size and growth speed could be boosted most efficiently by engineering them with growth genes from other fish species. In 2000 a Massachusetts and Canadian company, Aqua Bounty, was the first to seek permission from the U.S. Food and Drug Administration to grow and sell Atlantic salmon genetically engineered to grow faster and larger.

Subsequently, however, it was discovered during laboratory experiments that the new genes in the salmon were potentially catastrophic to the species. Researchers called them "Trojan" genes, reminiscent of Homer's account of the horse that entered Troy and ultimately caused its destruction. It turned out that the larger, engineered salmon were more attractive to mates during reproduction, but because of unexpected physiological havoc caused by the new genes, there was one-third greater die-off in the offspring of the gene-altered fish. This stood the concept of evolution on its head. It was survival of the unfittest. The engineered fish were triumphant in dominating reproduction, but they were destroying the species as they reproduced. When the researchers looked at the terrible reproductive arithmetic, they calculated that the release of only 60 of these genetically engineered salmon into the environment could result in the extinction of a native species of 60,000 salmon in just 40 generations.

It is important to realize that once the salmon engineered with the Trojan genes escape or are released, they cannot be recalled or eliminated. Chemical pollution most often dilutes over time, but biological pollution such as that caused by these engineered salmon is irreversible. The altered salmon, once in rivers or the ocean, will reproduce, mutate, and disseminate. Their polluting power will only gain with time. Extinction of the wild salmon will be impossible to halt.

Concrete steps such as filing law suits, protecting habitat, and staging protests are critical in protecting salmon, and nature itself, from the onslaught of the demands of capital, technology, and the market. It is becoming ever more evident, however, that these and similar actions will not be sufficient in and of themselves to generate the paradigm shift to a new Earth-centered economics.

The repeated refrains of the silver salmon's cycle and journey vibrate in me still. They have not left me, nor will they. The silvers have become actual and symbolic companions, both comforting and inspiring. Since my first encounter with them many years ago I have often returned to the Tsiu and nearby wilderness streams to be with the cohos for the mystery of their seasonal life-and-death journey (a time that includes my own birthday). Despite the frightening realities our current economic and technological systems have brought us and them, the salmon continue to teach me calmness and courage in my search, no longer for perfection or progress but for completeness and a life-giving return journey. I understand why they have so often attained the highest place in the hierarchy of native Alaskan totems. They have become for me, an often disillusioned child of Christian culture, both a sacrament (something that embodies the sacred) and a lesson about the cyclical journey of giving one's life so others may live.

Andrew Kimbrell is an internationally recognized writer, an activist, and public interest lawyer. He founded and is Executive Director of the Center for Food Safety. As an attorney, Kimbrell has successfully challenged federal agencies in several historic court cases. He initiated the court challenge that resulted in a U.S. Supreme Court victory forcing, for the first time, EPA regulation of greenhouse gases and their impact on climate change. He also pioneered the legal strategy that led to the Supreme Court ruling that DNA is not patentable due to being a "product of nature." Through his leadership at CFS, Kimbrell has been at the forefront of legal challenges to genetically engineered crops and lawsuits forcing FDA to adopt new food safety regulations.

NIH Study Finds Cell Phone/Smart Meter Radiation Causes Brain & Heart Cancers

The National Toxicology Program (NTP) under the National Institutes of Health has completed the largest-ever animal (rats and mice) study on nonionizing radiation and cancer. Partial results released on May 26th confirm whole body exposures to low level radiofrequency radiation (RFR) of the type emitted by cell phones, smart meters and other wireless devices and within currently allowable safety limits, are the "*likely cause*" of brain and heart cancers in these animals, according to Dr. John Bucher, Associate Director of the NTP.

The $25 million dollar study planned since 1999 showed one in twelve (12) male rats (8.3%) developed either malignant cancer (brain and rare heart tumors) or pre-cancerous lesions that can lead to cancer. Tumors called schwannomas were induced in the heart, and in the same kind of brain cells that have led to acoustic neuromas seen in human studies. The NTP says it is important to release these completed findings now given the implications to global health. No cancers occurred in the control group.

Dr. Lennart Hardell, MD, PhD of Sweden's Orebro University and an expert witness in the Maine Smart Meter Health Investigation says "*(T)he animal study confirms our findings in epidemiological studies of an increased risk for glioma and acoustic neuroma among people that use wireless phones, both cell phones and cordless phones (DECT). Acoustic neuroma is a type of Schwannoma, so interestingly this study confirms findings in humans of increased risk for glioma and acoustic neuroma. In 2013 we called for upgrading the risk in humans to Group 1, the agent is carcinogenic to humans. It is now time to re-evaluate both the cancer risk and other potential health effects in humans from radiofrequency radiation and also inform the public," says Hardell. "This NTP evidence is greatly strengthening the evidence of risk, is sufficient to reclassify cell phone radiation as a known cancer-causing agent, and confirms the inadequacy of existing public safety limits.*"

Dr. Christopher Portier, formerly with the NTP commented this is not just an associated finding—but that the relationship between radiation exposure and cancer is clear. *"I would call it a causative study, absolutely. They controlled everything in the study. It's [the cancer] because of the exposure. This is by far—far and away—the most carefully done cell phone bioassay, a biological assessment. This is a classic study that is done for trying to understand cancers in humans".*

We have written in Merrymeeting News since 2011about the dangers of radiofrequency radiation from wireless devices, particularly smart meters which bring exposures to rural Maine. Birds, bees, other insects and mammals all show adverse responses to low-level electromagnetic field exposures. As levels of "electrosmog" grow with wireless proliferation not only from land sources but now also space-based platforms, the harbinger of an "Electronic Silent Spring" should alarm anyone who cares about our wildlife and civilization, much the same as Rachel Carson's alarm did in bringing the effects of pesticide exposure to the public eye.

Dr. Jerry Phillips, PhD, is biochemist and director of the Excel Science Center at the University of Colorado at Colorado Springs. An educator and research scientist, Phillips conducted Motorola-funded research into the potential health impacts of cell phones during the 1990s while he was with the U.S. Department of Veterans Affairs' Pettis VA Medical Center in Loma Linda, California. Phillips and his colleagues looked at the effects of different radiofrequency signals on rats, and on cells in a dish. Phillips also testified for health advocates in Maine's smart meter investigation.

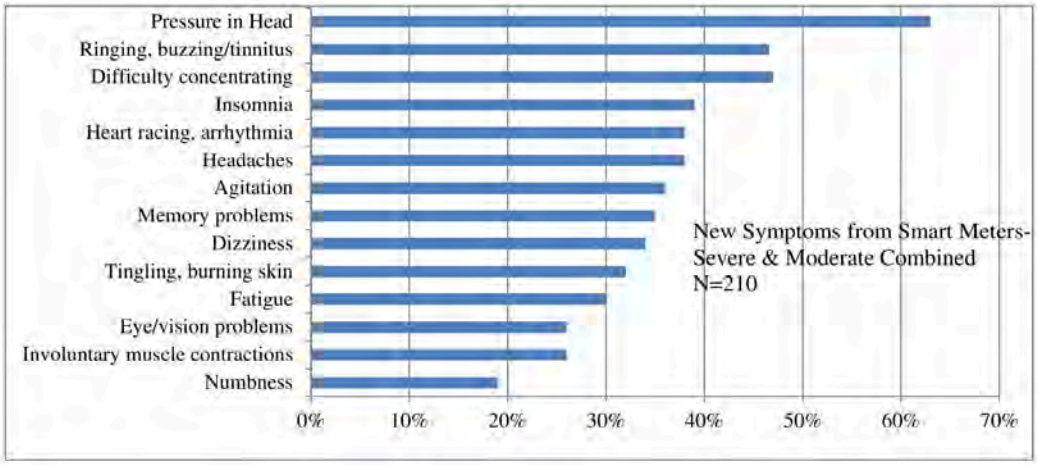
"The most troublesome finding to Motorola at the time is that these radiofrequency signals could interact with living tissues, which is what we saw in the rats," he said in a recent Scientific American interview, adding:

"But you have to realize that this issue opens up a much bigger can of worms than cell phones. If this radiation, this form of energy can interact with biological tissue then it's going to reopen a lot of what were supposedly settled issues regarding the safety of wireless communications. If we're going to be bathed in a whole new electromagnetic environment, how safe is it?"

While cancers from RFR are certainly of great concern, perhaps of greater concern are debilitating non-cancer symptoms disorienting and causing avoidance behavior and other biological and behavioral responses in wildlife and humans. In people,

NTP Study (continued)

relationships have commonly been stressed and destroyed, jobs have been lost and homes of many years sold or abandoned as a result of sensitivities to RFR. Consider if you suffer any or a number of the common RFR symptoms found in an international survey of those affected by smart meters as shown in this chart:



Conrad & Friedman, 2013. Smart Meter Health Effects Survey & Report

Smart meters in particular have sensitized many to any wireless device including routers and cell phones. The inability to use these common tools severely inhibits folks in their personal and economic lives. Their ability to live normal lives in the 21st century has been severely compromised immediately versus 10-30 year latency periods typical in cancer development. This change in ability to use these devices is directly correlated to smart meter exposure.

The suffering and the social and economic effects of chronic debilitating symptoms victims have experienced since smart meter exposure simply cannot be ignored, and provides ample evidence there is something about smart meters (evidence suggests the RF from up to 170,000 transmissions/day is conducted on home wiring) causing extreme harm to at least some, and possibly eventually all persons. While there is obviously only a portion of our population manifesting acute electromagnetic hypersensitivity (EHS) symptoms now (the canaries), and even fewer recognizing their source, we are all being exposed and are all susceptible.

"This is a game changer, there is no question," said Dr. David Carpenter, MD, PhD, director of the Institute for Health and the Environment at the University of Albany and also an expert witness in Maine. *"It confirms what we have been seeing for many years —though now we have evidence in animals as well as in humans."* Quoted in Microwave News, Carpenter went on to add, *"The NTP has the credibility of the federal government. It will be very difficult for the naysayers to deny the association any longer."*

Kennebec and Androscoggin Proposed Critical Habitat for Atlantic Sturgeon

NOAA Fisheries announced June 2, two proposed rules designating critical habitat for five distinct population segments [DPS] of federally listed Atlantic sturgeon. The proposed areas provide important protected river habitats for the threatened Gulf of Maine population segment and the endangered population segments of the New York Bight, Chesapeake Bay, Carolina and South Atlantic. NOAA Fisheries listed the Atlantic sturgeon under the Endangered Species Act in 2012. The two local designations include the Kennebec to Lockwood dam in Waterville and the Androscoggin to the Brunswick-Topsham dam.

The ESA requires NOAA Fisheries [formerly and often still known as the National Marine Fisheries Service or NMFS] designate critical habitat when a species is listed as threatened or endangered. Under the ESA, critical habitat is defined as geographic areas occupied by the species, and containing features essential to the conservation of that species. Critical habitat can also include geographical areas that are not currently occupied by the species, but that are essential to its conservation, historical habitat for example.

Critical habitat does not create preserves or refuges. Instead, when a federal agency is carrying out funding or authorizing an activity that may affect the critical habitat, the federal agency works with NOAA NOAA Fisheries to avoid or minimize

Atlantic Sturgeon (continued)

Photo credit - NOAA Fisheries

potential impacts to the species' habitat. The activity of the federal agency may need to be modified to avoid destroying or adversely modifying the critical habitat.

Shortnose sturgeon, smaller, relative to the threatened Atlantic sturgeon, are listed as endangered but are more abundant in the Merrymeeting Bay estuary. Sturgeon evolved over 200 million years ago. The species has been drastically diminished by over-fishing, toxics, habitat loss and dredging.

Spring Bay Day

May 17th dawned a spectacular Spring Bay Day at Chop Pt. School with blue skies and great temperatures. Students from Pittston, Chop Pt. and for the first time since consolidation of their schools, Brunswick, congregated at this lovely site to have fun learning about "things Bay" while getting their hands and feet dirty. Highlights included Angela Kimberk's Found Art session located right at the Chops being treated to an eagle from the new nest on West Chop Pt. catching a fish in front of them and a seal popping up to check student art works. Although, perhaps it was looking a bit further up the hill to where Lynda Doughty and Dominique Walk from Marine Mammals of Maine taught a session on marine mammal rescue!

Meanwhile over on the east side of the Point students tried their hands at beach seining with Nate Gray and caught a male stickleback in courtship colors while up on the grassy knoll, mud flew in the perennial favorite, watershed modeling taught by Steve Eagles and Kent Cooper. Also on the grass Kathleen McGee, taking a break [not really!] from her awesome job of scheduling students, chaperones and guides with classes for the day, spoke with students about anadromous and catadromous fish using the Bay for spawning and nursery habitat and then coached kids in the ancient practice of gyotaku or fish printing, using our custom school of rubber anadromous species, alewives, blueback herring, American shad, Atlantic salmon, rainbow smelt and striped bass.

Without our volunteers the day couldn't work. Thanks so much to our guides: Betsy Steen, Leslie Anderson, Kathleen McGee, Kent Cooper, Steve Eagles, Steve Musica, Angela Kimberk, Kerry Hardy, Geri Vistein, Jamie Silvestri, Nate Gray, Tom Weddle, Grant Connors, Lynda Doughty, Dominique Walk, Tina and Hannah Goodman, Blaine Carter, Cathy Reynolds, Helen Watts, George Sergeant, Mark Gershman and Amanda Troxell.

Chaperones: Eleanor Wilson, Tom Walling, Bob Fesler, Dana Cary, Jen Jones, Kennon Wilson, Kathie Duncan, David Whittlesey, Judith Clarke, Tina Phillips, Anne Harwood, Bert Singer, Carole Sargent, Tom Foote, David Hammond, Jeff Sebell, Martha Spiess, Joan McDuff, Madelyn Jones-Cressy, Tom Hughes, and Bob Goldman.

Lunch and Critter Wranglers: Joan Llorente and Martin McDonough
And special thanks to out wonderful hosts at Chop Pt. School and to Wild Oats for the fantastic lunch wraps!

We Need You! Please Support Our Important Work

FOMB Leadership

Our accomplishments are due to the hard work of dedicated volunteers, especially those who serve on our committees. If you want to get involved and serve, please contact the committee chair or Kathleen McGee. We always welcome member input and we'd love for you to join us!

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☐ $500 Wild Salmon
☐ $250 Striped Bass
☐ $100 Shad
☐ $50 Alewife
☐ $20 Smelt
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☐ $7 Enclosed (optional) for a copy of *Conservation Options: A Guide for Maine Land Owners* [$5 for book, $2 for postage].

☐ Renewal
☐ New Member
☐ Send information about volunteer opportunities
☐ I would like a sticker

Thanks to Will Zell and Zellous.org for newsletter layout.

Outside 2016!

All programs are FREE and open to the public

July 9 Bird Sounds Walk with Will Broussard - Bowdoinham, 7 - 9am, Call: Ed Friedman at 666-3372
July 17 Forest Insect Walk with Cathy Reynolds - Topsham, 1 - 3:00 pm, Call: Ed Friedman at 666-3372
Aug 18 Mushroom Walk with Michaelene Mulvey - Dresden, 6 pm, Call: Ed Friedman at 666-3372
Aug 23 Little Swan Island Evening Paddle with Warren Whitney - Richmond, 5:30 - 7:30 pm, Warren Whitney at 666-3376
Sep 16 Swan Island Outings with Jay Robbins*($8 Island Fee)* - Richmond, 9:00 am - 1 pm, Call: Jay Robbins at 737-2239
Sep 18 Swan Island Circumnavigation by Boat with Jay Robbins *($ Island Donation Appreciated)* - Richmond, 3:15 pm - 5:30 pm, Call: Jay Robbins at 737-2239

PRE-REGISTRATION REQUIRED. To register for a program or for questions, please call the contact number for each individual trip.

PADDLERS PLEASE NOTE: Participants must bring own boat and possess at least intermediate paddling skills. PFDs required.

Friends of Merrymeeting Bay
P.O. Box 233
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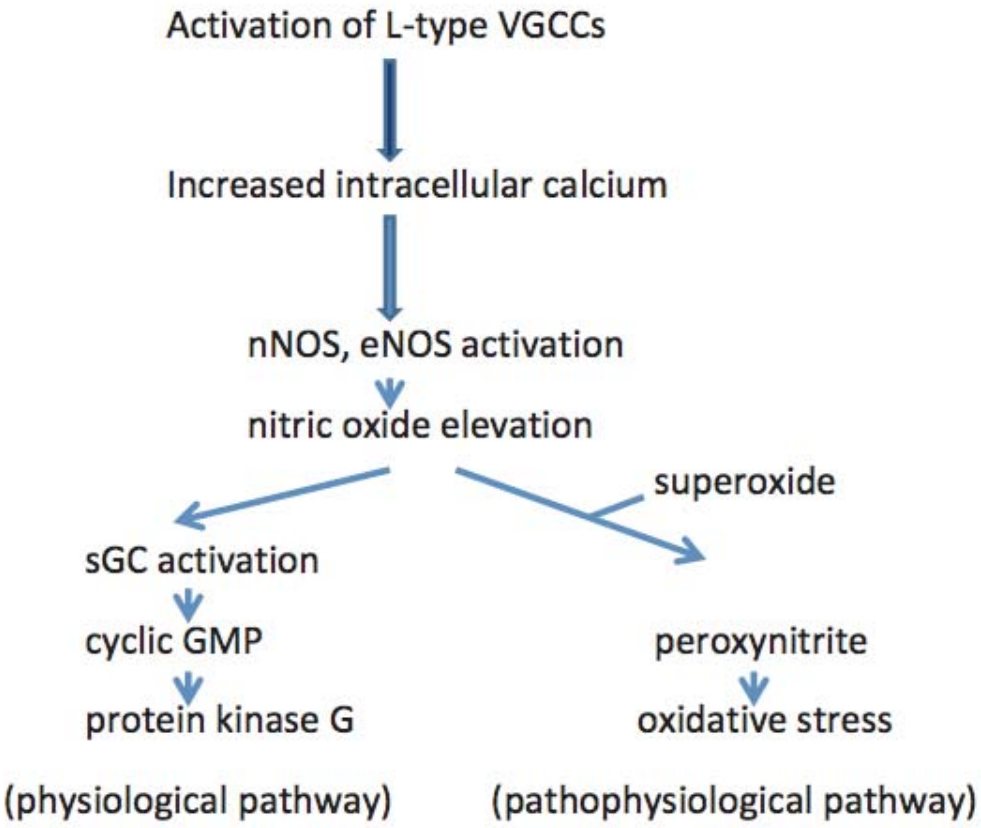
Sring Bay Day, A good time was had by all!

Beach Seining and Marine Mammals - Photo Credit: Ed Friedman


Activation of L-type VGCCs
Increased intracellular calcium
nNOS, eNOS activation
nitric oxide elevation
superoxide
sGC activation
cyclic GMP
protein kinase G
(physiological pathway)
peroxynitrite
oxidative stress
(pathophysiological pathway)

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Hearing of microwave pulses by humans and animals: effects, mechanism, and thresholds.

Lin JC[1], Wang Z.

Author information

Abstract

The hearing of microwave pulses is a unique exception to the airborne or bone-conducted sound energy normally encountered in human auditory perception. The hearing apparatus commonly responds to airborne or bone-conducted acoustic or sound pressure waves in the audible frequency range. But the hearing of microwave pulses involves electromagnetic waves whose frequency ranges from hundreds of MHz to tens of GHz. Since electromagnetic waves (e.g., light) are seen but not heard, the report of auditory perception of microwave pulses was at once astonishing and intriguing. Moreover, it stood in sharp contrast to the responses associated with continuous-wave microwave radiation. Experimental and theoretical studies have shown that the microwave auditory phenomenon does not arise from an interaction of microwave pulses directly with the auditory nerves or neurons along the auditory neurophysiological pathways of the central nervous system. Instead, the microwave pulse, upon absorption by soft tissues in the head, launches a thermoelastic wave of acoustic pressure that travels by bone conduction to the inner ear. There, it activates the cochlear receptors via the same process involved for normal hearing. Aside from tissue heating, microwave auditory effect is the most widely accepted biological effect of microwave radiation with a known mechanism of interaction: the thermoelastic theory. The phenomenon, mechanism, power requirement, pressure amplitude, and auditory thresholds of microwave hearing are discussed in this paper. A specific emphasis is placed on human exposures to wireless communication fields and magnetic resonance imaging (MRI) coils.

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Review

Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression

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ABSTRACT

Non-thermal microwave/lower frequency electromagnetic fields (EMFs) act via voltage-gated calcium channel (VGCC) activation. Calcium channel blockers block EMF effects and several types of additional evidence confirm this mechanism. Low intensity microwave EMFs have been proposed to produce neuropsychiatric effects, sometimes called microwave syndrome, and the focus of this review is whether these are indeed well documented and consistent with the known mechanism(s) of action of such EMFs. VGCCs occur in very high densities throughout the nervous system and have near universal roles in release of neurotransmitters and neuroendocrine hormones. Soviet and Western literature shows that much of the impact of non-thermal microwave exposures in experimental animals occurs in the brain and peripheral nervous system, such that nervous system histology and function show diverse and substantial changes. These may be generated through roles of VGCC activation, producing excessive neurotransmitter/neuroendocrine release as well as oxidative/nitrosative stress and other responses. Excessive VGCC activity has been shown from genetic polymorphism studies to have roles in producing neuropsychiatric changes in humans. Two U.S. government reports from the 1970s to 1980s provide evidence for many neuropsychiatric effects of non-thermal microwave EMFs, based on occupational exposure studies. 18 more recent epidemiological studies, provide substantial evidence that microwave EMFs from cell/mobile phone base stations, excessive cell/mobile phone usage and from wireless smart meters can each produce similar patterns of neuropsychiatric effects, with several of these studies showing clear dose–response relationships. Lesser evidence from 6 additional studies suggests that short wave, radio station, occupational and digital TV antenna exposures may produce similar neuropsychiatric effects. Among the more commonly reported changes are sleep disturbance/insomnia, headache, depression/depressive symptoms, fatigue/tiredness, dysesthesia, concentration/attention dysfunction, memory changes, dizziness, irritability, loss of appetite/body weight, restlessness/anxiety, nausea, skin burning/tingling/dermographism and EEG changes. In summary, then, the mechanism of action of microwave EMFs, the role of the VGCCs in the brain, the impact of non-thermal EMFs on the brain, extensive epidemiological studies performed over the past 50 years, and five criteria testing for causality, all collectively show that various non-thermal microwave EMF exposures produce diverse neuropsychiatric effects.

Contents

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Chemicals having roles:

Calcium(2+)
Nitric oxide (NO)
Oxido nitrite (peroxynitrite)

1. Introduction

Microwave syndrome (Hocking, 2001; Johnson Liakouris, 1998), a combination of various neuropsychiatric symptoms originally described in persons with occupational exposures to microwave frequency EMFs, has been disputed largely because of the lack of an apparent mechanism for generating these symptoms. It is reported to often include such symptoms as fatigue, headache, insomnia, dysesthesia (impaired sensation), irritability, lack of concentration and other symptoms (Hocking, 2001; Johnson Liakouris, 1998). Similar but more extensive combinations of symptoms have been reported following occupational exposures in two U.S. government reports from the 1970s/1980s (Naval Medical Research Institute Research Report, 1971; Raines, 1981) and following environmental exposures as described in two more recent reviews (Khurana et al., 2010; Levitt and Lai, 2010).

The goal here is not just to review the epidemiology, however, but more importantly to consider the issue of possible physiological mechanism(s). Hennekens and Buring (1989), on p. 40 in their textbook Epidemiology in Medicine state "The belief in the existence of a cause and effect relationship is enhanced if there is a known or postulated biologic mechanism by which the exposure might reasonably alter risk of developing disease." It is of critical importance therefore to assess possible biological mechanism before considering the epidemiological evidence.

Accordingly, this paper considers the mechanism by which low intensity microwave EMFs impact the cells of our bodies, how that mechanism may be predicted to impact the nervous system, evidence for such impact from experimental animal studies, genetic polymorphism evidence for that mechanism acting in humans to produce neuropsychiatric effects and finally, the epidemiological evidence for such effects in human populations with repeated low level microwave EMF exposure. Consideration of each of these types of evidence influences the overall interpretation presented in this paper.

2. Microwave/lower frequency EMFs act to activate voltage-gated calcium channels

In 24 different studies reviewed earlier (Pall, 2013) and two additional studies (Li et al., 2014; Lisi et al., 2006), microwave and lower frequency low intensity EMF effects were blocked or greatly lowered by calcium channel blockers, agents thought to be specific for blocking voltage-gated calcium channels (VGCCs). In these 26 studies, a total of 5 distinct types of channel blockers were used, with each type having a distinct structure and binding to a distinct site, such that it is essentially certain that these must be acting by blocking VGCCs, which is their only known common property. In each of these 26 studies, each of the responses studied, were blocked or greatly lowered by calcium channel blockers, showing that VGCC activation has roles in producing a wide variety of EMF effects. There is a large literature on changes in calcium fluxes and in calcium signaling following microwave EMF exposure (partially reviewed in Walleczek, 1992; Adey, 1993); each of these, including calcium efflux changes, can be explained as being due to VGCC activation, again suggesting a widespread role of VGCC activation in producing biological responses to EMFs. Pilla (2012) showed that pulsed microwave field exposure, produced an almost instantaneous increase in calcium/calmodulin-dependent nitric oxide (NO) signaling, providing strong evidence that these fields can produce an almost instantaneous VGCC activation. It is likely, that these EMFs act directly on the voltage sensor of the VGCCs to produce VGCC activation (Pall, 2015) with the voltage sensor being exquisitely sensitive to these EMFs because of its physical properties and location in the plasma membrane.

EMFs have been proposed to act to produce a wide variety of responses in the cell, via downstream effects of VGCC activation (Pall, 2013, 2014, 2015), including elevated intracellular calcium [Ca2+]i, excessive calcium and nitric oxide signaling and also excessive peroxynitrite, free radicals and oxidative stress.

VGCC activation has been shown to have a universal or near-universal role in the release of neurotransmitters in the brain and also in the release of hormones by neuroendocrine cells (Berridge, 1998; Dunlap et al., 1995; Wheeler et al., 1994), with such release being produced by calcium signaling. There are high densities of diverse VGCCs occurring in neurons throughout the nervous system. Both the high VGCC density and their function in neurotransmitter and neuroendocrine release throughout the nervous system suggests that the nervous system is likely to be highly sensitive to low intensity EMFs.

3. Genetic polymorphism studies

Genetic polymorphism studies are powerful tools for looking at the roles of specific proteins in human populations. In Table 1, a series of genetic polymorphism studies have been performed that show that an allele producing increased expression of the gene encoding the channel of the main L-type VGCC in the brain, produces diverse neuropsychiatric effects. These studies clearly show that excess L-type VGCC activity can cause neuropsychiatric effects. They also predict, therefore, that increased VGCC activity produced by microwave EMFs may be able to also produce widespread neuropsychiatric effects.

4. Histological and functional changes in central nervous system (CNS) and peripheral nervous system (PNS) in animals exposed to microwave EMFs

The most extensive literature on histological and functional changes in animals is from the Soviet literature from the 1950s/1960s with additional Western literature from the same time period. Both Soviet and non-Soviet literature were reviewed in an English language Publication by Tolgskaya and Gordon (1973). This publication is, therefore, the main focus of this section. That publication was divided into thermal and non-thermal exposure studies, with the non-thermal studies which occupy the majority of the text (pp. 53–137) being of sole interest here.

Table 1
Influence of genetic polymorphism of the CACNA1C in producing diverse neuropsychiatric effects.

Citation	Genetic polymorphism	Changes produced by allele of gene
Bhat et al. (2012)	Polymorphism producing Increased expression of CACNA1C L-type VGCC subunit	Review: The polymorphism Is associated with increased susceptibility to bipolar disorder, "depression, schizophrenia, autism spectrum disorders, as well as changes in brain function and structure in control subjects who have no diagnosable psychiatric illness."
Bigos et al. (2010)	Polymorphism producing Increased expression of CACNA1C L-type VGCC subunit	Associated with increases in both bipolar disorder and schizophrenia
Krug et al. (2010)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Negatively influences language production on a semantic level
Krug et al. (2014)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Influences episodic memory and retrieval
Soeiro-de-Souza et al. (2012)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Produces impaired facial emotion recognition
Tesli et al. (2013)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Produces increased activation of the amygdala during emotional processing
Thimm et al. (2011)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Associated with attention deficits including alerting, orienting and executive control of attention

These were all derived from the Tolgskaya and Gordon (1973) review and page numbers listed are page numbers from that document. All refer to changes produced by non-thermal exposures in the nervous system of experimental animals, with most being in rats.

This discussion scrolls down through Table 2.

The majority of the histological changes seen in these mostly rodent studies, are seen in the nervous system, despite its being less than 2% of the rodent cell mass. There are statements made that the nervous system, both central and peripheral, is the most highly sensitive tissue to these non-thermal microwave and lower frequency EMFs. Following the nervous system in sensitivity are the myocardium and the testis; myocardial cells are known to have very high densities of VGCCs with especially high densities in the pacemaker cells and the testis is known to have high densities specifically of the T-type VGCCs. Pulsed EMFs are more active in producing histological changes in the brain than are non-pulsed fields, in two studies reviewed; there is a much larger literature showing that in most cases pulsed fields are more biologically active (Pall, 2015; Pangopoulos et al., 2013; Belyaev, 2015).

A wide variety of brain and peripheral nervous system tissues show histological changes following non-thermal exposures. Among the important tissues impacted are the hypothalamus and pituitary gland, where both show similar patterns of changes in neuroendocrine activities. There Is an initial increase in neuroendocrine activity (this may be produced directly by VGCC stimulation of secretion), followed over time by "exhaustion" of neuroendocrine activity (this may be produced by tissue damage produced from long term intracellular calcium [Ca2+]i elevation).

There are widespread histological changes produced in neuronal and neuroendocrine tissues. These were repeatedly reported to be largely reversible on cessation of EMF exposure. They become, however, irreversible when exposure is extended in time. There are changes in EEG activity, which may be an easily measurable monitor of neurological damage.

In a summary statement, Tolgskaya and Gordon (1973) state, "This does not confirm the view, so widely held in the past among Soviet investigators and still maintained to a large extent even at the present time in the West, that the action of microwaves is entirely thermal."

While there were many studies of brain impact of non-thermal EMFs performed in the 1950s/60s that make the information content of Tolgskaya and Gordon (1973) quite high, there is also a substantial recent literature on brain effects of non-thermal microwave EMF exposures (see, for example: Ammari et al., 2008a,b; Bas et al., 2009; Brillaud et al., 2007; Carballo-Quintás et al., 2011; Eberhardt et al., 2008; Dasdag et al., 2009, 2012; Grafström et al., 2008; Kumlin et al., 2007; López-Martín et al., 2006; Mausset-Bonnefont et al., 2004; Odaci et al., 2008; Rağbetli et al., 2010; Salford et al., 2003; Sonmez et al., 2010).

5. Older epidemiological reviews and other related studies

Two U.S. Government reports each listed many apparent neuropsychiatric effects of microwave/radiofrequency EMFs and a third recognized the role of non-thermal effects on our bodies, but had only a little consideration of neuropsychiatric effects.

The earliest to these was a Naval Medical Research Institute (NMRI) Research Report (1971) which listed 40 apparent neuropsychiatric changes produced by non-thermal exposures including: 5 central/peripheral nervous system (NS) changes, 9 CNS effects, 4 autonomic system effects, 17 psychological disorders, 4 behavioral changes and 2 misc. effects. This NMRI report also provided a supplementary document listing over 2300 citations documenting these and other effects of microwave exposures in humans and in animals.

