Melnykovych, Andrew (PSC)

From: Melnykovych, Andrew (PSC)
Sent: Thursday, January 02, 2014 10:57 AM
To: 'song bird'
Subject: Documents you submitted in case 2012-00428

Dear Ms. Holloway:

We have received the documents you submitted in connection with the above-referenced case. Your comments will be placed into the case file for the Commission's consideration as it deliberates in this matter.

For ease of filing, the documents are being combined and filed as a single pdf file. Those that were not submitted in pdf format were converted. No alterations have been made to the content of any document. However, the formatting of several documents was slightly altered in order to enable conversion to pdf.

Records in the case are available on the PSC website at this location:
http://psc.ky.gov/Home/Library?type=Cases&folder=2012 cases/2012-00428

Thank you for your interest in this matter.

Andrew Melnykovych
Director of Communications
Kentucky Public Service Commission
211 Sower Boulevard
Frankfort, KY 40601
502-782-2564 cell:502-330-5981

-----Original Message-----
From: song bird [redacted]
Sent: Tuesday, December 31, 2013 4:37 PM
To: Melnykovych, Andrew (PSC)
Subject: Did you get all 5 documents?

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, studyNow 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 milligausah

	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

ELSEVIER

Pathophysiology xxx (2009) xxx–xxx

ISP PATHOPHYSIOLOGY

www.elsevier.com/locate/pathophys

Public health implications of wireless technologies

Cindy Sage [a,*], David O. Carpenter [b]

[a] *Sage Associates, 1396 Danielson Road, Santa Barbara, CA 93108, USA*
[b] *Institute for Health and the Environment, University at Albany, Rensselaer, NY, USA*

Received 18 January 2008; accepted 30 January 2009

Abstract

Global exposures to emerging wireless technologies from applications including mobile phones, cordless phones, DECT phones, WI-FI, WLAN, WiMAX, wireless internet, baby monitors, and others may present serious public health consequences. Evidence supporting a public health risk is documented in the BioInitiative Report. New, biologically based public exposure standards for chronic exposure to low-intensity exposures are warranted. Existing safety standards are obsolete because they are based solely on thermal effects from acute exposures. The rapidly expanding development of new wireless technologies and the long latency for the development of such serious diseases as brain cancers means that failure to take immediate action to reduce risks may result in an epidemic of potentially fatal diseases in the future. Regardless of whether or not the associations are causal, the strengths of the associations are sufficiently strong that in the opinion of the authors, taking action to reduce exposures is imperative, especially for the fetus and children. Such action is fully compatible with the precautionary principle, as enunciated by the Rio Declaration, the European Constitution Principle on Health (Section 3.1) and the European Union Treaties Article 174.

Keywords: Wireless technology; Brain cancer; Radiofrequency; Cell phones; Wireless antenna facilities; Childrens' health

1. Introduction and background

Exposure to electromagnetic fields (EMF) has been linked to a variety of adverse health outcomes that may have significant public health consequences [1–13]. The most serious health endpoints that have been reported to be associated with extremely low frequency (ELF) and/or RF include childhood and adult leukemia, childhood and adult brain tumors, and increased risk of the neurodegenerative diseases, Alzheimer's and amyotrophic lateral sclerosis (ALS). In addition, there are reports of increased risk of breast cancer in both men and women, genotoxic effects (DNA damage and micronucleation), pathological leakage of the blood–brain barrier, altered immune function including increased allergic and inflammatory responses, miscarriage and some cardiovascular effects [1–13]. Insomnia (sleep disruption) is reported in studies of people living in very low-intensity RF environments with WI-FI and cell tower-level exposures [85–93]. Short-term effects on cognition, memory and learning, behavior, reaction time, attention and concentration, and altered brainwave activity (altered EEG) are also reported in the scientific literature [94–107]. Biophysical mechanisms that may account for such effects can be found in various articles and reviews [136–144].

The public health implications of emerging wireless technologies are enormous because there has been a very rapid global deployment of both old and new forms in the last 15 years. In the United States, the deployment of wireless infrastructure has accelerated greatly in the last few years with 220,500 cell sites in 2008 [14–16]. Eighty-four percent of the population of the US own cell phones [16]. Annualized wireless revenues in 2008 will reach $144 billion and US spending on wireless communications will reach $212 billion by 2008. Based on the current 15% annual growth rate enjoyed by the wireless industry, in the next 5 years wireless will become a larger sector of the US economy than both the agriculture and automobile sectors. The annualized use of cell phones in the US is estimated to be 2.23 trillion minutes in 2008 [16]. There are 2.2 billion users of cell phones worldwide in 2008 [17] and many million more users of cordless phones.

Over 75 billion text messages were sent in the United States, compared with 7.2 billion in June 2005, according to

* Corresponding author. Tel.: +1 805 969 0557; fax: +1 805 969 5003.
E-mail address: sage@silcom.com (C. Sage).

0928-4680/$ – see front matter © 2009 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.pathophys.2009.01.011

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

CTIA, the Wireless Association, the leading industry trade group [16]. The consumer research company Nielsen Mobile, which tracked 50,000 individual customer accounts in the second quarter of this year, found that Americans each sent or received 357 text messages a month then, compared with 204 phone calls. That was the second consecutive quarter in which mobile texting significantly surpassed the number of voice calls [17].

The Electronics Industries Alliance (EIA) represents 80% of the $550 billion US electronics industry "that provides two million jobs for American workers." Its members include companies from the consumer electronics and telecommunications industries, among others [17].

There is intense industry competition for market share. Telecom taxes form an immense revenue generator for the government sector. Sale of the airwaves (auctions selling off wireless bandwidth) is a multi-million dollar industry for governments, and multi-billion dollar global advertising budgets are common. Lobbying dollars from the telecom-related industries are estimated to be $300 million annually. The media is nearly silent on health issues, perhaps in part because of global advertising revenues that compromise journalistic independence and discourage balanced coverage of health, equity and economic issues.

2. Evidence supporting a public health risk

Even if there is only a small risk to health from chronic use of and exposure to wireless technologies, there is the potential for a profound public health impact. RF radiation now saturates the airwaves, resulting in exposure to both users and non-users. The effects are both short-term (sleep disruption, hormone disruption, impairment of cognitive function, concentration, attention, behavior, and well-being) and they are almost certainly long-term (generational impacts on health secondary to DNA damage, physiological stress, altered immune function, electrosensitivity, miscarriage risks, effects on sperm quality and motility leading to infertiility, increased rates of cancer, and neurological diseases including Alzheimer's disease and ALS—at least for ELF exposures). (Chapters 5–12 of the BioInitiative Report [1] and papers in this Supplement.)

There is credible scientific evidence that RF exposures cause changes in cell membrane function, metabolism and cellular signal communication, as well as activation of proto-oncogenes and triggering of the production of stress proteins at exposure levels below current regulatory limits. There is also generation of reactive oxygen species, which cause DNA damage, chromosomal aberrations and nerve cell death. A number of different effects on the central nervous system have also been documented, including activation of the endogenous opioid systems, changes in brain function including memory loss, slowed learning, motor dysfunction and performance impairment in children, and increased frequency of headaches, fatigue and sleep disorders. Melatonin secretion is reduced, resulting in altered circadian rhythms and disruption of several physiological functions. (Chapters 5–12 of the BioInitiative Report [1] and papers in this Supplement.)

These effects can reasonably be presumed to result in adverse health effects and disease with chronic and uncontrolled exposures, and children may be particularly vulnerable [1,19]. The young are also largely unable to remove themselves from such environments. Second-hand non-ionizing radiation, like second-hand smoke may be considered of public health concern based on the evidence at hand.

2.1. Malignant brain tumors

At present, the most persuasive evidence for cancer resulting from RF exposure is that there is a significantly increased risk of malignant glioma in individuals that have used a mobile phone for 10 or more years, with the risk being elevated only on the side of the head on which the phone is used regularly (ipsilateral use) [1,3,4,6–8,18]. While the risk for adults after 10 or more years of use is reported to be more than doubled, there is some evidence beginning to appear that indicates that the risk is greater if the individual begins to use a mobile phone at younger ages. Hardell et al. [18] reported higher odds ratios in the 20–29-year-old group than other age ranges after more than 5 years of use of either analog or cordless phones. Recently in a London symposium Hardell reported that after even just 1 or more years of use there is a 5.2-fold elevated risk in children who begin use of mobile phones before the age of 20 years, whereas for all ages the odds ratio was 1.4. Studies from Israel have found that the risk of parotid gland tumors (a salivary gland in the cheek) is increased with heavy cell phone use [7]. The risk of acoustic neuroma (a benign but space-occupying tumor on the auditory nerve) is also significantly increased on the ipsilateral side of the head after 10 or more years of mobile phone use [1,3]. This relationship has also been documented in some of the published reports of the WHO Interphone Study, a decade-long 13-country international assessment of cell phone risks and cancer [6,8].

Kundi reports that "(E)pidemiological evidence compiled in the last 10 years starts to indicate an increased risk, in particular for brain tumors (glioma, meningioma, acoustic neuroma), from mobile phone use. Considering biases that may have been operating in most studies the risk estimates are rather too low, although recall bias could have increased risk estimates. The net result, when considering the different errors and their impact is still an elevated risk" [19].

The latency for most brain tumors is 20 years or more when related to other environmental agents, for example, to X-ray exposure. Yet, for cell phone use the increased risks are occurring much sooner than twenty years, as early as 10 years for brain tumors in adults and with even shorter latencies in children. This suggests that we may currently be significantly underestimating the impact of current levels of

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

use of RF technology, since we do not know how long the average latency period really is. If it is 20 years, then the risk rate will likely be much higher than an overall doubling of risk for cell phone users if the peak comes later than 10 years. It may also signal very troubling risks for those who start using cell phones, and perhaps all wireless devices, in early childhood. We may not have proof of effect for decades until many hundreds of thousands of new cases of malignant gliomas are set in motion by long-term cell phone use.

The preliminary evidence that mobile phone use at younger ages may lead to greater risk than for older persons is of particular concern. There is a large body of evidence that childhood exposure to environmental agents poses greater risk to health than comparable exposure during adulthood [20,21]. There is reason to expect that children would be more susceptible to the effects of EMF exposure since they are growing, their rate of cellular activity and division is more rapid, and they may be more at risk for DNA damage and subsequent cancers. Growth and development of the central nervous system is still occurring well into the teenage years so that neurological changes may be of great importance to normal development, cognition, learning, and behavior.

A greater vulnerability of children to developing brain cancer from mobile phone use may be the consequence of a combination of patterns of use, stage of development and physical characteristics related to exposure. In addition to the fact that the brain continues to develop through the teen years, many young children and teenagers now spend very large periods of time using mobile phones. The brain is the main target organ of cell phones and cordless phones, with highest exposure to the same side as the phone is used. Further, due to anatomical reasons, the brain of a child is more exposed to RF radiation than the brain of an adult [22,23]. This is caused by the smaller brain size, a thinner pinna of the ear, thinner skin and thinner skull bone permitting deeper penetration into the child's brain. A recent French study showed that children absorb twice the RF from cell phone use as do adults [24].

In addition to concerns about cancer, there is evidence for short-term effects of RF exposure on cognition, memory and learning, behavior, reaction time, attention and concentration, altered brainwave activity (altered EEG) [95–108], and all of these effects argue for extreme caution with regard to exposure of children. The development of children into adults is characterized by faster cell division during growth, the long period needed to fully develop and mature all organ systems, and the need for properly synchronized neural development until early adulthood. Chronic, cumulative RF exposures may alter the normal growth and development of children and adversely affect their development and capacity for normal learning, nervous system development, behavior and judgment [1,97,102].

Prenatal exposure to EMF has been identified as a possible risk factor for childhood leukemia (1). Maternal use of cell phones has been reported to adversely affect fetal brain development, resulting in behavioral problems in those children by the time they reach school age [25]. Their exposure is involuntary in all cases. Children are largely unable to remove themselves from exposures to harmful substances in their environments.

2.2. Plausible biological mechanisms for a relationship between RF exposure and cancer

2.2.1. DNA damage and oxidative stress

Damage to DNA from ELF and from RF cell phone frequencies at very low intensities (far below FCC and ICNIRP safety limits) has been demonstrated in many studies [1,2,26–35]. Both single- and double-strand DNA damage have been reported by various researchers in different laboratories. This is damage to the human genome, and can lead to mutations which can be inherited, or which can cause cancer, or both.

Non-ionizing radiation is assumed to be of too low energy to cause direct DNA damage. However both ELF and RF radiation induce reactive oxygen species, free radicals that react with cellular molecules including DNA. Free-radical production and/or the failure to repair DNA damage (secondary to damage to the enzymes that repair damage) created by such exposures can lead to mutations. Whether it is greater free-radical production, reduction in anti-oxidant protection or reduced repair capacity, the result will be altered DNA, increased risk of cancer, impaired or delayed healing, and premature aging [36–54]. Exposures have also been linked to decreased melatonin production, which is a plausible biological mechanism for decreased cancer surveillance in the body, and increased cancer risk [34,39,44,46,47,49,50,54]. An increased risk of cancers and a decrease in survival has been reported in numerous studies of ELF and RF [55–69].

2.2.2. Stress proteins (heat shock proteins or HSP)

Another well-documented effect of exposure to low-intensity ELF and RF is the creation of stress proteins (heat shock proteins) that signal a cell is being placed under physiological stress) [70–80]. The HSP response is generally associated with heat shock, exposure to toxic chemicals and heavy metals, and other environmental insults. HSP is a signal of cells in distress. Plants, animals and bacteria all produce stress proteins to survive environmental stressors like high temperatures, lack of oxygen, heavy metal poisoning, and oxidative stress.

We can now add ELF and RF exposures to this list of environmental stressors that cause a physiological stress response. Very low-level ELF and RF exposures can cause cells to produce stress proteins, meaning that the cell recognizes ELF and RF exposures as harmful. This is another important way in which scientists have documented that ELF and RF exposures can be harmful, and it happens at levels far below the existing public safety standards. An additional concern is that if the stress goes on too long, the protective effect is diminished. The reduced response with prolonged exposure means the cell is less protected against

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

damage, and this is why prolonged or chronic exposures may be harmful, even at very low intensities.

2.2.3. RF-induced gene expression changes

Many environment agents cause diseases, including cancer, not by direct damage to DNA but rather by up- or down-regulation of genes that regulate cell growth and function. Usually there are many genes whose expression is changed, and it is difficult to determine the exact changes responsible for the disease. Both ELF and RF exposures have been shown to result in altered gene expression. Olivares-Banuelos et al. [81] found that ELF exposure of chromaffin cells resulted in changed expression of 53 transcripts. Zhao et al. [82] investigated the gene expression profile of rat neurons exposed to 1800 MHz RF fields (2 W/kg) and found 24 up-regulated genes and 10 down-regulated genes after a 24-h exposure. The altered genes were involved in multiple cellular functions including cytoskeleton, signal transduction pathways and metabolism. Kariene et al. [83] exposed human skin to mobile phone radiation, and found by punch biopsy that 8 proteins were significantly altered in expression, consistent with gene induction. Several other studies have found altered gene expression following RF exposure, although none have been found that explain specific disease states [84].

DNA activation at very low ELF and RF levels, as in the stress response, and DNA damage (strand breaks and micronuclei) at higher levels, are molecular precursors to changes that are believed to lead to cancer. These, along with gene induction, provide plausible biological mechanisms linking exposure to cancer.

The biochemical pathways that are activated are the same for ELF and for RF exposures, and are non-thermal (do not require heating or induced electrical currents). This is true for the stress response, DNA damage, generation of reactive oxygen species as well as gene induction. Thus it is not surprising that the major cancers resulting from exposure to ELF and RF are the same, namely leukemia and brain cancer. The safety standards for both ELF and RF, based on protection from heating, are irrelevant and not protective. ELF exposure levels of only 5–10 mG have been shown to activate the stress response genes (http://www.bioinitiative.org, Sections 1 and 7 [1]).

3. Sleep, cognitive function and performance

The relationship of good sleep to cognition, performance and healing is well recognized. Sleep is a profoundly important factor in proper healing, anti-inflammatory benefits, reduction in physical symptoms of such as tendonitis, over-use syndrome, fatigue-induced lethargy, cognition and learning. Incomplete or slowed physiological recovery is common when sleep is impaired. Circadian rhythms that normalize stress hormone production (cortisol, for example) depend on synchronized sleep patterns.

People who are chronically exposed to low-level wireless antenna emissions report symptoms such as problems in sleeping (insomnia), as well as other symptoms that include fatigue, headache, dizziness, grogginess, lack of concentration, memory problems, ringing in the ears (tinnitus), problems with balance and orientation, and difficulty in multi-tasking [85–93,99]. In children, exposures to cell phone radiation have resulted in changes in brain oscillatory activity during some memory tasks [97,102]. Cognitive impairment, loss of mental concentration, distraction, speeded mental function but lowered accuracy, impaired judgment, delayed reaction time, spatial disorientation, dizziness, fatigue, headache, slower motor skills and reduced learning ability in children and adults have all been reported [85–108].

These symptoms are more common among "electrosensitive" individuals, although electrosensitivity has not been documented in double-blind tests of individual identifying themselves as being electrosensitive as compared to controls [109,110]. However people traveling to laboratories for testing are pre-exposed to a multitude of RF and ELF exposures, so they may already be symptomatic prior to actual testing. There is also evidence that RF exposures testing behavioral changes show delayed results; effects are observed after termination of RF exposure. This suggests a persistent change in the nervous system that may be evident only after time has passed, so is not observed during a short testing period.

3.1. Plausible biological mechanisms for neurobehavioral effects

3.1.1. The melatonin hypothesis

While there remains controversy as to the degree that RF and ELF fields alter neurobehavioral function, emerging evidence provides a plausible mechanism for both effects on sleep and cognition. Sleep is controlled by the central circadian oscillator in the suprachiasmatic nucleus, located in the hypothalamus. The activity of this central circadian oscillator is, in turn, controlled by the hormone, melatonin, which is released from the pineal gland [111]. There is considerable evidence that ELF exposure reduces the release of melatonin from the pineal gland—see Section 12 of the Bioinitiative Report [1]. There has been less study of the effects of RF exposure on melatonin release, but investigations have demonstrated a reduced excretion of the urinary metabolite of melatonin among persons using a mobile phone for more than 25 min per day [112]. In a study of women living near to radio and television transmitters, Clark et al. [113] found no effect on urinary melatonin metabolite excretion among pre-menopausal women, but a strong effect in post-menopausal women.

The "melatonin hypothesis" also provides a possible basis for other reported effects of EMFs. Melatonin has important actions on learning and memory, and inhibits electrophysiological components of learning in some but not all areas of the brain [114,115]. Melatonin has properties as a free-radical scavenger and anti-oxidant [116], and consequently,

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

a reduction in melatonin levels would be expected to increase susceptibility to cancer and cellular damage. Melatonin could also be the key to understanding the relationship between EMF exposure and Alzheimer's disease. Noonan et al. [117] reported that there was an inverse relationship between excretion of the melatonin metabolite and the 1–42 amino acid form of amyloid beta in electric utility workers. This form of amyloid beta has been found to be elevated in Alzheimer's patients.

3.1.2. Blood–brain barrier alterations

Central nervous system effects of EMFs may also be secondary to damage to the blood–brain barrier (BBB). The blood–brain barrier is a critical structure that prevents toxins and other large molecules that are in peripheral blood from having access to the brain matter itself. Salford et al. [118] have reported that a 2-h exposure of rats to GSM-900 radiation with a SAR of 2–200 mW/kg resulted in nerve cell damage. In a follow-up study, Eberhardt et al. report that 2-h exposures to cell phone GSM microwave RF resulted in leakage of albumin across the blood–brain barrier and neuronal death [119]. Neuronal albumin uptake was significantly correlated to occurrence of damaged neurons when measured at 28 days post-exposure. The lowest exposure level was 0.12 mW/kg (0.00012 W/kg) for 2 h. The highest exposure level was 120 mW/kg (0.12 W/kg). The weakest exposure level showed the greatest effect in opening the BBB [118]. Earlier blood–brain studies by Salford and Schirmacher [120,121] report similar effects.

4. What are sources of wireless radiation?

There are many overlapping sources of radiofrequency and microwave emissions in daily life, both from industrial sources (like cell towers) and from personal items [cell and cordless phones, personal digital assistants (PDAs), wireless routers, etc.]. Published data on typical levels found in some cities and from some sources are available at http://www.bioinitiative.org [1,122–124].

Cell phones are the single most important source of radiofrequency radiation to which we are exposed because of the relatively high exposure that results from the phone being held right against the head. Cell phones produce two types of emissions that should be considered. First, the radiofrequency radiation (typically microwave frequency radiation) is present. However, there is also the contribution of the switching battery pack that produces very high levels of extremely low frequency electromagnetic field [125–127].

Cordless telephones have not been widely recognized as similar in emissions to cell phones, but they can and do produce significant RF exposures. Since people tend to use them as substitutes for in-home and in-office corded or traditional telephones, they are often used for long periods of time. As the range of cordless phones has increased (the distance away that you can carry on a conversation is related to the power output of the phone), the more powerful the RF signal will be. Hence, newer cordless phones may in some cases be similar to the power output of cell phones. The cumulative emissions from cell and cordless phones taken together should be recognized when considering the relative risks of wireless communication exposures.

PDAs such as the BlackBerry, Treo and iPhone units are 'souped-up' versions of the original voice communication devices (cell phones). The often produce far higher ELF emissions than do cell phones because they use energy from the battery very intensively for powering color displays and during data transmission functions (email, sending and receiving large files, photos, etc.) [125–127]. ELF emissions have been reported from PDAs at several tens to several hundreds of milligauss. Evidence of significantly elevated ELF fields during normal use of the PDA has public health relevance and has been reported in at least three scientific papers [125,128,129]. In the context of repetitive, chronic exposure to significantly elevated ELF pulses from PDAs worn on the body, relevant health studies point to a possible relationship between ELF exposure and cancer and pregnancy outcomes [130–133].

We include discussion of the ELF literature for two reasons. As mentioned above ELF activates the same biology as RF, it contributes to the total EMF burden of the body. In addition, PDAs and cell phones emit both radiofrequency/microwave radiation (RF) and extremely low frequency ELF from the battery switching of the device (the power source). Studies show that some devices produce excessively high ELF exposures during voice and data transmission. ELF is already classified as a 2B (Possible) Carcinogen by IARC, which means that ELF is indisputably an issue to consider in the wireless technology debate. ELF has been classified as a Group 2B carcinogen for all humans, not just children. The strongest evidence came from epidemiological studies on childhood leukemia, but the designation applies to all humans, both adults and children [1,25].

Wireless headsets that allow for conversations with cell phones at a distance from the head itself reduce the emissions. Depending on the type of wireless device, they may operate (transmit signal) only during conversations or they may be operational continuously. The cumulative dose of wireless headsets has not been well characterized under either form of use. Substantial cumulative RF exposure would be expected if the user wears a wireless headset that transmits a signal continuously during the day. However a critical factor is where the cell phone is placed. If worn on a belt with a headset, the exposure to the brain is reduced but the exposure to the pelvis may be significant.

Cell towers (called "masts" in Europe and Scandinavian countries) are wireless antenna facilities that transmit the cell phone signals within communities. They are another major source of RF exposures for the public. They differ from RF exposures from wireless devices like cell phones in that they produce much lower RF levels (generally 0.05 to 1–2 $\mu W/cm^2$ in the first several hundred feet around them) in comparison to several hundred microwatts per centimeter

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

squared for a cell phone held at the head. However they create a constant zone of elevated RF for up to 24 h per day. many hours per day, and the exposure is whole body rather than localized at the head. These facilities are the distribution system for wireless voice communications, internet connections and data transmission within communities. They are often erected on free-standing towers. They may be constructed on telephone poles or electrical poles. They may be built into the façade or rooftops of buildings behind wood screening. These are called stealth installations for wireless antenna facilities. Some installations are camouflaged to resemble 'false trees or rocks'. They emit RF to provide cell service to specific "cells" or locations that receive the signal.

Other forms of wireless transmission that are common in areas providing cell service are wireless land area networks (WLAN), (WiMAX) and WIFI networks. Some cities are installing city-wide WIFI service to allow any user on the street to log into the internet (without cables or wire connections). WIFI installations may have a signal reach for a few hundred feet where WiMAX installations may transmit signal more than 10 miles, so produce a stronger RF emission for those in close proximity. Each type has its particular signal strength and intended coverage area, but what they have in common is the production of continuous RF exposure for those within the area. We do not know what the cumulative exposure (dose) might be for people living, working or going to school in continuously elevated RF fields, nor are the possible health implications yet known. However, based on studies of populations near cell sites in general, there is a constellation of generally observed health symptoms that are reported to occur [85–107]. In this regard it is important to note that children living near to AM radio transmitters have been found to elevated risks of leukemia [134,135]. While AM radio RF fields are lower in frequency than that common in mobile phones, this is a total body irradiation with RF. The fact that leukemia, not brain cancer, is apparent in these studies suggests that leukemia is the cancer seen at the lowest levels of both ELF and RF fields under the circumstances of whole-body exposure.

Commercial surveillance systems or security gates pose an additional source of strong RF exposures. They are ubiquitous in department stores, markets and shops at the entry and exit points to discourage shoplifting and theft of goods. Security gates can produce excessively high RF exposures (although transitory) and have been associated with interference with pacemakers in heart patients. The exposure levels may approach thermal public safety limits in intensity, although no one expects a person to stand between the security gate bars for more than 6 min (safety limits for uncontrolled public access are variable depending on the frequency, but are all averaged over a 6-min exposure period).

RFID chips (radiofrequency identification chips) are being widely used to track purchases and for security of pets, and in some cases to keep track of patients with Alzheimer's disease and of children. RFID chips are implanted in fabrics, inserted in many types of commercial goods, and can be implanted under the skin. They create a detectable signal to track the location of people and goods.

5. Problems with existing public health standards (safety limits)

If the existing standards were adequate none of the effects documented above should occur at levels to which people are regularly exposed. The fact that these effects are seen with our current ambient levels of exposure means that our existing public safety standards are obsolete. It also means that new, biologically based public exposure standards for wireless technologies are urgently needed. Whether it is feasible to achieve low enough levels that still work and also protect health against effects of chronic RF exposure – for all age groups – is uncertain. Whether we can protect the public and still allow the kinds of wireless technology uses we see today is unknown.

The nature of electromagnetic field interactions with biological systems has been well studied [136–144]. For purposes of standard-setting processes for both ELF and RF, the hypothesis that tissue damage can result only from heating is the fundamental flaw in the misguided efforts to understand the basic biological mechanisms leading to health effects.

The thermal standard is clearly untenable as a measure of dose when EMF stimuli that differ by many orders of magnitude in energy can stimulate the same biological response. In the ELF range, the same biological changes occur as in the RF, and no change in temperature can even be detected. With DNA interactions the same biological responses are stimulated in ELF and RF ranges even though the frequencies of the stimuli differ by many orders of magnitude. The effects of EMF on DNA to initiate the stress response or to cause molecular damage reflect the same biology in different frequency ranges. For this reason it should be possible to develop a scale based on DNA biology, and use it to define EMF dose in different parts of the EM spectrum. We also see a continuous scale in DNA experiments that focus on molecular damage where single and double strand breaks have long been known to occur in the ionizing range, and recent studies have shown similar effects in both ELF and RF ranges [144].

Existing standard-setting bodies that regulate wireless technologies, assume that there are no bioeffects of concern at exposure levels that do not cause measurable heating. However, it has been established beyond any reasonable doubt that bioeffects and some adverse health effects occur at far lower levels of RF and ELF exposure where no heating (or induced current) occurs; some effects are shown to occur a thousand times or more below the existing public safety limits. New, biologically based public exposure limits are urgently needed. New wireless technologies for cell and cordless phones, other wireless communication and data transmission systems affect living organisms in new ways that our antiquated safety limits have not foreseen, nor protected against.

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

The exposure of children to electromagnetic fields has not been studied extensively; in fact, the Federal Communications Commission (FCC) standards for exposure to radiofrequency radiation are based on the height, weight and stature of a 6-foot tall man, not scaled to children or adults of smaller stature. They do not take into account the unique susceptibility of growing children to exposures, nor are there studies of particular relevance to children.

In addition there is a problem in the consideration of the level of evidence taken into consideration by these bodies. There have not been adequate animal models shown to have cancer as an endpoint, and a perception that no single mechanism is proven to explain these associations. Thus these committees have tended to ignore or minimize the evidence for direct hazard to humans, and believe there is no proof of cause and effect. These bodies assume from the beginning that only conclusive scientific evidence (absolute proof) will be sufficient to warrant change, and refuse to take action on the basis of a growing body of evidence which provides early but consequential warning of risks.

The Radiofrequency Interagency Working Group of the US governmental agencies involved in RF matters (RFIAWG) issued a Guidelines Statement in June of 1999 that concluded the present RF standard "may not adequately protect the public" [145]. The RFIAWG identified fourteen (14) issues that they believe are needed in the planned revisions of ANSI/IEEE RF exposure guidelines including "to provide a strong and credible rationale to support RF exposure guidelines". In particular, the RFIAWG criticized the existing standards as not taking into account chronic, as opposed to acute exposures, modulated or pulsed radiation (digital or pulsed RF is proposed at this site), time-averaged measurements that may erase the unique characteristics of an intensity-modulated RF radiation that may be responsible for reported biologic effects, and stated the need for a comprehensive review of long-term, low-level exposure studies, neurological-behavioral effects and micronucleus assay studies (showing genetic damage from low-level RF) [145]. This important document from relevant US agencies questions existing standards in the following ways: (a) selection of an adverse effect level for chronic exposures not based on tissue heating and considering modulation effects; (b) recognition of different safety criteria for acute and chronic exposures at non-thermal or low-intensity levels; (c) recognition of deficiencies in using time-averaged measurements of RF that does not differentiate between intensity-modulated RF and continuous wave (CW) exposure, and *therefore may not adequately protect the public*; (d) having standards based on adult males rather than considering children to be the most vulnerable group.

6. Prudent public health responses

Emerging environmental health problems require preventative public health responses even where scientific and medical uncertainties still exist, but where policy decisions today may greatly reduce human disease and societal costs tomorrow.

Policy decisions in public health must address some amount of uncertainty when balancing likely benefits and estimated costs. Although new insight will allow better appreciation of difficult issues, such as those occurring in environmental and occupational health, an expanded perspective may also enlarge the list of problems that need to be managed. Ignoring the problems carries its own costs (as deferring a decision is a decision in itself). With environmental and other public health problems becoming increasingly complex and international in scope, scientific documentation alone rarely justifies simple solutions [146].

Social issues regarding the controversy over public and occupational exposures to ELF and RF center on the resolute adherence to existing ICNIRP and FCC/IEEE standards by many countries, in the face of growing scientific evidence of health risks at far lower levels [10]. The composition of these committees, usually with excessive representation of the physics and engineering communities rather than public health professionals, results in a refusal to adopt biologically based exposure standards. Furthermore, there is widespread belief that governments are ignoring this evidence and there is widespread distrust of and lack of confidence in governments and their health agencies. The basis on which most review bodies and standard-setting agencies have avoided the conclusion that the science is strong enough to warrant new safety limits for ELF and RF is to require a demonstration of absolute proof before taking action. A causal level of evidence, or scientific certainty standard is implicit in nearly all reviews of the ELF and RF science, although this runs counter to good public health protection policies.

There is no question that global implementation of the safety standards proposed in the Bioinitiative Report, if implemented abruptly and without careful planning, have the potential to not only be very expensive but also disruptive of life and the economy as we know it. Action must be a balance of risk to cost to benefit. The major risk from maintaining the status quo is an increasing number of cancer cases, especially in young people, as well as neurobehavioral problems at increasing frequencies. The benefits of the status quo are expansion and continued development of communication technologies. But we suspect that the true costs of even existing technologies will only become much more apparent with time. Whether the costs of remedial action are worth the societal benefits is a formula that should reward precautionary behavior. Prudent corporate policies should be expected to address and avoid future risks and liabilities, otherwise, there is no market incentive to produce safe (and safer) products.

The deployment of new technologies is running ahead of any reasonable estimation of possible health impacts and estimates of probabilities, let alone a solid assessment of risk. However, what has been missing with regard to EMF has been an acknowledgement of the risk that is demonstrated by

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

the scientific studies. There is clear evidence of risk, although the magnitude of the risk is uncertain, and the magnitude of doing nothing on the health effects cost to society is similarly uncertain. This situation is very similar to our history of dealing with the hazards of smoking decades ago, where the power of the industry to influence governments and even conflicts of interest within the public health community delayed action for more than a generation, with consequent loss of life and enormous extra health care costs to society. New standards are warranted now, based on the totality of scientific evidence; the risks of taking no-action, the large population at risk, costs associated with ignoring the problem in new and upgraded site selection and construction, and the loss of public trust by ignoring the problem.

Direct medical and rehabilitative health costs associated with treatment for diseases that are reasonably related to wireless technologies may be very large. Although there is uncertainty involved in how much disease is related to wireless exposures, the mere scale of the problem with several billion users of cell phones and even larger impacts on bystander populations (from cell site exposures, from other WI-FI and wireless exposures in-home and commercial use, etc.) the associated public health costs will likely be monumental. Furthermore the costs to families with cancers, neurological diseases or learning disabilities in children related in part or in whole to wireless technologies extend beyond medical costs. They may reasonably extend to family disruption and family psychological problems, losses in job productivity and income loss.

The history of governments and their official health agencies to deal with emerging and newly identified risks to health is not good [147–149]. This is particularly true where industry investments in new products and technologies occur without full recognition, disclosure or even knowledge of possible health consequences. Large economic investments in polluting industries often make for perilously slow regulatory action, and the public health consequences may be very great as a result [150,151].

Free markets do not internalize the costs to society of "guessing wrong". Unexpected or hidden health costs of new technologies may not be seen for many years, when the ability to recall or to identify the precise exposures related to disease outcomes is difficult or impossible. The penalty nearly always falls to the individual, the family or the taxpayer and not to the industry that benefits economically—at least in free-market economies. Thus, the profits go to industry but the costs may go to the individual who can suffer both diminished quality of life and health and economic disadvantage. If all disease endpoints that may be reasonably related to chronic exposure to electromagnetic fields are considered even a small attributable fraction for one or more industries, it will have enormous global impact on public health. The public health implications are immense. But they can be reduced by strong government and public health interventions providing information on alternatives to wireless technologies, public education campaigns, health advisories, requirements for redesign of wireless devices, proscription of use of wireless devices by children and teenagers, strong and independent research programs on causes and prevention of EMF-related diseases, and consultation with all stakeholders on issues relating to involuntary exposures (bystander or second-hand radiation exposures from wireless technologies) (Table 1).

Table 1
Public health implications of wireless technologies argue for change in governmental and health agency actions.

Secure US and EU legislative mandates for safer technologies for communication and data transmission, for security and surveillance needs.
Promote wired alternatives for voice and data communication (cable, fiber-optic)
Discourage or ban use of cell phones by children and young teen-agers
Provide permanent (unremovable) labels on cell phones "Not for use by children under the age of 16"
Implement national public education campaigns on health issues (cell phones, cordless phones, PDAs, wireless internet, city-wide WI-FI, WLAN and WiMAX exposures
Promote industry redesign for safer products: support innovation for alternatives and solutions
Slow or stop deployment of wireless technologies to discourage reliance on wireless technologies for communication and security needs
Put the burden of proof on industry to show "new wireless tech" is safe before deployment
Adopt and enforce restricted use areas for sensitive or more vulnerable segments of society including low-EMF environments in public areas and "No Cell" zones in airports, hospitals, schools
Acknowledge FCC and ICNIRP thermal safety standards are obsolete for wireless technologies
Appoint new standard-setting bodies familiar with biological effects to develop new guidelines for public safety limits.
Develop new biologically based standards that address low-intensity, chronic exposures
Require standard of evidence and level of proof = public health
Reject "causal" standard of evidence for taking action on science
Make industry financially liable for "guessing wrong" and ignoring health risks

The scientific information contained in this Supplement argues for thresholds or guidelines that are substantially below current FCC and ICNIRP standards for localized exposures to wireless devices and for whole-body exposure. Uncertainty about how low such standards might have to go to be prudent from a public health standpoint should not prevent reasonable efforts to respond to the information at hand. No lower limit for bioeffects and adverse health effects from RF has been established, so the possible health risks of wireless WLAN and WI-FI systems, for example, will require further research. No assertion of safety at any level of wireless exposure (chronic exposure) can be made at this time. The lower limit for reported human health effects has dropped 100-fold below the safety standard (for mobile phones and PDAs); 1000–10,000-fold for other wireless (cell towers at distance; WI-FI and WLAN devices). The entire basis for safety standards is called into question, and it is not unreasonable to question the safety of RF at any level.

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

It is likely that for both ELF and RF, as for other carcinogens, there is no threshold of exposure that is without risk, but the magnitude of the risk increases linearly with the level of exposure. Our society will not go back to the pre-electric and pre-wireless age, but the clear evidence of health hazards to the human population from exposure mandates that we develop ways in which to reduce exposure through education, new technologies and the establishment of biomedically based standards.

7. Conclusions and recommended actions

New ELF limits are warranted based on a public health analysis of the overall existing scientific evidence. These limits should reflect environmental levels of ELF that have been demonstrated to increase risk for childhood leukemia, and possibly other cancers and neurological diseases. ELF limits should be set below those exposure levels that have been linked in childhood leukemia studies to increased risk of disease, plus an additional safety factor. It is no longer acceptable to build new power lines and electrical facilities that place people in ELF environments that have been determined to be risky. These levels are in the 2–4 milligauss (mG) range (0.2–0.4 μT), not in the 10 s of mG or 100 s of mG. The existing ICNIRP limit is 1000 mG (100 μT) and 904 mG (90.4 μT) in the US for ELF is outdated and based on faulty assumptions. These limits are can no longer be said to be protective of public health and they should be replaced. A safety buffer or safety factor should also be applied to a new, biologically based ELF limit, and the conventional approach is to add a safety factor lower than the risk level.

While new ELF limits are being developed and implemented, a reasonable approach would be a 1 mG (0.1 μT) planning limit for habitable space adjacent to all new or upgraded power lines and a 2 mG (0.2 μT) limit for all other new construction. It is also recommended that a 1 mG (0.1 μT) limit be established for existing habitable space for children and/or women who are pregnant (because of the possible link between childhood leukemia and *in utero* exposure to ELF). This recommendation is based on the assumption that a higher burden of protection is required for children who cannot protect themselves, and who are at risk for childhood leukemia at rates that are traditionally high enough to trigger regulatory action. This situation in particular warrants extending the 1 mG (0.1 μT) limit to existing occupied space. "Establish" in this case probably means formal public advisories from relevant health agencies. While it is not realistic to reconstruct all existing electrical distribution systems, in the short-term; steps to reduce exposure from these existing systems need to be initiated, especially in places where children spend time, and should be encouraged. These limits should reflect the exposures that are commonly associated with increased risk of childhood leukemia (in the 2–5 mG (0.2–0.5 μT) range for all children, and over 1.4 mG (0.14 μT) for children age 6 and younger). Nearly all of the occupational studies for adult cancers and neurological diseases report their highest exposure category is 4 mG (0.4 μT) and above, so that new ELF limits should target the exposure ranges of interest, and not necessarily higher ranges.

Avoiding chronic ELF exposure in schools, homes and the workplace above levels associated with increased risk of disease will also avoid most of the possible bioactive parameters of ELF discussed in the relevant literature.

It is not prudent public health policy to wait any longer to adopt new public safety limits for ELF. These limits should reflect the exposures that are commonly associated with increased risk of childhood leukemia (in the 2–5 mG (0.2–0.5 μT) range for all children, and over 1.4 mG (0.14 μT) for children age 6 and younger). Avoiding chronic ELF exposure in schools, homes and the workplace above levels associated with increased risk of disease will also avoid most of the possible bioactive parameters of ELF discussed in the relevant literature.

The rapid deployment of new wireless technologies that chronically expose people to pulsed RF at levels reported to cause bioeffects, which in turn, could reasonably be presumed to lead to serious health impacts, is a public health concern. There is suggestive to strongly suggestive evidence that RF exposures may cause changes in cell membrane function, cell communication, metabolism, activation of proto-oncogenes and can trigger the production of stress proteins at exposure levels below current regulatory limits. Resulting effects can include DNA breaks and chromosome aberrations, cell death including death of brain neurons, increased free-radical production, activation of the endogenous opioid system, cell stress and premature aging, changes in brain function including memory loss, retarded learning, performance impairment in children, headaches and fatigue, sleep disorders, neurodegenerative conditions, reduction in melatonin secretion and cancers (BioInitiative Report Chapters 5–10, 12) [1].