The Raines (1981) NASA report reviewed extensive literature based on occupational exposures to non-thermal microwave EMFs, with that literature coming from U.S., Western European and Eastern European studies. There are no obvious differences in the literature coming from these different regions. Based on multiple studies, Raines (1981) reports 19 neuropsychiatric effects to be associated with occupational microwave/radiofrequency EMFs.

The Bolen (1994) report put out by the Rome Laboratory of the U.S. Air Force, acknowledged the role of non-thermal effects of microwave EMFs on humans. This report states in the Conclusion section that "Experimental evidence has shown that exposure to low intensity radiation can have a profound effect on biological processes. The nonthermal effects of RF/MW radiation exposure are becoming important measures of biological interaction of EM fields." Clearly Bolen (1994) rejects the claim that only thermal effects occur. Bolen (1994) discusses a specific non-thermal neuropsychiatric effect, where anesthetized animals are awakened when the head is irradiated with microwave EMFs. This suggests a similar mechanism to that acting in humans where such EMFs produce insomnia (see below).

6. Specific epidemiological studies on neuropsychiatric effects of microwave EMFs

There are 26 different epidemiological studies described in Table 3. Although 4 of these only studied a single neuropsychiatric effect, 22 of these each provide substantial evidence for the pattern described in the earlier U.S. reports, that a wide range of

Table 2
Histological and functional changes in brain function in animals following exposure to non-thermal microwave EMFs.

Observations including page numbers	Comment from Author
The majority of the histological changes seen following non-thermal exposures, occurred in the nervous system, despite its being only about 2% of the tissue mass in rodents; this suggests that the nervous system is highly sensitive to such exposures. Elsewhere (pp. 129, 136), it is suggested that the nervous system is the most sensitive tissue, followed by the heart and the testis, among all of the tissues of the body. The most severe histological changes produced by these non-thermal EMF exposures occur in the nervous system (pp. 136).	High CNS sensitivity to EMFs is predicted by the high density of VGCCs that occur in neurons throughout the nervous system, plus the VGCC role in neurotransmitter and neuroendocrine release.
Pulsed fields were more active than non-pulsed fields in producing histological changes (pp. 71, 97).	Pulsed fields have often been found to be more biologically active than are non-pulsed fields in many different studies from many countries (Pall, 2015; Pangopoulos et al., 2013; Belyaev, 2015).
Nervous system regions impacted by non-thermal microwave and lower frequency fields include: cortex, diencephalon including the hypothalamus and thalamus, hippocampus, autonomic ganglia, sensory fibers, pituitary gland including neurohypophysis.	
Neuroendocrine changes seem to undergo change over increased time of exposure. Neurosecretion in the hypothalamus and in the pituitary each go through a complex sequence over time, where EMF exposure initially produces increased hormone secretion but where over time, the neurosecretory cells become "exhausted", leading to lowered secretion and in some cases cell death (pp. 77–96).	Elevated [Ca2+]i stimulates hormone secretion. However when such elevated [Ca2+]i occurs over extended time periods it is highly damaging to the cell, leading in some cases to apoptosis; thus this time course of action should not be surprising.
Histological changes include boutons/argyrophilia, smaller neurons, vacuole formation in neuroendocrine cells, bead-like thickening along dendrites (pp. 66, 70, 71, 73, 97, 98, 100, 111, 115–117, 121–125). Spines near the ends of dendrites become deformed and with still more sessions of irradiation, disappeared entirely (p. 70). Sensory neurons, following exposures, developed changes characteristic of irritation, with "marked tortuosity of the nerve fibers." Many histological changes are seen in the hypothalamic cells (pp. 87–92) as their neuroendocrine function becomes impacted. Histological changes were found even with exposures that produced no apparent functional changes.	
Many histological and functional changes are reported to initially be reversible, following cessation of exposure, but progressively become irreversible with longer exposure. (pp. 64, 72, 74). Paralleling the development of irreversibility, it is found that "Repeated exposure leads to gradual increase in severity of observed changes." . . . including "increasingly severe disturbance of conditioned reflex activity in the animals, changes in responses of animals particularly sensitive to acoustic stimulation. . .." (p. 104).	If this is also true in humans, then claims that there cannot be non-thermal effects, claims which act to prolong exposures, may be causing irreversible damage to many humans.
EEG changes (pp. 55, 60, 102), including seizure activity following sensory provocation.	Lai (1997) has an extensive review of EEG changes in animals following non-thermal microwave EMF exposures
Neurodegeneration is reported in a number of places in this review (pp. 72, 83, 117).	
Synaptic connections in regions of the brain are disrupted (pp. 65–74, 97, 113, 121, 136), and at the extreme, some neurons are completely asynaptic (p. 73).	Synaptic connections are known to be disrupted in autism; could this suggest that autism may be generated by EMF exposure? No doubt, we need much more evidence on this.
"after prolonged and repeated irradiation with low-intensity centimeter waves, with no elevation of the body temperature and when the animal's condition remained satisfactory, changes were nevertheless found in the sensory fibers of the skin and viscera in the form of irritation phenomena. These findings concur with the view in the literature that the receptor system as a whole and, in particular its preterminal portions are highly sensitive." p. 76. This description is similar to what is reported to occur in electromagnetic hypersensitivity (EHS). Other such studies are described and include cumulative changes over time, that may also explain changes reported in EHS (pp. 75, 99, 100, 104).	One wonders whether almost 60 years ago, the Soviet literature may have already described a possible animal model for EHS. None is known to exist today, and because of that, EHS studies are severely constrained. Clearly one needs to be skeptical about this interpretation, but it is of great importance that this be further studied.

neuropsychiatric effects are produced by exposure to various non-thermal microwave frequency EMFs. Perhaps the most important of these 26 is the Santini et al. (2003) study of people living near cell phone base stations.

There are three recent studies on the generation of headache during or shortly following long mobile phone calls (listed under Chu et al., 2011 in Table 3). The timing of development of these headaches and the finding that they occur on the ipsilateral side of the head, the side receiving much higher EMF exposure during the call, both argue strongly that these headaches are caused by the long mobile phone calls. Such causality was concluded earlier by Frey (1998) based on earlier studies and is now still more strongly documented.

7. Criteria for assessing causality in epidemiological studies

It is important to consider the different criteria that allow one to judge whether a cause and effect relationship is justified by the studies listed in Table 3 and the individual studies cited in Raines (1981). There are five such criteria that should be considered in making that judgment (see pp. 39–43 in Hennekens and Buring, 1989):

Strength of Association: Is there a strong correlation between exposure and the neuropsychiatric symptoms? There clearly is for several studies cited in Raines (1981). One example is the Dwyer and Leeper (1978) study (see Table 3) where there is a large increase in symptoms and where that increase is greater with longer occupational exposure. Another example is the Lerner (1980) study of 1300 microwave workers, where workers with relatively low exposure levels had an approximate doubling of neurological complaints and where those with substantially higher exposure levels had an approximate tripling of neurological complaints over controls. Sadcikova (1974) found that 7 of 8 neuropsychiatric symptoms studied, showed a statistically significant rise in prevalence with longer occupational exposure (see Table 3). Sadcikova (1974), also found that microwave workers had increases of 3 to over 10-fold in: feeling of heaviness in the head; tiredness; irritability; sleepiness; partial loss of memory; and skin sensitivity. There is also a strong association where important new exposures occur – this is clearly the case with all of the studies of people living near cell/mobile phone base

Table 3
Neuropsychiatric symptoms apparently produced by exposure to various electromagnetic fields.

Citation	EMF exposure	Apparent neuropsychiatric symptoms
Abdel-Rassoul et al. (2007)	Living near mobile phone base station	Significant increases in neuropsychiatric complaints included: headache, memory changes, dizziness, tremors, depressive symptoms, sleep disturbance; attributed to effects of EMFs on the human nervous system.
Al-Khlaiwi and Meo (2004)	Mobile phone use	Higher prevalence of fatigue, headache, dizziness, tension and sleep disturbance; the authors conclude that mobile phone use is a risk factor for developing these symptoms.
Altpeter et al. (2000)	Short-wave broadcasting tower, ranging from 6.1 to 21.8 MHz	Sleep disruption shown to occur, correlated with exposures and apparent increase over time; short term suppression of melatonin shown, based on melatonin increases during a 3 day period when the tower was turned off.
Bortkiewicz et al. (2004)	Living near cell phone base station EMFs	Sleep disturbance, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite, headache, vertigo.
Bortkiewicz et al. (2012)	Living near mobile phone base stations	Dose response relationships for sleep disturbance, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite.
Chu et al. (2011), also Chia et al. (2000), Oftedal et al. (2000)	Mobile phone use	Headache during prolonged mobile phone use or within an hour following such use, with pain occurring on the ipsilateral side of the head; similar observations obtained in each of the 3 studies in column 1; see also Frey (1998).
Conrad (2013)	Smart meter EMF exposure	14 common new symptoms (both severe and moderate) among those exposed and symptomatic, 13 apparent neuropsychiatric: Insomnia, tinnitus, pressure in the head, concentration difficulty, headaches, memory problems, agitation, dizziness, fatigue, skin tingling/burning, involuntary muscle contractions, eye/vision problems, numbness; These ranged in prevalence from 63% to 19% of those experiencing symptoms, such that most symptomatic people experienced multiple symptoms.
Dasdag et al. (1992)	People working in MW broadcasting or at a television transmitter station	These groups suffered from headache, fatigue, irritability, stress, sleepiness, loss of appetite, loss of hearing.
Dwyer and Leeper (1978)	People working in radiofrequency EMFs	Headache, eyestrain, dizziness, disturbed sleep, daytime sleepiness, moodiness, mental depression, memory impairment, muscle and/or cardiac pain, breathing difficulties, increased perspiration, difficulty with sex life.
Eger and Jahn (2010)	Living near mobile phone base station	Neuropsychiatric symptoms, with most showing dose–response relationships: depression; headache; cerebral symptoms; dizziness; disorders of optical and acoustic sensory systems; sleep disturbance; skin changes; with the exception of dizziness, all of these had $p < 0.001$.
Johnson Liakouris (1998)	Study of personnel in U.S. embassy in Moscow exposed to microwave EMFs	Statistically significant increases in neurological (peripheral nerves and ganglia), dermographism (skin responses), irritability, depression, loss of appetite, concentration difficulties, peripheral ganglia and nerve dysfunction.
Khan (2008)	Excessive mobile phone use	Complaints of headache, fatigue, impaired concentration, memory disturbance, sleeplessness, hearing problems.
Kolodynskii and Kolodinska (1996)	Children living near a Radio Location Station, Latvia	Memory dysfunction, attention dysfunction, lowered motor function, slowed reaction time, lowered neuromuscular endurance.
Lamech (2014)	Exposure to wireless smart meter radiation in Victoria, Australia	The most frequent symptoms to develop after smart meter radiation exposure were insomnia, headache, tinnitus, fatigue, cognitive disturbances, dysesthesias (abnormal sensation), dizziness.
Navarro et al. (2003)	Living near cell phone base station	Statistically significant dose response relationships for fatigue, irritability, headache, nausea, loss of appetite, sleep disorder, depressive tendency, feeling of discomfort, difficulty of concentration, loss of memory, visual disorder & dizziness.
Oberfeld et al. (2004)	Living near cell phone base station	Statistically significant dose–response relationships for headache, fatigue, irritability, loss of appetite, visual disorder, nausea, sleeping disorders, dizziness, poor concentration, memory loss.
Oto et al. (1994)	Occupational exposure of 25 workers to either UHF television broadcasting (10) or to 1062 kHz medium wave broadcasting (15)	10 neuropsychiatric changes were assessed, all showing statistically significant changes compared with controls: Somatization*, obsessive compulsivity*, interpersonal sensitivity, depression, anxiety*, hostility*, phobic anxiety*, paranoid ideation, psychoticism*, sleeping disturbance. *$p < 0.001$.
Sadcikova (1974)	Occupational exposure to microwave radiation, including at $<.07$ mW/cm^2	Heaviness in head*, fatigue*, irritability*, sleepiness, memory loss*, cardiac pain*, dermographism (skin sensitivity)*, hyperhidrosis* * significant increase with time of exposure.
Salama and Abou El Naga (2004)	High cell (mobile) phone use	Most common effects were headache, ear ache, sense of fatigue, sleep disturbance, concentration difficulty, face burning sensation. The first three of these had very high statistical significance for correlation with extent of cell phone use.
Santini et al. (2003)	Living near cell phone base stations	Each of the following neuropsychiatric symptoms showed statistical significant dose–response relationships: nausea, loss of appetite, visual disturbance, irritability, depressive tendencies, lowered libido, headache, sleep disturbance, feeling of discomfort, fatigue.
Schüz et al. (2009)	Mobile phone use	Found a small, statistically significant increase in migraine and vertigo. Also found an apparent lowered occurrence of Alzheimer's, other dementia, Parkinson's and epilepsy – these latter were interpreted as being due to perhaps early symptoms of the developing diseases lowering probability of acquiring a mobile phone.
Söderqvist et al. (2008)	Use of mobile phone among adolescents	Increased mobile phone use was associated with increases in tiredness, stress, headache, anxiety, concentration difficulties and sleep disturbances.
Thomée et al. (2011)	High mobile phone use	High mobile phone use was associated with statistically significant rises in stress and sleep disturbance, with somewhat weaker association with depression.
Waldmann-Selsam et al. (2009)	Digital TV signaling	Constant headaches, pressure in head, drowsiness, sleep problems, tightness in chest, shortness of breadth, depressive mood, total apathy, loss of empathy, burning skin, inner burning, leg weakness, pain in limbs, stabbing pain in various organs, weight increase.

stations, listed in Table 3 and also with the two studies of people who become exposed to radiation from smart meters. The studies listed in Table 3 under Chu et al. (2011) (see also Chia et al., 2000; Oftedal et al., 2000) are of a special type. Here people making very long (over 1 h) cell/mobile phone calls develop headaches an hour or more following the initiation of the long call. So these occur within a specific time range following initiation of these long calls, such that headache would only occur very infrequently in that time frame by chance. So here again, there is a strong association. While there is no question that many of these studies show high strength of association, it is also clear that it is becoming progressively more difficult to do these studies. As exposures become almost universal in countries around the world, it is getting difficult if not impossible to find good negative controls. There may be a similar problem in doing animal studies, such that it may be necessary to raise animals in Faraday cages in order to avoid exposures that would otherwise occur as a consequence of our near ubiquitous EMFs.

Biological credibility is extremely strong here, with three aspects of the biology predicting that these low intensity fields cause widespread neuropsychiatric effects. This was discussed above and is reconsidered in the following section.

Consistency within the different epidemiological studies and with other types of studies. The epidemiological studies listed in Table 3 and also those showing neuropsychiatric effects that were cited in Raines (1981) have been performed in many different countries with different cultures. They have been performed in multiple countries in Western Europe, Eastern Europe, the Middle East and in East Asia, as well as in the U.S. and Australia. They are, therefore, not limited to one or two cultural contexts. This is deemed, therefore, an important indicator of causality. We also have a surprising consistency of apparent neuropsychiatric effects of different fields, including various occupational exposures and exposures to cell/mobile phone base stations, exposure to the phones themselves, exposure to smart meter pulses, and other EMFs (see Table 3). Pulsation patterns, frequencies and exact intensities may produce various biological responses (Pall, 2015; Pangopoulos et al., 2013; Belyaev, 2015) so it is a bit surprising that we have as much consistency as we do have across different types of exposures. We also have consistency with the biology discussed in the previous section. Because elevated VGCC activity produced by genetic polymorphism (Table 1) produces diverse neuropsychiatric effects, it is not surprising that elevation of VGCC activity produced by microwave EMF exposure apparently also produces diverse neuropsychiatric effects. Similarly because non-thermal EMF exposures produce widespread changes in brain structure and function in animals (Tolgskaya and Gordon, 1973), it is not surprising that the neuropsychiatric symptoms, which are produced as a consequence of brain dysfunction are produced by such EMFs.

Time sequence: It is clear that the all of these effects follow exposure in the various studies that have been published. In some studies, it is also clear that longer occupational exposure times produce increased symptom prevalence. These include Dwyer and Leeper (1978) and Baranski and Edelwejn (1975). These observations all support a causal relationship between exposure to EMF and the development of neuropsychiatric symptoms.

Dose–response relationship: It is assumed, here, that biological effects have a positive correlation with the intensity of the apparent causal stressor. This is not necessarily true of EMF effects, because it has been shown that there are "window effects" where specific intensities have larger biological effects, than *do either lower or higher intensities* (Pall, 2015; Pangopoulos et al., 2013; Belyaev, 2015). Nevertheless, where different intensities were studied in these epidemiological studies, they do show the dose–response relationship assumed here including Altpeter et al. (2000), Dwyer and Leeper (1978), Eger and Jahn (2010), Lerner (1980), Navarro et al. (2003), Oberfeld et al. (2004), Salama and Abou El Naga (2004), Santini et al. (2003) and Thomée et al. (2011). Thus these data do fit well to the assumed dose–response relationship, found in most causal roles. The Altpeter et al. (2000) study showed a special type of evidence for causality: during a 3-day period when the broadcasting tower was turned off, the melatonin levels recovered to near-normal levels. The studies of headache occurrence on prolonged cell/mobile phone calls (typically well over one hour) listed under Chu et al. (2011) in Table 3 also suggest the assumed dose–response relationship (see also Chia et al., 2000; Oftedal et al., 2000 and earlier citations listed in Frey, 1998). Because such headaches only occur with prolonged cell/mobile phone calls, these studies also provide evidence for a dose–response relationship because low doses are ineffective. Furthermore these same studies provide evidence for such a dose–response relationship from another type of observation. Because the headaches occur predominantly on the ipsilateral side of the head which receives much higher EMF exposure intensity, rather than on the contralateral side of the head, which receives much lower intensities, this provides an additional type of evidence for the predicted dose–response relationship.

While the evidence is convincing that the various neuropsychiatric apparent consequences of microwave EMF exposure are in fact caused by such exposures, there may be somewhat more controversy about another EMF-neuropsychiatric linkage. Havas et al. (2010) have reported a similar list of neuropsychiatric symptoms in electromagnetic hypersensitivity (EHS) patients. They found that each of the following symptoms were common in EHS: poor short term memory; difficulty of concentration; eye problems; sleep disorder; feeling unwell; headache; dizziness; tinnitus; chronic fatigue; tremors; body pain; difficulty speaking; tingling sensation in feet or hands; difficulty writing; difficulty walking; migraine. The similarity of these symptoms to the most commonly found symptoms following non-thermal microwave EMF exposures (Table 3), suggests that EHS is a genuine sensitivity to EMFs. In the bottom row in Table 2, sensitivities were found in rodent studies following non-thermal exposure that suggest a possible animal model for the study of EHS. Each of these EHS-related issues needs to be followed up experimentally.

8. Discussion and conclusions

In the previous section, each of the five criteria for assessing whether an epidemiological association is causal, were considered. Those five are (Hennekens and Buring, 1989): (1) strength of association; (2) biological credibility; (3) consistency; (4) time sequence; (5) dose–response relationship. Each of these five provide strong support for causality such that the combination of all five provides compelling evidence for causality. Low-intensity microwave frequency EMFs do cause diverse neuropsychiatric symptoms. While each of these five is important here, the one that is most important is the criterion of biological credibility.

Three related sets of biological observations each predict that low-intensity microwave EMFs produce widespread neuropsychiatric effects:

1. Such EMFs act via activation of VGCCs, acting through the VGCC voltage sensor which is predicted to be exquisitely sensitive to these EMFs (Pall, 2015). VGCCs occur in high densities throughout the nervous system and have essential roles throughout the nervous system in releasing neurotransmitters and neuroendocrine hormones. These properties predict, therefore, that these low intensity non-thermal microwave EMFs cause widespread changes in the nervous system, causing, in turn, diverse neuropsychiatric effects.

2. Elevated VGCC activity, produced by an allele of the CACNA1C gene which encodes the channel of the main L-type VGCC in the brain, produces various neuropsychiatric effects (Table 1). This predicts, that low intensity non-thermal microwave frequency EMFs which also produce elevated L-type and other VGCC activity, therefore produce widespread neuropsychiatric effects.
3. Studies reviewed in the Tolgskaya and Gordon, 1973 publication (Table 2) have shown that the cells of the mammalian nervous system show high sensitivity to various non-thermal microwave and lower frequency EMFs, being apparently more sensitive than any other organ in the body of rodents. These studies predict that the human nervous system is likely to be similarly sensitive to these EMFs, predicting, therefore, widespread neuropsychiatric effects in humans.

We not only have biological credibility but also more importantly, each of these distinct but interrelated biological considerations predicts that low-intensity, non-thermal microwave EMFs produce widespread neuropsychiatric effects. That common prediction is verified by extensive data summarized in citations provided by the Naval Medical Research Institute Research Report (June 1971), data provided by The Raines (1981) NASA report, and by 26 epidemiological studies summarized in Table 3.

The most commonly reported neuropsychiatric symptoms from these studies are summarized in Table 4.

A total of 22 different studies described in Table 3 were used for data for this table, but not 4 others that only assessed a single neuropsychiatric end point. The Altpeter study which only assessed sleep disturbance/melatonin depletion and the three studies listed under Chu et al. which only assessed headache occurrence following long cell phone calls, listed in Table 3 were not included. Because many of the studies only assessed from 3 to 7 specific symptoms, it is not surprising that the numbers of studies reporting a specific symptom fall far below 22. Where several symptom descriptions were included under one heading, such as dysesthesia, if a study had more than one of these symptom descriptions, it was only counted once.

All the symptoms listed in Table 4 should be considered established parts of microwave syndrome (Hocking, 2001; Johnson Liakouris, 1998). Even if the statistical significance in each study was of the lowest statistical significance ($p < .05$) one would expect only 1 positive study to occur at random out of the 22 studies included here. Because many individual symptoms were not surveyed in many individual studies, the expectation is substantially lower than that. Each of these, having shown positive results in 5 or more studies are highly unlikely, therefore, to have occurred by chance. Stong statistical significance is also seen for individual neuropsychiatric effects reported to have $p < 0.001$ in the Eger and Jahn (2010) and Oto et al. (1994) studies (see Table 3).

Table 4
Commonly reported neuropsychiatric symptoms following microwave EMF exposure.

Symptom(s)	Numbers of studies reporting
Sleep disturbance/insomnia	17
Headache	14
Fatigue/tiredness	11
Depression/depressive symptoms	10
Dysesthesia (vision/hearing/olfactory dysfunction)	10
Concentration/attention/cognitive dysfunction	10
Dizziness/vertigo	9
Memory changes	8
Restlessness/tension/anxiety/stress/agitation/feeling of discomfort	8
Irritability	7
Loss of appetite/body weight	6
Skin tingling/burning/inflammation/dermographism	6
Nausea	5

EEG changes may well be part of microwave syndrome, as well. While none of the studies described in Table 3 measured EEGs, six studies of human occupational exposure cited in the Raines (1981) showed EEG changes (Baranski and Edelwejn, 1975; Bise, 1978; Dumanskij and Shandala, 1974; Lerner, 1980; Sheppard and Eisenbud, 1977). Murbach et al. (2014) cited 10 human studies in support of their statement that "the most consistently reported effects (of mobile phone use) in various studies conducted by different laboratories are changes in the electroencephalogram (EEG) power spectrum." Three recent studies (Lustenberger et al., 2013; Schmid et al., 2012a,b) and several earlier studies cited in Wagner et al. (1998) have each shown EEG changes in sleeping humans exposed to non-thermal pulsed microwave fields. Two recent studies showed EEG changes in persons exposed to Wi-Fi fields (Maganioti et al., 2010; Papageorgiou et al., 2011). Lai (1997) described 8 animal studies showing changes in EEG patterns in animals exposed to non-thermal EMFs and three additional animal studies were described in Tolgskaya and Gordon (1973). With the exception of the 6 studies cited in the second sentence in this paragraph, all of these are direct experimental studies which are not, therefore, susceptible to the questions of causality that can be raised about epidemiological studies. It is the author's view that future studies should consider studying EEG changes as an objectively measurable assessment of brain physiology and that before and after increased exposure studies should be considered when a new EMF source is to be introduced into human populations. While such studies must be done carefully, given the complexity of EEGs, even very small numbers of individuals may produce highly statistically significant results in well designed studies analyzed with paired *t*-tests.

One of the citations from the previous paragraph, Bise (1978) reviewed earlier studies of low level microwave frequency exposures in humans and concluded that such EMFs produced the following neuropsychiatric effects: headache, fatigue, irritability, dizziness, loss of appetite, sleepiness, sweating, difficulty of concentration, memory loss, depression, emotional instability, dermographism, tremor, hallucinations and insomnia. The strong similarity of this list from 37 years ago and the list in Table 4 should be noted. The Bise (1978) list is based on occupational exposure studies whereas the current list in Table 4 is based primarily on EMF exposures from cell/mobile phone base stations, from heavy cell phone usage and from smart meters, *three types of exposures that did not exist in 1978*. The strong similarity between the Bise (1978) list and the current one 37 years later alone produces a compelling argument that the 11 neuropsychiatric effects found on both lists are caused by exposure to multiple types of low-intensity microwave EMFs.

The pattern of evidence is compelling in support of the earlier statement of Levitt and Lai (2010) that "the primary questions now involve specific exposure parameters, not the reality of complaints or attempts to attribute such complaints to psychosomatic causes, malingering or beliefs in paranormal phenomena."

We can barely imagine how the combinations of neuropsychiatric effects, including those in Table 4, will influence human behavior and social interactions, now that the majority of the human populations on earth are exposed to ever increasing intensities and diversity of microwave frequency EMFs. You may recall that three of the occupational exposure studies cited in (Raines, 1981 showed increasing prevalence of neuropsychiatric symptoms with years of exposure to consistent patterns of EMF exposure intensities (Dwyer and Leeper, 1978; Sadcikova, 1974;

Baranski and Edelwejn, 1975). With ever increasing exposures in human populations, we have no idea what the consequences of these ever increasing exposures will be.

Conflict of interest

The author declares no conflict of interest.

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Review

Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression

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ABSTRACT

Non-thermal microwave/lower frequency electromagnetic fields (EMFs) act via voltage-gated calcium channel (VGCC) activation. Calcium channel blockers block EMF effects and several types of additional evidence confirm this mechanism. Low intensity microwave EMFs have been proposed to produce neuropsychiatric effects, sometimes called microwave syndrome, and the focus of this review is whether these are indeed well documented and consistent with the known mechanism(s) of action of such EMFs. VGCCs occur in very high densities throughout the nervous system and have near universal roles in release of neurotransmitters and neuroendocrine hormones. Soviet and Western literature shows that much of the impact of non-thermal microwave exposures in experimental animals occurs in the brain and peripheral nervous system, such that nervous system histology and function show diverse and substantial changes. These may be generated through roles of VGCC activation, producing excessive neurotransmitter/neuroendocrine release as well as oxidative/nitrosative stress and other responses. Excessive VGCC activity has been shown from genetic polymorphism studies to have roles in producing neuropsychiatric changes in humans. Two U.S. government reports from the 1970s to 1980s provide evidence for many neuropsychiatric effects of non-thermal microwave EMFs, based on occupational exposure studies. 18 more recent epidemiological studies, provide substantial evidence that microwave EMFs from cell/mobile phone base stations, excessive cell/mobile phone usage and from wireless smart meters can each produce similar patterns of neuropsychiatric effects, with several of these studies showing clear dose–response relationships. Lesser evidence from 6 additional studies suggests that short wave, radio station, occupational and digital TV antenna exposures may produce similar neuropsychiatric effects. Among the more commonly reported changes are sleep disturbance/insomnia, headache, depression/depressive symptoms, fatigue/tiredness, dysesthesia, concentration/attention dysfunction, memory changes, dizziness, irritability, loss of appetite/body weight, restlessness/anxiety, nausea, skin burning/tingling/dermographism and EEG changes. In summary, then, the mechanism of action of microwave EMFs, the role of the VGCCs in the brain, the impact of non-thermal EMFs on the brain, extensive epidemiological studies performed over the past 50 years, and five criteria testing for causality, all collectively show that various non-thermal microwave EMF exposures produce diverse neuropsychiatric effects.

Contents

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Chemicals having roles:

Calcium(2+)
Nitric oxide (NO)
Oxido nitrite (peroxynitrite)

1. Introduction

Microwave syndrome (Hocking, 2001; Johnson Liakouris, 1998), a combination of various neuropsychiatric symptoms originally described in persons with occupational exposures to microwave frequency EMFs, has been disputed largely because of the lack of an apparent mechanism for generating these symptoms. It is reported to often include such symptoms as fatigue, headache, insomnia, dysesthesia (impaired sensation), irritability, lack of concentration and other symptoms (Hocking, 2001; Johnson Liakouris, 1998). Similar but more extensive combinations of symptoms have been reported following occupational exposures in two U.S. government reports from the 1970s/1980s (Naval Medical Research Institute Research Report, 1971; Raines, 1981) and following environmental exposures as described in two more recent reviews (Khurana et al., 2010; Levitt and Lai, 2010).

The goal here is not just to review the epidemiology, however, but more importantly to consider the issue of possible physiological mechanism(s). Hennekens and Buring (1989), on p. 40 in their textbook Epidemiology in Medicine state "The belief in the existence of a cause and effect relationship is enhanced if there is a known or postulated biologic mechanism by which the exposure might reasonably alter risk of developing disease." It is of critical importance therefore to assess possible biological mechanism before considering the epidemiological evidence.

Accordingly, this paper considers the mechanism by which low intensity microwave EMFs impact the cells of our bodies, how that mechanism may be predicted to impact the nervous system, evidence for such impact from experimental animal studies, genetic polymorphism evidence for that mechanism acting in humans to produce neuropsychiatric effects and finally, the epidemiological evidence for such effects in human populations with repeated low level microwave EMF exposure. Consideration of each of these types of evidence influences the overall interpretation presented in this paper.

2. Microwave/lower frequency EMFs act to activate voltage-gated calcium channels

In 24 different studies reviewed earlier (Pall, 2013) and two additional studies (Li et al., 2014; Lisi et al., 2006), microwave and lower frequency low intensity EMF effects were blocked or greatly lowered by calcium channel blockers, agents thought to be specific for blocking voltage-gated calcium channels (VGCCs). In these 26 studies, a total of 5 distinct types of channel blockers were used, with each type having a distinct structure and binding to a distinct site, such that it is essentially certain that these must be acting by blocking VGCCs, which is their only known common property. In each of these 26 studies, each of the responses studied, were blocked or greatly lowered by calcium channel blockers, showing that VGCC activation has roles in producing a wide variety of EMF effects. There is a large literature on changes in calcium fluxes and in calcium signaling following microwave EMF exposure (partially reviewed in Walleczek, 1992; Adey, 1993); each of these, including calcium efflux changes, can be explained as being due to VGCC activation, again suggesting a widespread role of VGCC activation in producing biological responses to EMFs. Pilla (2012) showed that pulsed microwave field exposure, produced an almost instantaneous increase in calcium/calmodulin-dependent nitric oxide (NO) signaling, providing strong evidence that these fields can produce an almost instantaneous VGCC activation. It is likely, that these EMFs act directly on the voltage sensor of the VGCCs to produce VGCC activation (Pall, 2015) with the voltage sensor being exquisitely sensitive to these EMFs because of its physical properties and location in the plasma membrane.

EMFs have been proposed to act to produce a wide variety of responses in the cell, via downstream effects of VGCC activation (Pall, 2013, 2014, 2015), including elevated intracellular calcium [Ca2+]i, excessive calcium and nitric oxide signaling and also excessive peroxynitrite, free radicals and oxidative stress.