This information now argues for thresholds or guidelines that are substantially below current FCC and ICNIPR standards for whole-body exposure. Uncertainty about how low such standards might have to go to be prudent from a public health standpoint should not prevent reasonable efforts to respond to the information at hand. No lower limit for bioeffects and adverse health effects from RF has been established, so the possible health risks of wireless WLAN and WI-FI systems, for example, will require further research and no assertion of safety at any level of wireless exposure (chronic exposure) can be made at this time. The lower limit for reported human health effects has dropped 100-fold below the safety standard (for mobile phones and PDAs); 1000–10,000-fold for other wireless (cell towers at distance; WI-FI and WLAN devices). The entire basis for safety standards is called into question, and it is not unreasonable to question the safety of RF at any level.

A cautionary target level for pulsed RF exposures for ambient wireless that could be applied to RF sources from cell tower antennas, WI-FI, WI-MAX and other similar sources

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

is proposed. The recommended cautionary target level is 0.1 microwatts per centimeter squared ($\mu W/cm^2$) (or 0.614 V per meter or V/m) for pulsed RF where these exposures affect the general public; this advisory is proportionate to the evidence and in accord with prudent public health policy. A precautionary limit of 0.1 $\mu W/cm^2$ should be adopted for outdoor, cumulative RF exposure. This reflects the current RF science and prudent public health response that would reasonably be set for pulsed RF (ambient) exposures where people live, work and go to school. This level of RF is experienced as whole-body exposure, and can be a chronic exposure where there is wireless coverage present for voice and data transmission for cell phones, pagers and PDAs and other sources of radiofrequency radiation. An outdoor precautionary limit of 0.1 $\mu W/cm^2$ would mean an even lower exposure level inside buildings, perhaps as low as 0.01 $\mu W/cm^2$. Some studies and many anecdotal reports on ill health have been reported at lower levels than this; however, for the present time, it could prevent some of the most disproportionate burdens placed on the public nearest to such installations. Although this RF target level does not preclude further rollout of WI-FI technologies, we also recommend that wired alternatives to WI-FI be implemented, particularly in schools and libraries so that children are not subjected to elevated RF levels until more is understood about possible health impacts. This recommendation should be seen as an interim precautionary limit that is intended to guide preventative actions; and more conservative limits may be needed in the future.

Broadcast facilities that chronically expose nearby residents to elevated RF levels from AM, FM and television antenna transmission are also of public health concern given the potential for very high RF exposures near these facilities (antenna farms). RF levels can be in the 10 s to several 100 s of $\mu W/cm^2$ in residential areas within half a mile of some broadcast sites (for example, Lookout Mountain, Colorado and Awbrey Butte, Bend, Oregon). Like wireless communication facilities, RF emissions from broadcast facilities that are located in, or expose residential populations and schools to elevated levels of RF will very likely need to be re-evaluated for safety.

For emissions from wireless devices (cell phones, personal digital assistant or PDA devices, etc.) there is enough evidence for increased risk of brain tumors and acoustic neuromas now to warrant intervention with respect to their use. Redesign of cell phones and PDAs could prevent direct head and eye exposure, for example, by designing new units so that they work only with a wired headset or on speakerphone mode.

These effects can reasonably be presumed to result in adverse health effects and disease with chronic and uncontrolled exposures, and children may be particularly vulnerable. The young are also largely unable to remove themselves from such environments. Second-hand radiation, like second-hand smoke is an issue of public health concern based on the evidence at hand.

In summary, the following recommendations are made:

- ELF limits should be set below those exposure levels that have been linked in childhood leukemia studies to increased risk of disease, plus an additional safety factor. It is no longer acceptable to build new power lines and electrical facilities that place people in ELF environments that have been determined to be risky (at levels generally at 2 mG (0.2 μT) and above).
- While new ELF limits are being developed and implemented, a reasonable approach would be a 1 mG (0.1 μT) planning limit for habitable space adjacent to all new or upgraded power lines and a 2 mG (0.2 μT) limit for all other new construction, It is also recommended for that a 1 mG (0.1 μT) limit be established for existing habitable space for children and/or women who are pregnant. This recommendation is based on the assumption that a higher burden of protection is required for children who cannot protect themselves, and who are at risk for childhood leukemia at rates that are traditionally high enough to trigger regulatory action. This situation in particular warrants extending the 1 mG (0.1 μT) limit to existing occupied space. "Establish" in this case probably means formal public advisories from relevant health agencies.
- While it is not realistic to reconstruct all existing electrical distributions systems, in the short-term; steps to reduce exposure from these existing systems need to be initiated and should be encouraged, especially in places where children spend time.
- A precautionary limit of 0.1 $\mu W/cm^2$ (which is also 0.614 V per meter) should be adopted for outdoor, cumulative RF exposure. This reflects the current RF science and prudent public health response that would reasonably be set for pulsed RF (ambient) exposures where people live, work and go to school. This level of RF is experienced as whole-body exposure, and can be a chronic exposure where there is wireless coverage present for voice and data transmission for cell phones, pagers and PDAs and other sources of radiofrequency radiation. Some studies and many anecdotal reports on ill health have been reported at lower levels than this; however, for the present time, it could prevent some of the most disproportionate burdens placed on the public nearest to such installations. Although this RF target level does not preclude further rollout of WI-FI technologies, we also recommend that wired alternatives to WI-FI be implemented, particularly in schools and libraries so that children are not subjected to elevated RF levels until more is understood about possible health impacts. This recommendation should be seen as an interim precautionary limit that is intended to guide preventative actions; and more conservative limits may be needed in the future.

References

[1] C. Sage, D.O. Carpenter (Eds.), BioInitiative Working Group BioInitiative Report: A Rationale for a Biologically-based Public

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

Exposure Standard for Electromagnetic Fields (ELF and RF), 2007. http://www.bioinitiative.org.

[2] REFLEX Program. 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, Key Action 4 (2004).

[3] L. Hardell, C. Sage, Biological effect from electromagnetic field exposure and public exposure standards, Biomed. Pharmacother. 62 (2008) 104–109, doi:10.1016/j.bipha.(2007)12.004.

[4] L. Hardell, M. Carlberg, F. Söderqvist, K. Hansson Mild, Meta-analysis of long-term mobile phone use and the association with brain tumours, Int. J. Oncol. 32 (2008) 1097–1103.

[5] P. Kan, S.E. Simonsen, J.L. Lyon, J.R.W. Kestle, Cellular phone use and brain tumor: a meta-analysis, J. Neurooncol. (2007), doi:10.1007/s11060-007-9432-1.

[6] E. Cardis, Interphone Study Memo, International Agency for Cancer Research, October 2008.

[7] S. Sadetzki, A. Chetrit, A. Jarus-Hakak, E. Cardis, Y. Deutch, S. Dvendevani, A. Zultan, I. Novikov, L. Freedman, M. Wolf, Cellular phone use and risk of benign and malignant parotid gland tumors—a nationwide case–control study, Am. J. Epidemiol. (2008), doi:10.1093/aje/kwm325.

[8] A. Lahkola, T. Salminen, J. Raitanen, S. Heinavaara, M.J. Schoemaker, H.C. Christensen, M. Feychting, C. Johansen, L. Klaeboe, S. Lonn, A.J. Swerdlow, T. Tynes, A. Auvinen, Meningioma and mobile phone use—a collaborative case–control study in five North European countries, Int. J. Epidemiol. Adv. Access (August) (2008), doi:10.1093/ije/dyn155.

[9] T. Takebayashi, S. Akiba, Y. Kikuchi, et al., Mobile phone use and acoustic neuroma risk in Japan, Occup. Environ. Med. 63 (2007) 802–807.

[10] D.O. Carpenter, C.L. Sage, Setting prudent public health policy for electromagnetic field exposures, Rev. Environ. Health 23 (2) (2008) 91–117.

[11] D.O. Carpenter, C.L. Sage, BioInitiative Working Group, Key scientific evidence and public health policy options, BioInitiative Report at http://www.bioinitiative.org, 17 (2007).

[12] European Commission, Health and Consumer Protection, Scientific Committee on SCENIHR Report on Emerging and Newly Identified Health Risks—Possible Effects of Electromagnetic Fields (EMF) on Human Health, 2007.

[13] World Health Organization, Extremely Low Frequency Fields Environmental Health Criteria Monograph 238, 2007. http://www.who.int/peh-emf/project/en and http://www.who.int/peh-emf/meetings/elf_emf_workshop_2007/en/index.html.

[14] http://news.cnet.com/Emerging-markets-fuel-cell-phone-growth/2100-1039_3-6159491.html.

[15] http://news.softpedia.com/news/2-14-billion-cell-phone-subscribers-in-2005-2120.shtml.

[16] http://www.ctia.org/media/industry_info/index.cfm/AID/10323.

[17] http://www.nytimes.com/2008/09/20/us/20messaging.html and Members Info. Electronics Industries Alliance Website, November, 2000.;
Members Info, Electronics Industries Alliance Website, November 2000.

[18] L. Hardell, M. Carlberg, K. Hansson Mild, Pooled analysis of two case–control studies on use of cellular and cordless telephones and the risk for malignant brain tumours diagnosed in 1997–2003, Int. Arch. Environ. Health 79 (2006) 630–639, doi:10.1007/s00420-006-0088-5.

[19] M. Kundi, The controversy about a possible relationship between mobile phone use and cancer, Environ. Health Persp. (September) (2008), doi: 101289/ehp.11902.

[20] J. Pronczuk-Garbino (Ed.), Children's Health and the Environment: A Global Perspective, World Health Organization, Geneva, Switzerland, 2005, p. 367.

[21] World Health Organization, Children's Health and Environment: A Review of Evidence: A Joint Report from the European Environmental Agency and The World Health Organization, 2002. http://www.who.int/peh-emf.

[22] O.P. Gandhi, G. Lazzi, C.M. Furse, Electromagnetic absorption in the human head and neck for mobile telephones at 835 and 1900 MHz, IEE Trans. Microw. Theory Tech. 44 (1996) 1884–1896.

[23] O.P. Gandhi, G. Kang, Some present problems and a proposed experimental phantom for SAR compliance testing of cellular telephones at 835 and 1900 MHz, Phys. Med. Biol. 47 (2002) 1501–1518.

[24] J. Wiart, A. Hadjem, M.F. Wong, I. Bloch, Analysis of RF exposure in the head tissues of children and adults, Phys. Med. Biol. 53 (2008) 3681–3695;
J. Wiatt, A. Hadjem, M.F. Wong, I. Bloch, Analysis of RF exposure in the head tissues of children and adults, Wiatt Phys. Med. Biol. 53 (June) (2008) 2771–2783.

[25] H.A. Divan, L. Kheifets, C. Obel, J. Olsen, Prenatal and postnatal exposure to cell phone use and behavioral problems in children, Epidemiology 19 (4) (2008).

[26] International Commission on Non-ionizing Radiation Protection, Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz). Health Phys. 74(4) (1998) 494–522. http://www.icnirp.de.

[27] Institute of Electrical and Electronics Engineers, Inc (IEEE), Section 4.2 of "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE C95.1-1992. New York, NY, 1992.

[28] H. Lai, N.P. Singh, Single and double strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromagnetic radiation, Int. J. Radiat. Biol. 69 (1996) 513–521.

[29] S. Ivancsits, A. Pilger, E. Diem, O. Jahn, H.W. Rudinger, Cell type-specific genotoxic effects of intermittent extremely-low frequency electromagnetic fields, Mutat. Res. 583 (2005) 184–188.

[30] J. Phillips, et al., DNA damage in molt-4 lymphoblastoid cells exposed to cellular telephone radiofrequency fields in vitro, Bioelectrochem. Bioenerg. 45 (1998) 103–110.

[31] R.J. Aitken, L.E. Bennetts, D. Sawyer, A.M. Wiklendt, B.V. King, Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline, Int. J. Androl. 28 (2005) 171.

[32] J.Y. Kim, S.Y. Hong, Y.M. Lee, S.A. Yu, W.S. Koh, J.R. Hong, T. Son, S.K. Chang, M. Lee, In vitro assessment of clastogenicity of mobile-phone radiation (835 MHz) using the alkaline comet assay and chromosomal aberration test, Environ. Toxicol. 23 (2008) 319.

[33] S. Lixia, K. Yao, W. Kaijun, l. Deglang, H. Huajun, G. Xiangwei, W. Baohong, Z. Wei, L. Jianling, W. Wei, Effects of 1.8 GHz radiofrequency field on DNA damage and expression of heat shock protein 70 in human lens epithelial cells, Mutat. Res. 602 (2006) 135.

[34] R. Paulraj, J. Behari, Single strand DNA breaks in rat brain cells exposed to microwave radiation, Mutat. Res. 596 (2006) 76.

[35] M. Mashevich, D. Folkman, A. Kesar, A. Barbul, R. Korenstein, E. Jerby, L. Avivi, Exposure of human peripheral blood lymphocytes to electromagnetic fields associated with cellular phones leads to chromosomal instability, Bioelectromagnetics 24 (2003) 82.

[36] I.G. Akoev, M.S. Pashovkina, L.P. Dolgacheva, T.P. Semenova, V.L. Kalmykov, Enzymatic activity of some tissues and blood serum from animals and humans exposed to microwaves and hypothesis on the possible role of free radical processes in the nonlinear effects and modification of emotional behavior of animals, Radiat. Biol. Radioecol. 42 (3) (2002) 32–330.

[37] C. Blackman, et al., The influence of 1.2 μT, 60 Hz magnetic fields on melatonin and tamoxifen-induced inhibition of MCF-7 cell growth, Bioelectromagnetics 22 (2) (2001) 122–128.

[38] D.E. Blask, S.M. Hill, Effects of melatonin on cancer: studies on MCF-7 human breast cancer cells in culture, J. Neural Transm. Suppl. 21 (1986) 433–449.

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

[39] J.B. Burch, J.S. Reif, C.W. Noonan, T. Ichinose, A.M. Bachand, T.L. Koleber, M.G. Yost, Melatonin metabolite excretion among cellular telephone users, Int. J. Rad. Biol. 78 (2002) 1029–1036.
[40] Girgert, et al., Induction of tamoxifen resistance in breast cancer cells by ELF electromagnetic fields, Biochem. Biophys. Res. Commun. 336 (2005) 1144–1149.
[41] Harland, et al., Environmental magnetic fields inhibit the antiproliferative action of tamoxifen and melatonin in a human breast cancer cell line, Bioelectromagnetics 18 (1997) 555–562.
[42] Harland, et al., Evidence for a slow time-scale of interaction for magnetic fields inhibiting tamoxifen's antiproliferative action in human breast cancer cells, Cell Biochem. Biophys. 31 (3) (1999) 295–306.
[43] A. Ilhan, A. Gurel, F. Armutcu, S. Kamisli, M. Iraz, O. Akyol, S. Ozen, Ginkgo biloba prevents mobile phone-induced oxidative stress in rat brain, Clin. Chim. Acta 340 (1–2) (2004) 153–162.
[44] Ishido, et al., Magnetic fields (MF) of 50 Hz at 1.2 μT as well as 100 μT cause uncoupling of inhibitory pathways of adenylyl cyclase mediated by melatonin 1a receptor in MF-sensitive MCF-7 cells, Carcinogenesis 22 (7) (2001) 1043–1048.
[45] H. Koylu, H. Mollaoglu, F.N. Ozguner, Melatonin modulates 900 Mhz microwave-induced lipid peroxidation changes in rat brain, Toxicol. Ind. Health 22 (5) (2006) 211–216.
[46] R.P. Liburdy, T.R. Sloma, et al., ELF magnetic fields, breast cancer, and melatonin: 60 Hz fields block melatonin's oncostatic action on ER+ breast cancer cell proliferation, J. Pineal Res. 14 (1993) 89–97.
[47] R.P. Liburdy, et al., Magnetic Fields, melatonin, tamoxifen and human breast cancer cell growth, in: R.G. Stevens, B.W. Wilson, L.E. Anderson (Eds.), The Melatonin Hypothesis—Breast Cancer and Use of Electric Power, Battelle Press, Columbus, Richland, 1997, pp. 669–700.
[48] L.I. Loberg, Gene expression in human breast epithelial cells exposed to 60 Hz magnetic fields, Carcinogenesis 20 (1999) 1633–1636.
[49] Luben, et al., Replication of 12 mG EMF effects on melatonin responses of MCF-7 breast cancer cells in vitro, in: Abstract A-1 of the 1996 Annual Review of Research on Biological Effects of Electric and Magnetic Fields from the Generation, Delivery and Use of Electricity, San Antonio, TX, November 17–21, 1996, p. 1.
[50] Luben, et al., Independent replication of 60-Hz 1.2 μT EMF effects on melatonin and tamoxifen responses of MCF-7 cells in vitro, in: Abstract A-3.4, Bioelectromagnetics Society Annual Meeting, St. Pete Beach, FL, June 7–11, 1998, pp. 17–18.
[51] Morris, In vitro exposure of MCF-7 human breast cancer cells to 60-Hz magnetic fields, in: Abstract p-125A, Bioelectromagnetics Society Annual Meeting, St. Pete Beach, FL, June 7–11, 1998, pp. 204–205.
[52] F. Oktem, F. Ozguner, H. Mollaoglu, A. Koyu, E. Uz, Oxidative damage in the kidney induced by 900-MHz-emitted mobile phone: protection by melatonin, Arch. Med. Res. 36 (4) (2005) 350–355.
[53] F. Ozguner, G. Aydin, H. Mollaoglu, O. Gokalp, A. Koyu, G. Cesur, Prevention of mobile phone induced skin tissue changes by melatonin in rat: an experimental study, Toxicol. Ind. Health 20 (6–10) (2004) 133–139.
[54] F. Ozguner, A. Altinbas, M. Ozaydin, A. Dogan, H. Vural, A.N. Kisioglu, G. Cesur, N.G. Yildirim, Mobile phone-induced myocardial oxidative stress: protection by a novel antioxidant agent caffeic acid phenethyl ester, Toxicol. Ind. Health 21 (9) (2005) 223–230.
[55] A.W. Guy, C.K. Chou, L.L. Kunz, J. Crowley. J. Krupp, Effects of long-term low-level radiofrequency radiation exposure on rats. US Air Force School of Aerospace Medicine Brooks Air Force Base, Texas TR-85-64 Final Report August 1985, Approved for public release: distribution is unlimited.
[56] C.K. Chou, Long-term low level microwave irradiation of rats, Bioelectromagnetics 13 (1992) 469–496.
[57] H. Dolk, et al., Cancer incidence near radio and television transmitters in Great Britain, Am. J. Epidemiol. 145 (1) (1997) 1–9.
[58] V. Garaj-Vrhovac, D. Horvat, Z. Koren, The relationship between colony-forming ability, chromosome aberrations and incidence of micronuclei in V79 Chinese hamster cells exposed to microwave radiation, Mutat. Res. 263 (3) (1991) 143–149.
[59] V. Garaj-Vrhovac, A. Fucic, D. Horvat, The correlation between the frequency of micronuclei and specific chromosome aberrations in human lymphocytes exposed to microwave radiation in vitro, Mutat. Res. 281 (3) (1992) 181–186.
[60] V. Garaj-Vrhovac, Micronucleus assay and lymphocyte mitotic activity in risk assessment of occupational exposure to microwave radiation, Chemosphere 39 (13) (1999) 2301–2312.
[61] M. Ha, H. Im, M. Lee, H.J. Kim, B.C. Kim, Y.M. Gimm, et al., Radio-frequency radiation exposure from AM radio transmitters and childhood leukemia and brain cancer, Am. J. Epidemiol. 166 (2007) 270–279.
[62] B. Hocking, et al., Cancer incidence and mortality and proximity to TV towers, Med. J. Aust. 165 (11–12) (1996) 601–605.
[63] B. Hocking, Decreased survival for childhood leukemia in proximity to TV towers, in: Poster Presented at the Annual Scientific Meeting of the Royal Australian College of Physicians in Adelaide, SA, Australia, May, 2000.
[64] D.E. Foliart, B.H. Pollock, G. Mezei, R. Iriye, J.M. Silva, K.L. Epi, L. Kheifets, M.P. Lind, R. Kavet, Magnetic field exposure and long-term survival among children with leukemia, Brit. J. Cancer 94 (2006) 161–164.
[65] A. Huss, A. Spoerri, M. Egger, Röösli for the Swiss national cohort study, residence near power lines and mortality from neurodegenerative diseases: longitudinal study of the Swiss population, Am. J. Epidemiol. (November) (2008) (Epub ahead of print).
[66] F. Marinelli, D. La Sala, G. Cicciotti, L. Cattini, C. Trimarchi, S. Putti, A. Zamparelli, L. Giuliani, G. Tomassetti, C. Cinti, Exposure to 900 MHz electromagnetic field induces an unbalance between pro-apoptotic and pro-survival signals in T-lymphoblastoid leukemia CCRF-CEM cells, J. Cell Physiol. 198 (2) (2004) 324–332.
[67] P. Michelozzi, C. Ancona, D. Fusco, F. Forastiere, C.A. Perucci, Risk of leukemia and residence near a radio transmitter in Italy, Epidemiology 9 (Suppl.) (1998) 354.
[68] M. Repacholi, et al., Lymphomas in Eμ-Pim1 transgenic mice exposed to pulsed 900 MHz electromagnetic fields, Radiat. Res. 147 (1997) 31–40.
[69] A. Stang, et al., The possible role of radiofrequency radiation in the development of uveal melanoma, Epidemiology 12 (1) (2001) 7–12.
[70] M. Blank (2007). Section 7, pp. 1–40. Evidence for Stress Response (Stress Proteins). In BioInitiative Report: A Scientific Perspective on Health Risk of Electromagnetic Fields. Published Online 31August 2007, http://www.bioinitiative.org/report/index.htm.
[71] C. Daniells, I. Duce, D. Thomas, P. Sewell, J. Tattersall, D. de Pomerai, Transgenic nematodes as biomonitors of microwave-induced stress, Mutat. Res. 399 (1998) 55–64.
[72] D. de Pomerai, et al., Non-thermal heat-shock response to microwaves, Nature 405 (2000) 417–418.
[73] S. Kwee, et al., The biological effects of microwave radiation, in: Proceedings of the Second World Congress for Electricity and Magnetism in Biology and Medicine, Bologna, Italy, June, 1997.
[74] S. Kwee, et al., Changes in cellular protiens due to environmental non-ionizing radiation. I. Heat-shock proteins, Electro Magnetobiol. 20 (2001) 141–152.
[75] D. Leszczynski, S. Oenväärä, J. Reivinen, R. Kuokka, Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: molecular mechanism for cancer- and blood–brain barrier-related effects, Differentiation 70 (2002) 120–129.
[76] D. Leszczynski, R. Nylund, S. Joenvaara, J. Reivinen, Applicability of discovery science approach to determine biological effects of mobile phone radiation, Proteomics 4 (2) (2004) 426–431.
[77] S. Lixia, Y. Ke, W. Kaijun, L. Dequiang, H. Huajun, G. Xiangwei, W. Baohong, Z. Wei, L. Jianling, W. Wei, Effects of 1.8 GHz

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

radiofrequency field on DNA damage and expression of heat shock protein 70 in human lens epithelial cells, Mutat. Res. (2006), doi:10.1016/j.mrfmmm.2006.08.010.