VGCC activation has been shown to have a universal or near-universal role in the release of neurotransmitters in the brain and also in the release of hormones by neuroendocrine cells (Berridge, 1998; Dunlap et al., 1995; Wheeler et al., 1994), with such release being produced by calcium signaling. There are high densities of diverse VGCCs occurring in neurons throughout the nervous system. Both the high VGCC density and their function in neurotransmitter and neuroendocrine release throughout the nervous system suggests that the nervous system is likely to be highly sensitive to low intensity EMFs.

3. Genetic polymorphism studies

Genetic polymorphism studies are powerful tools for looking at the roles of specific proteins in human populations. In Table 1, a series of genetic polymorphism studies have been performed that show that an allele producing increased expression of the gene encoding the channel of the main L-type VGCC in the brain, produces diverse neuropsychiatric effects. These studies clearly show that excess L-type VGCC activity can cause neuropsychiatric effects. They also predict, therefore, that increased VGCC activity produced by microwave EMFs may be able to also produce widespread neuropsychiatric effects.

4. Histological and functional changes in central nervous system (CNS) and peripheral nervous system (PNS) in animals exposed to microwave EMFs

The most extensive literature on histological and functional changes in animals is from the Soviet literature from the 1950s/1960s with additional Western literature from the same time period. Both Soviet and non-Soviet literature were reviewed in an English language Publication by Tolgskaya and Gordon (1973). This publication is, therefore, the main focus of this section. That publication was divided into thermal and non-thermal exposure studies, with the non-thermal studies which occupy the majority of the text (pp. 53–137) being of sole interest here.

Table 1
Influence of genetic polymorphism of the CACNA1C in producing diverse neuropsychiatric effects.

Citation	Genetic polymorphism	Changes produced by allele of gene
Bhat et al. (2012)	Polymorphism producing Increased expression of CACNA1C L-type VGCC subunit	Review: The polymorphism Is associated with increased susceptibility to bipolar disorder, "depression, schizophrenia, autism spectrum disorders, as well as changes in brain function and structure in control subjects who have no diagnosable psychiatric illness."
Bigos et al. (2010)	Polymorphism producing Increased expression of CACNA1C L-type VGCC subunit	Associated with increases in both bipolar disorder and schizophrenia
Krug et al. (2010)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Negatively influences language production on a semantic level
Krug et al. (2014)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Influences episodic memory and retrieval
Soeiro-de-Souza et al. (2012)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Produces impaired facial emotion recognition
Tesli et al. (2013)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Produces increased activation of the amygdala during emotional processing
Thimm et al. (2011)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Associated with attention deficits including alerting, orienting and executive control of attention

These were all derived from the Tolgskaya and Gordon (1973) review and page numbers listed are page numbers from that document. All refer to changes produced by non-thermal exposures in the nervous system of experimental animals, with most being in rats.

This discussion scrolls down through Table 2.

The majority of the histological changes seen in these mostly rodent studies, are seen in the nervous system, despite its being less than 2% of the rodent cell mass. There are statements made that the nervous system, both central and peripheral, is the most highly sensitive tissue to these non-thermal microwave and lower frequency EMFs. Following the nervous system in sensitivity are the myocardium and the testis; myocardial cells are known to have very high densities of VGCCs with especially high densities in the pacemaker cells and the testis is known to have high densities specifically of the T-type VGCCs. Pulsed EMFs are more active in producing histological changes in the brain than are non-pulsed fields, in two studies reviewed; there is a much larger literature showing that in most cases pulsed fields are more biologically active (Pall, 2015; Pangopoulos et al., 2013; Belyaev, 2015).

A wide variety of brain and peripheral nervous system tissues show histological changes following non-thermal exposures. Among the important tissues impacted are the hypothalamus and pituitary gland, where both show similar patterns of changes in neuroendocrine activities. There Is an initial increase in neuroendocrine activity (this may be produced directly by VGCC stimulation of secretion), followed over time by "exhaustion" of neuroendocrine activity (this may be produced by tissue damage produced from long term intracellular calcium [Ca2+]i elevation).

There are widespread histological changes produced in neuronal and neuroendocrine tissues. These were repeatedly reported to be largely reversible on cessation of EMF exposure. They become, however, irreversible when exposure is extended in time. There are changes in EEG activity, which may be an easily measurable monitor of neurological damage.

In a summary statement, Tolgskaya and Gordon (1973) state, "This does not confirm the view, so widely held in the past among Soviet investigators and still maintained to a large extent even at the present time in the West, that the action of microwaves is entirely thermal."

While there were many studies of brain impact of non-thermal EMFs performed in the 1950s/60s that make the information content of Tolgskaya and Gordon (1973) quite high, there is also a substantial recent literature on brain effects of non-thermal microwave EMF exposures (see, for example: Ammari et al., 2008a,b; Bas et al., 2009; Brillaud et al., 2007; Carballo-Quintás et al., 2011; Eberhardt et al., 2008; Dasdag et al., 2009, 2012; Grafström et al., 2008; Kumlin et al., 2007; López-Martín et al., 2006; Mausset-Bonnefont et al., 2004; Odaci et al., 2008; Rağbetli et al., 2010; Salford et al., 2003; Sonmez et al., 2010).

5. Older epidemiological reviews and other related studies

Two U.S. Government reports each listed many apparent neuropsychiatric effects of microwave/radiofrequency EMFs and a third recognized the role of non-thermal effects on our bodies, but had only a little consideration of neuropsychiatric effects.

The earliest to these was a Naval Medical Research Institute (NMRI) Research Report (1971) which listed 40 apparent neuropsychiatric changes produced by non-thermal exposures including: 5 central/peripheral nervous system (NS) changes, 9 CNS effects, 4 autonomic system effects, 17 psychological disorders, 4 behavioral changes and 2 misc. effects. This NMRI report also provided a supplementary document listing over 2300 citations documenting these and other effects of microwave exposures in humans and in animals.

The Raines (1981) NASA report reviewed extensive literature based on occupational exposures to non-thermal microwave EMFs, with that literature coming from U.S., Western European and Eastern European studies. There are no obvious differences in the literature coming from these different regions. Based on multiple studies, Raines (1981) reports 19 neuropsychiatric effects to be associated with occupational microwave/radiofrequency EMFs.

The Bolen (1994) report put out by the Rome Laboratory of the U.S. Air Force, acknowledged the role of non-thermal effects of microwave EMFs on humans. This report states in the Conclusion section that "Experimental evidence has shown that exposure to low intensity radiation can have a profound effect on biological processes. The nonthermal effects of RF/MW radiation exposure are becoming important measures of biological interaction of EM fields." Clearly Bolen (1994) rejects the claim that only thermal effects occur. Bolen (1994) discusses a specific non-thermal neuropsychiatric effect, where anesthetized animals are awakened when the head is irradiated with microwave EMFs. This suggests a similar mechanism to that acting in humans where such EMFs produce insomnia (see below).

6. Specific epidemiological studies on neuropsychiatric effects of microwave EMFs

There are 26 different epidemiological studies described in Table 3. Although 4 of these only studied a single neuropsychiatric effect, 22 of these each provide substantial evidence for the pattern described in the earlier U.S. reports, that a wide range of

Table 2
Histological and functional changes in brain function in animals following exposure to non-thermal microwave EMFs.

Observations including page numbers	Comment from Author
The majority of the histological changes seen following non-thermal exposures, occurred in the nervous system, despite its being only about 2% of the tissue mass in rodents; this suggests that the nervous system is highly sensitive to such exposures. Elsewhere (pp. 129, 136), it is suggested that the nervous system is the most sensitive tissue, followed by the heart and the testis, among all of the tissues of the body. The most severe histological changes produced by these non-thermal EMF exposures occur in the nervous system (pp. 136).	High CNS sensitivity to EMFs is predicted by the high density of VGCCs that occur in neurons throughout the nervous system, plus the VGCC role in neurotransmitter and neuroendocrine release.
Pulsed fields were more active than non-pulsed fields in producing histological changes (pp. 71, 97).	Pulsed fields have often been found to be more biologically active than are non-pulsed fields in many different studies from many countries (Pall, 2015; Pangopoulos et al., 2013; Belyaev, 2015).
Nervous system regions impacted by non-thermal microwave and lower frequency fields include: cortex, diencephalon including the hypothalamus and thalamus, hippocampus, autonomic ganglia, sensory fibers, pituitary gland including neurohypophysis.	
Neuroendocrine changes seem to undergo change over increased time of exposure. Neurosecretion in the hypothalamus and in the pituitary each go through a complex sequence over time, where EMF exposure initially produces increased hormone secretion but where over time, the neurosecretory cells become "exhausted", leading to lowered secretion and in some cases cell death (pp. 77–96).	Elevated [Ca2+]i stimulates hormone secretion. However when such elevated [Ca2+]i occurs over extended time periods it is highly damaging to the cell, leading in some cases to apoptosis; thus this time course of action should not be surprising.
Histological changes include boutons/argyrophilia, smaller neurons, vacuole formation in neuroendocrine cells, bead-like thickening along dendrites (pp. 66, 70, 71, 73, 97, 98, 100, 111, 115–117, 121–125). Spines near the ends of dendrites become deformed and with still more sessions of irradiation, disappeared entirely (p. 70). Sensory neurons, following exposures, developed changes characteristic of irritation, with "marked tortuosity of the nerve fibers." Many histological changes are seen in the hypothalamic cells (pp. 87–92) as their neuroendocrine function becomes impacted. Histological changes were found even with exposures that produced no apparent functional changes.	
Many histological and functional changes are reported to initially be reversible, following cessation of exposure, but progressively become irreversible with longer exposure. (pp. 64, 72, 74). Paralleling the development of irreversibility, it is found that "Repeated exposure leads to gradual increase in severity of observed changes." . . . including "increasingly severe disturbance of conditioned reflex activity in the animals, changes in responses of animals particularly sensitive to acoustic stimulation. . .." (p. 104).	If this is also true in humans, then claims that there cannot be non-thermal effects, claims which act to prolong exposures, may be causing irreversible damage to many humans.
EEG changes (pp. 55, 60, 102), including seizure activity following sensory provocation.	Lai (1997) has an extensive review of EEG changes in animals following non-thermal microwave EMF exposures
Neurodegeneration is reported in a number of places in this review (pp. 72, 83, 117).	
Synaptic connections in regions of the brain are disrupted (pp. 65–74, 97, 113, 121, 136), and at the extreme, some neurons are completely asynaptic (p. 73).	Synaptic connections are known to be disrupted in autism; could this suggest that autism may be generated by EMF exposure? No doubt, we need much more evidence on this.
"after prolonged and repeated irradiation with low-intensity centimeter waves, with no elevation of the body temperature and when the animal's condition remained satisfactory, changes were nevertheless found in the sensory fibers of the skin and viscera in the form of irritation phenomena. These findings concur with the view in the literature that the receptor system as a whole and, in particular its preterminal portions are highly sensitive." p. 76. This description is similar to what is reported to occur in electromagnetic hypersensitivity (EHS). Other such studies are described and include cumulative changes over time, that may also explain changes reported in EHS (pp. 75, 99, 100, 104).	One wonders whether almost 60 years ago, the Soviet literature may have already described a possible animal model for EHS. None is known to exist today, and because of that, EHS studies are severely constrained. Clearly one needs to be skeptical about this interpretation, but it is of great importance that this be further studied.

neuropsychiatric effects are produced by exposure to various non-thermal microwave frequency EMFs. Perhaps the most important of these 26 is the Santini et al. (2003) study of people living near cell phone base stations.

There are three recent studies on the generation of headache during or shortly following long mobile phone calls (listed under Chu et al., 2011 in Table 3). The timing of development of these headaches and the finding that they occur on the ipsilateral side of the head, the side receiving much higher EMF exposure during the call, both argue strongly that these headaches are caused by the long mobile phone calls. Such causality was concluded earlier by Frey (1998) based on earlier studies and is now still more strongly documented.

7. Criteria for assessing causality in epidemiological studies

It is important to consider the different criteria that allow one to judge whether a cause and effect relationship is justified by the studies listed in Table 3 and the individual studies cited in Raines (1981). There are five such criteria that should be considered in making that judgment (see pp. 39–43 in Hennekens and Buring, 1989):

Strength of Association: Is there a strong correlation between exposure and the neuropsychiatric symptoms? There clearly is for several studies cited in Raines (1981). One example is the Dwyer and Leeper (1978) study (see Table 3) where there is a large increase in symptoms and where that increase is greater with longer occupational exposure. Another example is the Lerner (1980) study of 1300 microwave workers, where workers with relatively low exposure levels had an approximate doubling of neurological complaints and where those with substantially higher exposure levels had an approximate tripling of neurological complaints over controls. Sadcikova (1974) found that 7 of 8 neuropsychiatric symptoms studied, showed a statistically significant rise in prevalence with longer occupational exposure (see Table 3). Sadcikova (1974), also found that microwave workers had increases of 3 to over 10-fold in: feeling of heaviness in the head; tiredness; irritability; sleepiness; partial loss of memory; and skin sensitivity. There is also a strong association where important new exposures occur – this is clearly the case with all of the studies of people living near cell/mobile phone base

Table 3
Neuropsychiatric symptoms apparently produced by exposure to various electromagnetic fields.

Citation	EMF exposure	Apparent neuropsychiatric symptoms
Abdel-Rassoul et al. (2007)	Living near mobile phone base station	Significant increases in neuropsychiatric complaints included: headache, memory changes, dizziness, tremors, depressive symptoms, sleep disturbance; attributed to effects of EMFs on the human nervous system.
Al-Khlaiwi and Meo (2004)	Mobile phone use	Higher prevalence of fatigue, headache, dizziness, tension and sleep disturbance; the authors conclude that mobile phone use is a risk factor for developing these symptoms.
Altpeter et al. (2000)	Short-wave broadcasting tower, ranging from 6.1 to 21.8 MHz	Sleep disruption shown to occur, correlated with exposures and apparent increase over time; short term suppression of melatonin shown, based on melatonin increases during a 3 day period when the tower was turned off.
Bortkiewicz et al. (2004)	Living near cell phone base station EMFs	Sleep disturbance, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite, headache, vertigo.
Bortkiewicz et al. (2012)	Living near mobile phone base stations	Dose response relationships for sleep disturbance, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite.
Chu et al. (2011), also Chia et al. (2000), Oftedal et al. (2000)	Mobile phone use	Headache during prolonged mobile phone use or within an hour following such use, with pain occurring on the ipsilateral side of the head; similar observations obtained in each of the 3 studies in column 1; see also Frey (1998).
Conrad (2013)	Smart meter EMF exposure	14 common new symptoms (both severe and moderate) among those exposed and symptomatic, 13 apparent neuropsychiatric: Insomnia, tinnitus, pressure in the head, concentration difficulty, headaches, memory problems, agitation, dizziness, fatigue, skin tingling/burning, involuntary muscle contractions, eye/vision problems, numbness; These ranged in prevalence from 63% to 19% of those experiencing symptoms, such that most symptomatic people experienced multiple symptoms.
Dasdag et al. (1992)	People working in MW broadcasting or at a television transmitter station	These groups suffered from headache, fatigue, irritability, stress, sleepiness, loss of appetite, loss of hearing.
Dwyer and Leeper (1978)	People working in radiofrequency EMFs	Headache, eyestrain, dizziness, disturbed sleep, daytime sleepiness, moodiness, mental depression, memory impairment, muscle and/or cardiac pain, breathing difficulties, increased perspiration, difficulty with sex life.
Eger and Jahn (2010)	Living near mobile phone base station	Neuropsychiatric symptoms, with most showing dose–response relationships: depression; headache; cerebral symptoms; dizziness; disorders of optical and acoustic sensory systems; sleep disturbance; skin changes; with the exception of dizziness, all of these had $p < 0.001$.
Johnson Liakouris (1998)	Study of personnel in U.S. embassy in Moscow exposed to microwave EMFs	Statistically significant increases in neurological (peripheral nerves and ganglia), dermographism (skin responses), irritability, depression, loss of appetite, concentration difficulties, peripheral ganglia and nerve dysfunction.
Khan (2008)	Excessive mobile phone use	Complaints of headache, fatigue, impaired concentration, memory disturbance, sleeplessness, hearing problems.
Kolodynskii and Kolodinska (1996)	Children living near a Radio Location Station, Latvia	Memory dysfunction, attention dysfunction, lowered motor function, slowed reaction time, lowered neuromuscular endurance.
Lamech (2014)	Exposure to wireless smart meter radiation in Victoria, Australia	The most frequent symptoms to develop after smart meter radiation exposure were insomnia, headache, tinnitus, fatigue, cognitive disturbances, dysesthesias (abnormal sensation), dizziness.
Navarro et al. (2003)	Living near cell phone base station	Statistically significant dose response relationships for fatigue, irritability, headache, nausea, loss of appetite, sleep disorder, depressive tendency, feeling of discomfort, difficulty of concentration, loss of memory, visual disorder & dizziness.
Oberfeld et al. (2004)	Living near cell phone base station	Statistically significant dose–response relationships for headache, fatigue, irritability, loss of appetite, visual disorder, nausea, sleeping disorders, dizziness, poor concentration, memory loss.
Oto et al. (1994)	Occupational exposure of 25 workers to either UHF television broadcasting (10) or to 1062 kHz medium wave broadcasting (15)	10 neuropsychiatric changes were assessed, all showing statistically significant changes compared with controls: Somatization*, obsessive compulsivity*, interpersonal sensitivity, depression, anxiety*, hostility*, phobic anxiety*, paranoid ideation, psychoticism*, sleeping disturbance. *$p < 0.001$.
Sadcikova (1974)	Occupational exposure to microwave radiation, including at $<.07$ mW/cm^2	Heaviness in head*, fatigue*, irritability*, sleepiness, memory loss*, cardiac pain*, dermographism (skin sensitivity)*, hyperhidrosis* * significant increase with time of exposure.
Salama and Abou El Naga (2004)	High cell (mobile) phone use	Most common effects were headache, ear ache, sense of fatigue, sleep disturbance, concentration difficulty, face burning sensation. The first three of these had very high statistical significance for correlation with extent of cell phone use.
Santini et al. (2003)	Living near cell phone base stations	Each of the following neuropsychiatric symptoms showed statistical significant dose–response relationships: nausea, loss of appetite, visual disturbance, irritability, depressive tendencies, lowered libido, headache, sleep disturbance, feeling of discomfort, fatigue.
Schüz et al. (2009)	Mobile phone use	Found a small, statistically significant increase in migraine and vertigo. Also found an apparent lowered occurrence of Alzheimer's, other dementia, Parkinson's and epilepsy – these latter were interpreted as being due to perhaps early symptoms of the developing diseases lowering probability of acquiring a mobile phone.
Söderqvist et al. (2008)	Use of mobile phone among adolescents	Increased mobile phone use was associated with increases in tiredness, stress, headache, anxiety, concentration difficulties and sleep disturbances.
Thomée et al. (2011)	High mobile phone use	High mobile phone use was associated with statistically significant rises in stress and sleep disturbance, with somewhat weaker association with depression.
Waldmann-Selsam et al. (2009)	Digital TV signaling	Constant headaches, pressure in head, drowsiness, sleep problems, tightness in chest, shortness of breadth, depressive mood, total apathy, loss of empathy, burning skin, inner burning, leg weakness, pain in limbs, stabbing pain in various organs, weight increase.

stations, listed in Table 3 and also with the two studies of people who become exposed to radiation from smart meters. The studies listed in Table 3 under Chu et al. (2011) (see also Chia et al., 2000; Oftedal et al., 2000) are of a special type. Here people making very long (over 1 h) cell/mobile phone calls develop headaches an hour or more following the initiation of the long call. So these occur within a specific time range following initiation of these long calls, such that headache would only occur very infrequently in that time frame by chance. So here again, there is a strong association. While there is no question that many of these studies show high strength of association, it is also clear that it is becoming progressively more difficult to do these studies. As exposures become almost universal in countries around the world, it is getting difficult if not impossible to find good negative controls. There may be a similar problem in doing animal studies, such that it may be necessary to raise animals in Faraday cages in order to avoid exposures that would otherwise occur as a consequence of our near ubiquitous EMFs.

Biological credibility is extremely strong here, with three aspects of the biology predicting that these low intensity fields cause widespread neuropsychiatric effects. This was discussed above and is reconsidered in the following section.

Consistency within the different epidemiological studies and with other types of studies. The epidemiological studies listed in Table 3 and also those showing neuropsychiatric effects that were cited in Raines (1981) have been performed in many different countries with different cultures. They have been performed in multiple countries in Western Europe, Eastern Europe, the Middle East and in East Asia, as well as in the U.S. and Australia. They are, therefore, not limited to one or two cultural contexts. This is deemed, therefore, an important indicator of causality. We also have a surprising consistency of apparent neuropsychiatric effects of different fields, including various occupational exposures and exposures to cell/mobile phone base stations, exposure to the phones themselves, exposure to smart meter pulses, and other EMFs (see Table 3). Pulsation patterns, frequencies and exact intensities may produce various biological responses (Pall, 2015; Pangopoulos et al., 2013; Belyaev, 2015) so it is a bit surprising that we have as much consistency as we do have across different types of exposures. We also have consistency with the biology discussed in the previous section. Because elevated VGCC activity produced by genetic polymorphism (Table 1) produces diverse neuropsychiatric effects, it is not surprising that elevation of VGCC activity produced by microwave EMF exposure apparently also produces diverse neuropsychiatric effects. Similarly because non-thermal EMF exposures produce widespread changes in brain structure and function in animals (Tolgskaya and Gordon, 1973), it is not surprising that the neuropsychiatric symptoms, which are produced as a consequence of brain dysfunction are produced by such EMFs.

Time sequence: It is clear that the all of these effects follow exposure in the various studies that have been published. In some studies, it is also clear that longer occupational exposure times produce increased symptom prevalence. These include Dwyer and Leeper (1978) and Baranski and Edelwejn (1975). These observations all support a causal relationship between exposure to EMF and the development of neuropsychiatric symptoms.

Dose–response relationship: It is assumed, here, that biological effects have a positive correlation with the intensity of the apparent causal stressor. This is not necessarily true of EMF effects, because it has been shown that there are "window effects" where specific intensities have larger biological effects, than *do either lower or higher intensities* (Pall, 2015; Pangopoulos et al., 2013; Belyaev, 2015). Nevertheless, where different intensities were studied in these epidemiological studies, they do show the dose–response relationship assumed here including Altpeter et al. (2000), Dwyer and Leeper (1978), Eger and Jahn (2010), Lerner (1980), Navarro et al. (2003), Oberfeld et al. (2004), Salama and Abou El Naga (2004), Santini et al. (2003) and Thomée et al. (2011). Thus these data do fit well to the assumed dose–response relationship, found in most causal roles. The Altpeter et al. (2000) study showed a special type of evidence for causality: during a 3-day period when the broadcasting tower was turned off, the melatonin levels recovered to near-normal levels. The studies of headache occurrence on prolonged cell/mobile phone calls (typically well over one hour) listed under Chu et al. (2011) in Table 3 also suggest the assumed dose–response relationship (see also Chia et al., 2000; Oftedal et al., 2000 and earlier citations listed in Frey, 1998). Because such headaches only occur with prolonged cell/mobile phone calls, these studies also provide evidence for a dose–response relationship because low doses are ineffective. Furthermore these same studies provide evidence for such a dose–response relationship from another type of observation. Because the headaches occur predominantly on the ipsilateral side of the head which receives much higher EMF exposure intensity, rather than on the contralateral side of the head, which receives much lower intensities, this provides an additional type of evidence for the predicted dose–response relationship.

While the evidence is convincing that the various neuropsychiatric apparent consequences of microwave EMF exposure are in fact caused by such exposures, there may be somewhat more controversy about another EMF-neuropsychiatric linkage. Havas et al. (2010) have reported a similar list of neuropsychiatric symptoms in electromagnetic hypersensitivity (EHS) patients. They found that each of the following symptoms were common in EHS: poor short term memory; difficulty of concentration; eye problems; sleep disorder; feeling unwell; headache; dizziness; tinnitus; chronic fatigue; tremors; body pain; difficulty speaking; tingling sensation in feet or hands; difficulty writing; difficulty walking; migraine. The similarity of these symptoms to the most commonly found symptoms following non-thermal microwave EMF exposures (Table 3), suggests that EHS is a genuine sensitivity to EMFs. In the bottom row in Table 2, sensitivities were found in rodent studies following non-thermal exposure that suggest a possible animal model for the study of EHS. Each of these EHS-related issues needs to be followed up experimentally.

8. Discussion and conclusions

In the previous section, each of the five criteria for assessing whether an epidemiological association is causal, were considered. Those five are (Hennekens and Buring, 1989): (1) strength of association; (2) biological credibility; (3) consistency; (4) time sequence; (5) dose–response relationship. Each of these five provide strong support for causality such that the combination of all five provides compelling evidence for causality. Low-intensity microwave frequency EMFs do cause diverse neuropsychiatric symptoms. While each of these five is important here, the one that is most important is the criterion of biological credibility.

Three related sets of biological observations each predict that low-intensity microwave EMFs produce widespread neuropsychiatric effects:

1. Such EMFs act via activation of VGCCs, acting through the VGCC voltage sensor which is predicted to be exquisitely sensitive to these EMFs (Pall, 2015). VGCCs occur in high densities throughout the nervous system and have essential roles throughout the nervous system in releasing neurotransmitters and neuroendocrine hormones. These properties predict, therefore, that these low intensity non-thermal microwave EMFs cause widespread changes in the nervous system, causing, in turn, diverse neuropsychiatric effects.

2. Elevated VGCC activity, produced by an allele of the CACNA1C gene which encodes the channel of the main L-type VGCC in the brain, produces various neuropsychiatric effects (Table 1). This predicts, that low intensity non-thermal microwave frequency EMFs which also produce elevated L-type and other VGCC activity, therefore produce widespread neuropsychiatric effects.
3. Studies reviewed in the Tolgskaya and Gordon, 1973 publication (Table 2) have shown that the cells of the mammalian nervous system show high sensitivity to various non-thermal microwave and lower frequency EMFs, being apparently more sensitive than any other organ in the body of rodents. These studies predict that the human nervous system is likely to be similarly sensitive to these EMFs, predicting, therefore, widespread neuropsychiatric effects in humans.

We not only have biological credibility but also more importantly, each of these distinct but interrelated biological considerations predicts that low-intensity, non-thermal microwave EMFs produce widespread neuropsychiatric effects. That common prediction is verified by extensive data summarized in citations provided by the Naval Medical Research Institute Research Report (June 1971), data provided by The Raines (1981) NASA report, and by 26 epidemiological studies summarized in Table 3.

The most commonly reported neuropsychiatric symptoms from these studies are summarized in Table 4.

A total of 22 different studies described in Table 3 were used for data for this table, but not 4 others that only assessed a single neuropsychiatric end point. The Altpeter study which only assessed sleep disturbance/melatonin depletion and the three studies listed under Chu et al. which only assessed headache occurrence following long cell phone calls, listed in Table 3 were not included. Because many of the studies only assessed from 3 to 7 specific symptoms, it is not surprising that the numbers of studies reporting a specific symptom fall far below 22. Where several symptom descriptions were included under one heading, such as dysesthesia, if a study had more than one of these symptom descriptions, it was only counted once.

All the symptoms listed in Table 4 should be considered established parts of microwave syndrome (Hocking, 2001; Johnson Liakouris, 1998). Even if the statistical significance in each study was of the lowest statistical significance ($p < .05$) one would expect only 1 positive study to occur at random out of the 22 studies included here. Because many individual symptoms were not surveyed in many individual studies, the expectation is substantially lower than that. Each of these, having shown positive results in 5 or more studies are highly unlikely, therefore, to have occurred by chance. Stong statistical significance is also seen for individual neuropsychiatric effects reported to have $p < 0.001$ in the Eger and Jahn (2010) and Oto et al. (1994) studies (see Table 3).

Table 4
Commonly reported neuropsychiatric symptoms following microwave EMF exposure.

Symptom(s)	Numbers of studies reporting
Sleep disturbance/insomnia	17
Headache	14
Fatigue/tiredness	11
Depression/depressive symptoms	10
Dysesthesia (vision/hearing/olfactory dysfunction)	10
Concentration/attention/cognitive dysfunction	10
Dizziness/vertigo	9
Memory changes	8
Restlessness/tension/anxiety/stress/agitation/feeling of discomfort	8
Irritability	7
Loss of appetite/body weight	6
Skin tingling/burning/inflammation/dermographism	6
Nausea	5

EEG changes may well be part of microwave syndrome, as well. While none of the studies described in Table 3 measured EEGs, six studies of human occupational exposure cited in the Raines (1981) showed EEG changes (Baranski and Edelwejn, 1975; Bise, 1978; Dumanskij and Shandala, 1974; Lerner, 1980; Sheppard and Eisenbud, 1977). Murbach et al. (2014) cited 10 human studies in support of their statement that "the most consistently reported effects (of mobile phone use) in various studies conducted by different laboratories are changes in the electroencephalogram (EEG) power spectrum." Three recent studies (Lustenberger et al., 2013; Schmid et al., 2012a,b) and several earlier studies cited in Wagner et al. (1998) have each shown EEG changes in sleeping humans exposed to non-thermal pulsed microwave fields. Two recent studies showed EEG changes in persons exposed to Wi-Fi fields (Maganioti et al., 2010; Papageorgiou et al., 2011). Lai (1997) described 8 animal studies showing changes in EEG patterns in animals exposed to non-thermal EMFs and three additional animal studies were described in Tolgskaya and Gordon (1973). With the exception of the 6 studies cited in the second sentence in this paragraph, all of these are direct experimental studies which are not, therefore, susceptible to the questions of causality that can be raised about epidemiological studies. It is the author's view that future studies should consider studying EEG changes as an objectively measurable assessment of brain physiology and that before and after increased exposure studies should be considered when a new EMF source is to be introduced into human populations. While such studies must be done carefully, given the complexity of EEGs, even very small numbers of individuals may produce highly statistically significant results in well designed studies analyzed with paired *t*-tests.

One of the citations from the previous paragraph, Bise (1978) reviewed earlier studies of low level microwave frequency exposures in humans and concluded that such EMFs produced the following neuropsychiatric effects: headache, fatigue, irritability, dizziness, loss of appetite, sleepiness, sweating, difficulty of concentration, memory loss, depression, emotional instability, dermographism, tremor, hallucinations and insomnia. The strong similarity of this list from 37 years ago and the list in Table 4 should be noted. The Bise (1978) list is based on occupational exposure studies whereas the current list in Table 4 is based primarily on EMF exposures from cell/mobile phone base stations, from heavy cell phone usage and from smart meters, *three types of exposures that did not exist in 1978*. The strong similarity between the Bise (1978) list and the current one 37 years later alone produces a compelling argument that the 11 neuropsychiatric effects found on both lists are caused by exposure to multiple types of low-intensity microwave EMFs.

The pattern of evidence is compelling in support of the earlier statement of Levitt and Lai (2010) that "the primary questions now involve specific exposure parameters, not the reality of complaints or attempts to attribute such complaints to psychosomatic causes, malingering or beliefs in paranormal phenomena."

We can barely imagine how the combinations of neuropsychiatric effects, including those in Table 4, will influence human behavior and social interactions, now that the majority of the human populations on earth are exposed to ever increasing intensities and diversity of microwave frequency EMFs. You may recall that three of the occupational exposure studies cited in (Raines, 1981 showed increasing prevalence of neuropsychiatric symptoms with years of exposure to consistent patterns of EMF exposure intensities (Dwyer and Leeper, 1978; Sadcikova, 1974;

Baranski and Edelwejn, 1975). With ever increasing exposures in human populations, we have no idea what the consequences of these ever increasing exposures will be.

Conflict of interest

The author declares no conflict of interest.

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Missouri SM Testimony

https://www.youtube.com/watch?v=c-HrE1KwwiQ

https://www.youtube.com/watch?v=c-HrE1KwwiQ

https://defensetech.org/2006/02/13/air-force-plan-hack-your-nervous-system/

Air Force Plan: Hack Your Nervous System

TOPICS:BizarroLasers and Ray Guns

Posted By: February 13, 2006

This is the first of a two-part series on plasma and electromagnetic weapons by David Hambling, author of Weapons Grade: How Modern Warfare Gave Birth to Our High-Tech World.

The brain has always been a battlefield. New weapons might be able to hack directly into your nervous system. "Controlled Effects" (see image, right) is one of the Air Forces ambitious long-term challenges. It starts with better and more accurate bombs, but moves on to discuss devices that "make selected adversaries think or act according to our needs… By studying and modeling the human brain and nervous system, the ability to mentally influence or confuse personnel is also possible."

The first stage is technology to remotely create physical sensations. They give the example of the Active Denial System "people zapper" which uses a high-frequency radiation similar to microwaves as a non-lethal means of crowd control.

Other weapons can affect the nervous system directly. The Pulsed Energy Projectile fires a short intense pulse of laser energy. This vaporizes the outer layer of the target, creating a rapidly-expanding expanding ball of plasma. At different power levels, those expanding plasmas could deliver a harmless warning, stun the target, or disable them – all with pinpoint laser precision from a mile away.

Early reports on the effects of PEPs mentioned temporary paralysis, then thought to be related to ultrasonic shockwaves. It later became apparent that the electromagnetic pulse caused by the expanding plasma was triggering nerve cells.

Details of this emerged in a heavily-censored document released to Ed Hammond of the Sunshine Project under the Freedom if Information Act. Called Sensory consequence of electromagnetic pulsed emitted by laser induced plasmas, it described research on activating the nerve cells responsible for sensing unpleasant stimuli: heat, damage, pressure, cold. By selectively stimulating a particular nociceptor, a finely tuned PEP might sensations of say, being burned, frozen or dipped in acid — all without doing the slightest actual harm.

The skin is the easiest target for such stimulation. But, in principle, any sensory nerves could be triggered. The Controlled Effects document suggests it may be possible to create synthetic imagesto confuse an individual' s visual sense or, in a similar manner, confuse his senses of sound, taste, touch, or smell.

In other words, it may be possible to use electromagnetic means to create overwhelming 'sound' or 'light', or indeed 'intolerable smell' which would exist only in the brain of the person perceiving them.

There is another side as well. The sensory consequences document also notes that the nervous system which controls muscles could be influenced to cause what they call Taser-like motor effects. The stun guns ability to shock the muscles into malfunction is relatively crude; we might now be looking at are much more targeted effects.

Tomorrow: Moscow moves in. Remote-controlled heart attacks, anyone?

— David Hambling

https://defensetech.org/2006/02/14/moscows-remote-controlled-heart-attacks/

Moscow's Remote-Controlled Heart Attacks

TOPICS:BizarroLasers and Ray Guns

Posted By: February 14, 2006

This is the second of David Hambling's two-part series on plasma and electromagnetic weapons. Check out part one here.

The American military may want to attack the nervous system, with pain rays and laser plasma pulses. But they're not the only ones. The Russians have long studied such systems, too — including one weapon that could, in theory, remotely trigger heart attacks.

In 2003, at the 2nd European Symposium on Non-Lethal Weapons, Anatoly Korolev and his colleagues from Moscow State University presented a paper with the snappy title "Bioelectrodynamic Criterion of the NLW Effectiveness Estimation and the Interaction mechanisms of the multilayer Skin Tissues with electromagnetic Radiation." This is a study of how radio-frequency weapons — like the American Active Denial System — affect the skin. After wading through a mass of technical data showing how complex the interactions are we reach the punch line:

The sensations modality (pricking, touch, pressure, gooseflesh, touch, burning pain etc) depends on the field parameters and individual concrete human being factors. As a matter of fact, we can really choose the non-lethal bioeffect.

The effects include sensations similar to those discussed previously, and more besides. The paper discusses effects on cell membranes and affecting the bodys normal function, including "information transfer to the organs of control."

At the same conference, V Makukhin of the Trymas Engineering Center in Moscow described "Electronic equipment for complex influence on biological objects." And when he says "biological objects," he means you and me.

His laboratory apparatus uses a modulated beam of radio waves to produce what he terms "disorder of autonomic nervous system," put forward as a possible non-lethal weapon. Makhunin notes that there is no general agreement on how EM waves disrupt nerves – he mentions ion channels similar to those in the plasma paper – but he certainly seems to be seeing the same effects as American researchers.

But it need not be a non-lethal weapon. Makhunin also mentions the effects of "change of electrocardiogram" and what he calls "function break of heart muscle."

The vulnerability of the heart to electrical stimulation (including that produced by EM waves) is well documented. A lethal device would interfere with the electrical potentials that keep the chambers of the heart synchronized, producing fibrillation and rapid death. A death ray doesnt need to be a truck-sized laser that reduces the target to smoking heap; a small device that stops the heart will do the job.

Little has been openly published in this area in the public domain, but this may be the tip of the iceberg. We are likely to be hearing more in future – especially if the Russians manage to find funding.

I dont think we need tinfoil hats just yet. But a layer of conducting mesh built into body armor might save a lot of heartache in years to come.

(If you want more, theres a whole chapter on different non-lethal directed energy weapons and where the technology might lead in my book Weapons Grade.)

— David Hambling

http://www.feb.se/ARTICLES/OlleJ.html

MYSTERY IN THE SKIN

Screen dermatitis, the effect of computer work on human skin.

An interview with associate professor Olle Johansson at the Experimental Dermatology Unit, Department of Neuroscience, Karolinska Institute, Stockholm, Sweden.

Mr. Helge Tiainen, former head of the Nokia Consumer Electronics in Sweden once said that "The results of Olle Johansson's research could very well deeply shake the world's electronics industry, but mankind still has to know!"

Some interests might feel threatened by the results of his research, but professor Johansson has been outspoken and committed to this scientific field. He started in the 1980's and he has since been continuously very productive and an advocate for the electrosensitive persons in Sweden as well as around the world. This interview will go into what professor Johansson has discovered in the skin of those injured by computer monitors, and also what remains to be done.

He has written a number of important scientific original articles as well as a great number of commentaries and debate articles in the daily newspapers. He has been awarded a series of prestigious awards, such as the Nokia Monitor Award, the Environmental/Medicin Award from the Swedish Cancer and Allergy Foundation and the SIF-Award (The Swedish Clerical and Technical Employees Union).

Altogether, his publication list within the field of neuroscience contains more than 450 original papers, review articles and conference summaries, and he has been a co-author of papers in high-impact journals, such as Nature and Science. His skill as a lecturer is very well documented and his overall knowledge in the areas of the neurosciences, health effects of electromagnetic fields, and in experimental dermatology is esteemed at the highest level.

FEB:
What made you first interested in studying people who had suffered injuries from working in front of computer monitors?

Professor Johansson:
It all started in the 1980's after having listened to a radio programme in which Ms Kajsa Vedin from Gothenburg, herself very active from a union point of view and the author of an excellent analysis entitled "In the shadow of a microchip" (about the occupational risks involved in computer-based work), asked for expertise in neurology. As a neuroscientist I thought I was close enough, and I strongly believed that the issues she wanted to highlight, using the conventional repertoire of scientific "tools", ought to be easily investigated. I did not realise at all that there were other forces not wanting to see such studies initiated, but very soon I understood that these very clear-cut and simple and obvious investigations proposed by Kajsa Vedin would be very, very hard to start.
The same type of propositions soon were brought forward by many other persons including the two journalists Gunni Nordstrom and Carl von Schéele, who later published their first book, "Sjuk av bildskarm" ("Ill from VDT work"; Tidens Forlag, 1989, ISBN 91-550-3484-5). Unfortunately, most of these proposed studies are still not brought into life, 15 years later.

FEB:
Many people abroad think that because electrosensitivity is so well known in Sweden, that we have conducted many important studies also. But this is not the case. Why is this?

Professor Johansson:
The reason is simple, I am afraid. It is not because of lack of ideas and projects, on the contrary, the only reason is lack of funding. This fact has been very important, thus, more or less putting a dead end to the pursuit of knowledge here in Sweden. It is sad, very sad, since I strongly believe a lot would have been understood today if scientists could have been in a situation to properly investigate this enigmatic disease. And, a great deal of unnecessary suffering among the patients could, thus, have been avoided.

FEB:
Did you ever doubt the people who claimed to have been injured using computer monitors?

Professor Johansson:
For me it was immediately clear that persons claiming skin reactions after having been exposed to computer screens very well could be reacting in a highly specific way and with a completely correct avoidance reaction, especially if the provocative agent was radiation and/or chemical emissions -- just as you would do if you had been exposed to e.g. sun rays, X-rays, radioactivity or chemical odours. The working hypothesis thus became that they reacted in a cellularly correct way to the electromagnetic radiation, maybe in concert with chemical emissions such as plastic components, flame retardants, etc., something later focussed upon by professor Denis L. Henshaw and his collaborators at Bristol University (this is covered in Gunni Nordstrom's book " Morklaggning - Elektronikens rattslosa offer" (Hjalmarson & Hogberg Forlag, 2000, ISBN 91-89080-41-6)).

Very soon, however, from different clinical colleagues a large number of other 'explanations' became fashionable, e.g. that the persons claiming screen dermatitis only were imagining this, or they were suffering from post-menopausal psychological abberations, or they were old, or having a short school education, or were the victims of classical Pavlovian conditioning. Strangely enough, most of the, often self-made, 'experts' who proposed these explanations had themselves never met anyone claiming screen dermatitis and these 'experts' had never done any investigations of the proposed explanatory models. The explanations were soon revealed to be excuses of a scientifically fraudulent nature! It is interesting to see that science at that time was mere witchcraft. It remains for skilful journalists to inquire how this came about.

FEB:
You created the name "screen dermatitis", a clinical term to explain the cutaneous damage developed in the late 1970's when office workers, first mostly women, began to be placed in front of computer monitors. Many of them became ill and developed cutaneous and neurological problems. Several clinical dermatologists, headed by the late professor Sture Lidén, instead talked about union-driven fears, mass media-based psychoses, imagination phenomena, Pavlovian conditioning and so forth. But you came to a totally different conclusion. Why?

Professor Johansson:
I refused to reduce people to an ill-defined psychologic home-made diagnosis, without any support even among experts in psychology and psychiatry. Instead, I called for action along lines of occupational medicine, biophysics and biochemistry, as well as neuroscience and experimental dermatology.

I support the democratic principle that citizens are allowed to be ill even in a disease, i.e. a new diagnosis, that is not yet acknowledged by the medical establishment. All diseases were once a "new diagnosis", and the medical profession strongly has doubted asbestosis, cold urticaria, AIDS, the mad cow disease, skin lice, etc. I usually end my lectures with a quotation from Albert Einstein "The important thing is not to stop questioning".
I have never stopped asking questions and I am using the answers to put into place the ever-growing number of pieces of a very, very complicated and enigmatic puzzle.

FEB:
Mr. Helge Tiainen, former head of the Nokia Consumer Electronics in Sweden, in February 23, 1994, said that "The results of Olle Johansson's research could very well deeply shake the world's electronics industry, but mankind still has to

know!" You have received death threats, and been generally harassed. Do you think this has anything to do with your attempts to let "mankind know" ?

Professor Johansson:
Unfortunately, yes.

FEB:
Your Ph.D. thesis was about neuropeptides in the central and peripheral nervous system. Are they also involved in the reactions in the skin of the electrically sensitive?

Professor Johansson:
This is a very important question you bring up! This is something we have wanted to study for many years, but so far we have not been able to pursue these lines of interest due to lack of funding. Since the persons claiming electrosensitivity/screen dermatitis report cutaneous sensations, such as itch, pricking pain, redness, etc., of course the peripheral as well as the central nervous system must be involved. And, by understanding alterations in the chemical neurotransmitter or neuromodulator levels, synthesis, break-down, release and re-uptake, much could be learnt and understood about the basis for these avoidance reactions based upon signals transmitted via the classical sensory and autonomic pathways.

The reaction pattern definitely points to a true biophysical effect, and not to anything else. And, finally, if you take into consideration the large number of publications showing severe changes or damages from low- or high-frequency irradiation of cells, tissues and non-human experimental animals, such alterations cannot ever be understood as "post-menopausal stress reactions", "imagination" or "techno-stress alterations"!

FEB:
You have in 1995 shown that histamine can exist in nerves in the skin. What does this mean?

Professor Johansson:
Already in 1953, the Swedish Nobel Laurate, professor Ulf von Euler had shown that peripheral nerves biochemically could contain histamine. It was argued at that time that it only was due to a contamination of histamine from mast cells present around the peripheral nerves. However, further physiological experiments indicated that maybe there could be both central neurons containing histamine (recently proved) as well as peripheral nerves in various target organs.

Using a histamine-based immunohistochemistry we could then, in 1995, show images revealing the presence of histamine-immunoreactive nerves in the skin (1). Naturally, such a finding is of paramount importance, since all studies on histamine effects in the skin have been based on the assumption that the histamine only is released from local mast cells. So, for instance regarding itch, now we have had to reconsider the function of nerve terminal-derived histamine, something also of the greatest impact for areas such as electrosensitivity.

(1) Johansson O, Virtanen M, Hilliges M, "Histaminergic nerves demonstrated in the skin. A new direct mode of neurogenic inflammation?", Exp Dermatol 1995; 4: 93-96

FEB:
When you look at a biopsy from an electrically sensitive person, what do you usually find?

Professor Johansson:
We are right now in the process of examining a larger number of facial skin samples, and from them the most common finding is a profound increase of mast cells. Nowadays we do not only use histamine, but also other mast cell markers such as chymase and tryptase, but the pattern is still the same as reported previously for other electrosensitive persons

(2). Furthermore, increases of similar nature have now been demonstrated in an experimental situation employing normal healthy volunteers in front of visual display units, including ordinary house-hold television sets (3).

Among earlier studies, one paper (4) ought to be mentioned. In it, facial skin from so-called screen dermatitis patients were compared with corresponding material from normal healthy volunteers.
The aim of the study was to evaluate possible markers to be used for future double-blind or blind provocation investigations.
Differences were found for the biological markers calcitonin gene-related peptide (CGRP), somatostatin (SOM), vasoactive intestinal polypeptide (VIP), peptide histidine isoleucine amide (PHI), neuropeptide tyrosine (NPY), protein S-100 (S-100), neuron-specific enolase (NSE), protein gene product (PGP) 9.5 and phenylethanolamine N-methyltransferase (PNMT).
The overall impression in the blind-coded material was such that it turned out easy to blindly separate the two groups from each other. However, no single marker was 100% able to pin-point the difference, although some were quite powerful in doing so (CGRP, SOM, S-100). However, it has to be pointed out that we cannot, based upon those results, draw any definitive conclusions about the cause of the changes observed. Whether this is due to electric or magnetic fields, a surrounding airborne chemical, humidity, heating, stress factors, or something else, still remains an open question.
Blind or double-blind provocations in a controlled environment (3) are necessary to elucidate the underlying causes for the changes reported in this particular investigation.

(2) Johansson O, Liu P-Y, ""Electrosensitivity", "electrosupersensitivity" and "screen dermatitis": preliminary observations from on-going studies in the human skin". In: Proceedings of the COST 244: Biomedical Effects of Electromagnetic Fields - Workshop on Electromagnetic Hypersensitivity (ed. D Simunic), EU/EC (DG XIII), Brussels/Graz, 1995; 52-57

(3) Johansson O, Gangi S, Liang Y, Yoshimura K, Jing C, Liu P-Y, "Cutaneous mast cells are altered in normal healthy volunteers sitting in front of ordinary TVs/PCs - results from open-field provocation experiments", J Cutan Pathol, 2001, in press

(4) Johansson O, Hilliges M, Han SW, "A screening of skin changes, with special emphasis on neurochemical marker antibody evaluation, in patients claiming to suffer from screen dermatitis as compared to normal healthy controls", Exp Dermatol 1996; 5: 279-285

FEB:
You made a sensational finding when you exposed two electrically sensitive individuals to a TV monitor. When you looked at their skin under a microscope, you found something that surprised you. What?

Professor Johansson:
I guess that you are aiming at one of the early papers (5). In this article, we used an open-field provocation, in front of an ordinary TV set, of 2 patients regarding themselves as suffering from skin problems due to work at video display terminals. Employing immunohistochemistry, in combination with a wide range of antisera directed towards cellular and neurochemical markers, we were able to show a high-to-very high number of somatostatin-immunoreactive dendritic cells as well as histamine-positive mast cells in skin biopsies from the anterior neck taken before the start of the provocation. At the end of the provocation the number of mast cells was unchanged, however, the somatostatin-positive cells had seemingly disappeared. The reason for this latter finding is discussed in terms of loss of immunoreactivity, increase of breakdown, etc. The high number of mast cells present may explain the clinical symptoms of itch, pain, edema and erythema. Naturally, in view of the present public debate, the observed results are highly provocative and, I believe, have to be taken much more seriously.

(5) Johansson O, Hilliges M, Bjornhagen V, Hall K, "Skin changes in patients claiming to suffer from "screen dermatitis": a two-case open-field provocation study", Exp Dermatol, 1994; 3: 234-238

FEB:
You mention mast cells in the skin. A doctor, John Holt, in Australia has written to us saying that when working with

microwaves (to irradiate cancer cells) he has observed that the microwaves from cell phones cause a doubling of histamine (which are released from mast cells) and that such electrosmog from mobile phones could be the cause of the ever increasing asthma and other allergies.
Does his reasoning make any sense?

Professor Johansson:
It certainly does! I have put forward this hypothesis many years ago, in public here in Sweden, and I am now happy to finally see more and more data gathering to support this idea. I and my collaborator, dr. Shabnam Gangi, have also addressed this in two recent publications (see below).

FEB:
You and your partner Shabnam Gangi have presented a theoretical model for how mast cells and substances secreted from them (e.g. histamine, heparin and serotonin) could explain sensitivity to electromagnetic fields. Could you, please, explain this? And also, please, explain the function of the Langerhans cells and how long it takes for them to return.

Professor Johansson:
Yes, we have published two papers of theoretical nature (6,7). They bounce off from known facts in the fields of UV- and ionizing irradiation-related damages, and use all the new papers dealing with alterations seen after e.g. power-frequency or microwave electromagnetic fields to propose a simple summarizing model for how we can understand the phenomenon of electrosensitivity. I strongly recommend the readers of this interview to familiarize themselves with these publications, since I fully believe they have a lot to offer as food for further thoughts.

In the first paper, in the journal Experimental Dermatology (6), we describe the fact that an increasing number of persons say that they get cutaneous problems as well as symptoms from certain internal organs, such as the central nervous system and the heart, when being close to electric equipment. A major group of these patients are the users of video display terminals, who claim to have subjective and objective skin- and mucosa-related symptoms, such as pain, itch, heat sensation, erythema, papules, and pustules. The central nervous system-derived symptoms are, e.g. dizziness, tiredness, and headache. Erythema, itch, heat sensation, edema and pain are also common symptoms of sunburn (UV dermatitis).
Alterations have been observed in cell populations of the skin of patients suffering from so-called screen dermatitis similar to those observed in the skin damaged due to ultraviolet light or ionizing radiation. In screen dermatitis patients a much higher number of mast cells have been observed.
It is known that UVB irradiation induces mast cell degranulation and release of TNF-alpha. The high number of mast cells present in the screen dermatitis patients and the possible release of specific substances, such as histamine, may explain their clinical symptoms of itch, pain, edema and erythema. The most remarkable change among cutaneous cells, after exposure with the above-mentioned irradiation sources, is the disappearance of the Langerhans' cells. This change has also been observed in screen dermatitis patients, again pointing to a common cellular and molecular basis. The results of this literature study demonstrate that highly similar changes exist in the skin of screen dermatitis patients, as regards the clinical manifestations as well as alterations in the cell populations, and in skin damaged by ultraviolet light or ionizing radiation.

In the second publication (7), from the journal Medical Hypotheses, the relationship between exposure to electromagnetic fields and human health is even more in focus. This is mainly because of the rapidly increasing use of such electromagnetic fields within our modern society. Exposure to electromagnetic fields has been linked to different cancer forms, e.g. leukemia, brain tumors, neurological diseases, such as Alzheimer's disease, asthma and allergy, and recently to the phenomenon of electrosensitivity and screen dermatitis. There is an increasing number of reports about cutaneous problems as well as symptoms from internal organs, such as the heart, in people exposed to video display terminals. These people suffer from subjective and objective skin and mucosa-related symptoms, such as itch, heat sensation, pain, erythema, papules and pustules (cf. above). In severe cases, people can not, for instance, use video display terminals or artificial light at all, or be close to mobile telephones. Mast cells, when activated, release a spectrum of mediators, among them histamine, which is involved in a variety of biological effects with clinical relevance, e.g. allergic hypersensitivity, itch, edema, local erythema and many types of dermatoses.

From the results of recent studies, it is clear that electromagnetic fields affect the mast cell, and also the dendritic cell, population and may degranulate these cells. The release of inflammatory substances, such as histamine, from mast cells in the skin results in a local erythema, edema and sensation of itch and pain, and the release of somatostatin from the dendritic cells may give rise to subjective sensations of on-going inflammation and sensitivity to ordinary light.
These are, as mentioned, the common symptoms reported from patients suffering from electrosensitivity/screen dermatitis. Mast cells are also present in the heart tissue and their localization is of particular relevance to their function. Data from studies made on interactions of electromagnetic fields with the cardiac function have demonstrated that highly interesting changes are present in the heart after exposure to electromagnetic fields.

(6) Gangi S, Johansson O, "Skin changes in "screen dermatitis" versus classical UV- and ionizing irradiation-related damage--similarities and differences.
Two neuroscientists' speculative review", Exp Dermatol 1997; 6: 283-291

(7) Gangi S, Johansson O, "A theoretical model based upon mast cells and histamine to explain the recently proclaimed sensitivity to electric and/or magnetic fields in humans", Med Hypotheses 2000; 54: 663-671

FEB:
Some electrically sensitive have symptoms similar to heart attacks after exposure to electromagnetic fields. Any comment on that?

Professor Johansson:
One could speculate that the cardiac mast cells are responsible for these changes due to degranulation after exposure to electromagnetic fields. However, it is still not known how, and through which mechanisms, all these different cells are affected by electromagnetic fields. In this article (7), we present a theoretical model, based upon the above observations of electromagnetic fields and their cellular effects, to explain the proclaimed sensitivity to electric and/or magnetic fields in humans.

FEB:
You have been called a scientist who has climbed down from his ivory tower to get in contact with the real world people live in. Has this been a hindrance to you?

Professor Johansson:
Unfortunately, yes, to a very, very large degree. For readers interested in this, I warmly recommend the books by Gunni Nordstrom and Carl von Scheele (8-10). They are of great value for persons wanting to acquaintance themselves with the political implications and impact of the phenomenon of new diagnoses in our society.

(8) "Sjuk av bildskarm" by Gunni Nordstrom and Carl von Schéele (Tidens Forlag, 1989, ISBN 91-550-3484-5)

(9) "Faltslaget om de eloverkansliga" by Gunni Nordstrom and Carl von Schéele (Tidens Forlag, 1995, ISBN 91-550-4083-7)

(10) "Morklaggning - Elektronikens rattslosa offer" by Gunni Nordstrom (Hjalmarson & Hogberg Forlag, 2000, ISBN 91-89080-41-6)

FEB:
How would you depict the world the electrically sensitive live in?

Professor Johansson:
As a healthy individual it is always very hard to try to describe patients' own situation, so I would rather have someone else to answer this. But, in essence, it must be a very tough daily life, having to always (very much as an allergic or

asthmatic person) look out for situations of provocative nature. And, where today would you find an electric environment equal to e.g. the 1950's? Or, even more mind-buggling, where would you find a high-frequency milieu the same as last year? Nowhere, I guess, since the growth of all such systems is so rapid and quickly covers us all.
Therefore, to enable the basic freedom of choosing where to live, where to work, etc., is impossible in relation to the electrosensitive persons' requirements. And, thus, the question of electrosensitivity becomes a question about democracy!

FEB:
Why do you think some people become electrically sensitive and others do not?

Professor Johansson:
This is also a most important and interesting question. As you know, in any kind of disease, not everyone is ill, and not at the same time. Everyone will not get cancer, everyone will not break a leg, everyone will not have malaria. This is governed by the biological statistical rules of the natural variation. But, maybe you should turn the issue around somewhat.
Perhaps all healthy persons, i.e. in the sense not being electrosensitive, ought to be extra happy for the electrosensitive ones, since they have acted as a warning for all of us? It could be, that we will owe them a lot since they reacted in time to something which the main bulk of mankind did not. Furthermore, the possibility is also that the electrosensitive persons will turn out to be tomorrow's great winners, given the fact that this Summer, twentyone world-leading scientists during a gathering in the French city Lyon, within IARC's (IARC = International Agency for Research on Cancer) expert panel, have concluded low-frequency magnetic fields as a possible cancer risk (=group 2B, containing in addition i.a. diesel and petrol fumes, chloroform, welding fume, lead and DDT). For children exposed to such low-frequency magnetic fields above 0.4 microTesla the cancer risk is doubled. (Therefore, I ask myself: How will people feel after having spent their everyday working hours at or around Vasagatan in Stockholm where the low-frequency magnetic field 1.2 meters above ground is between 0.3 and 2.2 microTesla, or in the commuter trains having levels between 1 and 100 microTesla in the traveller's compartment!?)

FEB:
Does it worry you that children use mobile telephones?

Professor Johansson:
Yes, definitely. And, as you know, also the British government has, in December last year, taken firm action in respect to this question.

FEB:
How will we look on mobile telephones in ten years?

Professor Johansson:
Hopefully without any remaining questions, scepticism or fear. I look forward to see the question-marks around this technology resolved, and a well-documented and 100% responsible, human-friendly technology being presented. And, hopefully, tomorrow's human-friendly technology will be made by Swedish companies, in that way creating a 'healthy wealth' for our country.

FEB:
What do you tell people who suggest that electric sensitivity is purely imagined or psychological?

Professor Johansson:
Well, I always ask them to then, in parallel, explain all the peer-review-published results around effects of, often very weak, electromagnetic fields on molecules, cells, tissues, organs and various non-human experimental animals, i.e. situations which cannot at all be understood in terms of imagination or psychology. In failing this task, I then ask them to

return to the first statement regarding humans, and to scrutinize and re-evaluate it. As you understand, people at that moment suddenly lack scientifically sound arguments, and most of them also confess this. As you know, in the same way it is also very easy to say that all Finns carry knives, but when you look upon this statement in a scientific way it is even easier to show that it is not true!

FEB:
There are many self-appointed 'experts' who have made life difficult for the electrically sensitive. Are they always scientists?

Professor Johansson:
I am, and have always been, very surprised to see how sloppy some of my colleagues address important issues such as the above. Very often one has to realize that all 'experts' are not true scientists and scholars.
Furthermore, it is also very annoying to see that 'experts' claiming, for instance, "that the best way to treat electrosensitive persons is to completely ignore them through silence", did not have to face any personal consequence...!? Nothing happened to them, their position was not questioned, their competence as physicians was not questioned, their suitability as representatives for the medical profession was not questioned. Nothing! What kind of society is that?

I am also very disturbed by the fact that even if the electrosensitive persons were victims of an illusion, where in the Swedish health and law system does it say that you can treat them so badly as several have done?
When I attended the medical school I was taught the very opposite: You should always address patients with kindness, a will to learn and help, support them, meet them and their concerns in a most respectful way, and so on. Where did that disappear? It seems as our world-famous Swedish health insurance policy contains very big gaps through which electrosensitive people, as well as other new diagnoses, fell, and still fall, head down!

FEB:
Do you know of anyone else in the world who has taken biopsies of electrically sensitive individuals?

Professor Johansson:
Yes, the assistant professor and histopathologist Bjorn Lagerholm at the Karolinska Hospital in Stockholm did that already in the middle of the 1980's. He also found an increase in the mast cell number, but, unfortunately, he could never publish it.

As a matter of fact, his interest very much started with a female bank employee that had received a work injury compensation for skin changes after sitting in front of a visual display monitor. Bjorn Lagerholm described in great detail her skin changes, which turned out to be very similar to the kind of cutaneous alterations you may encounter in connection with ultraviolet light or X-ray damage. It is to be noted that Bjorn Lagerholm's reputation as a histopathologist was, and is, undisputed. He had examined at least 10,000 biopsies from other skin diseases before this particular case. In addition to her, he also examined nearly 100 further screen dermatitis cases, all having the same skin changes.

Bjorn Lagerholm wrote an article in the Swedish Medical Journal ("Lakartidningen") to describe his observations. Apart from this he was never able to pursue his ground-breaking and very elegant studies. They would be burried for several years, until I and my collaborators re-initiated them in the early 1990's.

FEB:
Some doctors say that the radiation from a computer monitor could not possibly affect the human skin. The nerves are not that superficial, but what do you say?

Professor Johansson:
This is completely wrong! The idea of the deeply burried nerve fibers were put forward by the late professors David Ingvar and Bernard Frankenheuser.

However, we shortly after published the first true demonstration of the epidermal nerves in human skin (11), followed by an ultrastructural identification (12) as well as a detailed description and quantification of these very superficial nerves (13).

(11) Wang L, Hilliges M, Jernberg T, Wiegleb-Edstrom D, Johansson O, "Protein gene product 9.5-immunoreactive nerve fibres and cells in human skin", Cell Tissue Res 1990; 261: 25-33

(12) Hilliges M, Wang L, Johansson O, "Ultrastructural evidence for nerve fibers within all vital layers of the human epidermis", J Invest Dermatol 1995; 104: 134-137

(13) Johansson O, Wang L, Hilliges M, Liang Y "Intraepidermal nerves in human skin: PGP 9.5 immunohistochemistry with special reference to the nerve density in skin from different body regions", J Peripher Nerv Syst 1999; 4: 43-52

FEB:
Exactly how superficial are these nerves in the skin? When a person places his or her hands on a computer keyboard which gives off electromagnetic fields, can these fields affect the person enough to cause RSI (Repetitive Strain Injury). In Sweden this phenomenon is called "mouse arm" and is quite common.

Professor Johansson:
The nerves come as close as 10-40 micrometers from the stratum corneum, which could be, in e.g. the face, in itself very thin, thus, these nerves are very superficially located. Whether this is the cause for RSI, I honestly do not know, but, naturally, it is definitely a possibility to take into careful consideration.

FEB:
The skin is the largest organ of the body. It is also our foremost protector against the outside world. How does this protection-process work?

Professor Johansson:
This is a very large question, and it would take too much space and time to answer it in full detail. But, in brief, one could understand the skin as a very sensitive 'antenna system' containing, in addition, special sensory organs, such as the eyes, the nose and the ears. The function of the skin is, among many, to always guide us in an ever-changing environment, thus, enabling us to avoid tissue-damaging threats, such as heat, cold, UV-light, X-rays, radioactivity, etc. In the center of this avoidance system is, of course, our nervous system which will help us to go in the right direction, away from some situations, maybe including e.g. electromagnetic fields from computer screens and cellular telephones? The future will tell us if I was right or wrong.

FEB:
Does it seem alarming to you that so many people have reactions in their skin that point to the skin having defensive reactions from say computer work. What of the risk of developing cancer if the skin is always in a defensive mode?

Professor Johansson:
Yes, the whole concept of skin reactions is frightening, especially since the skin cancer forms, such as malignant melanoma and basalioma, are so quickly increasing their incidence. I have asked, over and over again, many colleagues if they really can rule out the surrounding electromagnetic fields as an important background factor for such cancers, and mostly they just do not even answer me.