[78] M. Simko, C. Hartwig, M. Lantow, M. Lupke, M.O. Mattsson, Q. Rahman, J. Rollwitz, Hsp 70 expression and free radical release after exposure to non-thermal radiofrequency electromagnetic fields and ultrafine particles in human Mono Mac 6 cells, Toxicol. Lett. 161 (2006) 73–82 (Elsevier Science Direct).

[79] S. Velizarov, The effects of radiofrequency fields on cell proliferation are non-thermal, Bioelectrochem. Bioenerg. 48 (1999) 177–180.

[80] D. Weisbrot, H. Lin, L. Ye, M. Blank, R. Goodman, Effects of mobile phone radiation on reproduction and development in *Drosophila melanogaster*, J. Cell Biochem. 89 (1) (2003) 48–55.

[81] T. Olivares-Banuelos, L. Navarro, A. Gonzalez, R. Drucker-Colin, Differentiation of chromaffin cells elicited by ELF MF modifies gene expression pattern, Cell Biol. Int. 28 (2004) 273–279.

[82] R. Zhao, S. Zhang, Z. Xu, L. Ju, D. Lu, G. Yao, Studying gene expression profile of rat neuron exposed to 1800 MHz radiofrequency electromagnetic fields with cDNA microassay, Toxicology 235 (2007) 167–175.

[83] A. Karinen, S. Heinavaara, R. Nylund, D. Leszczynski, Mobile phone radiation might alter protein expression in human skin, BMC Genomics 9 (2008) 77, doi:10.1186/1471-2164-9-77.

[84] J. Vanderstraeten, L. Verschaeve, Gene and protein expression following exposure to radiofrequency fields from mobile phones, Environ. Health Persp. 116 (2008) 1131–1135.

[85] G. Abdel-Rassoul, O.A. El-Fateh, M.A. Salem, A. Michael, F. Farahat, M. El-Batanouny, E. Salem, Neurobehavioral effects among inhabitants around mobile phone base stations, Neurotoxicology 28 (2007) 434–440.

[86] P. Acherman, Exposure to pulsed high-frequency electromagnetic field during waking affects human sleep EEG, Neuroreport 11 (15) (2000) 3321–3325.

[87] E.S. Altpeter, T.H. Krebs, Study on health effects of the shortwave transmitter station of Schwarzenburg, Bern, Switzerland, University of Bern BEW Publications Study No. 56, The Federal Office of Energy, 1995.

[88] A.A. Borbely, et al., Pulsed high-frequency electromagnetic field affects human sleep and sleep electroencephalogram, Neurosci. Lett. 275 (3) (1999) 207–210.

[89] R. Huber, T. Graf, K.A. Cote, L. Wittmann, E. Gallmann, D. Matter, J. Schuderer, N. Kuster, A.A. Borbely, P. Achermann, Exposure to pulsed high-frequency electromagnetic field during waking affects human sleep EEG, Neuroreport 11 (15) (2000) 3321–3325.

[90] K. Mann, Effects of pulsed high-frequency electromagnetic fields on human sleep, Neuropsychobiology 33 (1996) 41–47.

[91] G. Oberfeld, The microwave syndrome—further aspects of a Spanish study, in: Proceedings of the Third International Workshop on Bioelectromagnetic Effects of Electromagnetic Fields, Kos, Greece, 2004.

[92] R. Santini, M. Seigne, L. Bonhomme-Faivre, S. Bouffet, E. Defrasne, M. Sage, Symptoms experienced by users of digital cellular phones: a pilot study in a French engineering school, Pathol. Biol. (Paris) 49 (3) (2001) 222–226.

[93] R. Santini, P. Santini, P. Le Ruz, J.M. Danze, M. Seigne, Survey study of people living in the vicinity of cellular phone base stations, Electromag. Biol. Med. 22 (2003) 41–49.

[94] TNO Physics and Electronics Laboratory, The Netherlands, Effects of Global Communication System Radio-frequency Fields on Well-being and Cognitive Functions of Human Beings With and Without Subjective Complaints, Netherlands Organization for Applied Scientific Research (2003), pp. 1–63.

[95] E.S. Altpeter, T.H. Krebs, Study on health effects of the shortwave transmitter station of Schwarzenburg, Bern, Switzerland, University of Bern BEW Publications Study No. 56, The Federal Office of Energy, Switzerland, 1995.

[96] S.E. Chia, Prevalence of headache among handheld cellular telephone users in Singapore: a community study, Environ. Health Persp. 108 (11) (2000) 1059–1062.

[97] H. Chiang, et al., Health effects of environmental electromagnetic fields, J. Bioelectr. 8 (1989) 127–131.

[98] H. D'Costa, et al., Human brain wave activity during exposure to radiofrequency field emissions from mobile phones, Aust. Phys. Eng. Sci. Med. 26 (4) (2003).

[99] H.P. Hutter, H. Moshammer, P. Wallner, M. Kundi, Subjective symptoms, sleeping problems and cognitive performance in subjects living near mobile phone base stations, Occup. Env. Med. 63 (2006) 307–313.

[100] M. Koivisto, et al., Effects of 902 MHz electromagnetic field emitted by cellular telephones on response times in humans, Neuroreport 11 (2000) 413–415.

[101] M. Koivisto, et al., The effects of electromagnetic field emitted by GSM phones on working memory, Neuroreport 11 (2002) 1641–1643.

[102] A.A. Kolodynski, V.V. Kolodynska, Motor and psychological functions of school children living in the area of the Skrunda radio location station in Latvia, Sci. Total Environ. 180 (1996) 87–93.

[103] C.M. Krause, L. Sillanmaki, M. Koivisto, A. Haggqvist, C. Saarela, A. Revonsuo, M. Laine, H. Hamalainen, Effects of electromagnetic field emitted by cellular phones on the EEG during a memory task, Neuroreport 11 (4) (2000) 761–764.

[104] C.M. Krause, L. Sillanmaki, M. Koivisto, A. Haggqvist, C. Saarela, A. Revonsuo, M. Laine, H. Hamalainen, Effects of electromagnetic fields emitted by cellular phones on the electroencephalogram during a visual working memory task, Int. J. Radiat. Biol. 76 (12) (2000) 1659–1667.

[105] J. Lass, et al., Effects of 7 Hz-modulated 450 MHz electromagnetic radiation on human performance in visual memory tasks, Int. J. Radiat. Biol. 73 (10) (2002) 937–944.

[106] A.A. Marino, E. Nilsen, C. Frilot, Nonlinear changes in brain electrical activity due to cell phone radiation, Bioelectromagnetics 24 (5) (2003) 339–346.

[107] G. Oberfeld, et al., The microwave syndrome—further aspects of a Spanish study, in: Proceedings of the Third International Workshop on Bioelectromagnetic Effects of Electromagnetic Fields, Kos, Greece, 2004.

[108] A. Preece, et al., Effect of a 915-MHz simulated mobile phone signal on c function in man, Int. J. Radiat. Biol. 75 (1999) 447–456.

[109] S.J. Regel, S. Negovetic, M. Roosli, V. Berdinas, J. Schuderer, A. Huss, U. Lott, N. Kuster, P. Achermann, UMTS base station-like exposure, well-being and cognitive performance, Environ. Health Persp. 114 (2006) 1270–1275.

[110] S. Eltiti, D. Wallace, A. Ridgewell, K. Zougkou, R. Russo, F. Sepulveda, D. Mirshekar-Syahkal, P. Rasor, R. Deeble, E. Fox, Does short-term exposure to mobile phone base station signals increase symptoms in individuals who report sensitivity to electromagnetic fields? A double-blind randomized provocation study, Environ. Health Persp. 115 (2007) 1603–1608.

[111] E.F. Pace-Schott, J.A. Hobson, The neurobiology of sleep: genetics, cellular physiology and subcortical networks, Nat. Rev. Neurosci. 3 (2002) 591–605.

[112] J.B. Burch, J.S. Reif, C.W. Noonan, T. Ichinose, A.M. Bachand, T.L. Koleber, M.G. Yost, Melatonin metabolite excretion among cellular telephone users, Int. J. Radiat. Biol. 78 (2002) 1029–1036.

[113] M.L. Clark, J.B. Burch, M.G. Yost, Y. Zhai, A.M. Bachand, C.T. Fitzpatrick, J. Ramaprasad, L.A. Cragin, J.S. Reif, Biomonitoring of estrogen and melatonin metabolites among women residing near radio and television broadcasting transmitters, J. Occup. Environ. Med. 49 (2007) 1149–1156.

[114] L.M. Wang, N.A. Suthana, D. Chaudhury, D.R. Weaver, C.S. Colwell, Melatonin inhibits hippocampal long-term potentiation, Eur. J. Neurosci. 22 (2005) 2231–2237.

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

[115] M. Ozcan, B. Yilmaz, D.O. Carpenter, Effects of melatonin on synaptic transmission and long term potentiation in two areas of mouse hippocampus, Brain Res. 1111 (2006) 90–94.
[116] R.J. Reiter, L. Tang, J.J. Garcia, A. Munoz-Hoyos, Pharmacological actions of melatonin in oxygen radical pathophysiology, Life Sci. 60 (1997) 2255–2271.
[117] C.W. Noonan, J.S. Reif, J.B. Burch, T.Y. Ichinose, M.G. Yost, K. Magnusson, Relationship between amyloid beta protein and melatonin metabolite in a study of electric utility workers, J. Occup. Environ. Med. 44 (2002) 769–775.
[118] L.G. Salford, A.E. Brun, et al., Nerve cell damage in mammalian brain after exposure to microwaves from GSM mobile phones, Environ. Health Persp. 111 (2003) 881–883.
[119] J.L. Eberhardt, B.R.R. Persson, A.E. Brun, L.G. Salford, L.O.G. Malmgren, Blood–brain barrier permeability and nerve cell damage in rat brain 14 and 28 days after exposure to microwaves from GSM mobile phones, Electromagn. Biol. Med. 27 (2008) 215–229. doi:10.1080_1536370802344037.
[120] L.G. Salford, et al., Permeability of the blood brain barrier induced by 915 MHz electromagnetic radiation continuous wave and modulated at 8, 16, 50 and 200 Hz, Microsc. Res. Tech. 27 (1994) 535–542.
[121] A. Schirmacher, Electromagnetic fields (1.8 GHz) increase the permeability of sucrose of the blood–brain barrier in vitro, Bioelectromagnetics 21 (2000) 338–345.
[122] Y. Hamnerius, Microwave exposure from mobile phones and base stations in Sweden, in: Proceedings of the International Conference on Cell Tower Siting, sponsored by the University of Vienna & Land-Salzburg, Salzburg, Austria, June 7–8, 2000.
[123] E.D. Mantiply, Summary of measured radiofrequency electric and magnetic fields (10 kHz–30 GHz) in the general and work environment, Bioelectromagnetics 18 (1997) 563–577.
[124] Sage Associates, 2004. An Overview of Low-intensity radiofrequency/microwave radiation studies relevant to wireless communications and data, Bioelectromagnetics Society Annual Meeting, Washington DC, June, 2004.
[125] C. Sage, O. Johansson, S.A. Sage, Personal digital assistant (PDA) cell phone units produce elevated extremely-low frequency electromagnetic field emissions, Bioelectromagnetics 28 (7) (2007) 581–582.
[126] C. Sage, O. Johansson, Response to comment on personal digital assistant (PDA) cell phone units produce elevated extremely-low frequency electromagnetic field emissions, Bioelectromagnetics (July) (2007), 17654541.
[127] C. Sage, O. Johansson, Response to comment on measuring ELF fields produced by mobile phones and personal digital assistants (PDAs), Bioelectromagnetics (July) (2007), 17654536.
[128] M. Tuor, S. Ebert, J. Schuderer, N. Kuster, Assessment of ELF magnetic fields from five mobile handsets, in: ITIS Foundation, Conference Presentation, Monte Verita, 2005.
[129] T. Linde, K.H. Mild, Measurement of low frequency magnetic fields from digital cellular telephones, Bioelectromagnetics 18 (1997) 184–186 (Brief communication).
[130] B. Armstrong, G. Theriault, P. Guenel, J. Deadman, M. Goldberg, P. Heroux, Association between exposure to pulsed electromagnetic fields and cancer in electrical utility workers in Ontario and Quebec, Canada, and France 1970–1989, Am. J. Epidemiol. 140 (1994) 805–820.
[131] G.M. Lee, R.R. Neutra, L. Hristova, M. Yost, R.A. Hiatt, A nested case–control study of residential and personal magnetic field measures and miscarriages, Epidemiology 13 (1) (2002) 21–31.
[132] K.D. Li, R. Oudouli, S. Wi, T. Janevic, I. Golditch, T.D. Bracken, R. Senior, R. Rankin, R. Iriye, A population-based prospective cohort study of personal exposure to magnetic fields during pregnancy and the risk of spontaneous abortion, Epidemiology 13 (2002) 9–20.
[133] G. Theriault, M. Goldberg, A.B. Miller, B. Armstrong, P. Guenel, J. Deadman, E. Imbernon, T. To, A. Chevalier, D. Cyr, C. Wall, Cancer risks associated with occupational exposure to magnetic fields among utility workers in Ontario and Quebec, Canada and France: 1970–1989, Am. J. Epidemiol. 139 (1994) 550–572.
[134] P. Michelozzi, A. Capon, U. Kirchmayer, F. Forastiere, A. Biggeri, A. Barca, C.A. Perucci, Adult and childhood leukemia near a high-power radio station in Rome, Italy, Am. J. Epidemiol. 155 (2002) 1096–1103.
[135] M. Ha, H. Im, M. Lee, H.J. Kim, B.C. Kim, Y.M. Gimm, J.K. Pack, Radio-frequency radiation exposure from AM radio transmitters and childhood leukemia and brain cancer, Am. J. Epidemiol. 166 (2007) 270–279.
[136] C. Sage, D.O. Carpenter (Eds.), BioInitiative Working Group BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF), 2007. www.bioinitiative.org.;
C. Blackman, H. Lai, Chapters 6 and 14 of the BioInitiative Report, 2007.
[137] A. Chiabrera, B. Bianco, E. Moggia, J.J. Kaufman, Bioelectromagnetics 21 (4) (2000) 312–324.
[138] D.J. Panagopoulos, L.H. Margaritis, in: A.C. Harper, R.V. Buress (Eds.), Mobile Telephony Radiation Effects on Living Organisms, 2008, pp. 107–149. ISBN 978:1-60456-436-5.
[139] W.R. Adey, in: P.J. Rosch, M.S. Markov (Eds.), Potential Therapeutic Applications of Nonthermal Electromagnetic Fields: Ensemble Organization of Cells in Tissue as a Factor in Biological Field Sensing, Bioelectromagnetic Medicine, 2004, pp. 1–16.
[140] S. Engstrom, in: P.J. Rosch, M.S. Markov (Eds.), Magnetic Field Generation and Dosimetry, Bioelectromagnetic Medicine, 2004, pp. 39–50.
[141] A. Pilla, in: F.S. Barnes, B. Greenebaum, (Eds.), Mechanisms and Therapeutic Applications of Time-varying and Static Magnetic Fields in Biological and Medical Aspects of Electromagnetic Fields, third edition, 2007, pp. 351–412.
[142] M. Blank, R. Goodman, Initial interactions in electromagnetic field-induced biosynthesis, J. Cell. Physiol. 199 (2004) 359–363.
[143] M. Blank, R. Goodman, A biological guide for electromagnetic safety: the stress response electromagnetic initiation of transcription at specific DNA sites, Bioelectromagnetics 25 (2004) 642–646.
[144] M. Blank, BEMS Soc. Newslett. (January–February) (2008) 6–7.
[145] G. Lotz, Letter from Greg Lotz, PhD, Chief Physical Agents Effects Branch, Division of Biomedical and Behavioral Science, National Institute of Occupational Safety and Health to Richard Tell, Chair, IEEE SCC28 (SC4) Risk Assessment Work Group, June 17, 1999.
[146] P. Grandjean, Implications of the precautionary principle for primary prevention and research, Am. Rev. Public Health 25 (2004) 199–223.
[147] D. Davis, The Secret History of the War on Cancer, Basic Books, 2008.
[148] R. Proctor, Cancer Wars, Harper Collins Publishers, 1995.
[149] European Environmental Agency, Late Lessons from Early Warnings. The Precautionary Principle 1896–2000. Copenhagen, Denmark, 2001.
[150] P. Landrigan, How much do chemicals affect our health? Discover Mag. (2008).
[151] California Air Resources Board, Appendix III Proposed Identification of Environmental Tobacco Smoke as a Toxic Air Contaminant. Part B—Health Effects, 2005.

Please cite this article in press as: C. Sage, D.O. Carpenter, Public health implications of wireless technologies, Pathophysiology (2009), doi:10.1016/j.pathophys.2009.01.011

Sleep EEG alterations: effects of different pulse-modulated radio frequency electromagnetic fields

MARC R. SCHMID[1,2,*], SARAH P. LOUGHRAN[1,*], SABINE J. REGEL[1], MANUEL MURBACH[3], ALEKSANDRA BRATIC GRUNAUER[1,2], THOMAS RUSTERHOLZ[1,2], ALESSIA BERSAGLIERE[1,2], NIELS KUSTER[3] and PETER ACHERMANN[1,2,4]

[1]Institute of Pharmacology and Toxicology, University of Zurich, Zurich, Switzerland, [2]Neuroscience Center Zurich, University and ETH Zurich, Zurich, Switzerland, [3]IT'IS Foundation, Zurich, Switzerland and [4]Zurich Center for Integrative Human Physiology, University of Zurich, Zurich, Switzerland

Keywords
cognition, electroencephalogram, mobile phone, spectral power, spindle frequency

Correspondence
Peter Achermann, Institute of Pharmacology and Toxicology, University of Zurich, Winterthurerstrasse 190, CH-8057 Zurich, Switzerland.
Tel.: +41-44-63-559-54;
fax: +41-44-63-557-07;
e-mail: acherman@pharma.uzh.ch
*M. R. S. and S. P. L. contributed equally to this study.