FEB:
Helmut Kohls wife recently committed suicide due to a severe and lengthy light sensitivity condition. She had to remain in total darkness and could never go out. Many electrically sensitive have experienced precisely the same light sensitivity

after their work with computers. You have written about a woman who became so light sensitive after working with a computer that she had to live in total darkness. Could you tell us more about what goes on in the skin to cause such sensitivity to light.

Professor Johansson:
Yes, to begin with, light sensitivity is increasing as a general problem in the population, and reports have been published in several countries about this. The reason behind it is not known, but from our work one could just speculate around the heat-, light- and UV-adsorbing cellular layer in the epidermis, the so-called melanocytes and their production of the pigment melanin. In the above-mentioned case-report (14), it was evident that this layer, for some unknown reason, was, more or less, completely gone. We used protein S-100 and HLA-DR (human histocompatibility complex class II (subregion DR)) as markers, and it was found that the immunoreactive dendritic cells were dramatically decreased in number, especially in the epidermis.

One could imagine that e.g. increased levels of light or UV-light, or increased levels of other frequencies of electromagnetic fields, such as microwaves, have led to a wear-down of the protective cellular shield in the skin after a long-term continuous irradiation period. If such a damage takes place, maybe the first sign would be light sensitivity in parallel to a modest electrosensitivity. However, if the damage proceeds naturally the situation could be very difficult for the patient, finally leading to a life in basically complete darkness. Several such cases have been reported, but too few studies have been done, again due to lack of funding. In our own case report (14), we could also demonstrate that vitamin A was effective as a treatment for the patient. During the vitamin A treatment, the patient was to a large extent rehabilitated regarding her general light sensitivity, however, she was still sensitive to the presence of electric equipment, although not as much as before. The metabolism of vitamin A should be considered, since, in the human visual system, vitamin A is converted to alpha-cis-retinol, which is an essential chromophore component of rhodopsin, the photoreceptor protein of the retinal rods and is therefore essential for human vision. Maybe vitamin A influences cutaneous (as well as other) cellular systems similar to the retina. One explanation is that the patient for a time lost her melanocytes (or melanocytic content) as seen with the S-100 immunofluorescence, in response to an external or internal provocation. As a reaction to this, also her HLA-DR positive dendritic cells were affected. The vitamin A may have been capable of restoring this balance, as least partially.

(14) Johansson O, Liu P-Y, Enhamre A, Wetterberg L, "A case of extreme and general cutaneous light sensitivity in combination with so-called 'screen dermatitis' and 'electrosensitivity' - a successful rehabilitation after vitamin A treatment - a case report", J Aust Coll Nutr & Env Med 1999; 18: 13-16

FEB:
You conducted a blind test to see if electrically sensitive persons reacted to microwaves from mobile phones, What was the outcome?

Professor Johansson:
I, and my collaborators, have done a series of such tests, some done here in Stockholm, some in Goteborg and also some in Linkoping. The experiments in Stockholm and Goteborg failed, maybe due to the fact that the surrounding environment could not be controlled from the point of low- and high-frequency signals, which may have interacted with the tests subjects.
However, the study in Linkoping (15) was done in the country-side, more than 1 kilometer from the nearest live electric power source. One person was actually able to respond correctly to a mobile phone-based double-blind provocation experiment, 9 times out of 9 tests ($p<2/1000$), both in the 'acute' phase as well as in the 'chronic' phase ($p<1/1000$). This would mean that there may very well be negative health effects from such mobile telephones, most likely depending on their high-frequency fields.

(15) Johansson O, "Eloverkanslighet samt overkanslighet mot mobiltelefoner:
Resultat fran en dubbel-blind provokationsstudie av metodstudiekaraktar", Enheten for Experimentell Dermatologi, Karolinska Institutet, Stockholm, Rapport nr. 2, 1995; ISSN 1400-6111

FEB:
The author and journalist Gunni Nordstrom has in an interview expressed herself in the following way:
"The government seems to listen to those who have the right message, the message they wish to hear. Sometimes one wonders if the authorities have these reports custom-made or if someone in the background is masterminding all important positions and is handing out investigations to those with the correct beliefs or to the untalented. The independent thinkers get their heads chopped off as soon as possible at any rate."
Do you find this to be true?

Professor Johansson:
This is, naturally, impossible to precisely know at this stage, but from a speculative point of view one must say that it is odd, very odd to say the least, that the appointed experts nearly always seems to be persons that, for instance, you in the FEB would not propose. And, also when it comes to representatives in international organizations only 'yes-sayers' are invited, and never any 'whistle-blowers'. From a philosophical point of view this can prove to be sad and badly wrong, since, without the latter, companies, authorities as well as governments can be fooled and tricked into the completely wrong corner. And, to fool your own government is, as far as I know, high treason, right? Personally, if I were the prime minister, I would be very afraid never to listen to the 'whistle-blowers' since it could be a big, big mistake, from a public health point of view, not to!

FEB:
You mentioned "whistleblowers". There have been many attempts to wear you down. Most recently you were asked to move your laboratories to a corridor containing all the rooms for household garbage, radioactive vaste, dead animal carcasses, etc.! Does it come a time when it is no longer worth being a "whistleblower"?

Professor Johansson:
For the future, I would like to propose to governments and likewise to ensure that scientists dealing with new, provocative research, even with a great impact on the general economy, that they should be given a 'safety net', i.e. their personal situation, their career possibilities, etc., must be protected and not in any way hampered by the fact that they deal with the 'wrong' kind of scientific field. How, otherwise, would you have future young scientists wanting to throw away all their personal possibilities?
Otherwise, I am deeply afraid that there will come a time when it is no longer worth being a "whistleblower".

FEB:
Have you received sufficient funding?

Professor Johansson:
No, never. And if not the Swedish Cancer and Allergy Foundation would have been around, I do not think I would have had the strength to carry on. But they have always argued for the importance of new, courageous and daring science, and along the lines of cancer, allergy and their connection to the environment. This has also become a leading star for me.

FEB:
What if you suddenly got unlimited funds. What would you like to pursue?

Professor Johansson:
I guess, to begin with, that I would try to accurately characterize the electrosensitive patients from a clinical as well as cellular point of view. Depending on the results, I would then continue with more detailed studies based on theories emanating from the above data. It is, more or less, impossible to say at this point what such studies would be. One thing I would, for sure though, is to employ some additional personnel since I have been very much left alone through-out the years.

FEB:
What about the EU work for a safer electromagnetic environment?

Professor Johansson:
Within this context, one very interesting, and on-going, movement is the EC-based "The European framework for protection from exposure to electromagnetic fields". About it, to begin with, there are some general comments to be made. The EC does not seem to be interested in yet another 'BSE scandal', therefore they are carefully keeping an eye on the issues around health effects and health risks (N.B. Note the difference between health effects, identified and calculated health risks and unknown health risks) from electromagnetic fields, especially from high-frequency telecommunication, such as mobile telephony. Furthermore, the EC does not regard the above-mentioned irradiation systems to be proven safe. On the contrary, I believe they strongly understand it could be a major mistake to whole-body irradiate the whole European (as well as the world's) population, 24 hours around.

FEB:
We often hear about "safe levels" of exposure and that there is "no proof of health effects". What is your response to these seemingly reassuring statements?

Professor Johansson:
It is very important to realize, from a consumer's point of view, that "no accepted proof for health effects" is not the same as "no risk". Too many times, 'experts' have claimed to be experts in fields where actually the only expert comment should have been: "I/we just do not know". Such fields were e.g. the DDT, X-ray, radioactivity, smoking, asbestos, BSE, heavy metal exposure, depleted uranium, etc., etc., etc., where the "no risk"-flag was raised before true knowledge came around. Later on, the same flag had to be quickly lowered, many times after enormous economic costs and suffering of many human beings. Along those lines, it is now (regarding "the protection from exposure to electromagnetic fields" issue) very important to clearly identify the background and employment (especially if they sit, at the same time, on the industry's chairs) of every 'expert' in different scientific committees, and likewise. It is, of course, very important (maybe even more important?) to also let 'whistleblowers' speak at conferences, to support them with equal amounts (or even more?) of economical funding as those scientists and other 'experts' who, already from the very beginning, have declared a certain source or type of irradiation, or a specified product, to be 100% safe.

FEB:
Should the precautionary principle always be our guide?

Professor Johansson:
In the case of "protection from exposure to electromagnetic fields", it is of paramount importance to act from a prudence avoidance/precautionary principle point of view. Anything else would be highly hazardous! Total transparency of information is the key sentence here, I believe consumers are very tired of always having the complete truth years after a certain catastrophy already has taken place. It shall be noted, that today's recommendation values for mobile telephony, the SAR-value, are just recommendations, and not safety levels. Since scientists observe biological effects at as low as 20 microWatts/kg, is it then really safe to irradiate humans with 2 W/kg (i.e., with 100.000 times stronger radiation!), which is the recommendation level for us? And, furthermore, it is very strange to see, over and over again, that highly relevant scientific information is suppressed or even left out in various official documents, as high up as at the governmental level of society. This is not something that the consumers will gain anything good from, and, still, the official declaration or explanation (from experts and politicians) very often is: "If we (=the experts) would let everything out in the open, people would be very scared and they would panic." Personally, I have never seen this happen, but instead I have frequently seen great disappointment from citizens who afterwards have realized they have been fooled by their own experts and their own politicians...

Another misunderstanding is the use of scientific publications (as the tobacco industry did for many years) as 'weights' to balance each other.
But you can NEVER balance a report showing a negative health effect with one showing nothing! This is a misunderstanding which, unfortunately, is very often used both by the industrial representatives as well as official

authorities. The general audience, naturally, easily is fooled by such an argumentation, but if you are bitten by a deadly poisonous snake, what good does it make for you that there are 100 miljon harmless snakes around?

FEB:
In her book " Morklaggning - Elektronikens rattslosa offer " (10), the author and journalist Gunni Nordstrom has identified a group of Swedish obfuscators, mainly Lidén, Berg, Hillert, Arnetz and Bergkvist, who have attempted to put a psychological stamp on what you would term "screen dermatitis". These people have, Gunni Nordstrom claims, written a series of articles in international journals, always quouting one another, always making sure not to mention your findings. This has, as FEB has evidence of, hindered doctors and others to understand the electrically sensitive in other countries, causing them much suffering. How can one prevent a similar scenario for future health risks, or does one always have to go through an obfuscating or denying phase before admitting to the true facts?

Professor Johansson:
Well, I certainly hope not! According to the work of professor Klas Amark at the Stockholm University this has, unfortunately, always been the case previously, but, of course, this tendency must be completely altered in the future. No democratic and humanitarian society can hold up such principles as you indicate in your question. We have to meet the future health problems in a much more 'grown-up' fashion!

FEB:
What do you see in the future?

Professor Johansson:
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Professor Johansson will gladly answer your questions, but due to a heavy workload, he might not be able to answer all questions. Therefore, try to be as brief as possible.

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New Quality-Control Investigations on Vaccines: Micro- and Nanocontamination

Abstract

Vaccines are being under investigation for the possible side effects they can cause. In order to supply new information, an electron-microscopy investigation method was applied to the study of vaccines, aimed at verifying the presence of solid contaminants by means of an Environmental Scanning Electron Microscope equipped with an X-ray microprobe. The results of this new investigation show the presence of micro- and nanosized particulate matter composed of inorganic elements in vaccines' samples which is not declared among the components and whose unduly presence is, for the time being, inexplicable. A considerable part of those particulate contaminants have already been verified in other matrices and reported in literature as non biodegradable and non biocompatible. The evidence collected is suggestive of some hypotheses correlated to diseases that are mentioned and briefly discussed.

Keywords: Vaccine; Disease; Contamination; Protein corona; Biocompatibility; Toxicity; Nanoparticle; Immunogenicity; Foreign body; Environment; Industrial process; Quality control

Research Article

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Introduction

Vaccines are one of the most notable inventions meant to protect people from infectious diseases. The practice of variolation is century-old and is mentioned in Chinese and Indian documents dated around 1000 A.D. Over time, variolation has been replaced by vaccination, vaccines have been enhanced as to technology, and the vaccination practice is now standardized worldwide.

Side effects have always been reported but in the latest years it seems that they have increased in number and seriousness, particularly in children as the American Academy of pediatrics reports [1,2]. For instance, the diphtheria-tetanus-pertussis (DTaP) vaccine was linked to cases of sudden infant death syndrome (SIDS) [3]; measles-mumps-rubella vaccine with autism [4,5]; multiple immunizations with immune disorders [6]; hepatitis B vaccines with multiple sclerosis, etc.

The notice of Tripedia DTaP by Sanofi Pasteur reports "Adverse events reported during post-approval use of Tripedia vaccine include idiopathic thrombocytopenic purpura, SIDS, anaphylactic reaction, cellulitis, autism, convulsion/grand mal convulsion, encephalopathia, hypotonia, neuropathy, somnolence and apnea". The epidemiological studies carried out did not show a clear evidence of those associations, even if in 2011 the National Academy of Medicine (formerly, IOM) admitted: "Vaccines are not free from side effects, or adverse effects"[7].

Specific researches on components of the vaccines like adjuvants (in most instances, Aluminum salts) are already indicated as possible responsible of neurological symptoms [8-10] and in some cases, in-vivo tests and epidemiological studies demonstrated a possible correlation with neurological diseases [10,11]. Neurological damages induced in patients under hemodialysis treated with water containing Aluminum are reported in literature [12].

Recently, with the worldwide-adopted vaccines against Human Papillomavirus (HPV), the debate was reawaken due to some adverse effects reported by some young subjects.

Specific studies communicated the existence of symptoms related to never-described-before syndromes developed after the vaccine was administered. For instance, Complex Regional Pain Syndrome (CRPS), Postural Orthostatic Tachycardia Syndrome (POTS), and Chronic Fatigue Syndrome (CFS) [13]. The side-effects that can arise within a relatively short time can be local or systemic.

Pain at the site of injection, swelling and uncontrollable movement of the hands (though this last symptom can also be considered systemic) are described. Among the systemic effects, fever, headache, irritability, epileptic seizures, temporary speech loss, lower limbs dysaesthesia and paresis, hot flashes, sleep disorders, hypersensitivity reactions, muscle pain, recurrent syncope, constant hunger, significant gait impairment, incapacity to maintain the orthostatic posture are reported [14].

It is a matter of fact that every day millions of vaccine doses are administered and nothing notable happens, but it is also irrefutable that, regardless of the amount of side effects that are not recorded and the percentage of which remains in fact unknown, in a limited number cases something wrong occurs. No satisfactory explanation or, in many cases, no explanation at all has been given and it seems that those adverse effects happen on a random and stochastic basis.

Those situations induced us to verify the safety of vaccines from a point of view which was never adopted before: not a biological, but a physical approach. So, we developed a new analysis method based on the use of a Field Emission Gun Environmental Scanning Electron Microscope investigations to detect possible physical contamination in those products.

Materials and Methods

44 types of vaccines coming from 2 countries (Italy and France) were analyzed. Table 1 groups them in terms of name, brand and purpose.

Table 1: List of vaccines analyzed, according to their purpose.

N	Name	Brand Name, Country of Distribution	Description	Production Batch, Expiry Date
1	Vivotif Berna	Berna Biotech SA, Italy	Anti-Thyphoid Vaccine (Live), group Ty21a	3000336 [2004]
2	Typhim Vi	Aventis Pasteur MSD, Italy	Anti-Salmonella typhi Vaccine	U1510-2 [2004]
3	Typherix	GlaxoSmithKline S.p.a., Italy	Anti-Thypoid Vaccine (polysaccharide Vi)	ATYPB061BB [2009]
4	Anatetall	Chiron (now Novartis) Italy	Adsorbed anti-Tetanus Vaccine	030106 [2004]
5	Anatetall	Novartis Vaccines and Diagnostics, Italy	Adsorbed anti-Tetanus Vaccine	060510 [2009]
6	Tetabulin	Baxter AG, Italy	Adsorbed anti-Tetanus Vaccine	VNG2G006A [2009]
7	Dif-Tet-All	Novartis Vaccines and Diagnostics, Italy	Adsorbed anti-Tetanus and diphtheria Vaccine	070501 [2009]
8	Infanrix	GlaxoSmithKline S.p.a., Italy	Anti-Diphtheria, tetanus and pertussis vaccine	AC14B071AJ [2009]
9	Infanrix hexa	GlaxoSmithKline Biologicals s, Italy	Anti-diphtheria, tetanus, pertussis, hepatitis B, poliomyelitis and disease caused by Haemophilus influenzae type b	A21CC512A [2017]
10	Infanrix hexa	GlaxoSmithKline Biologicals s. a. France	Anti-diphtheria, tetanus, pertussis, hepatitis B, poliomyelitis and disease caused by Haemophilus influenzae type b	A21CC421A [2017]
11	M-M-R vaxPro	Sanofi Pasteur MSD, Italy	M-M-R vaxPro (measles, mumps, and rubella) analyzed in Cambridge	L012437 [2017]
12	Repevax	Sanofi Pasteur MSD, France	Anti-diphtheria-tetanus-pertussis-polio-vaccine	L0362-1 [2017]
13	Repevax	Sanofi Pasteur MSD SNC France	Anti-diphtheria-tetanus-pertussis-polio-vaccine	L0033-1 [2016]
14	Priorix	GlaxoSmithKline S.p.a., Italy	Anti--measles-mumps, and rubella (MMR) vaccine	A69CB550A [2009]
15	Morupar	Chiron (now Novartis,), Italy	Anti-measles- mumps, and rubella (MMR) vaccine	7601 [2004]
16	Varilrix	GlaxoSmithKline S.p.a., Italy	Anti-Chicken pox vaccine (group OKA)	A70CA567A [2009]
17	Stamaril Pasteur	Sanofi Pasteur MSD, Italy	anti-yellow fever vaccine	A5329-6 [2009]
18	Allergoid-Adsorbat 6-Graser Starke B.	Allergopharma, Germany	Antiallergic vaccine	Ch-B.:30005999-B [2006]
19	Engerix-B	GlaxoSmithKline S.p.a., Italy	Adsorbed anti-hepatitis B vaccine	AHBVB468BD [2009]
20	Prenevar 13	Pfizer, Italy	Antipneumococcal vaccine	G79324 [2013]
21	Prevenar 13	Pfizer, France	Antipneumococcal vaccine	N27430 [2018]
22	Mencevax Acwy	GlaxoSmithKline, Italy	anti-Neisseria meningococcal group A, C, W135 and Y vaccine	N402A47B 12 [2004]
23	Meningitec	Pfizer, Italy	(group C 10) (adsorbed on Al-Phosphate)	H92709 [2015]
24	Meningitec	Pfizer-Italy	Anti-meningococcus (group C 10) vaccine (adsorbed on Al-Phosphate)	H20500 [2014]

25	Meningitec	Pfizer-Italy	Anti-meningococcus vaccine sequestred by Procura della Repubblica	G76673 [2014]
26	Meningitec	Pfizer-Italy	Anti-meningococcus vaccine sequestred by Procura della Repubblica	H99459 [2015]
27	Meningitec	Pfizer-Italy	Anti-meningococcus vaccine sequestred by Procura della Repubblica	H52269 [2015]
28	Menjugate	Novartis Vaccines and Diagnostics	Anti-meningococcus group C	YA0163AB [2010]
29	Menveo	Novartis Vaccines and Diagnostics	Antimeningococcus groups A, C, W135, Y	A15083 [2017]
30	Meningitec	Wyeth Pharmaceutical - France	Anti-meningococcus group C vaccine	E83920 [2011]
31	Inflexal V	Berna Biotech	Anti-flu vaccine 2008/2009	3001463-01 [2009]
32	Vaxigrip	Sanofi Pasteur MSD	Anti-flu vaccine 2008/2009	D9703-1 [2009]
33	Vaxigrip	Sanofi Pasteur	Anti-flu vaccine 2012/2013	J8401-1 [2013]
34	Vaxigrip	Sanofi Pasteur, Italy	Anti-flu vaccine, with inactivated and split virus	M7319-1 [2016]
35	Focetria	Novartis Vaccines and Diagnostics	Anti-pandemic flu H1N1 vaccine	0902401 [2010]
36	Agrippal	Novartis	Anti-flu vaccine 2012/2013	127002A [2013]
37	Agrippal	Novartis vaccines, Italy	Anti-flu vaccine with inactivated and split virus 2015/2016 -	152803 [2016]
38	Agrippal S1	Novartis Vaccines and Diagnostics	Anti-flu inactivated/superficial antigene v - 2014/2015	147302A [2015]
39	Fluarix	GlaxoSmithKline - GSK	Anti-flu vaccine 2013	AFLUA789AA [2014]
40	Fluad	Novartis Vaccines and Diagnostics	Anti-flu inactivated/superficial antigene vaccine - 2014/2015	142502 [2015]
41	Gardasil	Sanofi Pasteur MSD, Italy	Anti-HPV types 6,11,16,18 vaccine	NP01250 [2012]
42	Gardasil	Sanofi Pasteur MSD, Italy	Anti-HPV (types 6,11,16,18) vaccine	K023804 [2016]
43	Cervarix	GlaxoSmithKline Biological, Italy	Anti-HPV (type 16,18)	AHPVA238AX [2017]
44	Feligen CRP	Virbac S.A. - Carros - Italy	anti-panleucopenia, infectious rhinotracheitis and infections by Calcivirus, veterinary Vaccine for cats	3R4R [2013]

Some vaccines, in fact a minority, are meant to deal with a single bacterium or virus, while others are multi-valent. The list of vaccines we analyzed may contain repeated names, because we considered different batches and years of production of the same vaccine: the ones against influenza in particular.

The study was aimed at verifying a possible physical contamination. To do that, we performed a new kind of investigation based on observations under a Field Emission Gun Environmental Electron Scanning Microscope (FEG-ESEM, Quanta 200, FEI, The Netherlands) equipped with the X-ray microprobe of an Energy Dispersive Spectroscope (EDS, EDAX, Mahwah, NJ, USA) to detect the possible presence of inorganic, particulate contaminants and identify their chemical composition.

A drop of about 20 microliter of vaccine is released from the syringe on a 25-mm-diameter cellulose filter (Millipore, USA), inside a flow cabinet. The filter is then deposited on an Aluminum stub covered with an adhesive carbon disc. The sample is immediately put inside a clean box in order to avoid any contamination and the box is re-opened only for the sample to be inserted inside the FEG-ESEM chamber. We selected that particular type of microscope as it allows to analyse watery and oily samples in low vacuum (from 10 to 130 Pa) at a high sensitivity.

When the water and saline the vaccine contains are evaporated, the biological/physical components emerge on the filter and it is then possible to observe them. This type of microscope

(low-vacuum observations) prevents the possible sample contamination and the creation of artefacts. The observations are made with different sensors (SE: secondary-electron sensor and BSE: backscattered-electron sensor), and are performed at a pressure of 8.9 e-1 mbar, at energies ranging from 10 to 30kV to detect the particulate matter's size, morphology and its elemental composition. The method identifies clearly inorganic bodies with a higher atomic density (looking whiter) than the biological substrate. So, organic entities are visible and easy to distinguish from inorganic ones. The method cannot distinguish between proteins and organic adjuvants (e.g. squalene, glutamate, proteins, etc.) or viruses, bacteria, bacteria's DNA, endo-toxins and bacteria's waste, but their comparatively low atomic density allows us to identify these entities as organic matter. In some vaccines, the organic matter contains white-looking debris named aggregates, while a high concentration or inorganic debris is called a cluster.

Single inorganic particles or organic-inorganic aggregates are identified, evaluated and counted. The counting procedure is repeated three times by three different operators, with an error lower than 10%. When a layer of salts (Sodium chloride or Aluminum) is detected, we record the situation but we do not do body count.

Results

The investigations verified the physical-chemical composition of the vaccines considered according to the inorganic component as declared by the Producer. In detail, we verified the presence of saline and Aluminum salts, but further presence of micro-, sub-micro- and nanosized, inorganic, foreign bodies (ranging from 100nm to about ten microns) was identified in all cases, whose presence was not declared in the leaflets delivered in the package of the product (Table 2).

Table 2: List of the vaccines according to their manufacturers with the chemical composition of the debris identified in each sample. The elements most represented are reported.

N	Company	Name	Alluminum	Elements Identified
1	Allergopharma - Germany	Allergoid	yes	Al
2	Aventis Pasteur MSD Lyon - Francie	Typhim Vi	no	BrKP, PbSi, FeCr, PbClSiTi
3	Baxter AG	Tetabulin	no	SiMg, Fe, SiTiAl, SBa, Zn
4	Berna Biotech	Vivotif Berna	no	FeAl, ZrAlHf, SrAl, BiAlCl
5	Berna Biotech	Inflexal V	no	CuSnPbZn, Fe, CaSiAl, SiAl, NaPZn, ZnP, AlSiTi
6	Chiron	Anatetall	$Al(OH)_3$	FeAl, SZnBaAl
7	Chiron	Morupar	no	/
8	GlaxoSmithKline- Belgium	Mencevax ACWY	no	FeCrNi, ZrAl, FeCrNiZrAlSi
9	GlaxoSmithKline	Infanrix	$Al(OH)_3$	Al, AlTi, AlSi
10	GlaxoSmithKline Biologicals	Infanrix hexa	$Al(OH)_3$	SBa, FeCu, SiAl, FeSi, CaMgSi, AlCaSi, Ti, Au, SCa, SiAlFeSnCuCrZn, CaAlSi
11	GlaxoSmithKline Biologicals	Infanrix hexa	$Al(OH)_3$,$AlPO_4$. $2H_2O$	W, FeCrNi, Ti
12	GlaxoSmithKline	Typherix	no	Ti, TiW, AlSiTiWCr, SBa, W, SiAl, AlSiTi
13	GlaxoSmithKline	Priorix	no	WCa, WFeCu, SiAl, SiMg, PbFe, Ti, WNiFe
14	GlaxoSmithKline	Engerix-B	no	Al (precipitates)
15	GlaxoSmithKline	Varilrix	no	FeZn, FeSi, AlSiFe, SiAlTiFe, MgSi, Ti, Zr, Bi
16	GlaxoSmithKline	Fluarix	no	AlCu, Fe, AlBi, Si, SiZn, AlCuFe, SiMg, SBa, AlCuBi, FeCrNi, SPZn
17	GlaxoSmithKline Biologicals	Cervarix	$Al(OH)_3$	AlSi,FeAl, SiMg,CaSiAl, CaZn, FeAlSi, FeCr, CuSnPb
18	Novartis Vaccines and Diagnostics	Anatetall	$Al(OH)_3$	Al, FeCrNi, AlCr, AlFe, BaS, ZnAl
19	Novartis Vaccines and Diagnostics	Dif-Tet-All	$Al(OH)_3$	Fe,SBa, SiSBa, AlZnCu, AlZnFeCr
20	Novartis Vaccines and Diagnostics	Menjugate kit	$Al(OH)_3$	SiAl,Ti,FeZn, Fe, Sb, SiAlFeTi, W, Zr
21	Novartis Vaccines and Diagnostics	Focetria	no	Fe, FeCrNiCu, FeCrNi, SiFeCrNi, Cr, SiAlFe, AlSiTiFe, AlSi, SiMgFe, Si, FeZn

22	Novartis	Agrippal S1	no	Ca, Fe, SBa, SBaZn, Cr, Si, Pb, Bi, e FeSiAlCr, SiAlSBaFe, CaAlSi, Zn, CeFeTiNi, FeCrNi
23	Novartis Vaccines and Diagnostics	Agrippal S1	no	SiAlK, Si, SiMgFe, CaSiAl, SBaZn
24	Novartis vaccines	Agrippal	no	Cr, Ca, SiCaAl, ZrSi, SBa, CuZn, SCa
25	Novartis Vaccines and Diagnostics S	Fluad	no	CaSiAl, FeSiTi,SiMgAlFe, SBa
26	Novartis Vaccines and Diagnostics	Menveo	no	CaSiAl, SiAlFe, FeCrNi, Fe, Al, SBa
27	Pfizer	Prenevar 13	no	FeCr
28	Pfizer	Prevenar 13	no	W, CaAlSi, Al, CaSiAlFe, FeS, FeCr, FeCrNi, Fe, , CaP, FeTiMn, Ba, SiMgAlFe
29	Pfizer	Meningitec - ctrl	no	Cr, Si
30	Pfizer	Meningitec - ctrl	no	FeCrNi, W
31	Pfizer	Meningitec	no	CaSiAl, CaSi, SiAlFeTi, FeCrNi, W, Fe, Pb
32	Pfizer	Meningitec	no	Cr (precipitates), Ca, AlSi
33	Pfizer	Meningitec	no	W, SiCa, CaSi, Pb, FeCrNi, Cr
34	Wyeth Pharmaceutical - UK	Meningitec	no	SiAlFe, SiAlTi, SiMgFe, W, Fe, Zr, Pb, Ca, Zn, FeCrNi
35	Sanofi Pasteur MSD-France	Vaxigrip	no	Fe, FeCrNi, SiAlFe, AlSi, SiAlFeCr
36	Sanofi Pasteur MSD	Stamaril Pasteur	no	CaSiAl, AlSi, Fe, SiMgFe, SiMgAlFe, CrSiFeCr, CrSiCuFe
37	Sanofi Pasteur MSD	Gardasil	$AlPO_4$. $2H_2O$	AlCuFe, PbBi, Pb, Bi, Fe
38	Sanifi Pasteur MSD	Gardasil	$AlPO_4$. $2H_2O$	CaAlSi, AlSi, SiMgFe, Al,Fe, AlCuFe, FeSiAl, BiBaS, Ti, TiAlSi
39	Sanofi Pasteur	Vaxigrip	no	Ca, CrFe, FeCrNi, CaSZn, CaSiAlTiFe, Ag, Fe
40	Sanofi Pasteur	Vaxigrip	no	SiMgFe, CaSiAl, AlSiFe, AlSi,FeCr, FeZn, Fe
41	Sanofi Pasteur MSD	Repevax	$AlPO_4$.$2H_2O$	Bi, Fe, AlSiFe, SiMg, SBa, Ca
42	Sanofi Pasteur MSD S	Repevax	$AlPO_4$.$2H_2O$	Ti, Br, AuCuZn, Ca, SiZn, SiAuAgCu, SiMgFe,FeCrNi. AlSiMgTiMnCrFe, SiFeCrNi, FeAl
43	Sanofi Pasteur MSD	M-M-R vaxPro	no	Si, SiFeCrNi, FeCrNi,FeNi, Fe, SCa, AlSiCa, CaAlSiFeV, SBa, Pt, PtAgBiFeCr
44	Virbac S.A. - Carros - France	Feligen CRP	no	Ca,SiAl

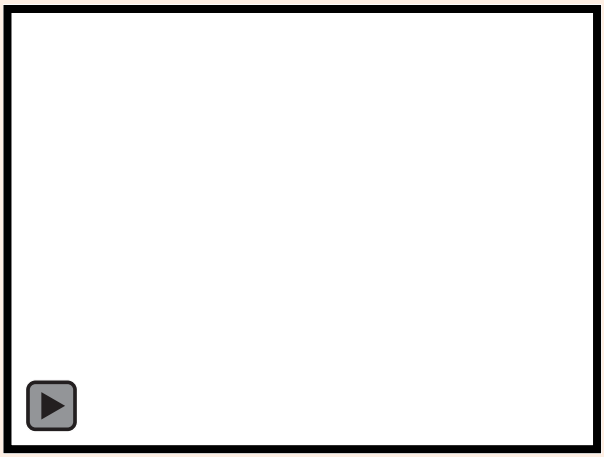

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Figure 1a shows a layer of crystals of Sodium chloride (NaCl) embedding salts of Aluminum phosphate ($AlPO_4$) in a drop of Gardasil (anti-HPV vaccine by Merck) as the EDS spectrum (Figure 1b) shows. Saline is the fluid base to any vaccine preparation and Aluminum salts or Aluminum hydroxide [$Al(OH)_3$] are the adjuvants which are usually added.

Looking at the area outside these precipitates but inside the liquid drop, we identified other things: single particles, clusters of particles and aggregates (organic-inorganic composites) that are due to an interaction of the inorganic particulate matter with the organic part of the vaccine.

Figure 2a-2f shows the different typology of entities identified in the vaccines (Repevax, Prevenar and Gardasil); single particles, cluster of micro- and nanoparticles (<100nm) and aggregates with their EDS spectra (Figure 2d-2f). The images (Figure 2a & 2d) show debris of Aluminum, Silicon, Magnesium and Titanium; of Iron, Chromium, Silicon and Calcium particles (Figure 2b & 2e) arranged in a cluster, and Aluminum -Copper debris (Figure 2c & 2f) in an aggregate.

As can be seen, the particles are surrounded and embedded in a biological substrate. In all the samples analyzed, we identified particles containing: Lead (Typhym, Cervarix, Agrippal S1, Meningitec, Gardasil) or stainless steel (Mencevax, Infarix Hexa, Cervarix. Anatetall, Focetria, Agrippal S1, Menveo, Prevenar 13, Meningitec, Vaxigrip, Stamaril Pasteur, Repevax and MMRvaxPro).

Figure 3a-3d show particles of Tungsten identified in drops of Prevenar and Infarix (Aluminum, Tungsten, Calcium chloride).

Figure 4a-4d present singular debris found in Repevax (Silicon, Gold, Silver) and Gardasil (Zirconium).

Some metallic particles made of Tungsten or stainless steel were also identified. Other particles containing Zirconium, Hafnium, Strontium and Aluminum (Vivotif, Meningetec); Tungsten, Nickel, Iron (Priorix, Meningetec); Antimony (Menjugate kit); Chromium (Meningetec); Gold or Gold, Zinc (Infarix Hexa, Repevax), or Platinum, Silver, Bismuth, Iron, Chromium (MMRvaxPro) or Lead,Bismuth (Gardasil) or Cerium (Agrippal S1) were also found. The only Tungsten appears in 8/44 vaccines, while Chromium (alone or in alloy with Iron and Nickel) in 25/44. The investigations revealed that some particles are embedded in a biological substrate, probably proteins, endo-toxins and residues of bacteria. As soon as a particle comes in contact with proteic fluids, a nano-bio-interaction [6] occurs and a "protein corona" is formed [7-10]. The nano-bio-interaction generates a bigger-sized compound that is not biodegradable and can induce adverse effects, since it is not recognized as self by the body.

Figure 5a-5f show examples of these nano-bio-interactions. Aggregates can be seen (stable composite entities) containing particles of Lead in Meningitec, (Figure 5a & 5b) of stainless steel (Iron, Chromium and Nickel, Figure 5c & 5d) and of Copper, Zinc and Lead in Cervarix (Figure 5e & 5f). Similar aggregates, though in different situations (patients suffering from leukemia or cryoglobulinemia), have already been described in literature.

The link between these two entities generates an unfolding of the proteins that can induce an autoimmune effect once those proteins are injected into humans.

Figure 6a & 6b show one of the foreign bodies identified in Agrippal. The particle is composed of Cerium, Iron, Titanium and Nickel. (Figure 7a & 7b) present an area of Repevax where the morphology of red cells - we cannot tell whether they are human or animal- is clearly visible.

Table 3 summarizes the number and morphology of the debris identified, in term of single particles, clusters of particles or aggregates (organic-inorganic compounds), while Figure 8 shows the graph obtained calculating the total number of particles (particles plus clusters plus aggregates) identified for 20 microl of every vaccine.

Similar aggregates were already described by other scientists who identified them in the blood e.g. in leukemic patients [15] and in subjects affected by cryoglobulinemia [16].

Not all the vaccines analyzed contain the same contamination, though the same vaccine belonging to different batches and, in some cases, coming from different countries can contain a similar contamination (e.g. the vaccines by Glaxo Infarix, Typherix and Priorix contain Tungsten. Tungsten was also identified in Menjugate kit by Novartis, and Prevenar, Meningitec by Pfizer and Meningitec by Wyeth).]

Feligen, the only veterinary vaccine tested, proved to be the only sample free from inorganic contamination, while Allergoid generates a layer of inorganic salts so thick that it does not allow to detect other particulate contaminants.

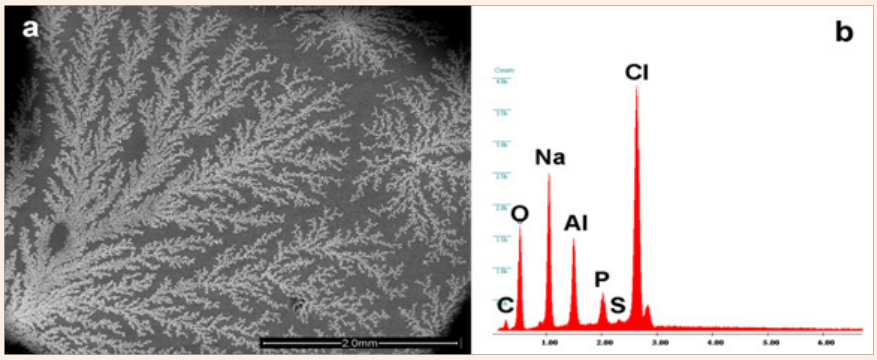

Figure 1: Crystals of saline solution and Aluminum Phosphate and corresponding EDS spectra.

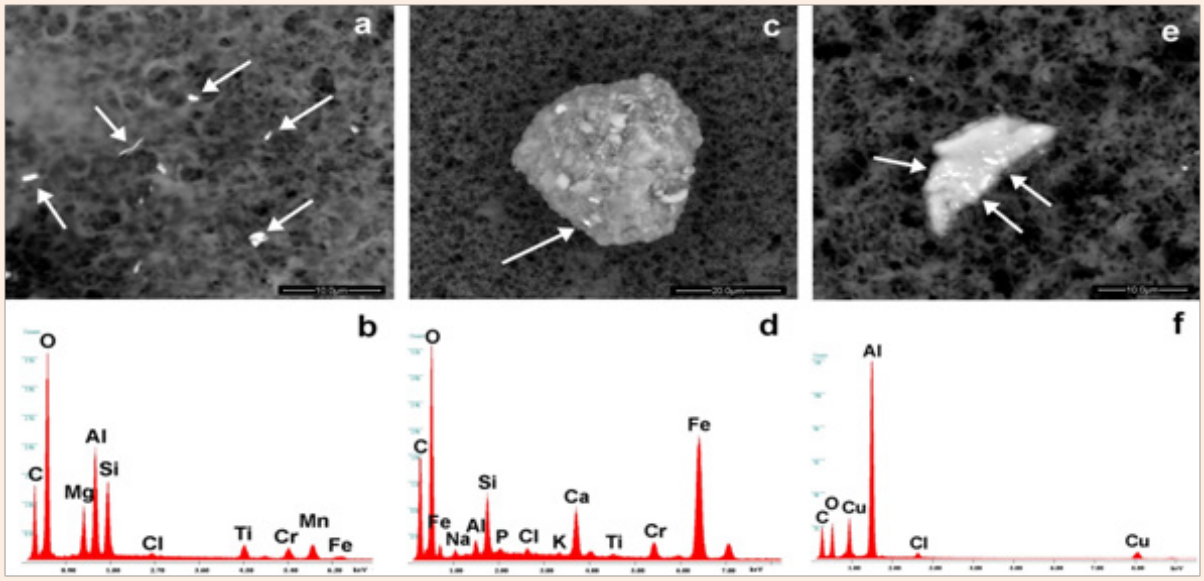

Figure 2: Images of single particles, cluster of micro- and nanoparticles (<100nm) andaggregates with their EDS spectra. They are respectively composed of (a,b) Aluminum, Silicon, Magnesium, Titanium, Chromium, Manganese, Iron, (c,d) Iron, Silicon, Calcium Titanium, Chromium, (e,f) Aluminum, Copper. The arrows show the points where EDS spectra were taken.

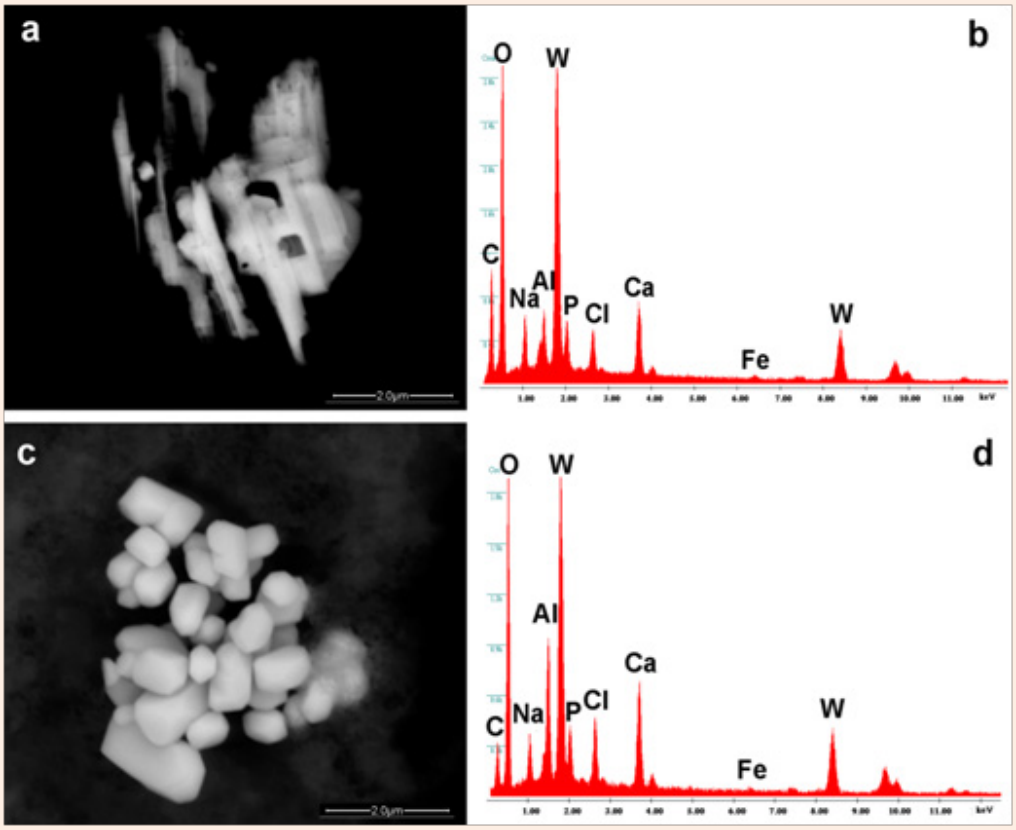

Figure 3: Images of Tungsten particles identified in drops of Prevenar and Infarix. They are composed respectively of Tungsten, Aluminum, Iron but in different concentrations. The arrows show the points where EDS spectra were taken.

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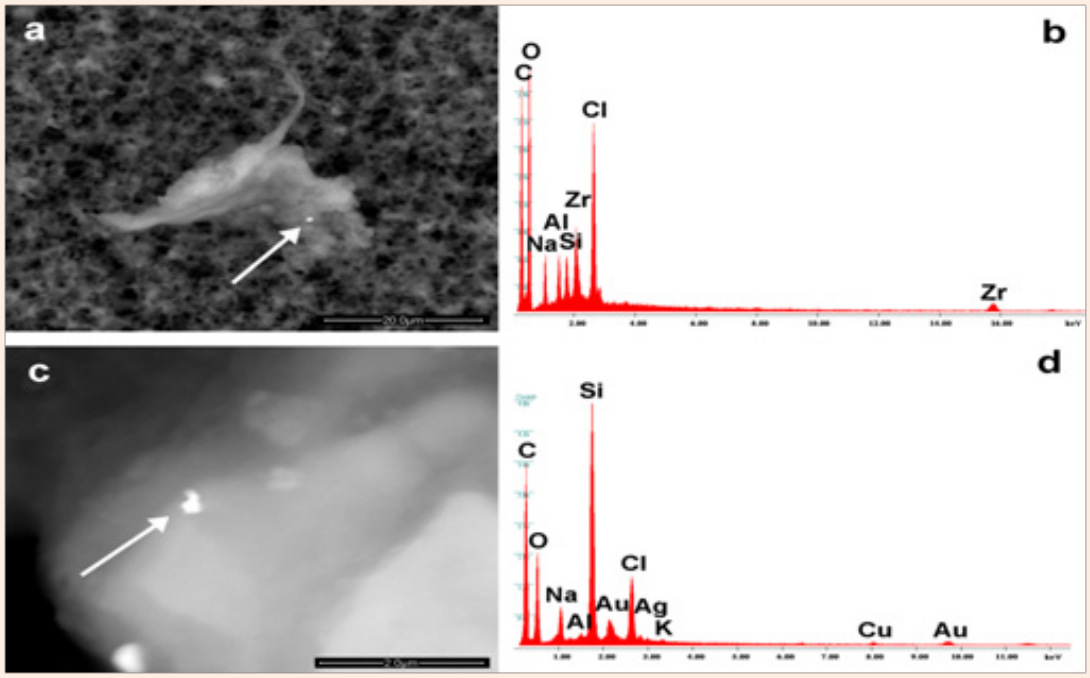

Figure 4: Images show examples of nano biointeraction. The aggregate (a,b) identified in Gardasil contains nanoparticles of Chlorine, Silicon, Aluminum, Zirconium, while the debris found in Repevax contains Silicon, Gold, Silver (c,d). The arrows show the points where EDS spectra were taken.

Table 3: List of the debris' number identified in each vaccine as single particle, clusters and aggregates. Characterization is made by shape, size range and variability of the number of particles counted in each aggregate [in brackets].

Name	Total Debris n.	Size Range in μm	Cluster n.	Size Range in μm	Aggregate n.(Range of Particles)	Size Range μm
Allergoid	NaCl precipitates	/	/	/	/	/
Typhim Vi	394	0,1-2,5			3[9-350]	2-35
Tetabulin	519	0,1-15			3[100-180]	25-60
Vivotif Berna	4	1,5-15				
Inflexal V	103	0,1-17	1	20	3[35-45]	10-25
Anatetall	2	1-3				
Morupar	/		/		/	
Mencevax ACWY	13	0,2-5				
Infanrix	3	1-5	1	25		
Infanrix hexa	1821	0,1-15			15[1820]	20-140
Infanrix hexa	162	0,3-7	12	60	2[7 debris]	3.5-44
Typherix	8	0,2-8	1	15		
Priorix	641	0,05-30	1	10	3[600]	20-70
Engerix-B	precipitates			/		
Varilrix	2723	0,1-4			36 [120-2000]	15-40

Fluarix	1317	0,1-40			3[83]	7-30
Cervarix	1569	0,2-3	2	5-10	4[1400]	8-30
Anatetall	47	0,05-40				
Dif-Tet-All	111	0,2-3				
Menjugate	73	0,1-5				
Focetria	35	0,7-10				
Agrippal S1	430	0,2-6	13	0.2-80	5[410]	20
Agrippal S1	1029	0,1-12			9[1025]	35-80
Agrippal	480	0,1-6			11[460]	2-80
Fluad	605	0,2-15	4	12-25	6[600]	70
Menveo	452	0,1-13			4[430]	30-110
Prenevar 13	precipitates + 5 debris	1-7				
Prevenar 13	precipitates + 81 debris	0,2-50	3	5-40	1 [60]	25
Meningitec	3	10-20				
Meningitec	24	8-60				
Meningitec	673	0,1-20	1	7	9[624]	5-110
Meningitec	precipitates + 40	0,1-3,5			2[40]	25-70
Meningitec	177	0,2-10			3[165]	15-100
Meningitec	241	0,1-15	1	50	2[230]	50
Vaxigrip	86	0,1-7			2[50]	2-2,5
Stamaril Pasteur	152	0,1-7	2	5-7	3[145]	4-20
Gardasil	304	0,05-3			1[300]	15
Gardasil	454	0.1-30	2	7-20	9[445]	5-60
Vaxigrip	304	0,1-10	1	13	2[300]	35
Vaxigrip	674	0,3-25	2	2-12	10[660]	9-150
Repevax	137	0,1-20			2[130]	40-50
Repevax	214	0,1-10			6[150]	5-30
M-M-R vaxPro	93	0,1-15			2[50]	Oct-15
Feligen CRP	92	0,1-12	1	12	1 (40 debris)	25

Discussion

The quantity of foreign bodies detected and, in some cases, their unusual chemical compositions baffled us. The inorganic particles identified are neither biocompatible nor biodegradable, that means that they are biopersistent and can induce effects that can become evident either immediately close to injection time or after a certain time from administration. It is important to remember that particles (crystals and not molecules) are bodies foreign to the organism and they behave as such. More in particular, their toxicity is in some respects different from that of the chemical elements composing them, adding to that toxicity which, in any case, is still there, that typical of foreign bodies. For that reason, they induce an inflammatory reaction.

After being injected, those microparticles, nanoparticles and aggregates can stay around the injection site forming swellings and granulomas [17]. But they can also be carried by the blood circulation, escaping any attempt to guess what will be their final destination. We believe that in many cases they get distributed throughout the body without causing any visible reaction, but it is also likely that, in some circumstances, they reach some organ, none excluded and including the microbiota, in a fair quantity. As happens with all foreign bodies, particularly that small, they induce an inflammatory reaction that is chronic because most of those particles cannot be degraded. Furthermore, the protein-corona effect (due to a nano-bio-interaction [18]) can produce organic/inorganic composite particles capable of stimulating the immune system in an undesirable way [19-22]. It is impossible not to add that particles the size often observed in vaccines can enter cell nuclei and interact with the DNA [23].

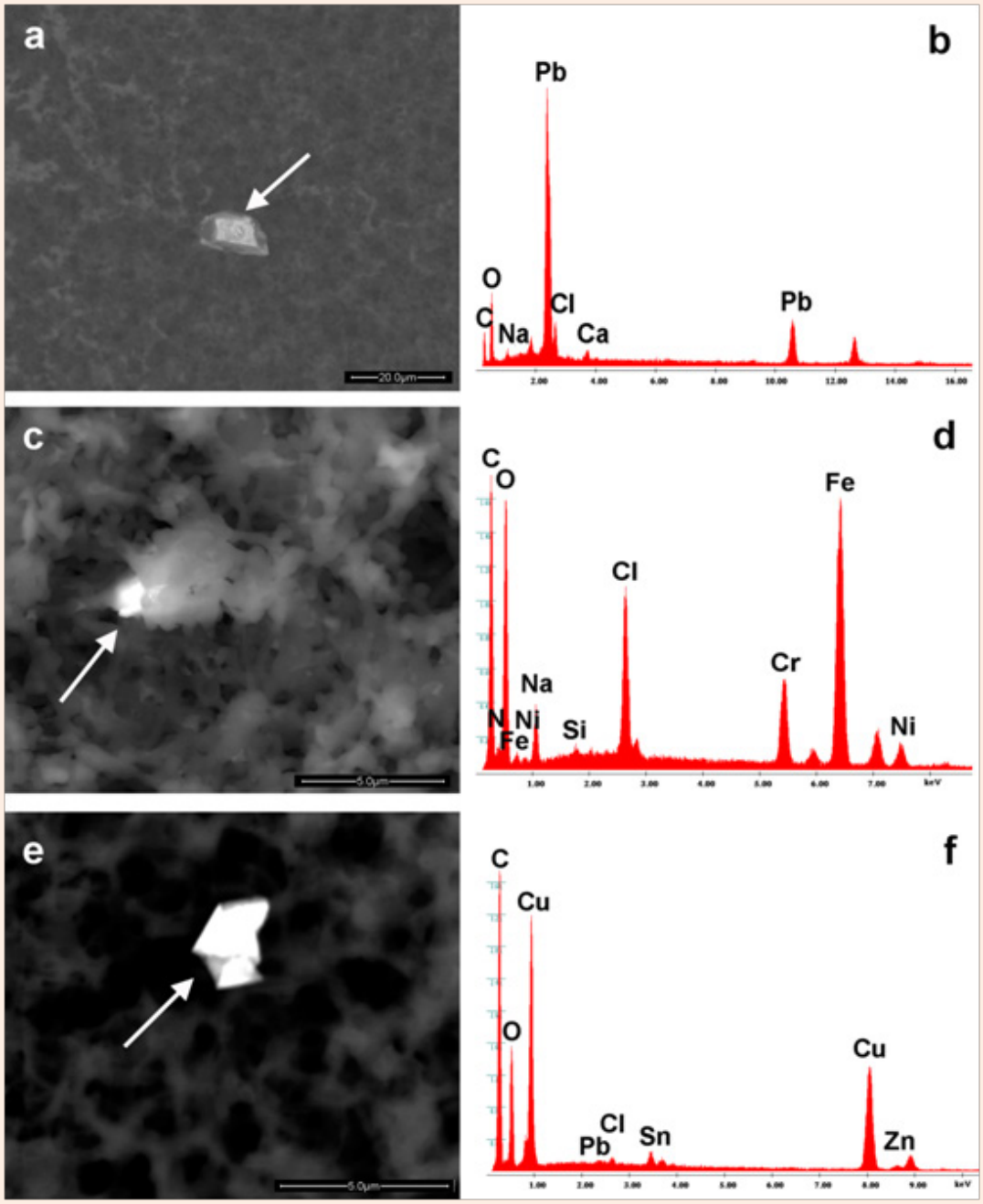

Figure 5: show particles surrounded by an organic compound. They are composed of Lead (a,b), Iron, Chromium, Nickel (stainless steel; c,d), Copper, Tin, Lead (e,f). The arrows show the points where EDS spectra were taken.

In some cases, e.g. as occurs with Iron and some Iron alloys, they can corrode and the corrosion products exert a toxicity affecting the tissues [24-26].

The detection of presence of Aluminum and NaCl salts is obvious as they are substances used by the Producers and declared as components, but other materials are not supposed to be in the vaccine or in any other injectable drug, at that, and, in any case, Aluminum has already been linked with neurological diseases [27-29].

Given the contaminations we observed in all samples of human-use vaccines, adverse effects after the injection of those vaccines are possible and credible and have the character of randomness, since they depend on where the contaminants are carried by the blood circulation. It is only obvious that similar quantities of these foreign bodies can have a more serious impact on very small organisms like those of children. Their presence in the muscles, due an extravasation from the blood, could heavily impair the muscle functionality [30,31].

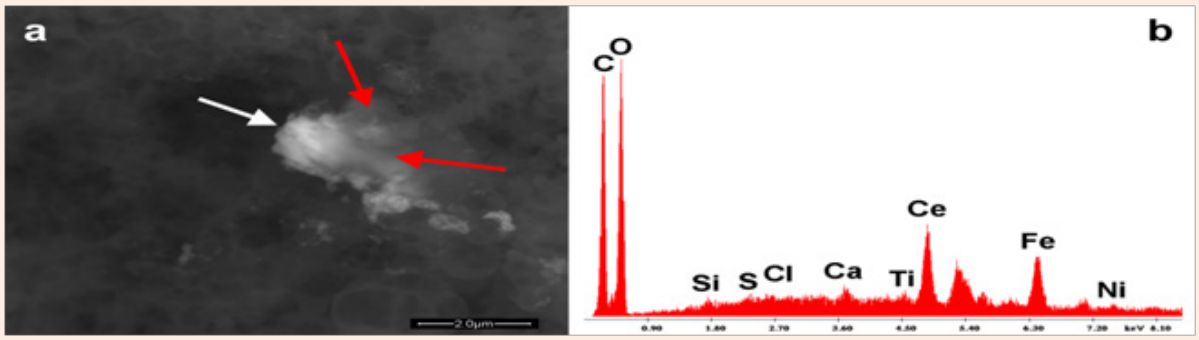

Figure 6: show an organic aggregate containing a debris made of Cerium, Iron, Nickel, Titanium. The red arrow indicates the organic layer (less atomically dense) that covers the Cerium particle.

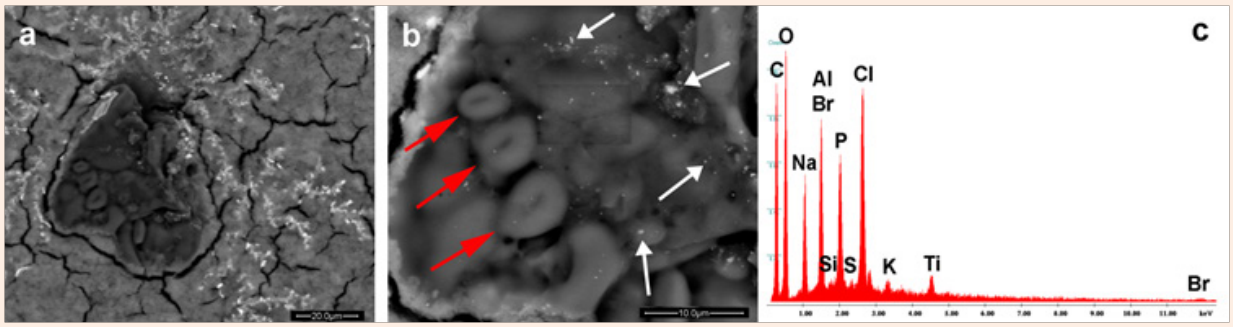

Figure 7: Image of an area in a Repevax drop where the morphology of red cells (red arrows) were identified. It is impossible to know whether they are human or animal origin. Among the debris of saline and Aluminum phosphate, there is the presence of debris (white arrows) composed of Aluminum, Bromine, Silicon, Potassium, Titanium.

We come across particles with chemical compositions, similar to those found in the vaccines we analyzed, when we study cases of environmental contamination caused by different pollution sources. In most circumstances, the combinations detected are very odd as they have no technical use, cannot be found in any material handbook and look like the result of the random formation occurring, for example, when waste is burnt. In any case, whatever their origin, they should not be present in any injectable medicament, let alone in vaccines, more in particular those meant for infants.

Other forms of so-far unknown contaminations have recently been observed and, in any case, vaccines contain components that could themselves be the cause of adverse effects. It is a well-known fact in toxicology that contaminants exert a mutual, synergic effect, and as the number of contaminants increases, the effects grow less and less predictable. The more so when some substances are unknown.

As a matter of fact, no exhaustive and reliable official data exist on the side-effects induced by vaccines. The episodic evidence reported by people allegedly damaged by vaccines is twofold: some say the damage occurred and became visible within a few hours from administration, and some maintain that it was a matter of some weeks. Though we have no indisputable evidence as to the reliability of those attestations, we can put forward a hypothesis to explain the different phenomena. In the former case, the pollutants contained in the drug have reached the brain and, depending on the anatomical site interested, have induced a reaction. If that is the case, the whole phenomenon is very rapid. In the latter circumstance, the pollutants reached the microbiota, thus interfering with the production of enzymes necessary to carry out neurological functions [32-35]. That possibility takes time, as it involves the production of chemical compounds in a sufficient quantity, and an elapse of some weeks between injection and clinical evidence is reasonable. Of course, ours is no more than a hypothesis open to discussion and in need of proof, hoping that a chance of further investigation is allowed.

Conclusion

The analyses carried out show that in all samples checked vaccines contain non biocompatible and bio-persistent foreign bodies which are not declared by the Producers, against which the body reacts in any case. This new investigation represents a new quality control that can be adopted to assess the safety of a vaccine. Our hypothesis is that this contamination is unintentional, since it is probably due to polluted components or procedures of industrial processes (e.g. filtrations) used to produce vaccines, not investigated and not detected by the Producers. If our hypothesis is actually the case, a close inspection of the working places and the full knowledge of the whole procedure of vaccine preparation would probably allow to eliminate the problem.

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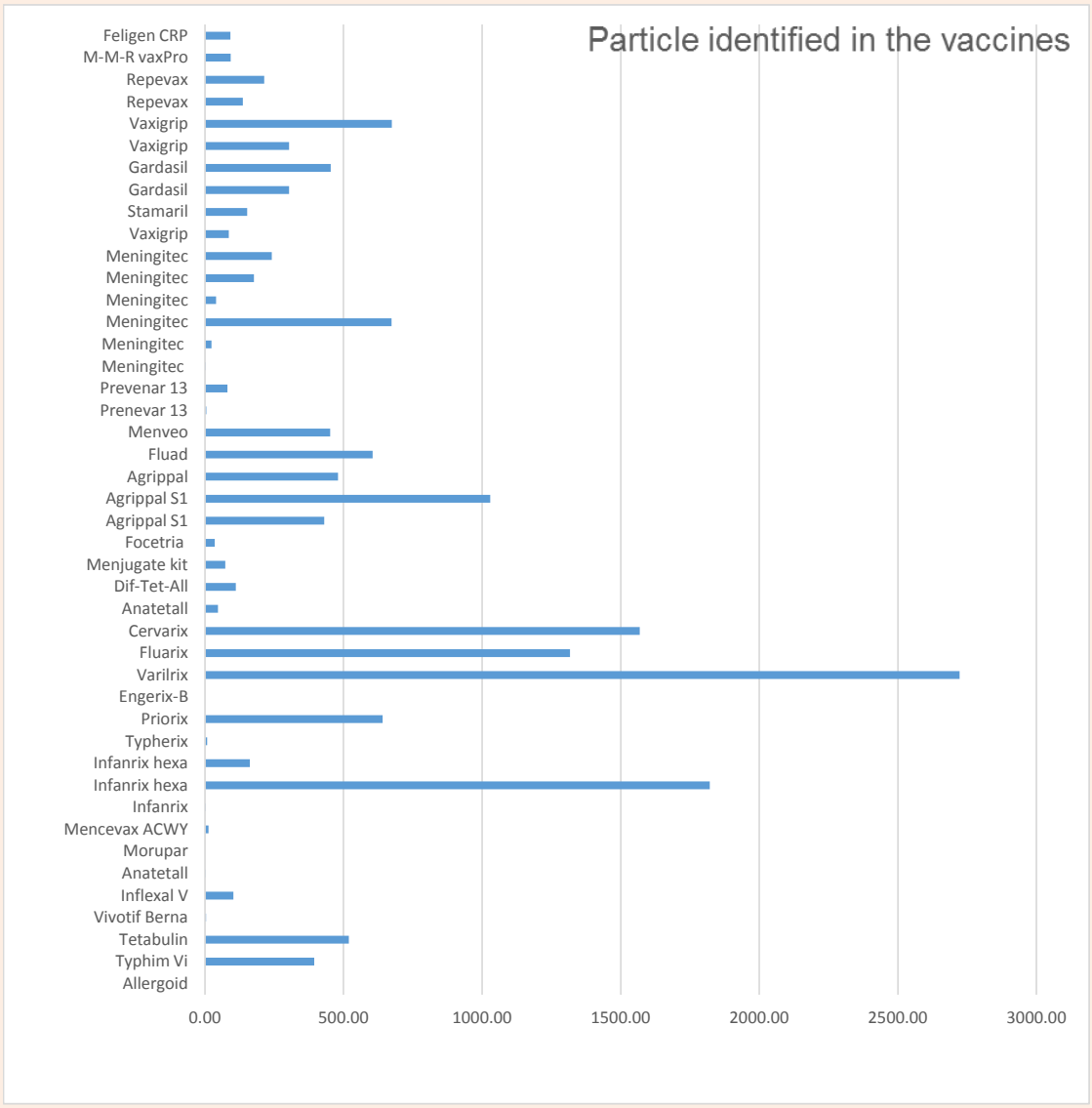

Figure 8: Graph of the debris' quantities identified in a 20 microl drop of every vaccine.