Accepted in revised form 12 March 2011; received 1 November 2010

DOI: 10.1111/j.1365-2869.2011.00918.x

SUMMARY

Previous studies have observed increases in electroencephalographic power during sleep in the spindle frequency range (approximately 11–15 Hz) after exposure to mobile phone-like radio frequency electromagnetic fields (RF EMF). Results also suggest that pulse modulation of the signal is crucial to induce these effects. Nevertheless, it remains unclear which specific elements of the field are responsible for the observed changes. We investigated whether pulse-modulation frequency components in the range of sleep spindles may be involved in mediating these effects. Thirty young healthy men were exposed, at weekly intervals, to three different conditions for 30 min directly prior to an 8-h sleep period. Exposure consisted of a 900-MHz RF EMF, pulse modulated at 14 Hz or 217 Hz, and a sham control condition. Both active conditions had a peak spatial specific absorption rate of 2 W kg^{-1}. During exposure subjects performed three different cognitive tasks (measuring attention, reaction speed and working memory), which were presented in a fixed order. Electroencephalographic power in the spindle frequency range was increased during non-rapid eye movement sleep (2nd episode) following the 14-Hz pulse-modulated condition. A similar but non-significant increase was also observed following the 217-Hz pulse-modulated condition. Importantly, this exposure-induced effect showed considerable individual variability. Regarding cognitive performance, no clear exposure-related effects were seen. Consistent with previous findings, our results provide further evidence that pulse-modulated RF EMF alter brain physiology, although the time-course of the effect remains variable across studies. Additionally, we demonstrated that modulation frequency components within a physiological range may be sufficient to induce these effects.

INTRODUCTION

Mobile phones have become important devices of modern communication. As a result of the widespread increase in use of this technology, concerns have been raised regarding the potential impact on human health, particularly on the CNS. Despite numerous studies having been performed to address this issue, it still remains unclear how and to what extent the human brain is affected by radio frequency electromagnetic fields (RF EMF) emitted by mobile phones.

Several experiments have revealed short-term changes in electroencephalographic (EEG) spectral power during both waking (Croft *et al.*, 2002, 2008, 2010; Curcio *et al.*, 2005; Regel *et al.*, 2007a) and sleep (Borbély *et al.*, 1999; Huber *et al.*, 2000, 2002; Loughran *et al.*, 2005; Regel *et al.*, 2007b) in conjunction with exposures to mobile phone-like RF EMF.

Particularly in relation to sleep, which is also the focus of the current study, it should be noted that some studies have failed to find any RF EMF exposure-related effects on the EEG (Fritzer *et al.*, 2007; Wagner *et al.*, 1998, 2000). However, when study and statistical methodologies are taken into account, as well as dosimetric and exposure parameters, the studies that have given greater emphasis to these important factors have consistently shown RF EMF-induced effects on EEG spectral power during sleep (Borbély *et al.*, 1999; Huber *et al.*, 2000, 2002; Loughran *et al.*, 2005; Regel *et al.*, 2007b). This increase in EEG power has been shown during and following RF EMF exposures, and has mostly been observed in the spindle frequency range during non-rapid eye movement (NREM) sleep (approximately 11–15 Hz). One recent study also suggested that the increase in EEG spectral power may be dose dependent (Regel *et al.*, 2007b). Other results indicate that pulse modulation of the RF EMF, as employed by the most widely used system for mobile telephony (Global System for Mobile Communications, GSM), is crucial to induce changes in brain activity, as continuous wave exposure at the same intensities did not induce any effects on the EEG (Huber *et al.*, 2002; Regel *et al.*, 2007a). Despite these consistent exposure-related enhancements of EEG power in the spindle frequency range during sleep, it should be noted that the time-course of the effect has been somewhat variable across studies, with effects observed at several different time-points, as well as throughout the sleep period (Borbély *et al.*, 1999; Huber *et al.*, 2000, 2002; Loughran *et al.*, 2005; Regel *et al.*, 2007b). Overall, these previous studies indicate that pulse-modulated RF EMF exposure does have an influence on the sleep EEG, which is in line with two recent reviews that also conclude there is sufficient evidence of exposure-related effects (Valentini *et al.*, 2007; Van Rongen *et al.*, 2009).

In addition to changes in brain activity, changes in cognitive performance in response to RF EMF exposures have previously been reported, most notably in relation to reaction speed and accuracy of performance in various cognitive tasks. However, the findings have been largely inconsistent, with some studies showing improvements (e.g. Koivisto *et al.*, 2000; Preece *et al.*, 1999), some showing impairments (e.g. Regel *et al.*, 2007b), and others finding no measureable effects (e.g. Haarala *et al.*, 2003, 2004). These conflicting reports have led to uncertainty regarding potential effects on cognition; however, a recent meta-analysis by Valentini *et al.* (2010) concluded that mobile phone-like RF EMF exposure does not seem to cause cognitive effects.

Overall, while no consistent effects on cognition have been observed, studies have repeatedly shown similar effects of mobile phone-like RF EMF exposures on the EEG. The observation that pulse-modulated, but not continuous wave, RF EMF affects the EEG in sleep points towards a non-thermal biological mechanism in which pulse modulation plays an important role. However, it remains unclear which components of the RF EMF could be responsible for the changes seen in EEG spectral power, or whether the strength of certain low-frequency modulation components or the crest factor (the ratio between pulse peak power and time-averaged power) of the applied field are key elements to induce an effect.

The present study aimed to investigate which field parameters may be responsible for the previously reported results on electrical brain activity during sleep, while also providing an indication of the underlying mechanisms involved. We hypothesized that pulse-modulation components in the sleep spindle frequency range (e.g. 14 Hz) could act as potential mediators, as the majority of previous studies found an influence of RF EMF exposure in this frequency range. Additionally, we investigated pulse modulation at 217 Hz, as this is the strongest component of the GSM signal and has been consistently included in the exposure signal of previous studies reporting effects on EEG spectral power. Cognitive tasks were also implemented during exposure with the aim to address previous inconclusive results regarding the effects of exposure to pulse-modulated RF EMF on cognition.

MATERIALS AND METHODS

Subjects

Thirty young healthy men, aged between 20 and 26 years [mean age 23.0 ± 0.3 years (±SEM)] were recruited by advertisement at the University of Zurich and ETH Zurich. All subjects were right-handed, non-smokers and free of sleep complaints, drugs or medication. All participants owned a mobile phone and reported to use it <2 h per week (average use 41.1 ± 6.2 min per week).

A screening night was performed to identify and exclude subjects with sleep disturbances (sleep apnoea and nocturnal myoclonus) and sleep efficiency of <80%. Participants had to abstain from caffeine and alcohol consumption, and adhere to regular bedtimes (8 h, according to their scheduled bedtime in the sleep lab) starting 3 days before the study. Compliance was controlled by breath alcohol tests, wrist-worn actimeters and sleep logs. On all study days physical exercise had to be avoided, and on the exposure days mobile phone calls were prohibited. The study protocol was approved by the cantonal ethical committee, and participants gave their written informed consent and were recompensed upon completion of the study.

Study procedure

The study was carried out in the sleep laboratory of the Institute of Pharmacology and Toxicology, University of Zurich. The protocol consisted of six study nights (three exposure nights at weekly intervals, each preceded by an adaptation night). Because only two persons could be exposed simultaneously, participants were divided into pairs and scheduled at different times for the exposure. Therefore, respective bedtimes were either from 22:40 to 06:40 hours or 23:20 to 07:20 hours, with each participant assigned to the same time schedule for exposure and

sleep throughout the study. During exposure subjects performed three different cognitive tasks while their heads were positioned between two planar antennas. Exposure lasted 30 min and ended 10 min before subjects had to go to bed. After exposure subjects were asked to indicate whether they were able to perceive a field. Prior to bedtime and after waking up in the morning, subjects filled in questionnaires rating their current mood state and wellbeing on a visual analogue scale.

Exposure conditions

Three exposure conditions were applied in a partially balanced, randomized double-blind crossover design: (i) a pulse-modulated RF EMF at 14 Hz (crest factor = 30.95, pulse width = 2.3 ms); (ii) a pulse-modulated RF EMF at 217 Hz (crest factor = 8, pulse width = 0.577 ms); and (iii) a sham condition. A broader pulse width was used in the 14-Hz condition due to safety considerations. Both active field conditions were applied at the left side of the subject's head with a carrier frequency of 900 MHz and a time-average peak spatial specific absorption rate (SAR, 10 g average) of 2 W kg^{-1} (for detailed SAR distribution, see Huber *et al*., 2003, 2005; Boutry *et al*., 2008; note that the illustrated exposed hemisphere is the opposite to that of the current study, and that 0 dB now equals 2 W kg^{-1}), corresponding to the exposure limit for the general public (International Commission on Non-Ionizing Radiation Protection., 1998). Higher harmonics were present due to the rectangular pulse structures (for details on signal characteristics, see Fig. 1).

To ensure a well-defined position with respect to the two planar antennas, the subjects' heads were positioned between two plates such that the centre of the antenna was 42 mm vertically above the ear canal at a distance of 115 mm from the head (Huber *et al*., 2000, 2003). Electrode leads were placed horizontally to the emitted field in order to minimize any possible interference of the RF EMF. To avoid acoustic perception of the active field conditions, a brown noise (spectral density proportional to $1/f^2$) was generated by a loudspeaker in the exposure room. Average sound pressure levels were estimated to be <35 dB without noise (below threshold of the device), and 43 ± 2 dB with applied brown noise at the level of the subjects' heads.

Polysomnographic recordings

During 8 h of nighttime sleep we continuously recorded the EEG (derivation C3A2), electrooculogram, electromyogram (EMG; mental or submental) and electrocardiogram (ECG) with a polygraphic amplifier Artisan (Micromed, Mogliano Veneto, Italy). The analogue signals were conditioned by a

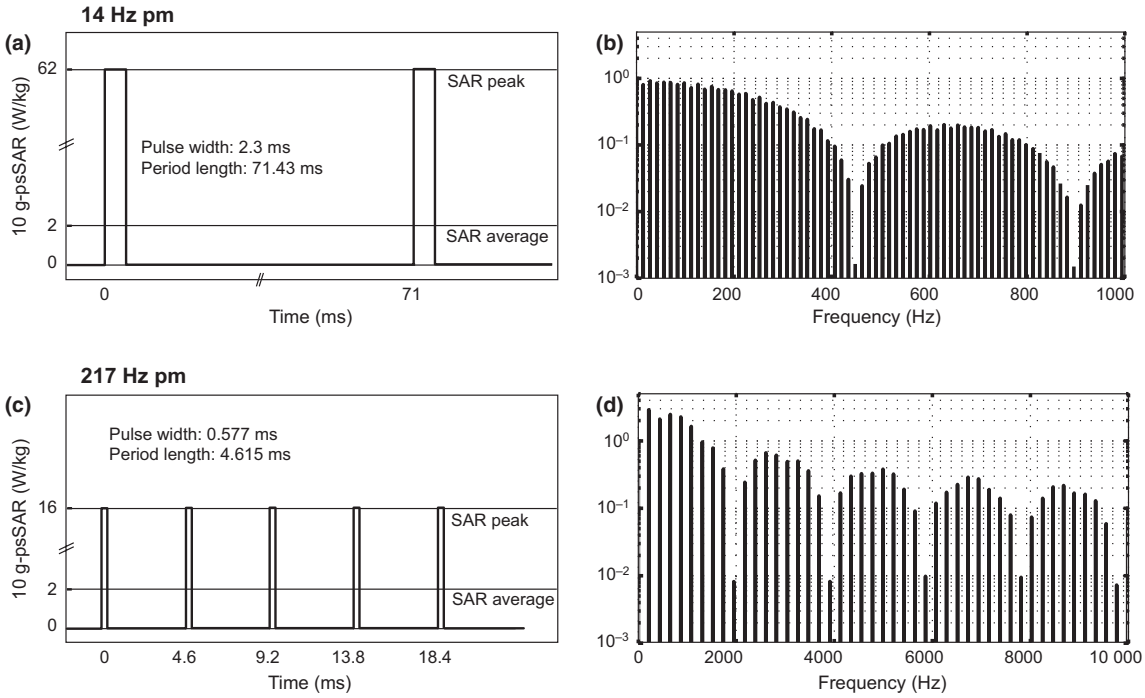


Figure 1. Signal characteristics of the two applied field conditions and their corresponding amplitude spectra. The 10 g peak spatial specific absorption rate (SAR) was 2 W kg^{-1} for both signals. (a) Pulse structures of the 14-Hz pulse-modulated RF EMF. Pulse width was 2.3 ms with a SAR peak of 61.9 W kg^{-1}. The crest factor (ratio of pulse peak power to average power) was 30.95. (b) Amplitude spectra of the envelope (normalized to 100 at 0 Hz, as in Huber *et al*., 2005) of the 14-Hz pulse-modulated (pm) RF EMF. (c) Pulse structures of the 217-Hz pulse-modulated RF EMF. Pulse width was 0.577 ms with a SAR peak of 16 W kg^{-1} and crest factor of 8. (d) Amplitude spectra of the envelope of the 217-Hz pm RF EMF.

high-pass filter (EEG: −3 dB at 0.15 Hz; EMG: 10 Hz; ECG: 1 Hz) and an anti-aliasing low-pass filter (−3 dB at 67.2 Hz), digitized at 256 Hz, and transmitted via fibre-optic cables to a computer, running the software Rembrandt DataLab (Version 8.0; Embla Systems, Broomfield, CO, USA).

Visual scoring of 20-s epochs was performed according to the criteria of Rechtschaffen and Kales (1968). Sleep cycles were defined according to Feinberg and Floyd (1979). EEG power spectra of consecutive 20-s epochs (FFT routine, Hanning window, averages of five 4-s epochs) were computed, and artefacts were removed both visually and with a semi-automatic procedure (Huber *et al*., 2000). The frequency resolution was 0.25 Hz, and frequencies between 0.75 and 20 Hz were analysed.

Mean power spectra of NREM and stage 2 sleep (for the first four NREM sleep episodes) were calculated and analysed with linear mixed models (SAS 9.1.3; SAS Institute, Cary, NC, USA), presuming an identical intraclass correlation for all subjects. We included the factors *Condition* (sham, 14-Hz and 217-Hz pulse modulation) and *Order* (sequence of applied conditions), as well as their interaction. Where the factor *Condition* or the interaction *Condition* × *Order* was significant, *post hoc* paired *t*-tests were performed (level of significance $\alpha < 0.05$). Additionally, analyses of the temporal evolution of the spectral power in the two specific frequency bands where an effect was observed (11–11.5 Hz, 12.75–13 Hz) were performed across the first four NREM sleep episodes. The linear mixed model included the factors *Condition*, *Episode* (1–4) and the *Condition* × *Episode* interaction.

As spindle peak locations in the power density spectra vary considerably among individuals, individual peaks were detected in the range from 10 to 15 Hz based on whole-night power density spectra of stage 2 sleep. If more than one peak was present (observed in five of 29 participants), the peak with the higher frequency was selected (due to effects most commonly being observed in the fast spindle frequency range). Corresponding spindle peak power was calculated in stage 2 sleep of NREM sleep episodes as power in the range of ±0.5 Hz around the peak for each subject.

For rapid eye movement (REM) sleep, average power spectra were calculated and analysed for each episode with linear mixed models using the factors *Condition*, *Order* and the corresponding interaction. Subjects who had <5 min of artefact-free epochs within a REM sleep episode were excluded for that episode. Furthermore, outliers with relative EEG power changes of more than 100% compared with sham were excluded (based on the most consistent changes in NREM sleep in the current study being of a magnitude of 80% or less). The first REM sleep episode was not considered, due to an insufficient number of subjects reaching the 5-min criterion ($n = 9$). Twenty subjects contributed to episodes 2 and 4, and 21 to episode 3.

Sleep variables as derived from visual scoring (Tables 1 and 2) were analysed with a linear mixed model ANOVA including the factors *Condition*, *Order* and their interaction. One subject was excluded from the sleep analysis due to insufficient sleep efficiency in all three exposure nights. Heart rate was derived from R–R intervals detected in the ECG and averaged for each NREM and REM sleep episode. Analysis was performed as for the power spectral data.

Table 1 Sleep variables as derived from visual scoring

	Sham	*14-Hz pm*	*217-Hz pm*
Total sleep time (min)	456.5 (2.4)	454.3 (2.1)	456.3 (2.5)
Sleep latency (min)	13.8 (2.2)	14.4 (1.7)	15.2 (2.7)
REM sleep latency (min)	73.0 (2.8)	71.2 (2.7)	68.7 (2.3)
Waking after sleep onset (min)	3.5 (1.5)	4.7 (1.5)	2.2 (0.6)
Stage 2 (min)	200.9 (5.9)	201.0 (4.9)	206.9 (5.6)
Slow wave sleep (min)	120.3 (5.5)	119.8 (4.8)	118.6 (3.8)
REM sleep (min)	121.6 (4.1)	120.1 (2.9)	116.8 (4.9)
Movement time (min)	6.9 (0.6)	6.5 (0.6)	6.5 (0.5)
Sleep efficiency (%)	95.0 (0.5)	94.6 (0.4)	95.0 (0.5)

Data are provided in minutes with standard error of the mean in parentheses ($n = 29$). Sleep efficiency is given as a percentage of total sleep time. Sleep latency was measured as interval from lights off to the first occurrence of stage 2. Rapid eye movement (REM) sleep latency was measured from sleep onset to the first occurrence of REM sleep. Slow wave sleep includes stages 3 and 4 of non-rapid eye movement sleep. Time in bed was 8 h. No significant differences between the exposure conditions were observed.

Table 2 Amount of NREM, REM and stage 2 sleep per sleep cycle

	Sham	*14-Hz pm*	*217-Hz pm*
Cycle 1			
NREMS (min)	73.0 (2.8)	71.2 (2.7)	68.7 (2.3)
REMS (min)	15.7 (2.7)	13.8 (2.2)	14.8 (2.0)
Stage 2 (%)	24.2 (1.7)	23.7 (1.6)	23.6 (1.9)
Cycle 2			
NREMS (min)	76.5 (2.9)	76.8 (2.5)	79.5 (2.3)
REMS (min)	30.8 (2.5)	30.8 (2.4)	29.7 (2.9)
Stage 2 (%)	52.8 (4.1)	50.4 (3.6)	53.5 (3.1)
Cycle 3			
NREMS (min)	75.4 (2.6)	75.2 (2.6)	71.5 (2.3)
REMS (min)	34.3 (2.7)	34.1 (3.1)	35.3 (3.1)
Stage 2 (%)	76.0 (2.9)	72.9 (2.6)	74.7 (2.7)
Cycle 4			
NREMS (min)	61.0 (1.8)	61.1 (1.9)	61.8 (2.5)
REMS (min)	39.8 (3.5)	44.9 (3.4)	40.7 (4.8)
Stage 2 (%)	74.9 (3.3)	80.4 (3.6)	76.6 (3.1)

Non-rapid eye movement sleep (NREMS) and rapid eye movement sleep (REMS) durations are provided in minutes, and stage 2 sleep provided as the proportion of NREMS (%), with standard error of the mean in parentheses ($n = 29$). Not every participant reached four full sleep cycles (defined as having at least 5 min of REMS), therefore different numbers of participants contributed to the amount of REMS in sleep cycle 4 (sham: $n = 22$; 14-Hz pm: $n = 28$; 217-Hz pm: $n = 26$). No significant differences between the exposure conditions were observed.

Cognitive tasks

During the 30 min of exposure, subjects performed three different cognitive tasks ['simple reaction time task' (SRT); '2-choice reaction time task' (CRT); '*N*-back task' (*N*-back)]. To assess possible changes that might occur during exposure, the 30 min was divided into two 15-min sessions in which each task was presented twice in a fixed order (SRT, CRT, 1-, 2-, 3-back). In the SRT, subjects had to press a '0' on the response box with the right index finger whenever a '0' appeared on the screen. During the CRT, they had to press a 'J' or 'N' button (right index and middle finger) on the response box whenever 'JA' (yes) or 'NEIN' (no) was shown on the screen. The *N*-back task included three levels showing a one-by-one random sequence of consonants, and subjects had to compare the current letter with the letter one, two or three trials back and respond by pressing 'J' for same letters or 'N' for different letters. The cognitive tasks were applied and analysed as described by Regel *et al.* (2007b). As residuals of speed [1/reaction time, (1/s)] for SRT were not normally distributed, a non-parametric Wilcoxon-signed-rank test was performed to compare the two exposure conditions with sham for sessions 1 and 2, and the difference between the two sessions. For the CRT and *N*-back a linear mixed model ANOVA was performed, which included the factors *Condition* (sham, 14 Hz, 217 Hz), *Session* (1, 2), *Order* (sequence of applied conditions), as well as interaction effects. Significant differences were further analysed by *post hoc* paired *t*-tests. Accuracy (percentage of correct answers) for the CRT and *N*-back tasks was statistically analysed with non-parametric Wilcoxon-signed-rank tests. Comparisons of both exposure conditions versus sham were performed for sessions 1 and 2, and the difference between the two sessions. Multiple endpoint adjustment for cognitive outcomes was performed as in Regel *et al.* (2007b), and the significance level was adjusted accordingly to $P < 0.015$. One subject had to be excluded from the analysis of the cognitive tasks because one session could not be started on time due to software problems.

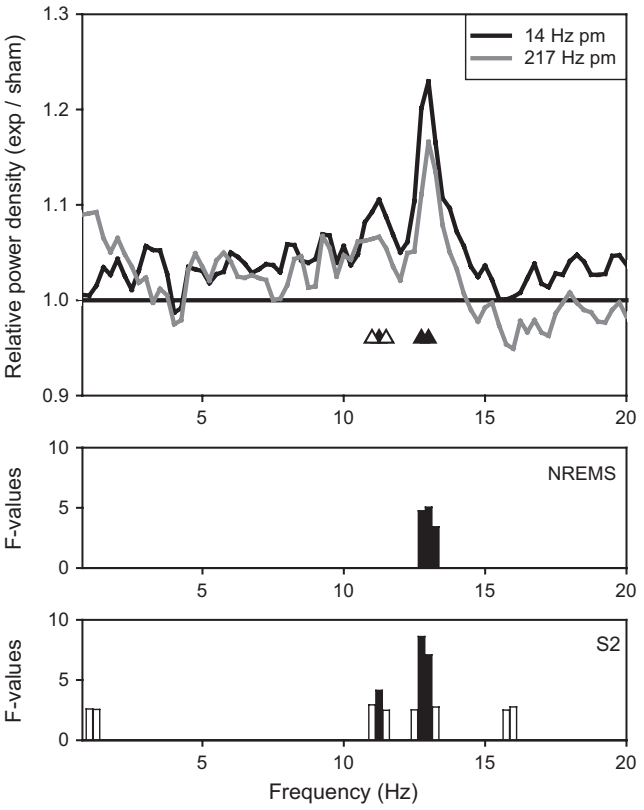


Figure 2. Average relative EEG power density spectra (derivation C3A2, 0.25-Hz bins, $n = 29$) for stage 2 sleep during the second non-rapid eye movement (NREM) sleep episode [14-Hz pulse modulation (pm): black; 217-Hz pm: grey] expressed relative to the sham condition (sham = 1.0). Statistical analysis revealed an increase within the spindle frequency range during NREM sleep (NREMS: 12.75–13.25 Hz; spectra are basically superimposed on the stage 2 spectra and therefore for clarity are not shown) and stage 2 (S2: 11.25 Hz and 12.75–13 Hz) of the second NREM sleep episode following the 14-Hz pulse-modulated condition. *F*-values ($P < 0.05$, black bars; $P < 0.1$, open bars) of the analysis with linear mixed model ANOVA (factor *Condition*) are illustrated. Frequency bins following the 14-Hz pulse-modulated condition that were significantly different from sham (paired *t*-test) are indicated with black triangles ($P < 0.05$), trends with open triangles ($P < 0.1$).

RESULTS

Sleep variables and subjective measures

Spectral analysis of the sleep EEG revealed an increase of power in the spindle frequency range following exposure in the second NREM sleep episode [*Condition*, $F_{2,58} > 3.42$, $P < 0.04$ (NREM); $F_{2,58} > 4.14$, $P < 0.03$ (stage 2)]. *Post hoc* analyses revealed that this increase was significant in both stage 2 and NREM sleep following the 14-Hz pulse-modulation condition ($P < 0.05$: 12.75–13.25 Hz in NREM sleep; $P < 0.05$: 11.25, 12.75–13 Hz in stage 2 sleep; Fig. 2). The maximum increase for both NREM and stage 2 sleep was seen at 13 Hz, with a magnitude of 18% and 23%, respectively. Trend level increases (approximately 11%) were also observed in several adjacent frequency bins ($P < 0.1$: 11 and 11.5 Hz in stage 2 sleep). A similar increase in spectral power was observed following the 217-Hz pulse-modulation condition (approximately 16%); however, it did not reach significance.

The temporal evolution of the effect following the 14-Hz pulse modulation was analysed for the first four NREM sleep episodes in the affected frequency ranges in stage 2 sleep (slow spindle range: 11–11.5 Hz; fast spindle range: 12.75–13 Hz). Statistical analysis revealed a significant *Condition* effect ($F_{1,203} = 4.75$, $P = 0.031$) for the fast spindle range only. *Post hoc* analysis showed a significant increase of power in the second NREM sleep episode ($P = 0.008$; Fig. 3).

The effect was further explored for each individual's spindle peak in the power density spectra (power ± 0.5 Hz around peak) in stage 2 sleep of the second NREM sleep episode. A relative increase or decrease was arbitrarily

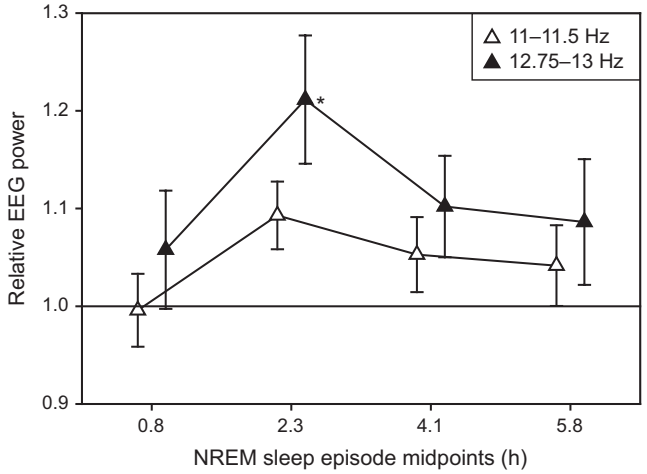


Figure 3. Temporal evolution of EEG spectral power (mean ± SEM) following the 14-Hz pulse-modulation condition relative to sham (sham = 1.0) in the first four NREM sleep episodes within the two affected frequency ranges (slow spindle range: 11–11.5 Hz, open triangles; fast spindle range: 12.75–13 Hz, black triangles) of stage 2 sleep. NREM sleep episode midpoints are indicated in hours after lights off (0.84, 2.32, 4.09 and 5.79 h). Linear mixed model ANOVA followed by a *post hoc* paired *t*-test performed separately for the two bands showed a significant difference in the second NREM sleep episode for the fast spindle range only (*$P = 0.008$, paired *t*-test).

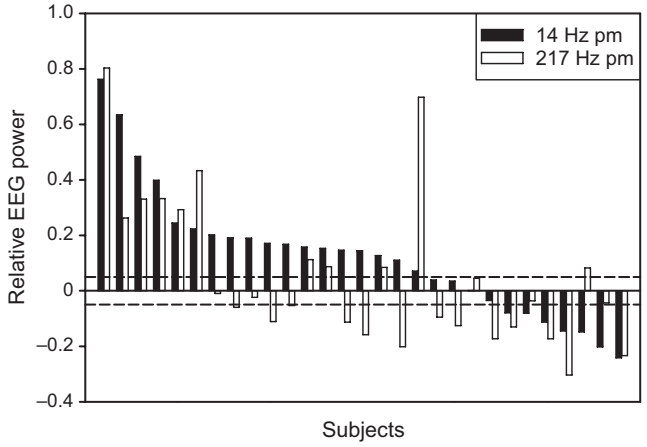


Figure 4. Individual change in spindle peak power (±0.5 Hz around individual peak location) relative to sham (=0) in stage 2 of the second NREM sleep episode for the 14-Hz and 217-Hz pulse-modulation (pm) conditions. The two dashed lines indicate a ±5% change.

defined as a ≥5% change from sham. Following the 14-Hz pulse-modulated exposure, 62% (18/29) of subjects had an increased amplitude (maximal increase 76%), while 24% (7/29) showed a decrease in power compared with sham (maximal decrease 24%; Fig. 4). Individual spindle peak power following the 217-Hz pulse-modulated exposure showed both increases (11/29, 38%) and decreases (13/29, 45%) compared with sham, but there was no association with the respective change in the 14-Hz pulse-modulated condition. The specificity of the effect was also investigated; however, there was no correlation between the distance of each individual's spindle peak frequency from 14 Hz and their respective increase or decrease in spindle peak after exposure to the 14-Hz pulse-modulated field.

Analysis of spectral data during REM sleep showed a few scattered significant *P*-values for both RF EMF conditions in the second and third REM sleep episode, and an increase of approximately 11% (11.75–12.25 Hz, $P < 0.03$, paired *t*-test) in the fourth REM sleep episode compared with sham for the 217-Hz pulse-modulated condition.

No significant effects on sleep architecture were found (Table 1). In particular, sleep efficiency, waking after sleep onset and REM sleep percentage/latency were not affected by exposure. The amount of NREM and REM sleep for each cycle, as well as the contribution of stage 2 sleep to NREM sleep, is shown in Table 2. No exposure-related changes were observed. Additionally, heart rate, as derived from ECG data (R–R intervals), was analysed separately for each NREM and REM sleep episode and showed no exposure-related alterations.

Subjects were unable to identify the exposure conditions, with the majority of responses (64/90) reporting no perception of a field at all. Where subjects did report having perceived a field (14), they were mostly incorrect and no one was able to correctly identify all three conditions. Furthermore, no differences between exposure conditions were observed for subjective mood, wellbeing or sleep quality.

Cognitive tasks

A significant session effect (1st versus 2nd half of exposure) was seen in all cognitive tasks, independent of exposure condition. Overall, reaction speed tended to be lower across tasks during active exposure conditions compared with sham (Fig. 5); however, this was not always the case. After correction for multiple comparisons no significant differences in speed were observed in the SRT and CRT. In the 1-back and 2-back tasks, speed was significantly affected by exposure (*Condition*, 1-back: $F_{2,145} = 6.64$, $P = 0.002$; 2-back: $F_{2,145} = 7.52$, $P = 0.0008$); however, *post hoc* analyses showed that there was only a trend level decrease in speed in the first session of the 2-back task for the 217-Hz pulse-modulated condition ($P = 0.035$). Accuracy was significantly decreased in the first session of the 3-back task in the 14-Hz pulse-modulation condition ($P = 0.013$, Wilcoxon-signed-rank test). No further effects on reaction speed or accuracy were observed.

DISCUSSION

Consistent with previous research, the current study showed that pulse-modulated RF EMF alters brain physiology. Specifically, exposure led to an increase in EEG power during NREM sleep in the spindle frequency range, which has also been reported previously by a number of well-controlled studies (Borbély *et al.*, 1999; Huber *et al.*, 2000,

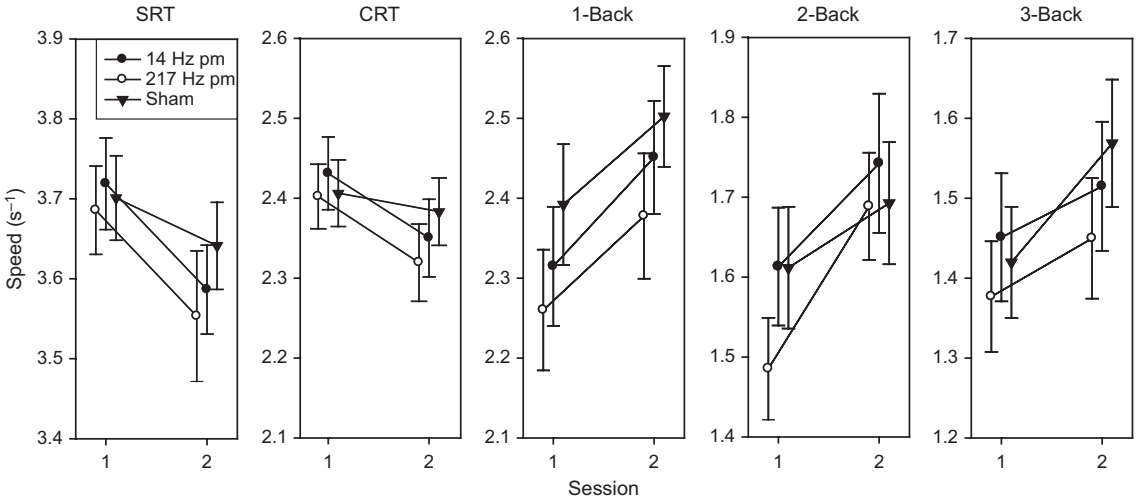


Figure 5. Mean reaction speed (±SEM) for all five cognitive tasks performed during the 30-min exposure (n = 29) in the 14-Hz and 217-Hz pulse-modulation (pm) conditions and sham. Sessions indicate the first and second 15 min of exposure. In the 1-back and 2-back tasks, reaction speed in the active field conditions was different from the sham condition (mixed model ANOVA, factor '*Condition*'; $P < 0.015$). However, *post hoc* analyses showed that there was only a trend level decrease in speed in the first session of the 2-back task for the 217-Hz pulse-modulated condition ($P = 0.035$). (SRT, simple reaction time task; CRT, 2-choice reaction time task).

2002; Loughran *et al*., 2005; Regel *et al*., 2007b). The increase in EEG spectral power was present following the 14-Hz pulse-modulated exposure condition in both stage 2 and NREM sleep in the second NREM sleep episode. This suggests that the 14-Hz pulse-modulation component, which is in proximity to the physiological sleep spindle frequency, is one potential mediator of the observed effects on the sleep EEG.

The 14-Hz pulse modulation led to a significant increase in EEG spectral power; however, there was also a smaller but non-significant increase observed following the 217-Hz condition. This suggests that the specificity of the pulse modulation may not be the most important factor as, to a certain extent, both pulse-modulation frequencies resulted in an enhancement of EEG spectral power in the spindle frequency range during sleep. Thus, it may be that any biologically relevant pulse modulation of RF EMF (that is, pulse modulation in a physiological range) would be sufficient to induce changes in electrical brain activity. In support of this, an enhancement of frequency-related biological rhythms was reported by Bawin *et al.* (1973), who showed that exposure to high-frequency (147 MHz) EMF, amplitude-modulated at frequencies close to the biologically dominant frequency, acted as a reinforcer and increased the rate of occurrence of spontaneous rhythms. Furthermore, stimulation frequency-dependent effects on brain activity have also been observed with transcranial magnetic stimulation (for review, see Sack and Linden, 2003), while another recent study reported altered intracortical excitability specifically in relation to GSM mobile phone exposure (Ferreri *et al*., 2006).

The relative non-specificity of the applied pulse modulation could imply that, aside from the frequency of the pulse modulation, the power of the RF EMF may also play an important role in inducing changes to sleep EEG spectral power such as those observed in both the current study and previous studies. For example, as pulse peak power was almost four times higher for the 14-Hz pulse-modulated exposure (crest factor = 30.95) than for the 217-Hz pulse-modulated exposure (crest factor = 8), this could be partly responsible for the more prominent increase in sleep EEG spectral power observed following the 14-Hz exposure condition.

Further to the specificity of the pulse modulation and the applied power of the RF EMF, the possible contribution of higher harmonics in the applied signal can also not be excluded as a potential factor in the current study. Exposure consisted of pulse-modulation components of either 14 Hz or 217 Hz, plus the associated higher harmonics (Fig. 1). Therefore, the observed effect could depend on different frequencies or a combination of different frequencies to a certain extent. Further research employing exposures that attenuate these higher harmonics would help to clarify the impact of these signal characteristics in relation to the effects on the sleep EEG.

In terms of the temporal evolution of the effect, the enhancement of EEG spectral power was most prominent for both exposure conditions in the second NREM sleep episode, which corresponds to approximately 2–3 h after sleep onset and exposure cessation. This observed effect declined in the latter sleep episodes and, although still present, did not reach significance. These results provide further evidence that the effect of pulse-modulated RF EMF outlasts exposure by several hours. However, the time-course of the effect is a characteristic that has varied across previous studies, which have reported an increase of the effect towards the end of sleep (Huber *et al*., 2002), similar

levels throughout sleep (Regel *et al*., 2007b), or that the effect is only present at the beginning of sleep and/or decreases in the course of sleep (Borbély *et al*., 1999; Huber *et al*., 2000; Loughran *et al*., 2005). It remains unclear why the temporal evolution of the effect has been so variable. The discrepancies could be due to a number of experimental factors that have differed between studies. For example, the different exposure parameters (such as duration and intensity of exposure, crest factors and modulation schemes) employed across studies or the influence of individual variability in response to exposure to pulse-modulated RF EMF could play a role. Indeed, there was considerable variability in the effect of exposure on spectral EEG power during sleep in the current study, with the majority of participants showing an increase, while some showed no change or even a decrease following the 14-Hz pulse-modulated exposure. The presence of individual differences in response to RF EMF exposure was also recently shown by Loughran *et al*. (2008), which highlights the importance of the consideration of inter-individual variability when conducting human research on RF-related biological effects.

Despite the changes observed in NREM sleep EEG spectral power following exposure, there were no effects on sleep architecture. This is consistent with the majority of previous studies, and confirms that the responses seen in the EEG do not result in any changes to the overall pattern or quality of sleep. In contrast to most previous research, it must be noted that some small effects on EEG spectral power during REM sleep were seen in the present study. Only one early study reported effects on REM sleep EEG power (Mann and Röschke, 1996), and this was unable to be replicated by the same researchers in subsequent studies (Wagner *et al*., 1998, 2000) or by other independent researchers (Borbély *et al*., 1999; Huber *et al*., 2000, 2002; Loughran *et al*., 2005; Regel *et al*., 2007b). There was no clear pattern in the small changes of EEG power observed during REM sleep, and therefore until independently verified or replicated, interpretation remains difficult.

Regarding effects on cognition, it is still unclear to what extent RF EMF influences cognitive performance, such as attention, reaction speed and working memory. In the current study reaction speed tended to be slower with 217-Hz pulse modulation in all tasks, whereas accuracy of performance was largely unaffected. A number of previous studies have investigated exposure-related effects on cognition, using the same or similar tasks, and although changes in reaction speed and accuracy have been reported, no consistent effects have been observed. This may suggest that there are no repeatable effects of pulse-modulated RF EMF on cognitive performance, or that the tests currently employed may not be sensitive enough to elucidate such effects (Regel and Achermann, 2011). Additionally, a recent review and meta-analysis by Valentini *et al.* (2010) highlighted the heterogeneity of results from previous studies, and concluded that there is currently no evidence that cognition is influenced by mobile phone-like RF EMF exposure.

In conclusion, our results provide further evidence for short-term effects of RF EMF exposure on the sleep EEG in healthy, young male adults. In particular, we showed that pulse-modulation frequency components within a physiological range are sufficient to induce these effects. Despite these repeatable short-term effects on the sleep EEG, there is no indication of an impact on overall sleep quality, neither objective nor subjective, or on cognitive performance. Further research on the specificity of pulse-modulation components may help to provide an insight into potential mechanisms behind the observed EEG alterations, which may also bring us closer to potential consequences of mobile phone use for public health.

ACKNOWLEDGEMENTS

The authors thank Mona Neubauer, Melanie Achermann and Patricia Milz for their help during the experiment, Karl Wüthrich and Dr Roland Dürr for technical support, and Dr Sven Kühn for exposure-related support. This study was supported by the Swiss National Science Foundation (National Research Programme 57: 'Non-Ionising Radiation – Health and Environment').

CONFLICTS OF INTEREST

All authors declare no conflict of interest.

REFERENCES

Bawin, S. M., Gavalas-Medici, R. J. and Adey, W. R. Effects of modulated very high frequency fields on specific brain rhythms in cats. *Brain Res*., 1973, 58: 365–384.

Borbély, A. A., Huber, R., Graf, T., Fuchs, B., Gallmann, E. and Achermann, P. Pulsed high-frequency electromagnetic field affects human sleep and sleep electroencephalogram. *Neurosci. Lett*., 1999, 275: 207–210.

Boutry, C. M., Kuehn, S., Achermann, P., Romann, A., Keshvari, J. and Kuster, N. Dosimetric evaluation and comparison of different RF exposure apparatuses used in human volunteer studies. *Bioelectromagnetics*, 2008, 29: 11–19.

Croft, R. J., Chandler, J. S., Burgess, A. P., Barry, R. J., Williams, J. D. and Clarke, A. R. Acute mobile phone operation affects neural function in humans. *Clin. Neurophysiol*., 2002, 113: 1623–1632.

Croft, R. J., Hamblin, D. L., Spong, J., Wood, A. W., Mckenzie, R. J. and Stough, C. The effect of mobile phone electromagnetic fields on the alpha rhythm of human electroencephalogram. *Bioelectromagnetics*, 2008, 29: 1–10.