A further purification of the vaccines could improve their quality and could probably decrease the number and seriousness of the adverse incidental effects.

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Future Strategic Issues/Future Warfare [Circa 2025]

The Future Is Now!

Dennis Bushnell, Chief Scientist - NASA Langley Research Center

WARFARE STRATEGY DOCUMENT - THE FUTURE IS NOW!

U.S. Air Force/DARPA/CIA/FBI/ Southern Command/Atlantic Command/Australian DOD and more

http://www.stopthecrime.net/nasa.html

THESE ARE JUST A FEW EXAMPLES OF WHAT IS IN THE N.A.S.A. DOCUMENT THAT ARE HAPPENING NOW !

www.StopTheCrime.net/nasa .html

www.StopTheCrime.net

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Future Strategic Issues/Future Warfare [Circa 2025]

- Capabilities of the "Enemy After Next"
  - -Ongoing Worldwide Technological Revolutions
  - -Economic Trends
- Potential Nature of Farther Term Warfare

The ‘Bots, ‘Borgs, ‘& Humans Welcome You to 2025 A.D.

THIS PRESENTATION BASED ON "FUTURES" WORK FOR/WITH

- USAF NWV
- USAF 2025
- National Research Council
- Army After Next
- ACOM Joint Futures
- SSG of the CNO
- Australian DOD
- NRO, DSB
- DARPA, SBCCOM
- DIA, AFSOC, EB, AU
- CIA, STIC, L-M, IDA
- APL, ONA, SEALS
- ONI, FBI, AWC/SSI
- NSAP, SOCOM, CNO
- MSIC, TRADOC, QDR
- NGIC, JWAC, NAIC
- JFCOM, TACOM
- SACLANT, OOTW

THIS PRESENTATION

- **Is meant to incite thought/ discussion**
- **Is based in all cases upon existing data/trends/analyses/technologies (e.g., NO PIXIE DUST)**
- **Provides in some cases a somewhat broader view of prospective developments and issues**

Utilization/Application of 2025+ Projections

- Inputs to Future Warfighting Concepts Development(s) (Enemy After Next & Blue)
- Inputs to New Procurement Decision (15+ years to Produce, 40+ years in Inventory
- "Heads Up" for Intel Community ("Watches and Warnings")
- Inputs to DOD R&D Planning

"Going In" Assumptions

- Politics can/does change "overnight" (e.g. Russia, Iran, Iraq, Pakistan, etc.), Potential CAPABILITIES is the future warfare issue, not Who but WHAT

Need to Plan "Differently"

- **WORLD is in the throes of triple/exponential (IT/Bio/Nano) Technological Revolutions**
- **Changes occurring at scales of months (instead of decades)**
- **Zeroth order potential effects upon Defense/Offense equipment/conops/threat**

Future Strategic Issues, 7/01

"SPACESHIP EARTH"

The crew are:

- **Plundering the ship's supplies**
- **Tinkering with the temperature and life-support controls**
- **Still looking for the instruction manual**
- **Engaging in bloody skirmishes in every corner of the vessel**
- **Increasing the size of the crew by 2 million PER WEEK**

P. Creola

Future Strategic Issues, 7/01

Humans Have "Taken Over" and Vastly Shortened "Evolution"

- **Of the Planet**
  - **Global Warming/Pollution/Deforestation**
  - **Huge "Public Work" (e.g. 3 Gorges Dam)**
- **Of the Human Species**
  - **Genomic Design and Repair**
  - **"Mind Children" (Moravec)**
- **Products/Life Forms**
  - **Cross Species Molecular Breeding**
  - **"Directed Evolution" (Maxygen etc.)**

Future Strategic Issues, 7/01

CURRENTLY

- **Order of 70% of Worlds Research conducted outside of U.S. (to first order, a % of GDP, U.S. produces order of 18% of worlds GDP)**
- **Order of 70% of U.S. Research now "Commercial" (as opposed to Government sponsored)**

NanoTechnology Research

- 29% in Europe
- 28% in Japan
- 27% in U.S.
- 16% “Other(s)”

Future Strategic Issues, 7/01

Technological Ages of Humankind

- Hunter/Killer groups [Million BC~10K BC]
- Agriculture [10K BC~1800 AD]
- Industrial [1800~1950]
- IT [1950~2020]
- Bio/NANO [2020-?]
- Virtual

Future Strategic Issues, 7/01

- **Hunter-Gatherer - "Nature Provided"**
- **Agriculture - Controlled Nature (Plants/Animals)**
- **Industrial - Mechanized Agriculture**
- **IT/BIO/Nano - Automating Industry/Agriculture**
- **Virtual - Robotization of IT/Bio/Nano/Industry/Agriculture**

Future Strategic Issues, 7/01

KEY "FUTURE TECHNOLOGIES"

(all highly synergistic/at the frontiers of the small, in a "feeding frenzy" off each other)

- **IT**
  - **Silicon/bio/optical/quantum/nano computing ("no end in sight," another 10^6 +)**
  - **(Virtual reality/holographic) immersive ubiquitous comms., hyperspectral sensors, "virtual presence"**
  - **Automatic/robotic "everything"**
  - **Huge cost reductions**
- **Bio**
  - **Life span doubling**
  - **Genetic engineering before birth**
  - **Plants irrigated by seawater (food, petro-chem feed stock, minerals, terraforming)**
- **Nano**
  - **Carbon nanotubes (600X strength-to-weight of steel)**
  - **"Assemblers"/"living factories"**
  - **Huge cost reductions**

Future Strategic Issues, 7/01

Worldwide IT Revolution

- **Comms/Computing/Sensors/Electronics**
- **U.S. Commercial IT R&D ~ $100B/yr.**
- **Factor of 1 Million further improvement [Silicon,Molecular,Quantum,Bio,Optical]**
- **Beyond Human AI?**
- **Automatics/Robotics "in the large"**
- **Immersive multi-sensory VR/"Holodecks"**
- **Ubiquitous multi physics/hyperspectral sensors [land/sea/air/space]**
- **Micro/Nano sats/GNC/sensors,etc.**

[Worldwide] Impacts of Ongoing IT Revolution Upon Society

- **Tele-commuting**
- **Tele-shopping**
- **Tele-entertainment**
- **Tele-travel**
- **Tele-Education**
- **Tele-medicine**
- **Tele-commerce**
- **Tele-politics**
- **Tele-socialization**

IT Status

- 10E6 improvements in Computing since '59, 10E8 further possible next 30 years (10E3 provides "better than Human" capabilities)
- 100 Million Telecommuters Worldwide NOW (expected to at least double in 15 years)
- India graduates three times more software engineers than the U.S., More software written in Bangalore than Southern CA
- IW effectively constitutes a 4th WMD

Future Strategic Issues, 7/01

SOME IT "PREDICTIONS"

- Quantum computing initially available in 5 years
- 15% of all power today is used by computers, will reach 60% by 2010
- Wearable/implantable (on-person) electronics--comms, computing, sensory augmentation, health monitoring, brain stimulation

Future Strategic Issues, 7/01

AI (AND BEYOND) COMPUTING

Human Brain Characteristics/Capabilities

- 100 billion neurons
- 100 trillion connections
- 200 calculations/second, (slow) speed of neural circuitry
- 20 million billion calculations/second
- Excellent at (parallel-computing) pattern recognition, "poor" at sequential thinking
- Operates via "random tries"

Machine Capabilities

- Currently, 10,000 billion calculations/second; 100,000 billion by 2004
- By 2010, 20 million billion is available (by 2025, on a PC)
- By 2030, PC has collective computing power of a town full of human minds

Future Strategic Issues, 7/01

U.S. "HUMAN BRAIN PROJECT"

- **Begun in early 90's, funded by 16 organizations across 5 agencies (NIH, NSF, DOD, NASA, DOE)**
- **AKA "Neuroinformatics" (intersection of neuroscience and informatics)**
- **"Exploding field;" 10,000 individual presentations at annual meeting of Society for Neuroscience (from molecular geneticists to cognitive psychologists)**
- **Determining detailed neuroanatomy of human brain ("digital brain atlas")**
- **Use of IT to study brain, use of brain info to aid IT/AI**

Future Strategic Issues, 7/01

THE "IMAGINATION ENGINE"

aka "Creativity Machine," aka "Creative Agent"

- **Current AI "best bet," not a rule based/expert system**
- **GENERATES new ideas/concepts via starving a trained neural net of meaningful inputs, forcing it to "dream"/"cavitate," create new concepts, etc. An attendant neural net used to capture/record/evaluate and report on these "writings."**

"In this [Worldwide] economy our ability to create wealth is not bounded by physical limits/resources but by our ability to come up with new ideas"

[However,even "universal wealth" will not obviate the other causes of warfare which include Politics,"Face",Religion, Megalomania and Territorial Disputes]

Future Strategic Issues, 7/01

Global Problems/"Solutions"

- (Serious) Problems
  - Energy (2)
  - Water (2)
  - Food (2)
  - Land (2)
  - Population Growth (1)
  - Wealth Generation (1)
  - "Pollution/Warming" (2)
- "Killer Ap Solutions"
  - **(1)** Motivational/inexpensive Web-based Asynchronous "Distance Learning"
  - **(2)** Bio mass/food via seawater irrigation in current "wastelands"

Inexpensive Motivational Asynchronous Web-Based Distance Education Enables:

- Demise of the U.S. "underclasses"
- Wealth Creation from enabled "Invention"
- Stabilization of World Population
- [Even More] Rapid Technology Diffusion
- Equalization of "Haves" and "Havenots"
- Altered Political/military outlooks Worldwide
  - I.E. Changes "Everything"

Future Strategic Issues, 7/01

Motivational learner/web-based asynchronous distance learning ~~allows~~ only method of providing requisite/improved educational

- BREADTH
- DEPTH
- QUALITY
- RESPONSIVENESS to shifting global economic warfare requirements/ accelerated increase in knowledge

At orders of magnitude

(1) reduced societal/individual cost

(2) increased convenience/accessibility

Future Strategic Issues, 7/01

By ~ 2025, 40% of Private and 15% of Public Colleges and Universities are Expected to Close Due to Web-Based Competition

A Northern VA Business man recently donated ~ $100M to set up a FREE Ivy League Class On-Line University

Future Strategic Issues, 7/01

The "Ultimate" Education Approach - Plug and Play

Direct Silicon (or other such) device connection to brain, (very rapid) uploads, Education in minutes instead of (many) years

Future Strategic Issues, 7/01

Advantages of Shallow Sea/Desert Production of Biomass (Via Seawater Irrigation)

- Closed CO2 Cycle (Obviates Global Warming)
- Food
- Petro-chemical feedstock
  - Materials/clothing, etc.
  - ENERGY (end reliance on Middle East)
- Terraforming, alter desertification etc.
- Preservation/Production of Fresh Water
- Rich Mineral source (Seawater)
- Utilization of "Wastelands" (Sahara, etc.)

Future Strategic Issues, 7/01

Probable Circa 2025 Societal Changes

- (Much) Increased Life Span (Bio)
- "Solution" to Energy/Water/"Warming" (Bio)
- (Far More) Global Distribution of Technology, Education, Economics, Wealth (IT)
- (Tremendous) Increases in Capability of Automatic/Robotic "Everythings" (IT/Bio/Nano)
  - Resulting in Reduced Tensions Associated with "Have/Have Nots" and Historical/Religious Issues
  - Also Resulting in (Greatly) Increased Individual destructive power (Bio, IW, etc.) and General Societal Disaffection WRT "Machines"

Future Strategic Issues, 7/01

Major Emerging Law Enforcement "Issues"

- Privacy (Ubiquitous micro/nano sensors)
- IT/Net Crime (wide spectrum)
- Bio Crime (binary pathogens, genetics)
- Protection of Human Electronic Implants
- Protection of CONUS (Beyond Terrorism)
- Societal Disaffection/Upheaval Caused by Rapid Technological Change(s) (Road/Air Rage, Psychosomatic Illnesses, Withdrawal)

Future Strategic Issues, 7/01

Of Particular Concern

Uncontrolled/Uncontrollable

SELF-REPLICATION

Of

- Brilliant Robots (IT)

- Nano-Replicators (Nano)

- Rampant Recombinant Bio

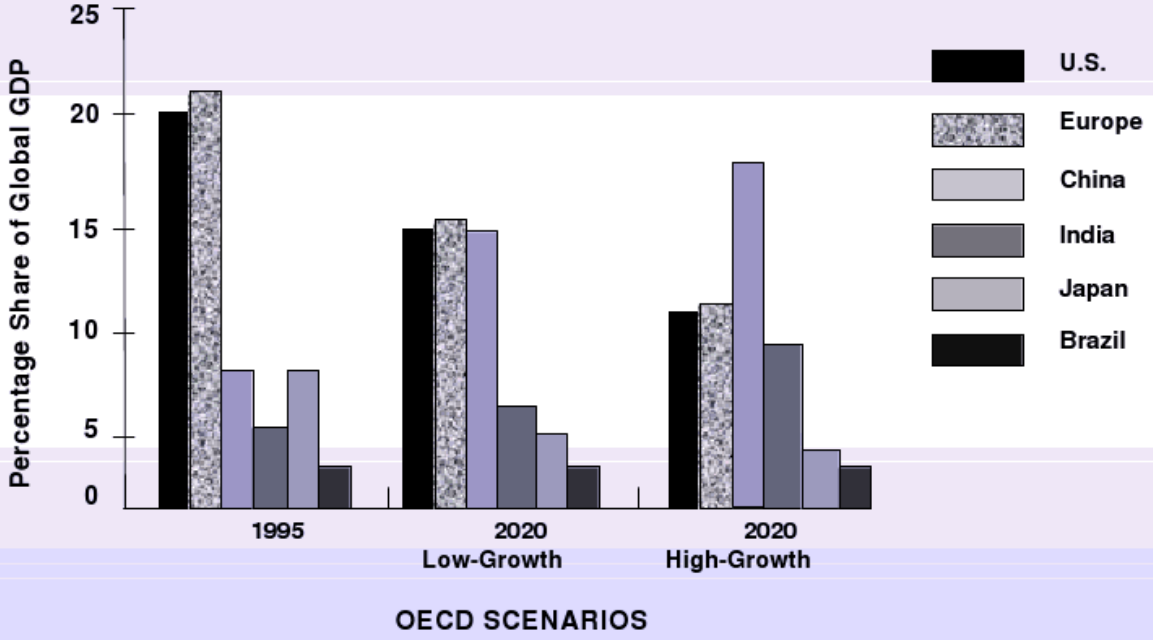
Future Strategic Issues, 7/01

Current Competitive Landscape

- U.S. produces only 18% of Worlds GDP
- ~70% of Research conducted offshore
- $400B/yr trade deficit
- 32 other nations devote a larger % of their GDP to Research
- 5th in No of R&D personnel/labor unit
- 3% savings rate vs. 30% in Asia
- 13th out of 30 - Student Math/Science Scores

Future Strategic Issues, 7/01

AN EMERGING MULTIPOLAR ECONOMIC WORLD



Source: OCED, The World in 2020, p. 92

Future Strategic Issues, 7/01

Bio Revolution Applications

- "Pharm Animals" [drugs, spare parts]
- Fast Growing plants on/near sea surface & sea water irrigated plants for biomass energy/closed CO2 cycle
- Polymer growing plants
- Spider genes in goats allow spider silk spinning from goat milk for "Biosteel", 3.5X strength of aramid fibers for Armor
- Binary Bio-weaponry

Future Strategic Issues, 7/01

Examples
Confluence of IT/Bio/Nano

- **Brain of a sea lampry inserted/connected to body of a robotic fish (an initial cyborg)**
- **"Chew-Chew" - a flesh/plant eating robot that hunts/bio-digests "natural foods" to "live off the land"**

Carbon Nanotubes

- C1,000,000, Buckminister Fullerine Carbon
- 100X strength, 1/6 weight of steel
- 8X better Armor
- Low energy Molecular/Petaflop Computing (10^{-4} En. Usage)
- Ultra Capacitor/High Temperature SC

Revolutionary Power Generation/Storage Opportunities

- Ultracapacitors
- Adv. Fuel Cells (e.g. Lithium/water/air)
- HEDM (e.g. Solid H2, Isomers, anti-matter, etc.
- Adv. PV (50%?)
- Room Temperature SC/SMES
- C-Nanotube storage of H2 (non-cryo)?
- Offshore Methane Hydrate
- Black light power?
- LENR
- ZPE

Future Strategic Issues, 7/01

Free Form Fabrication

- **Powder/Wire Metallurgy using robotic magnetically steered electron beams to create accreting local melts - GROW instead of CUT**
- **No fasteners, no strong backs for fasteners**
- **Nearly infinite fatigue life, excellent metallurgy**
- **(Repairable) metals at lower weight than far more expensive composites**

Future Strategic Issues, 7/01

Aluminum/Vortex Combustor

- **Micro powdered Aluminum fed into a vortex combustor "burns" SEAWATER**
- **Provides AIP with high energy density/efficiency for:**
  - **-inexpensive SS with "near SSN" perf.**
  - **-Transoceanic UUV's**
- **Would allow "Enemy After Next" to AFFORDABLY Threaten CONUS via Multitudinous in-shore short-time-of-flight "popups"**

Future Strategic Issues, 7/01

(Sample) New(er) Sensors

- Lidar w/ 50% efficiency via S-C optical Amplifiers, Also Fempto-second Lasers
- Molec./Bio Sensors
- Nanotags
- Smart Card Sensors
- Sensors implanted during Manuf./Servicing
- Nano IR (10E-6 Sensitivity)
- Smart Dust

Future Strategic Issues, 7/01

Some Sensor "Swarms"

- SMART DUST
  - Cubic mm or less
  - Combined sensors, comms and power supply
  - Floats in air currents
- NANOTAGS
  - Placed on everything/everywhere
  - Identification and Status Info
- Co-opted INSECTS

Future Strategic Issues, 7/01

Some "Explosive" Smart Dust Opportunities

- **Optimal Positioning of Explosive Dust - Dust/Air Explosives**
- **Formation of "Explosive Lenses"**
- **Infiltration of Deeply Buried/other such targets**

Micro Dust Weaponry

A Mechanical Analog to Bio, Micron sized mechanized "dust" which is distributed as an aerosol and inhaled into the lungs. Dust mechanically bores into lung tissue and executes various "Pathological Missions."

A Wholly "New" class of Weaponry which is legal.

Future Strategic Issues, 7/01

"Givens" (Now-to-"Soon")

- Gb data transfer rates, optical comms
- Petaflop + computing
- Exceptional AI (from Bioinfomatics, biomimetics)
- Wonderous/Ubiquitous land/sea/air/space multiphysics/hyperspectral sensor swarms (military/commercial/scientific)
- Survival requires dispersion/size reduction and concealment
- Robotic/swarm technologies primarily commercial/endemic worldwide

Future Strategic Issues, 7/01

(Agreed Upon) Assumptions, Combat in 2025

- Proliferation of TBM's, IT, Precision strike/targeting, ubiquitous micro sensors, camo/spoofing, robotics, bio/chem munitions
- Logistic assets highly vulnerable in or out of theater
- In and near theater ports/airfields possibly unusable
- Beam weapons increasingly prevalent

Future Strategic Issues, 7/01

Cruise Missiles (Current Status)

- **Range/payload similar to TBM at fraction of the cost and far greater accuracy**
- **75,000 in inventory of 75 countries, 130 different versions produced in 19 countries (10 "exporting" countries)**
- **German V-1 cruise killed 5,000; injured 40,000**
- **LO, launchable "anywhere/from anything," highly maneuverable**
- **"Then Year" costs potentially reduced to 10K - 25K**
- **Warhead(s) de jour/de hour (HE/carbon fibers/EMP/sub munitions/CNB/volumetric)**

Future Strategic Issues, 7/01

Cruise Missiles (Potential Outlook)

- **Any RPV/UAV (or UUV) is a potential "cruise missile" (50 countries have UAV's!)**
- **Low cost and "ready availability" of requisite technology/components essentially ensure the "Enemy after Next" will have/inventory/ field "hordes" of very capable/easily concealed/very difficult (and expensive) to counter/accurate cruise "missiles" with a potential "devil's brew" of warheads.**

Future Strategic Issues, 7/01

"Volumetric" Weaponry

[Alternatives to HE]

- EMP
- Info/Net/Psy warfare
- Miniature brilliant sensor/mine combo's
- Fuel/air & dust/air/Thermobarics
- RF
- Chem/bio Antifunctionals/antifauna
- Isomers, Strained Bond Energy Release, etc.
- Carbon fibers and "Blades," Acoustics etc.

Future Strategic Issues, 7/01

Antipersonnel MW/RF Weaponry

- **Heating [High Power Requirements(s)]**
- **Surface Effects**
- **Brain Interactions [Low Frequency Modulation]**

EFFECTS OF LOW POWER MICROWAVES (U.S. ARMY, SRI, WALTER REED)

- Behavioral performance decrements
- Seizures
- Gross alteration in brain function
- 30% to 100% increases in brain blood flow
- Lethality
  - Interactions between low power (microwatts per sq. cm./.4 to 3 GHz) MW and brain function

Future Strategic Issues, 7/01

Often "Fingerprintless" Bio Archipelago

- Bacteriological
- Viruses
- Prions
- Parasites
- Fungi
- Carcinogens
- Toxins
- Hormones/Regulators

- Fatal-to-disabling
- Short-to-long time scales
- Anti-flora/fauna/functional
- Direct and (undetectable) Binary
- Natural, Genomic
- Bio-Hacking

Future Strategic Issues, 7/01

Some Interesting "Then Year" BW Possibilities

- Aflatoxin - ("natural," parts-per-billion, carcinogen)
- Airborne varieties of Ebola, Lassa, etc.
- Binary agents distributed via imported products (Vitamins, Clothing, Food)
- Genomicaly (individual/societal) targeted pathogens
- Long term/fingerprintless campaign (as opposed to "shock and awe" BW)

An (Existing Bio Calmative - VEE (Venezuelan Equine Encephalitis)

- Ideal Incap. BW Agent
- Weaponized by U.S. & USSR in 50's/60's
- Easily transmitted via Aerosol
- Highly infectious, Low Fatality Rate
- 1 to 5 day incubation, 3 week recovery
- Tested on Humans (Operation Whitecoat)
- No Treatment Available

Future Strategic Issues, 7/01

Frontiers of (Rapidly Growing/Genomic/Insitu) "Bio on the Battlefield"

- **Sustainment:**
  - Food
  - Water (soil/air/purif.)
  - Energy (HC, H2, PV)
  - Meds/"Health"
  - Computing, Clothing

GREATLY REDUCES "LOGISTICS TAIL" & ENHANCES CAPABILITIES

- **Lethality**
  - Capabilities Enhancement
  - Armor
  - Concealment (living camo)
  - Sensors, FOF ID
  - Bio-weaponry (anti-personnel/functional, bio virus into bio computer)
  - Explosives (e.g. N2 fixation, grow overnite)

Future Strategic Issues, 7/01

What is Apparently "Legal"

- **Microwave/RF Anti-Functional and Anti-Personnel Weaponry**
- **Chemical Anti-Functional Weaponry**
- **Chemical "Psychological Effects" via Sensory Organs Weaponry (e.g. smell)**
- **Chemical Personnel Incapacitation Weaponry ["Non-Warfare" (e.g. Hostage/Terrorism) only]**
- **PSYWAR**
- **Acoustic Weaponry**
- **Mechanical Micro Dust**

Future Strategic Issues, 7/01

(FUTURE) NON-NUCLEAR EXPLOSIVES FOR "VOLUMETRIC"/ WEAPONS OF "MASS EFFECT"

- Metastable interstitial composite (MIC/Cubanes)
  - Order of 6 x TNT
- Fuel-air/dust-air explosives
  - Order of 15 x TNT
- Strain-bond energy release (SBER)
  - Order of 100 x TNT
- Hafnium (metastable) isomers
  - Order of 1,000 to 100,000 x TNT
- Atomic boron, carbon, hydrogen

Future Strategic Issues, 7/01

High Energy Density Materials (HEDM) (Power, Explosives, Propellants)

- Tetrahedral N (Isp → 600+ sec)
- Atomic Born, C, H (Isp → 600+ sec)
- Metastable He (Isp → 1500 sec)
- Metallic Hz (Isp → 2000 sec)
- ISOMERS (→ 10^5 x TNT)
- Anti-matter, LENR's

Future Strategic Issues, 7/01

Transoceanic UAV's

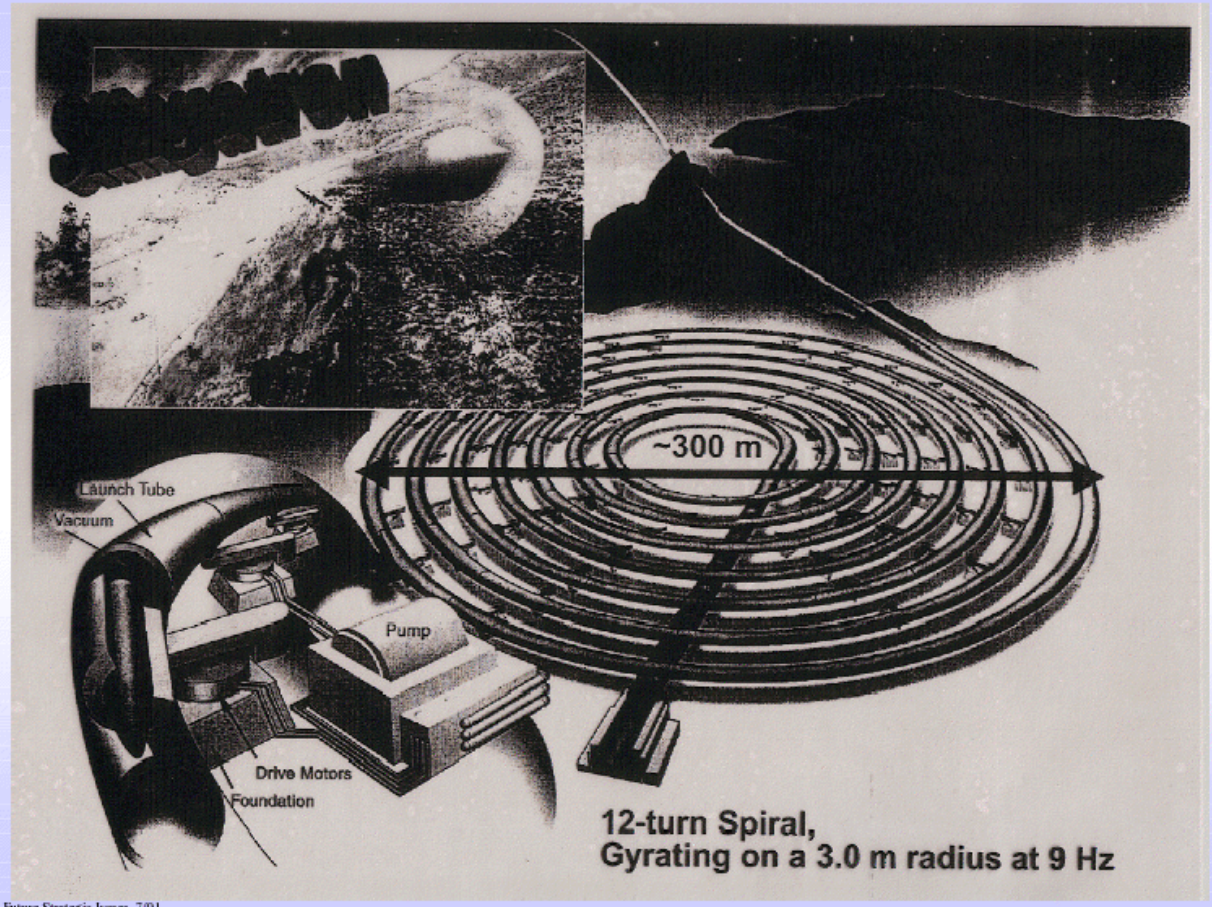
- **Current Capability - ('98 - 29 lbs, 2000 mi., 1.5 gals. Fuel; '01 - Transpac, 5000 mi.**
- **Provides Capability for Undetectable Ultra-inexpensive Swarms Against CONUS**
- **Interesting (Precision) "Payloads"**
  - **ISR**
  - **Smart Dust/Explosive**
  - **Target/explode Hazmat Trucks, Chem. Plants, Oil Storage/Refineries, etc.**
  - **Bio Dispensers (Anti-People, Things, Plants)**
  - **IW/EMP**
  - **Brilliant/Miniature sensor/Mine Combos**
  - **CNT's (Power Lines, "Wire Blade")**

Future Strategic Issues, 7/01

Blast Wave Accelerator

- Global Precision Strike "On the Cheap"
- No barrel, ~200 ft. notched rails, sequentially detonated Distributed HE
- Mach 21 or less as desired, up to 3000 lb
- Base anywhere, ~$200/lb of projectile
- Excellent stealth [no plume], affordability, ferocity, reaction time, survivability, recallability, effectiveness
- Being worked at Aberdeen and NASA MSFC for lofting of Fuel and Nanosats

Future Strategic Issues, 7/01



Future Strategic Issues, 7/01

"Slingatron" for Global Precision Strike

- 10Kg projectiles, up to thousands/minute
- Global, or less, range
- $20M/device, 80m diameter
- Mechanical "on-the-ground" propulsion via Gyrating Spiral Guide Tube (a multiple "hula hoop"
- "Poor Mans" Global Precision Strike/"Takedown Weapon"

Future Strategic Issues, 7/01

Then Year Targeting/ Connectivity etc.