Croft, R. J., Leung, S., Mckenzie, R. J. *et al.* Effects of 2G and 3G mobile phones on human alpha rhythms: resting EEG in adolescents, young adults, and the elderly. *Bioelectromagnetics*, 2010, 31: 434–444.

Curcio, G., Ferrara, M., Moroni, F., D'inzeo, G., Bertini, M. and De Gennaro, L. Is the brain influenced by a phone call? An EEG study of resting wakefulness *Neurosci. Res*., 2005, 53: 265–270.

Feinberg, I. and Floyd, T. C. Systematic trends across the night in human sleep cycles. *Psychophysiology*, 1979, 16: 283–291.

Ferreri, F., Curcio, G., Pasqualetti, P., De Gennaro, L., Fini, R. and Rossini, P. M. Mobile phone emissions and human brain excitability. *Ann. Neurol*., 2006, 60: 188–196.

Fritzer, G., Goder, R., Friege, L. *et al.* Effects of short- and long-term pulsed radiofrequency electromagnetic fields on night sleep and cognitive functions in healthy subjects. *Bioelectromagnetics*, 2007, 28: 316–325.

Haarala, C., Bjornberg, L., Ek, M. *et al.* Effect of a 902 MHz electromagnetic field emitted by mobile phones on human cognitive function: a replication study. *Bioelectromagnetics*, 2003, 24: 283–288.

Haarala, C., Ek, M., Bjornberg, L. *et al.* 902 MHz mobile phone does not affect short term memory in humans. *Bioelectromagnetics*, 2004, 25: 452–456.

Huber, R., Graf, T., Cote, K. A. *et al.* Exposure to pulsed high-frequency electromagnetic field during waking affects human sleep EEG. *Neuroreport*, 2000, 11: 3321–3325.

Huber, R., Treyer, V., Borbély, A. A. *et al.* Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking EEG. *J. Sleep Res.*, 2002, 11: 289–295.

Huber, R., Schuderer, J., Graf, T. *et al.* Radio frequency electromagnetic field exposure in humans: estimation of SAR distribution in the brain, effects on sleep and heart rate. *Bioelectromagnetics*, 2003, 24: 262–276.

Huber, R., Treyer, V., Schuderer, J. *et al.* Exposure to pulse-modulated radio frequency electromagnetic fields affects regional cerebral blood flow. *Eur. J. Neurosci.*, 2005, 21: 1000–1006.

International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). *Health Phys.*, 1998, 74: 494–522.

Koivisto, M., Krause, C. M., Revonsuo, A., Laine, M. and Hamalainen, H. The effects of electromagnetic field emitted by GSM phones on working memory. *Neuroreport*, 2000, 11: 1641–1643.

Loughran, S. P., Wood, A. W., Barton, J. M., Croft, R. J., Thompson, B. and Stough, C. The effect of electromagnetic fields emitted by mobile phones on human sleep. *Neuroreport*, 2005, 16: 1973–1976.

Loughran, S. P., Jackson, M., Howard, M. E. and Croft, R. J. Individual differences in the effects of the radiofrequency electromagnetic fields emitted by mobile phones on human sleep. In: *29th URSI General Assembly*, Chicago, Illinois, USA, 2008.

Mann, K. and Röschke, J. Effects of pulsed high-frequency electromagnetic fields on human sleep. *Neuropsychobiology*, 1996, 33: 41–47.

Preece, A. W., Iwi, G., Davies-Smith, A. *et al.* Effect of a 915-MHz simulated mobile phone signal on cognitive function in man. *Int. J. Radiat. Biol.*, 1999, 75: 447–456.

Rechtschaffen, A. and Kales, A. Manual of Standardized Terminology, Techniques and Scoring Systems for Sleep Stages of Human Subjects. National Institutes of Health, Bethesda, Maryland, 1968.

Regel, S. J. and Achermann, P. Cognitive performance measures in bioelectromagnetic research – critical evaluation and recommendations. *Environ. Health*, 2011, 10: 10.

Regel, S. J., Gottselig, J. M., Schuderer, J. *et al.* Pulsed radio frequency radiation affects cognitive performance and the waking electroencephalogram. *Neuroreport*, 2007a, 18: 803–807.

Regel, S. J., Tinguely, G., Schuderer, J. *et al.* Pulsed radio-frequency electromagnetic fields: dose-dependent effects on sleep, the sleep EEG and cognitive performance. *J. Sleep Res.*, 2007b, 16: 253–258.

Sack, A. T. and Linden, D. E. Combining transcranial magnetic stimulation and functional imaging in cognitive brain research: possibilities and limitations. *Brain Res. Brain Res. Rev.*, 2003, 43: 41–56.

Valentini, E., Curcio, G., Moroni, F., Ferrara, M., De Gennaro, L. and Bertini, M. Neurophysiological effects of mobile phone electromagnetic fields on humans: a comprehensive review. *Bioelectromagnetics*, 2007, 28: 415–432.

Valentini, E., Ferrara, M., Presaghi, F., De Gennaro, L. and Curcio, G. Systematic review and meta-analysis of psychomotor effects of mobile phone electromagnetic fields. *Occup. Environ. Med.*, 2010, 67: 708–716.

Van Rongen, E., Croft, R., Juutilainen, J. *et al.* Effects of radiofrequency electromagnetic fields on the human nervous system. *J. Toxicol. Environ. Health B Crit. Rev.*, 2009, 12: 572–597.

Wagner, P., Röschke, J., Mann, K., Hiller, W. and Frank, C. Human sleep under the influence of pulsed radiofrequency electromagnetic fields: a polysomnographic study using standardized conditions. *Bioelectromagnetics*, 1998, 19: 199–202.

Wagner, P., Röschke, J., Mann, K. *et al.* Human sleep EEG under the influence of pulsed radio frequency electromagnetic fields. Results from polysomnographies using submaximal high power flux densities. *Neuropsychobiology*, 2000, 42: 207–212.

http://www.rblank.com/2013/08/05/genotoxicity-of-cell-phone-wifi-emf-radiation/

The Genotoxicity of Cell Phone & WiFi EMF Radiation

http://www.theforbiddenknowledge.com/hardtruth/nonconsensual_mindcontrol.htm

Nonconsensual Brainwave and Personality Studies by the U.S. Government

http://www.stopthecrime.net/

Radio Frequencies Compromising Buildings

http://www.youtube.com/watch?v=sVTBH8pPX_Q&feature=player_embedded

http://emfsafetynetwork.org/smart-meters/smart-meter-health-complaints/

Friday, June 25, 2010

Further Harm from Smart Meters / Cruelty and Death of Siberian Tigers by Radio Collars? / "Rapid response" to the original BMJ article

W.E.E.P. News

Wireless Electrical and Electromagnetic Pollution News

25 June 2010

Hi Martin, Yes, please feel free to send my letter.

I was unaware of the dangers of Smart Meters until one was put on my house. I was wary of cell phones but I had NO physical symptoms from cell phones, wi-fi or cell towers that I was aware of. I had been using a cell phone (with a headset, because early on I had heard Dr. George Carlo on the radio) and we had wi-fi in our house. I had not been avoiding EMR.

Now it all makes me sick.

It has been both a nightmare and an awakening.

This is a documentation that I wrote about my experiences-

March 30, 2010

Dear Sir/Madam:

In June 2009 Con Edison installed a new digital electric meter on my house and a new digital gas meter in my basement in Hastings on Hudson, New York. Con Edison told me that the new meters were being used so that it could read the meters with electronic devices from the street. The electric meter is as follows:

Electric Meter CENTRON

0716701200 CL200 240V 3W TYPE C1SRP 30TA 1.okh Ca 0.5 FM 2s 60Hz A72AQ 7978929. 59689 345

In about late September I began to notice I was having some odd symptoms, including the following:

*Agitation

*Memory loss

*Inability to concentrate

*Nervousness

*Inability to get my work done

*Interrupted sleep

I felt as if I were becoming unhinged.

During the time between September and earlier this month my husband and son seemed agitated too. My husband's blood pressure rose and he had to begin taking blood pressure medication. He was also experiencing sleep disruptions.

On February 25th and 26th there was a huge snowstorm here. During the storm I spent many hours in my living room, near my fireplace, about five feet away from the electric meter, which is installed outside my living room window. My right ear was facing the meter. My husband was traveling and my son was not at home for the same length of time that I was. The electricity went on and off several times during those two days. At one point I heard a piercing sound along with pressure in my ears. Along with the symptoms I had previously experienced, I began to develop worse symptoms, including the following:

*Heart palpitations
*A buzzing-pulsing sound, especially in my right ear
*Agitation
*Interrupted sleep with nightmares of being attacked
*Accelerated heartbeat
I was afraid that I would have a heart attack. The symptoms would lessen when I went outside. It seemed that there was something wrong inside my home, perhaps with the electricity.
Through research and talking to electricians, I began to realize that my symptoms might be traceable to something relating to the meters. They were the only recently installed appliances in our home with radio frequencies.
After many desperate phone calls to Con Edison, it removed the digital meters, but only after I presented a note from my doctor, upon which Con Edison insisted. In place of the electric meter Con Edison installed another electric, digital meter that it assured me emitted NO radio frequency. It was as follows:
Electric Meter- Schlumberger Centron
CL200 120V 3W Type CN15 30TA 1.okh Ca. 0.5 FM 25S 60Hz HF5006914736AAV* 71BQ 6914736 25 440 021
Con Edison also told me that I would need in the future to provide it with meter readings. Con Edison told me that both my doctor and I would be receiving a follow up communication from its health department, which we never did.
Whether the people at Con Edison lied or did not know what they were talking about is a question that needs to be answered. This meter also had a radio frequency (Note the FM25S.) I realized this when my symptoms got worse.
I was truly afraid that I would have a heart attack. I became terrified in my own home and could not find a comfortable place to sleep, because the buzzing pulsing sound in my ear was so disturbing. Before all of this started I was a healthy 51 year old.
Again, after making many more calls to Con Edison, on March 4 they removed that meter from my house and replaced it with an analog meter (this is the same type of meter Con Edison had initially removed in June 2009).
My immediate responses were so remarkable that I recorded them.
*Tingling in arms
*Legs felt very heavy
*The buzzing-pulsing became quieter.
*I felt as if my body was weighted down with exhaustion
Within hours I began feeling better. The loud buzzing-pulsing sound quieted down and my thoughts were less scrambled.
But my difficulties continued. In our home we have lived with wireless appliances, cell phones and fluorescent light bulbs for at least three years, and to my knowledge they have never been a problem for me. Now I cannot be near any of these things because I get a buzzing in my ears and my heart starts to race. The only possible cause for this change is that Con Edison placed meters emitting radio frequencies on and in my home in June.
Since Con Edison removed the digital meters and replaced them with an analog meter I am feeling better, but some of the symptoms have not gone away completely.
I have learned from my research that the digital meters with radio frequencies were never

properly tested on human beings.
http://www.electricalpollution.com/smartmeters.html
http://emfsafetynetwork.org/?page_id=872
http://www.smartmeterdangers.com
http://www.ncil.org/resources/radiofrequencyarticle.html
When I asked the Con Edison "Meter Relations" department (212-460-4111) if I could see a copy of the test results for human exposure to the frequencies in the meters, I was told that I must obtain a subpoena to acquire that information.
Con Edison also told me that the FCC had approved the meters. When I called the FCC, I was told that it does not address human health issues, but only with regulating frequencies, and the person with whom I was speaking hung up on me.
This could be a very dangerous situation. These meters are being used across New York State and the country. People might become sick from them and not know what is happening to them.
I am requesting that the meter replacement program be stopped immediately and that home owners be given the right to opt-out of receiving these meters if they do not want them, until further testing is done to learn the effects of the frequencies they emit, especially in combination with other frequencies to which we are already being exposed.
Thank you.
Michele Hertz
62 Euclid Avenue
Hastings on Hudson, New York 10706

Cruelty and Death of Siberian Tigers by Radio Collars?

The headline on the story below should probably be - Are Siberian Tigers being killed by radio frequency (or microwave) radiation from the radio collars they are forced to wear?
Any intelligent researcher using radiofrequency collars on animals should be aware of the health effects of electro magnetic radiation and should strongly consider that, as the cause of their illnesses.
Whatever happened to investigative reporters? Are there no reporters or editorial staff at The Observer who are aware about the health effects of electro magnetic radiation on people and on animals?
Martin Weatherall

Siberian tiger threatened by mystery disease

Conservationists say an epidemic is destroying the big cats' ability to hunt and turning them into potential man-eaters

- Patrick Evans
- The Observer, Sunday 20 June 2010
- http://www.guardian.co.uk/environment/2010/jun/20/siberian-tiger-mystery-disease-extinction

The number of Siberian tigers has fallen 40% in five years. Photograph: Grant Faint/Getty Images

A mystery disease is driving the Siberian tiger to the edge of extinction and has led to the last animal tagged by conservationists being shot dead in the far east of Russia because of the danger it posed to people.

The 10-year-old tigress, known to researchers as Galya, is the fourth animal that has had a radio collar attached to it for tracking to die in the past 10 months. All had been in contact with a male tiger suspected of carrying an unidentified disease that impaired the ability to hunt. "We may be witnessing an epidemic in the Amur tiger population," said Dr Dale Miquelle, the Wildlife Conservation Society's (WCS) Russia director.

Galya had recently abandoned a three-week-old litter of cubs and come into the town of Terney looking for an easy meal. Following a series of all-night vigils by researchers, attempts to scare the tigress away failed. She was reported to the Primorsky State Wildlife Department as an official "conflict tiger", and a state wildlife inspector was called in to destroy her earlier this month.

"This tiger had lost its fear of humans – typically Amur tigers will never expose themselves for observation. It was like seeing someone you know turn into a vampire," Miquelle said.

Scientists are attempting to understand what compromised the tigress's ability to capture wild prey, which she had lived upon almost exclusively since birth. Her cubs, which were subsequently found dead at the den, are likely to have had their mother's disease transmitted to them through the placenta. "Initial necropsy results show an empty digestive tract, which is highly unusual. We're still waiting for results of further tests, but the abnormal behaviour suggests disease, possibly neurological," said Miquelle. "We are extremely concerned about the possibility of an epidemic that could be sweeping through this region. Animals we have studied extensively, and known well, have demonstrated radically changed behaviour, which is extremely disconcerting."

Weighing only 91kg at death – down from an estimated 140kg at full health – the tigress's death represents the end of an 11-year lineage of related "study" tigers, and leaves the WCS's Siberian Tiger Project with no radio-collared animals for the first time in 18 years. WCS Russia has tracked more than 60 tigers since inception in 1992.

In March this year, Miquelle raised the prospect of disease as a potential threat to an already endangered Siberian tiger population. The Siberian Tiger Monitoring Program reported in October 2009 a possible 40% decline in numbers since the last full survey in

2005, from 428 to as little as 252 adult tigers. The tiger's range has been reduced to a small pocket in the corner of the country within the region of Primorsky Krai.
Speaking at a conference in Vladivostok, Miquelle said that anything above a 15% mortality rate in adult females could kill off all Amur tigers. With around 150 adult females in the population, any more than 22 deaths of adult females per year may wipe out the species. Poaching accounts for about 75% of all Amur tiger deaths, with 12 to 16 adult females killed annually. "We're in a new era where disease could seriously affect the Amur tiger."
The Russian draft federal tiger conservation strategy has recently been amended to take account of disease, including a section on vaccination against canine distemper, a viral disease which is common in the Russian far east in domestic dogs and cats.
"The addition of disease-related deaths to existing sources of mortality could push this population over a tipping point," said Miquelle.
The federal strategy, which is being designed by a number of scientific groups including WCS Russia, is being prepared for the first global Tiger Summit due to take place in St Petersburg this September. Along with World Bank president Robert Zoellick, Vladimir Putin is due to preside over the conference.
WCS Russia hopes to recommence the capture of study tigers in September. "We aim to change the focus of why we study tigers, with a new emphasis on disease," said Miquelle. "The only consolation in this grisly process is that, for once, a serious threat is not originating from human actions, although even that, for now, is open to debate."
• This article was amended on 24 June 2010 to correct the source of figures on tiger decline from Wildlife Conservation Society, Russia to The Siberian Tiger Monitoring Program.
Submitted by Anna

"Rapid response" to the original BMJ article
You can find my "rapid response" to the original BMJ article below
or at: -
http://www.bmj.com/cgi/eletters/340/jun22_1/c3015
Best wishes
Andrew
Andrew Goldsworthy,
Lecturer in Biology - retired
Home London W5 1JD
Send response to journal:
Re: Doesn't prove anything I'm afraid
The choice of 700 metres as the radius of the sample may be misleading. If, as many people believe, the bulk of the biological effects occur within 400 metres of the mast, increasing the radius of the sample to 700 metres will dilute it with people who are relatively unaffected.
Insofar as the area of the circle around the mast (and presumably the number of people living in it) increases with the square of the radius, this means that the sample around the mast will contain approximately twice as many "unexposed" as "exposed" people. If the cancer cases are more tightly bunched around the mast, this error becomes even greater.
Also, if the people concerned were regular mobile phone users, the exposure to the signal

from their own phone would be greater with increasing distance, which would confound the experiment and make any result appear less significant.

Also, it takes no account of other sources of radiation, which would also make it more difficult to disentangle the effects of the mast.

Lastly, in this day and age, where do you find unexposed controls? Picking people at random from a register certainly won't do it.

While the intentions of the study might have been to reassure the general public that living close to mobile phone masts will not harm them, it was not well designed and the results are virtually meaningless.

I'm afraid no one can take comfort from it.

Competing interests: None declared

Web site www.weepinitiative.org e-mail contactweep@weepinitiative.org

To sign up for WEEP News: newssignup@weepinitiative.org (provide name and e-mail address)

W.E.E.P. – The Canadian initiative to stop Wireless Electrical and Electromagnetic Pollution

http://emfsafetynetwork.org/smart-meters/smart-meter-fires-and-explosions/

Smart Meter Fires
By Bill Sweet
Posted 5 Sep 2012 | 19:06 GMT

We are seeing a spate of report from around the United States—and indeed around the world—of fires believed to have been caused by smart meters that were faulty, incorrectly installed, or connected to circuits where there were unfortunate and unforeseen effects. This appears to be not just a matter of freak incidents that may or may not have taken place here or there. In a compilation made by the EMF Safety Network, which specializes in EMF and RF precaution, there are at least a couple of dozen smart meter fire reports from Australia to Canada and virtually all regions of the United States, and some of those reports concern a couple of dozen fire incidents. In some cases fires appear to have originated in the meters themselves, in other cases in appliances like microwave ovens or refrigerators (as in the photo above), because of power surges.

To be sure, those reports are not necessarily going undisputed by local utilities and energy companies. In one instance, for example, California's PG&E and fire officials have taken issue with an initial report of meter induced fires in Santa Rosa; a short circuit in the distribution system blew out a number of meters, both conventional and two-way, the local fire chief said. On the other hand, just last week Commonwealth Edison of Illinois confirmed three smart meter fires in its operating area, and earlier last month its sibling company Peco Energy suspended smart meter installations in the Mid-Atlantic states after 15 reports of smart meter fires, one in Philadelphia.

Britain's Electrical Safety Council considers meters generally a fire hazard, as cables or fuses deteriorate with time, and it has warned electricity users against storing flammable items like rags or paper near electrical intake equipment.

Obviously all companies with smart meter programs, and all their suppliers and sub-contractors, are going to have to take a close look at the issue of fire hazards. This is just the beginning of a difficult story. Companies installing smart meters already have run into a lot of consumer push-back because of concerns about privacy, security, and--sometimes--higher rather lower electricity costs. The last thing the smart grid needs is meters causing fires.

Smart Meter Fires and Explosions

The following is a compilation of reports from the US , Australia and Canada about fires, explosions or burned out appliances due to Smart Meter installations. If you have experienced similar problems, please post your story in the comment section below.

The US Consumer Products Safety Commission (CPSC) is a federal agency that will take complaints on utility smart meters from all US states. If you have or had smart meter electrical or fire problems CALL: (800) 638-2772 Monday through Friday from 8:00 a.m. to 5:30 p.m. ET or submit your complaint by email.

8/2013 Lakeland fire sparks concerns about ‘smart meters’ (Florida) TV news reported , “A charred electrical box is what’s left of a very scary weekend outside Cherie Oberg’s Carillon Lakes condo in

Lakeland. Oberg says the digital "smart meter" on her home burst into flames damaging two adjoining meters. The flames fizzled out by the time Lakeland firefighters arrived, but the fear sparked by the situation is still smoldering for Oberg and her neighbors." The report and video confirm the Consumer Product and Safety Commission is taking complaints on smart meters.
WFLA-TV News Channel 8

On December 18, 2012 a PG&E meter reader whistleblower tells the California Public Utilities Commission judge that:

- Smart Meters CAUSE FIRES.
- PG&E is covering up the Smart Meter fire risk.
- PG&E fired him because he was unwilling to keep quiet.