- **MILITARY overheads/systems**
- **Ubiquitous COMMERCIAL overheads/systems**
- **SCIENTIFIC overheads/systems**

IN the context of:

- **Inexp. Reconstitution via micro/nano sats**
- **Optical comms /GPS etc.**
- **Ubiquitous inexp. UAV/HALE adjuncts**

EXAMPLE: POTENTIAL "COMPETITOR" MILITARY (SURVELIANCE/INTELLIGENCE/TARGETING/DAMAGE ASSESSMENT) UTILIZATION OF INTERNATIONAL SCIENTIFIC "GLOBAL CHANGE" PROGRAMS/ASSETS

- Extensive/increasing international assets (land-based, ship, aircraft (conventional/HALE), spacecraft) dedicated to measuring, on a global scale, details of land, atmospheric, ice, ocean, biota status/"dynamics" (to understand total Earth "system" and effects of humans on the global environment)
- Extensive/magnificent/often redundant wide coverage and detailed instrumentation suite(s) (imaging radars/SARS/LIDARS/radar altimeters/laser altimeters/radiometers/scatterometers/spectrometers/IR sensors/ magnetomiters/etc.
- Terrabites+ of data archived/readily/publicably available increasingly in near real time
- Sample measurements include: OH, O_3, HCI, NO, NO_2, N_2 O, CO, CH_2 , HNO_3 , CO_2, H_2 O, aerosols, wind speed/vector/profile(s), vegetation type, temperature profile(s), humidity profile(s), soil moisture/composition, snow cover/depth/moisture content, cloud/surface reflectance, sea ice type/coverage/temperature, ocean temperature(s)/sediments/topography/salinity/currents, magnetic field(s), surface emissivities/reflectance, leaf area index, land topography/use/temperature/cover, ice sheet elevation/topography gravity field/gradients, fires extension/temperature, 3-D cloud distributions/temperatures/ice content, pressure distribution(s), ocean wave heights/period(s)/direction(s)

Future Strategic Issues, 7/01

Then Year, Global Targeting Capabilities are a Given - Major Issue is "Legs"/Range for Increasingly Miniaturized Affordable Payloads/Systems

- **Range Enhancement Approaches:**
  - **Airbreathing or "water breathing," to first order doubles range**
  - **Initial boost for cruise (ala Blast Wave Acceleror)**
  - **HEDM Fuels [Atomic Boron, Carbon, Isomers, etc.)**
  - **Drag Reduction (Wave/Friction/Drag-due-to-lift, Increased Dia.)**
  - **Hypersonic Maneuvering Boost-Glide**

Future Strategic Issues, 7/01

Summary - Major Influences of IT/Bio/Nano Upon Future Warfare

- Ubiquitous miniaturized/networked multi physics,hyperspectral sensors
- Robotics/Automatics "in the large"
- Long range precision strike/targeting
- Info/net Warfare
- Mini/micro/nano Sats, Cruise, UAV's
- Binary Bio Weaponry
- Miniature/ubiquitous "smart mines"

Future Strategic Issues, 7/01

Increasingly Critical Human Limitations/Downsides

- **Large**
- **Heavy**
- **Tender**
- **Slow (Pysically, Mentally)**
- **Require Huge Logistic Train(s)**
  i.e. Humans have rapidly decreasing-to-negative "Value Added"

Future Strategic Issues, 7/01

ROBOTICS "IN THE LARGE"

(saves lives, enhances affordability, redefines risk/threat environment, enhances effectiveness)

"Unattended"

- Munitions
- Sensors
- Platforms
  - Air (UAV's)
  - Sea (UUV's)
  - Land (UGV's)

- Logistics
- Spoofing/obscurants
- RSTA (including NBC)
- Defense (across the board including counter recon/ambush)
- Offense
  - Obstacle breaching
  - "The Shooter" (especially Mout)
  - Mine Clearing

Future Strategic Issues, 7/01

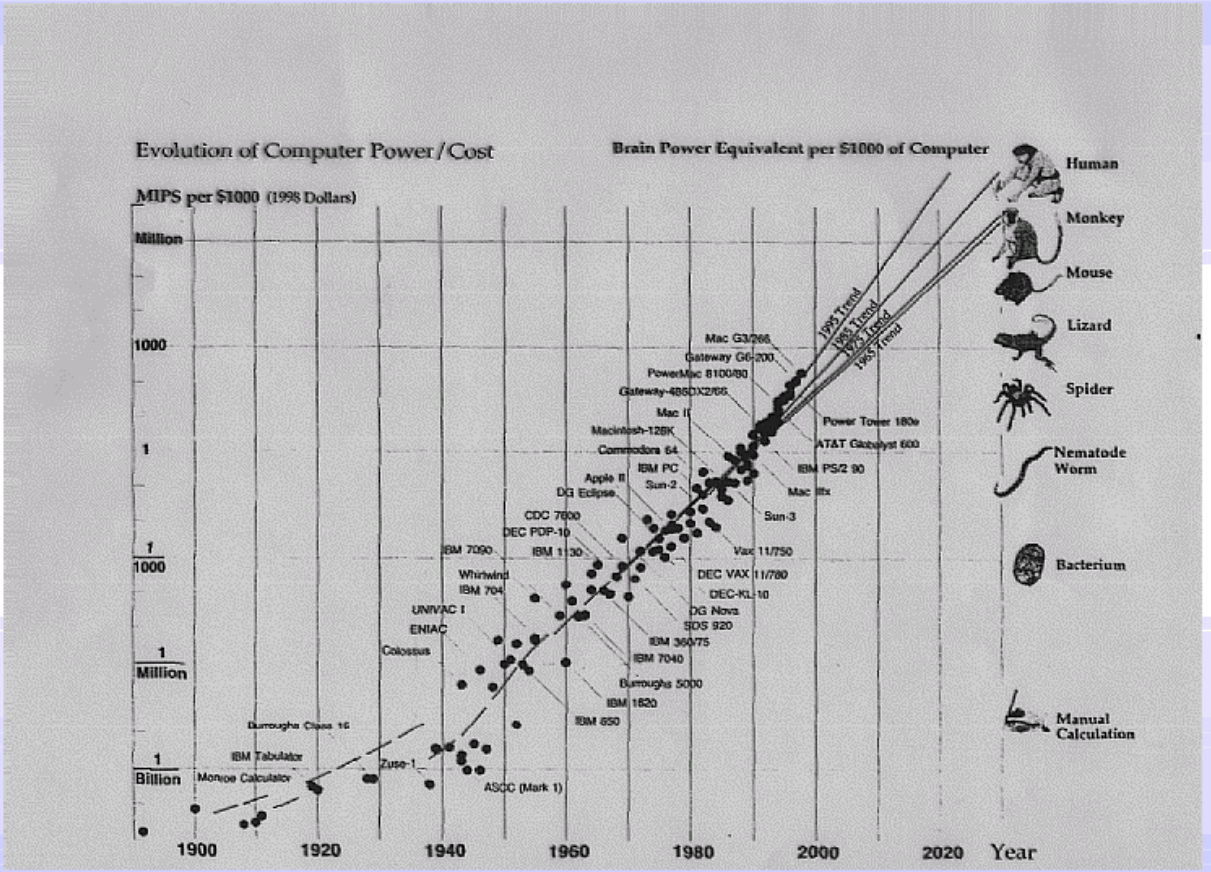
Emerging Characteristics of Robotic Systems (Enabled by Ongoing IT Revolutions- Comms/Sensors/Computation/Miniaturization

- From expert systems toward AI and beyond
- Much more reactive than humans, greatly increased tempo
- Greatly improved hyperspectral sensors/data fusion
- Greatly improved accuracy and lethality
- Greatly improved affordability/miniaturization
- Redefines "risk," minimal casualties, salutes CNN syndrome
- Greatly reduced logistics

Future Strategic Issues, 7/01

Robotic Intelligence

- Two "flavors
  - Traditional AI - Rule Based
  - Experiential - Behavior Based (Neural Nets/other "Soft Computing"
- Combination of these is current "best bet" (per Moravec) to produce artificial/cyber "life" which will possibly-to-probably be sentient but will not be anthropomorphic



Future Strategic Issues, 7/01

WHAT IS BEYOND ROBOTIC SYSTEMS (SENSORS/PLATFORMS/WEAPONS/ MUNITIONS)

- Robotic/automatic → autonomous warfare?
  - Computer capability will exist (beyond terra flop) to do "AI" (or better?), required connectivity is a "given"
  - Competitor capabilities /tempo sidelines the innate inadequacies of human interactions/education/conscious decision timelines
  - Little-to-no "troops" → "Acme warfare Ltd."
  - Flat hierarchy → demise of "main in the chair?"
  - High level/"soft sciences" human aspects "boundary conditions"
    - Sociological/"humanitarian"
    - Political
    - Environmental
    - Religious
    - Psychological
    - Economics
    - Etc.

Extent/scale, projected effects/ Damage(s), personnel attrition (general-to-specific)

Future Strategic Issues, 7/01

"Non-Explosive Warfare"

- IW/IO
- PSYWAR "In-the-Large"
- Anti-Functionals
  - MW
  - Chem
  - Bio
  - Micro-Mechanical
- Anti-Personnel MW/RF, Micro-Mechanical

Future Strategic Issues, 7/01

"Natural Warfare"

- **Sensors:**
  - **Utilize insitu plants/animals/insects as sensor platforms/instruments to indicate presence/movement/characteristics**
- **Weapons/Munitions:**
  - **Utilize animals (e.g. urban rats)/insects as "delivery systems"/munitions ("feeding," swarming, biting, poisoning)**
  - **Utilize insitu explosive/destructive capability (e.g. offshore Methane Hydrate, Dams, etc.)**

Characteristics - Future/Emerging Sensors/Munitions/Weapons/Platforms

- Inexpensive
- Numerous-to-Hordes/Clouds/Swarms
- Small/light/ubiquitous
- Readily Available (Largely Comm. Tech.)
- Long Range
- "Volumetric" or "Precise"
- Both "Explosive" and "Non-Explosive"
- Smart-to-Brilliant

Future Strategic Issues, 7/01

Potential Future "Orders of Magnitude" Increases in Overall Weapon Effectiveness/Availability at Orders of Magnitude Reduced Cost(s)

- Bio/Chem/Molec./Nano Computing - (E6)
- Ubiquitous Optical Comms - (E4)
- Micro/Nano/Ubiquitous Sensors - (E4)
- BioWeaponry - (EN)
- Co-operative Swarms of Cheap/Small Weapons/Sensors - (E4)
- Volumetric Weaponry - (E4)
- Cyber/Artificial Life (Beyond AI) - (E?)

Future Strategic Issues, 7/01

Major (Anti-U.S.) Asymmetries

- Long increasingly vulnerable logistics chain
- Long, "undefendable" coastline (esp. against underwater threats)
- Sensitivity to casualties (greatly enhanced by the "CNN syndrome")
- Vulnerabilities to "terrorism" (esp. IT, bio)
- Increasing over reliance upon vulnerable "overhead" assets

Future Strategic Issues, 7/01

Potential En-route Logistic Vulnerabilities

Logistic surface ships and aircraft are non-LO and undefended, could be targeted and attrited inside the continental shelf by:

- **"Eggs" [subsurface floating encapsulated missiles implanted by freighters/SS/air]**
- **SS [torps/missiles/subsam]**
- **Transoceanic UUV's, UAV's, USV's**
- **Blast wave accelerator**
- **Cruise, TBM's**
- **MINES**

Future Strategic Issues, 7/01

Fundamental Problem With Future U.S. Power Projection

- **"EAN" can have "country sized magazines" filled with hordes of inexpensive Precision strike "Munitions" - Area Denial**
- **U.S. Forces run out of "bullets" and die**

  [Beam weapons not panacea, inexpensive workarounds available]
- **Deep Water Subs with large loadout/"swimin" weaponry only survivable "Close-in" platform**

Future Strategic Issues, 7/01

Sampling of TBM/Cruise Missile "Penaids" (Derived from Extensive Worldwide ICBM/IRBM RV Cold War Defensive/Offensive Studies Over Some Three Decades

- **Decoys (anti-sensor)**
- **Ablative/subliming coatings (thermal [laser/mw] protection)**
- **Fluid injection (laser protection)**
- **Wake modification(s) (anti-sensor)**
- **Electronic/optical "shielding" (MW protection)**
- **RAM/RAS/shaping (anti-sensor)**

e.g., current efforts involving beam weapons (laser, MW) "kills" of undefended"/"unpenaided" "dumb" incoming NOT REALISTIC

Future Strategic Issues, 7/01

Potential "Workarounds" for Beam Weapon Effects on Missile Sensors/Comms

- **Off board sensors (networked, everywhere, on everything)**
- **Optical Comms**
- **Optical/fluidic Computing**
- **Optical GPS**

Future Strategic Issues, 7/01

Example 'Then Year" Direct Conus Attack Capabilities

[~80% of CONUS population/infrastructure within ~ 50 Miles of a "coastline"]

- Inexp. Transoceanic UUV's/UAV's/Cruise
- Inexp. Blast Wave Accelerators
- Inexp. Info/Net/Psywar
- Inexp. Inshore AIP SS [mines/torps/SLCM]
- Inexp. Binary Bio into Food Supply
- Inexp. Semi-submerged Missile "eggs"
- Inexp. 'Trojan Horse" "civilian" systems

[Above in addition to ICBM/TBM]

Future Strategic Issues, 7/01

"Unconventional" Nuc Delivery

- Sink a ship offshore, detonate to produce Tidal Waves with Radioactive spume
- Transcontinental UAV's, UUV's (nano, AI)
- Ballons with GPS sport 'chutes
- Ganged Micro Rockets (ala MIT)
- Trojan Horse Everything (ships, boats, planes, cars, trucks, packages, cargo, containers)
  - Targeted "Effects" include Tidal Waves, EMP, Earthquakes, Radiation, Blast

Future Strategic Issues, 7/01

(Civilian) IW Examples/CONUS

- (National) Banking System Computers
  - 3 sites/nodes - HE/EMP/IW/C/B (attack buildings, power, software, hardware)
  - Interruptions in National/International Payments system irrecoverable
- Railroads
  - 4 sites, attack options as above
  - All freight cars networked, "everyone" on "just in time," no reserves/stockpiles
  - Takes down Auto Industry, power grid, chicken farms, all movements of "War Materials," ETC!!!

The Revolutionary Size/Capability/Cost Warfighting Spiral

1. **Commercial electronics/GNC/Comms/Sensors (Much smaller/cheaper/better - Allows:**
2. **IO and "Precision" - Reduces Reqd. munition size and Numbers much-Leads to:**
3. **Small/Light/Deadly/Inexpensive Munitions -**
4. **Which Reduces requisite Platform size/cost -**
5. **Which is reduced still further by (also enabled) "Automatics/Robotics" - Uninhabited**
6. **Combined with Much lighter/cheaper Revol. Materials/Fabrication for structure and energetics (propul./warhead) - Yields "Cheap Warfare"**

Future Strategic Issues, 7/01

And Then There Is NANO ...

Future Warfare
"On The Cheap"

- Info/net warfare
- Binary bio [anti-functional/fauna]
- Non-lethals
- Miniature brilliant sensor-mines
- Micro/Nano Sats
- LO/Long leg/precision UUV's/UAV's/Cruise
- Inexp./Superb/survivability ISR/comms
- Blast wave accelerator

Future Strategic Issues, 7/01

"Then Year"
"Peer Competitors"

Peer Competitor no longer defined by "megatonnage" of obsolescent Industrial age steel and aluminum Artifacts. The Drastically reduced entry investment enabled by "Warfare on the Cheap" ensures almost any nation or sizable organization can be a very worrisome Military "peer."

Future Strategic Issues, 7/01

SOME INTERESTING POSSIBILITIES

- **Surreptitious nano "tagging" (with MW interrogation) of "everything/everyone" (imprinted during manufacture/maintenance etc.)**
- **Detonation of offshore seabed methane hydrate deposits to produce tactical/strategic level tidal waves against littoral regions**
- **Demise of "stealth" via ubiquitous multi-static, multi-physics sensors operated on "take-a-vote"**

Future Strategic Issues, 7/01

"Anti-Access"

- MINES
- Hordes/Swarms (country-sized/dispersed magazines) of small/inexpensive/brilliant cruise/UAVs, micro rockets, BWA/slingatron projectiles, UUVs (e.g. RPGs on jet skis)
- Tyvek nets
- Attrite/"take out"/threaten APODS/SPODS
- EMP, IW/IO
- TBM/Cruise/HPM/Lasers
- "The Sensor Web"

Future Strategic Issues, 7/01

Counters to U.S. "Information Dominance"

- EMP ("conventional," Isomers/other HEDM, Nuc.)
- Jammers "in the Large"
- "Fry" (MW, Lasers), "Blowup"
- Anti-Sensor (various, include D&D)
- "Software" (subvert/deception/decimation/Trojan Horse/viruses/etc., other IO/IW)
- "Chaos" (Excite circuit nonlinearitys)
- PSYWAR

Future Strategic Issues, 7/01

Counter U.S. Logistics

- **Take out pre-positioned everything**
- **Ubiquitous nano inexpensive multiphysics, hyperspectral land/sea/air/space military, scientific, commercial sensors; Nano tags (aka "The Sensor Web")**
- **Target/attrite logistic air/sea lift over continental shelf via Brilliant mines, cruise, UAVs, UUVs, TBMs, Micro missiles, prepositioned semi-submerged missile "eggs," AI/vortex SS weaponry (include Subsam), BWA, slingatron, Automatic MANPADS in CONUS (via Blast/EMP etc.)**
- **Small number of military ports/airfields in CONUS; C-17/5/141, Ro-Ro/other ships, trains inside CONUS are non LO, undefended**

Future Strategic Issues, 7/01

Anti-U.S. RMA "Strategies/Tactics"

- Threaten Bio to force "suit-up"/degrade effectiveness
- Keep forces beyond range of short-legged fighters
- Attrite JSTARS/AWACS/ABL/Missile "cows" etc. platforms
- Miniaturize/Disperse EVERYTHING - no large/massed/ interesting targets
- Use "Hard to Degrade"/Jam optical Comms/GPS
- Operate out of cities/International Commercial Entities
- Degrade U.S. Info Dominance
- Machine Intell. "automatic warfare," (much) tighter OUDA loop (faster than Human ops)

Future Strategic Issues, 7/01

Exploit "CNN Syndrome"

- Sink Carrier(s) via "swarm attacks"
- Capture/torture Americans in living color on prime time
- "Terror" attacks within CONUS (binary bio, critical infrastructure "takedown," IO/IW, EMP, RF against Brain, etc.)
- Serious "Psywar" (collateral damage exploitation, etc.)

Future Strategic Issues, 7/01

The Key Technologies

- **Free form/"point of use" fabrication**
- **Beyond silicon computing (quantum, optical, bio, nano, molec.**
- **Optical comms/nav**
- **Nano sensors/tags/materials/bots/GNC**
- **HEDM explosives and propellants (NANO POWDERS, CUBANES, SBER, ISOMERS, LENR, THERMOBARICS, F-S LASERS/4TH GEN NUCS)**
- **Anti-personnel/material (Binary) Bio, MW**
- **Robotics/Machine Intelligence**
- **Miniaturized/brilliant/lightweight/low-power/inexpensive swarms of <u>everything</u> (SATS, weapons, robots, sensors, mines, etc.)**

Future Strategic Issues, 7/01

Fundamental Military Issues/Metrics

- **Affordability** ["Warfare on the Cheap"]
- **Survivability** ["Can see everything, Anything you can see you can kill"]
- **Effectiveness** [Lethality of Precision and Volumetric weaponry]

I.E. Simultaneous ongoing Revolutions in all three of the major Warfare Metrics

Future Strategic Issues, 7/01

Given the Superb/Ubiquitous World Wide Sensor Suites and Precision Strike Capabilities "Then Year" the Following WILL NOT BE SURVIVABLE

- APODS/SPODS
- Runways
- Surface Ships
- Manned (logistic/combat) Aircraft
- Manned (logistic/combat) Ground Vehicles

Due to their size & (multi-physics) signatures

Future Strategic Issues, 7/01

CONCERNING (CURRENT) FARTHER TERM (U.S.) DEFENSE "STRATEGIC STUDIES"

- **Almost wholly dedicated to/concentrated on offensive operations (DOO?)**
  - **Across the board (Army, Navy, Air Force, Marines, OSD)**
- **(Apparent) wholly inadequate consideration of defense**
  - **Defense of Conus, especially from short time of flight inshore undersea attack**
  - **Defense of the offensive forces [especially in terms of the "enemy after next" capabilities definitization and response(s) thereto]**
  - **Defense of the logistics assets, especially "out of theater"**

Future Strategic Issues, 7/01

Typical Scenario - "Takedown" of U.S. by 10 People and <$10M

- Binary Bio [via (imported Vitamins/Clothing, etc., food supply(s)]
- Terror Bio (e.g. Aflatoxin)
- IW ("usual" plus physical against key nodes such as Railroads - take down the economy)
- Selective anti-personnel RF/MW (Towers)
- Water Supply Contamination via Intercontinental UAV's

Accompanied by SERIOUS "PSYWAR"

Future Strategic Issues, 7/01

Trends Summary

- Tele-everything
- U.S. just "one of the crowd" economically
- "Warfare on the cheap," many potential "peers"
- Warfare Increasingly Robotic
- Survivable/Affordable power projection via deep water subs and Blast Wave Accelerators
- CONUS and Logistics Defense increasingly worrisome

FROM U.S. COMMISSION ON NATIONAL SECURITY/21ST CENTURY

- It will soon be possible to connect human brain cells to silicon chips
- Due to IT technology we will witness the "death of distance"
- More than 2/3rds of the satellites are foreign owned
- Large scale missile attacks will be able to overwhelm defensive systems
- Development of genetically engineered pathogens that will thwart our bio detection/defense measures/cycles

Future Strategic Issues, 7/01

"Circa 2025"

- **Machines as creative/"smart" as humans "Robotics" the "norm"**
- **Zeroth order "warstopper" - Binary bio into nation's agric./food distrib. system (every home/fox hole)**
- **Next level of concern: Ubiquitous/Cheap micro-to-nano EVERYTHING (sensors, munitions, weapons swarms/hordes)**
- **Battlefield attrition/CNN syndrome forces U.S. Army to look/act like SOCOM**

Future Strategic Issues, 7/01

(Suggested) Major U.S. Future (2025) Warfare Issues

- **CONUS Defense (Requirement(s) for, potential approaches)**
- **Logistics Defense/Protection (in/out of theater)**
- **Survivability/Effectiveness of U.S. Forces on/near the "Killing Ground" in an era of affordable ubiquitous multiphysics hyperspectral sensors, precision strike, volumetric weaponry, "swarms" and hardened munitions**

Future Strategic Issues, 7/01

- **"Non-explosive Warfare" (psywar, biowar IT/net war, "anti-operability war," Beam weaponry including RF, Spoofing/Cammo**
- **Robotic Warfare "in the large"/better than human AI/"Cyber life"**
- **Alternative Power Projection Approaches (e.g. Deep Water depth/death sphere, blast wave accelerator, etc.)**

Future Strategic Issues, 7/01

Future "Power Projection"?

- Humans "hold" instead of "take" ground (go in after "Sanitization")
- Sanitization via:
  - IW/Psywar
  - Global Reach "Guns" (BWA/Slingatron)
  - Deep water/large loadout Subs w/"swimins"
  - "Robotic Everything" w/Volumetric weaponry, non-explosive warfare

Future(s) of SOF

- **Becomes THE (only survivable) HUMAN Strike Force (Army/Marines forced to become "SOF-Like")**

- **Increasingly The "Overseas FBI" to counter the increasingly capable (IO/Bio WMD) & horrific destructive power of INDIVIDUALS and Groups**

- **Ops involve increasingly difficult-to-deal-with omni-present/omni-physics sensor/ID suites, Few-to-No exploitable Interstices for Covert/Clandestine "work" - THE Challenge**

Future Strategic Issues, 7/01

Future "Warfare"

- "Defense" against the "then year" multitudinous conventional and unconventional delivery methods for volumetric and precision munitions is essentially neither doable nor affordable.
- Suggested National Defense Approaches:
  - Work Technology, Intel, Diplomacy, SOCOM for detection/interdiction/deflection of the "pre-delivery" phases (causes of war, motivational and decision processes, design and construction, test)
  - Work and ADVERTISE a REALLY EFFECTIVE RETRIBUTION to deter delivery (ala MAD)

Changing Nature of Warfare

Hunter/ Gatherer	*Hunting Grounds*	*Tribal Bands*	*Hand Held/ Thrown*
Agricultural	*Farm Lands*	*Prof. Armies*	*Hand Held/ Thrown*
Industrial	*Natural Resources*	*Mass Levee*	*Mech./Chem.*
IT/Bio/Nano	*Societal Disruption*	*Everyone*	*IT/Bio'Bots*

Future Strategic Issues, 7/01

RMA Planning "Shortfalls" (NPS)

- **"Indications of the innovative paths adversaries might take or how they might adapt technologies from the civilian world"**
  (Being worked in the "Technical War Games")
- **"The path from todays systems and capabilities to those hypothesized for the future (2020+)"**

What is needed is a "Then Year" (~2030) Serious/Holistic Vision of Warfare Changes Resulting from the On-going IT/Bio/Nano/Virtual Technological Revolutions

- Such does not exist, "bumper sticker" attempts extant.
- All are agreed, warfare will become increasingly robotic and probably more affordable, swarms of sensors/shooters are a given.
- A longer term "Vision" of these changes would enable "mapping" from the present, NOT AT ALL CLEAR HOW TO "Get There From Here" as do not know where "there" is!

Future Strategic Issues, 7/01

"War between mass armies weighed down with baroque equipment has become a third world sport. The advanced world, too vulnerable to survive a war of attrition or mass destruction, must learn to conduct its affairs by the Rapier--by the threat or use of small specialized forces exploiting high tempo and strategic surprise"

R. E. Simpkin, "Race to the Swift: 1985

In the second half of the 1900's Nuclear/Bio Warfare was "Unthinkable"

In the first half of the 2000's "conventional" warfare may become so deadly/effective as to become "Unthinkable" ("Killer Aps" available to mitigate the "Causes of War")

Future Strategic Issues, 7/01

Approaches to Countering Group/Individual Deployment of IO/Bio WMD

PREVENTION -

- Universal inexpensive Web based educ.
- Biomass via sea water irrigation

DISCOVERY -

- All Source Intel/Fusion/AI Analysis

PREEMPTION/RETRIBUTION -

- SOF (Foreign)

Future Strategic Issues, 7/01

(Usual) Reactions to this Presentation

- Is in the "Too Hard Box"
- Not being done yet by anyone, therefore, will not be done
- They would not do that
- We have to Hope they would not do that
- Why go there, cannot defend against it
- Some Disbelief, but agreement there is too much there to disregard

September 1976

BIBLIOGRAPHY OF REPORTED BIOLOGICAL PHENOMENA ('EFFECTS') AND CLINICAL MANIFESTATIONS ATTRIBUTED TO MICROWAVE AND RADIO-FREQUENCY RADIATION: COMPILATION AND INTEGRATION OF REPORT AND SEVEN SUPPLEMENTS

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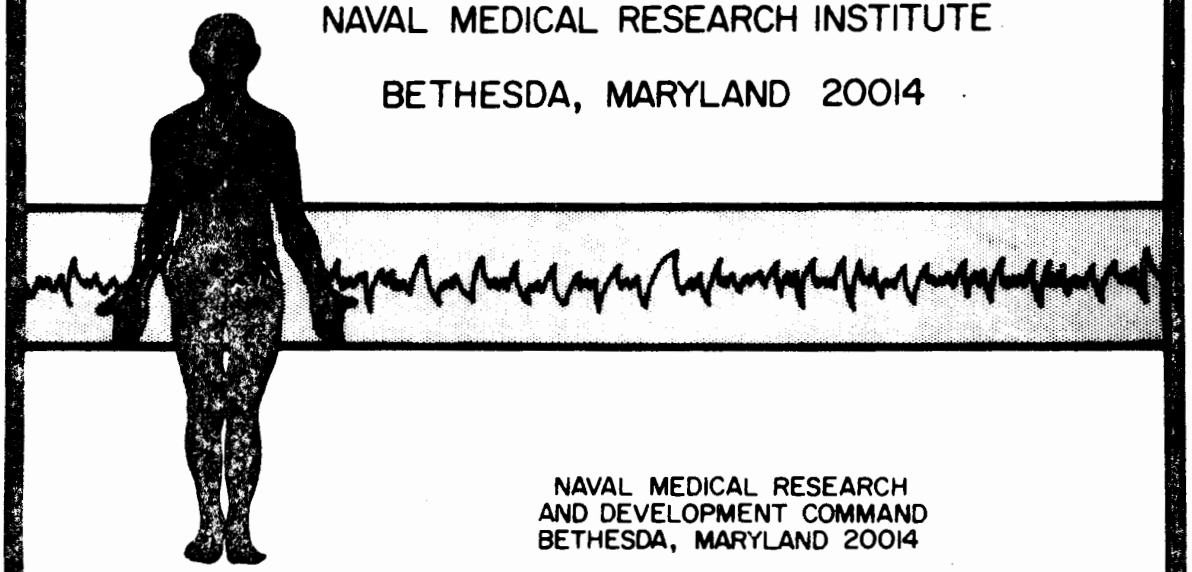

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This report is a compilation and integration of the first seven supplements, and the alphabetical addenda (appended to the original bibliography), with the revised bibliography of April 1972. The report is a successor to Naval Medical Research Institute (NMRI, Bethesda, MD 20014) Research Report No. 2, completed under Research Work Unit MF12.524.015-0004B in October 1971, by the senior author, and available from National Technical Information Service (Springfield, VA 22151) as AD #734-391. The original report was revised and reprinted in April 1972, and also contains the first three supplements; No. 1 dated October 1971, No. 2 dated November 1971, and No. 3 dated April 1972. The revised report which consists of more than 2300 literature citations, is available from NTIS as AD #750-271, and includes, as the first chapter, an outline of the effects which have been attributed to radio frequency and microwave radiation. Supplement No. 4 (containing 327 citations) was completed in June 1973, as an Electromagnetic Radiation (EMR) Project Office Report, Bureau of Medicine and Surgery (Navy), (Washington, DC 20372), and is available from NTIS as AD #770-621. Supplement No. 5 (containing 497 citations) was completed in July 1974 as an EMR Project Office Report, Naval Medical Research and Development Command (NMR&DC, Bethesda, MD 20014), and is available from NTIS as AD #784-007. The sixth Supplement (containing 241 citations) was completed in June 1975 (also as an EMR Project Office, NMR&DC Report), and is available from NTIS as AD #A015-622. The seventh Supplement (containing 345 citations) was completed in May 1976 as a NMRI Report, and is available from NTIS as AD #A025-354. Supplement No. 8 (not included in this report, but containing 331 citations), was completed in August 1976 as a NMRI Report, and is available from NTIS as AD #A029-430.

27 September 1976

(Supersedes AD #734-391, #750-271, #770-621, #784-007, #A015-622, & #A025-354)

ABSTRACT

More than 3700 references on the biological responses to radio frequency and microwave radiation, published up to May 1976, are included in this bibliography of the world literature. Particular attention has been paid to the effects of non-ionizing radiation on man at these frequencies. The citations are arranged alphabetically by author (where possible), and contain as much information as possible so as to assure effective retrieval of the original documents. Soviet and East European literature is included in detail.

This report is a compilation and integration of the first seven supplements, and the alphabetical addenda (appended to the original bibliography), with the revised bibliography of April 1972. The report is a successor to Naval Medical Research Institute (NMRI, Bethesda, MD 20014) Research Report No. 2, completed under Research Work Unit MF12.524.015-0004B in October 1971, by the senior author, and available from National Technical Information Service (Springfield, VA 22151) as AD #734-391. The original report was revised and reprinted in April 1972, and also contains the first three supplements; No. 1 dated October 1971, No. 2 dated November 1971, and No. 3 dated April 1972. The revised report which consists of more than 2300 literature citations, is available from NTIS as AD #750-271, and includes, as the first chapter, an outline of the effects which have been attributed to radio frequency and microwave radiation. Supplement No. 4 (containing 327 citations) was completed in June 1973, as an Electromagnetic Radiation (EMR) Project Office Report, Bureau of Medicine and Surgery (Navy), (Washington, DC 20372), and is available from NTIS as AD #770-621. Supplement No. 5 (containing 497 citations) was completed in July 1974 as an EMR Project Office Report, Naval Medical Research and Development Command (NMR&DC, Bethesda, MD 20014), and is available from NTIS as AD #784-007. The sixth Supplement (containing 241 citations) was completed in June 1975 (also as an EMR Project Office, NMR&DC Report), and is available from NTIS as AD #A015-622. The seventh Supplement (containing 345 citations) was completed in May 1976 as a NMRI Report, and is available from NTIS as AD #A025-354. Supplement No. 8 (not included in this report, but containing 331 citations), was completed in August 1976 as a NMRI Report, and is available from NTIS as AD #A029-430.

Relevant presentations made at technical meetings are included in a separate section.

The "outline of bio-effects" which appeared in the original Bibliography has been included in this report as an Appendix.

Key Words

Biological Effects
Bibliography
Electromagnetic Radiation Bio-Effects
Radio Frequency (RF) Radiation
Radiation Effects
Thermogenesis
Health Effects
Radiobiology (Non-Ionizing)
Non-Ionizing Radiation
Microwave Radiation
Electric-Field Bio-Effects
Magnetic Bio-Effects
Human Factors
Pulsed Electromagnetic Radiation
Stress Physiology
Radar Safety

COMPILATION AND INTEGRATION OF REPORT AND SEVEN SUPPLEMENTS to

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