"Smart Meter Disaster" is an Australian TV news report on the meter hazards, including fires.(From 2012)

2013 When 'Smart' Meters Kill: The Story of Larry Nikkel — Details Emerge of Vacaville, CA Smart Meter Fire Death Larry Nikkel died in a house fire related to smart meter installation in Vacaville CA. The burnt out computer, loud humming in the house were classic signs that the smart meter was arcing. The case was settled out of court.

2/2013 FOX 5 Investigates: Smart meters spark controversy "I was walking to the seventh tee, when the pro came up and said,'Jump in the car. We just got a call. Your house is on fire," Michael Capetto said. He lives in Upper Makefield, near Philadelphia, where the utility PECO this past summer reported at least 15 smart meters caught fire or got so hot, the meters melted. Similar fires have been reported in other states too."…"..the meter sizzling inside the casing like a piece of bacon"

3/2013 "Memphis Light Gas and Water Division officials on Tuesday told a City Council committee that "smart meters" slated to replace the utility's traditional meters don't cause fires….But problems with the metal electrical boxes, or "meter sockets" into which meters are plugged, could cause overheating and spark a "flash over" fire, they reported. Made of plastic, smart meters also can melt."
http://www.commercialappeal.com/news/2013/mar/05/memphis-city-council-briefs/

1/17/2013 Electric Meter Catches Fire at Winchester Resident's Home
A Sensus Smart Meter caught fire on a Winchester TN home. The damage was contained by the brick siding. The owner, Brandon McClain is asking the utilities to pay for the smoke damage to his garage, the loss of his wages to deal with the problems, and the cost to replace the meter base. He states, "I believe the fault lies in the Sensus Smart FlexNet meters Winchester Utilities is currently using, or the utility employees spread the terminals when the smart meter was installed. My family could've been seriously harmed."

11/27/2012 Fire captain finds hazardous power surges follow Smart Meter installations
Matt Beckett, a CA Fire captain stated, "Two years ago PG&E replaced that meter [analog] with a "Smart Meter". Immediately following we noticed power surges in the form of our refrigerator motor intermittently speeding up simultaneously with our lights becoming brighter. As a seventeen year veteran and current Fire Captain this caused me to become very concerned." The Smart meter on his house was replaced with an analog, and there were no problems, until a new Smart Meter was reinstalled. This time he had two surge protectors burn out. Read more: http://emfsafetynetwork.org/?p=9013

11/2012 Michigan Is your electric meter dangerous? (see video in link.) Some say new meters are leading to fires: "Bonnie and Owen Medd said they never had a problem with the electric meter on their Ann Arbor home until DTE Energy replaced it with a new advanced "smart" meter. Then, it exploded.
"The DTE man told me we were very lucky our house didn't go up in flames," said Bonnie.
The Medds blame their new smart meter."… "After hearing about the fire at the Medd's meter, 7 Action News started digging. We found similar fires are being reported across the country. Our sister station, WPTV in West Palm Beach, Florida, has covered several fires linked in part to smart meters."

11/29/2012 Examiner: Something is still wrong with the smart meters Writer Norman Lambe outlines his

concerns regarding smart meters and gas explosions. “A glitch in the construction of the meters soon became apparent to the installers, and created a situation in which arcing could take place creating a spark, and if a natural gas leak existed anywhere in the vicinity serious problems could result, as witnessed to by the San
Bruno explosion.” He calls for a federal probe on the possible connection between Smart Meters and gas explosions stating, ” I believe it is time for a federal probe into finding out once and for all the responsibility for the natural gas explosions taking place to
determine if the smart meters are responsible.”

November 2012 : A recent article recognizes the connection between Smart Meter installations in Reno Nevada and Smart Meters exploding and burning out appliances. According to the article NV Energy Gary Smith admitted to problems with arcing and burnt out appliances, stating, “What happens is sometimes in the panel itself, you can get heating in those clips (where the smart meter’s prongs plug in) if they’re worn out or damaged,” Smith said. “Then we get what we call a ‘hot socket’ and you’ll have arcing and you’ll have a flashover.”

IEEE Smart Meter Fire Reports “Obviously all companies with smart meter programs, and all their suppliers and sub-contractors, are going to have to take a close look at the issue of fire hazards. This is just the beginning of a difficult story. Companies installing smart meters already have run into a lot of consumer push-back because of concerns about privacy, security, and–sometimes–higher rather lower electricity costs. The last thing the smart grid needs is meters causing fires.”

In August 2012 GE recalled 1.3 million dishwashers due to reports of 15 fires. GE also makes Smart Meters.

GEORGIA Family reports smart meter fire. In the photo the homeowner holds the charred remains of a smart meter which exploded and caught fire on her home, causing $11,000 worth of damage. According to the news report Georgia installed the same type of meters-Sensus- that have sparked fires in other states. (See video available here)

Smart Meter Causes Dumb Fire
“In June 2010, Shirley Bayliff was sitting at the piano in her suburban Illinois home, giving music lessons to a student, when she heard a “pop” outside the house before the power went out. When she and her husband looked out the window, they saw five-foot flames shooting out from a new General Electric smart meter their utility company had installed as part of a pilot project.”…”Since then, two more of the 130,000 smart meters Commonwealth Edison installed in the area have burst into flames, one in 2011 and one this last July, according to the newspaper.

Three states utility regulators investigating Smart Meter fires
“The Pennsylvania Utilities Commission wants more information about PECO Energy’s handling of its smart meter program, including failure rates of its meters, the number of overheating incidents and how many overheating incidents resulted in damage.
…Regulators in other states, including Illinois and Maryland, are investigating allegations of dangerously overheating electric smart meters and reports of meter fires.”

9/7/2012 Home Scorched by PECO “Smart Meter:” Fire Officials
PECO confirms to NBC10 that there have been 26 incidents of smart meters overheating

8/30/2012 Chicago Utility Company admits to Smart Meter related fires
The Chicgo Tribune reports, “Commonwealth Edison (ComEd) confirmed on Thursday that three of its smart meters, which wirelessly relay power-use data between homes and the company, have been involved in “small fires” in the Chicago region.”
Recently Maryland utility regulators held a hearing with four major electricity companies about smart meters. The Baltimore Gas and Electric Co. was reported to admit their company experienced five incidents of the smart meters overheating.

According to the Tribune, ComEd replaced 15 heat damaged Smart Meters, and is sending its meter designs for independent evaluation, before it deploys more meters next year.

8/25/2012 Woman wants electric company to replace TV (Texas) " Long blames the installation of a smart meter at her house for shorting out her flat screen and causing her microwave to act up. She also said her radio now broadcasts more static than music. "I left the house (to run some errands) and when I came back, nothing was working," …It appears an electrical surge fried the TV set and might be responsible for putting the microwave on the fritz. At least, that's what Long said her electrician told her."

8/23/2012 Houston Smart Meter Fire " A southwest Houston woman is blaming a smart meter for a fire that left her home in shambles in July… Harwood provided KHOU 11 news with a document that appears to be from the Houston Fire Department. The letter states "an unspecified electrical malfunction in the electrical meter" caused the fire…." (article includes a video)

Home owner blames smart meter installation for destructive fire (Global TV BC News)
…"The family says the electrical fire shorted out no fewer than 20 different appliances, and a number of electrical outlets…"I got a panic call from my mom saying that there was a fire in the house. So I ran over and there was lots of black smoke. Luckily I could put out the fire out fast with an extinguisher."…The daughter, who did not want to be identified, says the fire follows the smart meter installation by BC Hydro, and the damage is far worse than just the microwave…"Really anything you can name inside the house. All the air conditioning is gone, the phone inside the house is gone, the TV boxes, all the electronic devices are gone."… (article includes a video)

Philadelphia Utility Company Halts smart meter installation due to fire risk

---

8/12/2012 Power mishap damages appliances for Livermore residents
28 smart meters were replaced by PG&E when a power line replacement caused a power surge which fried appliances, TVs and air conditioners. "The surge of electricity ripped through 28 homes on Hudson Way in Livermore."
"All these neighbors have to buy the items lost and then bill the contractor. These homes lost hundreds if not thousands of dollars of electrical items to the problem. PG&E spokesperson Brian Swanson says it all could have been avoided by a flick of a switch. "When the contractor was switching over to the new 21kV line, they forgot to switch the transformer from 12kV to 21kV," said Swanson. "

August 3, 2012 Fire guts Mission home after BC Hydro smart meter installed
Excerpt: "BC Hydro claims a Mission homeowner is ultimately liable for a fire that originated at the base of a smart meter one day after it was installed.
A report by the Mission fire department said the blaze, which destroyed Trish Regan's house in the 7900-block of Burdock Street and leaped to the roof of a neighbouring home on June 15, originated at an insulating "lug" in the lower left corner of the meter base. The report says the terminal, which attached the meter base to the home, appeared cracked and "radiated heat to combust the wall at or near the meter base."
The base is the mounting plate for the meter, which measures how much electricity a home consumes during each utility-service billing period. Electricity must pass from the meter through the lugs to connect with the house wiring.
BC Hydro maintains the meter base is part of the house and thus any damage or faulty wiring is the customer's responsibility."

6/20/2012 Canada: Residential fire erupts one day after a Smart Meter was installed. Fire Investigators looking into the cause:
5/12/2012
A BLAZE ripped through the front end of a Moorabool St house (Australia).

” Witnesses said they saw smoke pouring from a recently installed smart meter just moments before the fire started.”… “But firemen later ruled out the smart meter as being the cause of the blaze.”

Alabama whistle blower alleges fire risk from smart meters. Sensus Qui Tam Complaint
According to the lawsuit, the plaintiff is an engineer and was an AMI smart grid project manager. He alleges the smart meters were not properly tested, and were seriously flawed. He found that the Sensus iConA had a “tendency to drastically overheat, and melt or burn”. He was asked to keep quiet and was eventually terminated for failing to do so.

3/15/2012 Dunaway Paint Store in Petaluma CA, from the incident report:
“After investigation of the smoke source we found that old or faulty wire inside the conduit from the meter to the breaker box had come into contact with one another melting the smart meter and the mounting box of the meter. Some of the wood was burnt around the area as well. The smoldering of the wood and plastic over what appeared to be an extended amount of time caused the smoke in the building. PG&E was called to the scene to isolate the meter and shut down the power to the building . . .”

3/15/2012 Florida report: State Fire Marshal working with St. Lucie Fire District to review smart meter safety on Treasure Coast
“Kenny Nail is president of the property owners association at Parks Edge, where St. Lucie County Fire Chief Ron Parrish said the outside of a home adjacent a newly installed meter sustained damage Feb. 17. Nail said he wants FPL to tell its customers how many house fires have started at a smart meter, instead of just saying the meters themselves cannot start fires.
“Explain to me how a house can be sitting there 35 years, with that old meter spinning around like a top and not causing a fire, then a fire starts after a new meter is put in,” Nail said.”

3/1/2012 From Norman Lambe (LA Home and Business Insurance Examiner). “For myself, as an adjuster, I believe the Smart Meters are a real a threat to the safety of your home, business and property. I have personally worked two large homeowner fires in which the Smart Meters were determined as responsible. Also, they have been responsible for several small fires in which appliances and computers have been destroyed.”

Australia: Electrical Trades Union again calls for suspension of smart meter rollout
“THE state’s electrical union fears someone will have to die before safety concerns about controversial smart meters are addressed…The Electrical Trades Union has repeated demands to suspend the rollout until power companies commit to mounting all meters on flame-resistant boards.”
ETU secretary Dean Mighell said about half a dozen more damaged meters had “exploded” since last week in Hadfield, Coburg and Pascoe Vale. About 1700 homes in the Pascoe Vale area had been affected by power surges, he said. Power supplier Jemena has replaced six smart meters around Pascoe Vale that failed during a power surge in early January. Spokesman Scott Parker said a further 55 would be replaced by next Wednesday as a precaution.”

2/10/2012 From WPTV news: A Florida reporter, Randy wrote, “This the fire the smart meter started in my house. I am now stuck in a dispute between Honeywell and FPL. I had damage to many electrical items in my home due to massive power surges caused by the meter fire.”

2/4/2012 Victorian Premier Ted Baillieu has again defended the roll-out of smart meters, amid concerns they are causing a growing number of house fires.
Metropolitan Fire Brigade (MFB) smart meter fire review concluded they could have been caused by faulty installation. “Hamish Fitzsimmons, an ABC reporter for Lateline, raised concerns about the meters after a fire at his Northcote home on the weekend…Fitzsimmons says the fire, which started behind the smart meter, caused extensive damage to at least one room of the house.”

12/16/2011 Explosion during SmartMeter installation leaves Florida utility sub contractor with 2nd and third degree burns from arcing.

12/06/2011 Melted smart meter at heart of SF house fire

12/03/2011 Nanaimo Canada mother of two left without power for two days after Smart meter smoked and caused a power outage: BC Hydro says its the homes wiring to blame, not the Smart Meter http://youtu.be/9NO6wlx8UFc

Some homeowners worry installing new 'smart meters' could spark fires
Florida TV news, Contact 5 investigates fire complaints from Smart Meters. The concern seems to be related to incompatibility between the new meters and older electrical home wiring. Florida resident, "Margie Albernaz woke up in July to the smell of smoke in her Greenacres home. "I went over to the FPL meter and it had caught on fire, it was all black smoke and charred," said Albernaz.
The report continues, "After some more digging, we discovered similar fire concerns have been reported across the country with different power companies and different brands of smart meters."
But the Florida utility assured residents that it was nothing to worry about, smart meters don't cause fires….however a spokesperson for the utility said they'd responded to 30 complaints related to meter fires and that "you could have wiring issues if you have dimming lights or power issues on one end of your home and not the other."

11/07/2011 In Australia, the Metropolitan Fire Brigade launched an official investigation into fires, linked to Smart Meters. They ordered "all firefighters to report fires, where smart meters are present and has advised officers not to allow power companies to take the meters from the scene. " Listen to the audio for more information at this site: http://www.3aw.com.au/blogs/breaking-news-blog/fires-linked-to-smart-meters/20111107-1n2jz.html

10/04/2011 Toronto Sun Pickering smart meter explodes. Worse, couple may have to pay for replacement.

9/29/2011 Smart meter leaves owners dumbfounded
After an attempted smart meter installation went bad, a British Columbia Canada home was left with no power, and the utility company told them they had to hire an electrician to fix the problem. "It is really upsetting," Rieke told The Richmond Review. "They're trying to tell you you're at fault, that it's a fire hazard and that you're responsible."
The article states, "During the installation, one of the four clips that connects the smart meter to the home's electrical wiring, inexplicably snapped off."

Palo Alto Power surge, raises questions about Smart Meters, "a good example of how sometimes the old way is the good way".
"Mindy Spatt, communications director for The Utility Reform Network (TURN), said the utility-consumer advocacy group received many complaints about surges damaging appliances when the SmartMeters were first installed. In the best-case scenario, the event in East Palo Alto is an additional cause for concern, she said."
Comparing analog to the new meters, she added, "In the collective memory of TURN, we have not seen similar incidents with analog meters."

Fridge blows after smart meter installed
Canadian News reports an 81 year old's refrigerator failed minutes after a Smart Meter was installed.

http://youtu.be/Xtcw4hgvgU8
From You Tube:
"This is the aftermath of one of those new smart meters not being properly installed. The guy who installed it did not know what he was doing and caused the main electric line to the box to become lose and over time it ended up touching the electric meter/box casing causing a fire and a huge firework festival on the side of our house. If I was not home we would have lost the house and our 3 dogs. We are NOT happy with our electric company and we were NOT given a choice if we wanted the smart meter or not.
You can see on the front of the box where the wire touched and started the whole fiasco. Mind you the electric company when I called in the next day as instructed to claimed it was our fault and we'd have to pay for repairs. We aren't paying for a darn thing and we will be filing a claim with the electric company. Thanks to them I can hardly sleep now and I am paranoid beyond belief."

Action Line: Remodeler finds SmartMeter interference with circuit breakers
By Dennis Rockstroh of mercurynews.com Posted: 09/12/2010
Q One item you did not cover in your Sept. 7 SmartMeter article was interference with arc-fault circuit interrupters (AFCI).
This is a type of circuit breaker that code requires in new and remodel construction. Its job is to detect arcing, which has been shown to be a cause of fires. Normal circuit breakers will not always break when arcing occurs. If arcing is detected by the AFCI, the breaker trips, stopping the potentially dangerous arc.
Long story short, I did some remodeling recently. City code required that I use an AFCI for one of the bedroom circuits that was being remodeled. Some weeks after I completed the remodel, the AFCI started tripping. This meant I had to inspect each junction box and outlet to determine where an arc might be occurring.
Coincidentally, the problem started not long after a SmartMeter was installed toward the end of the remodel. Finally, after severe frustration, I phoned PG&E for help on this matter. A crew came out and looked at the AFCI breaker for a few seconds. One went to the truck and came back with a conventional meter, a mechanically driven version, and swapped it for the SmartMeter that was installed some days before. It took some prodding, but eventually one of the PG&E crew told me that they have been observing that AFCIs are sensitive to the meter's radio transmissions.
Dave Zittin, San Jose CA

Electrician Steps Up When CenterPoint Won't
Houston Texas News report on another situation where a new wireless utility meter has exploded.
According to the article, "The power company not only refuses to fix the meter case that left Vallain's [A Houston Grandmother] family without power, but now representatives say the problem never happened.
"They said it was never an explosion, and my granddaughter and I saw it, and he [the Centerpoint technician] jumped back himself," Vallain said. "

Appling Family Blames House Fire On Georgia Power Meter- News Video
According to this news article a Georgia family is displaced by a house fire, the fire department says it was an electrical accident, and the family blames the new Smart Meters installed two weeks ago.
" The Burns family was watching TV when the fire started around 10:00 a.m. Monday morning. Family members say sparks started flying from the TV and power box. Around the same time, down the street, another homeowner's TV reportedly started sparking and smoking. A daughter says their electrical problems started after Georgia Power installed new meters. Angela Dent, Appling, GA: "That's when we noticed the changes. It also happened at my brother's house…his TV's have been acting strange…popping and surging in and out…her lights have been dimming also."

PG&E recently installed 'smart' meters in my neighborhood. They do not tell you when they will come, but warn you to shut off things like computers that might be damaged when power is restored. When I arrived home, I only had power in my kitchen. The PGE repairman said that installation of smart meters was frying many meter receiver boxes. He was not qualified to fix it, and the power remained off for another 24 hours while PGE scheduled a qualified repairman to come out. Apparently this result is common in older subdivisions (mine was built around 1975) when the smart meters were installed. The older boxes, due to wear and age, burned out when PGE put in the new meters. The disturbing thing is that PGE will NOT replace the burned out boxes -they send out a guy with a box of spare parts, who cobbles together a sort of replica of the old box. I wonder how many home fires will result from PGE's installation of the no-so-Smart meters. (CPUC Complaint, 11/2009, Concord CA)

The following letter and photo were sent to the EMF Safety Network from a California fire department captain (Ross) who saved his home from a potential Smart Meter fire in 2009. PG&E has admitted that Smart Meters have interfered with GFI's and AFCI's, but they have not admitted to any connection with a Smart Meter fire. Smart Meter Arcing Hazard

---

After a Smart Meter was installed in this Florida woman's home she said the meter "caught fire and fried my beautiful new kitchen" – over $31,000 in damages to many of her home appliances. The Florida power company refuses to take the blame. See this video: Help Me Howard, FPL Smartmeter

The following reader comments were posted on the above online story:
(Boater39) “In our apartment complex, we had a fire last week at our sprinkler pump. Afterwards, I went to investigate and it was the electric meter that burned up. Took out decent-sized FP&L feeder in the process. I have an electrical background, and from my professional experience, whatever caused the meter to burn up was a dead short carrying a very large amount of current. Based on the damage, the problem was AT THE METER–not at the customer equipment attached to the meter. (like I said, I have professional experience). At the time I found it strange, until I saw this report on TV…. I will be sending some pictures to Patrick today–they can use them on whatever followup they want. It appears that we have a major design flaw with these new meters!!!!!!!!!!!!!”
(Jenny White) “After FPL installed the new meter at my dad’s house all his wires were burned as well and the house almost caught on fire. The problem is those new meter.”
(April) “I too had my smartmeter burn out and had a hell of a time getting FPL to fix everything. Their meter burned the wiring in my home behind the box that they said was up to me to get fixed on my own and that they could only repair the meter and wires from the pole to the box. I had 2 electricians come out and they said it was an FPL problem. Ended up there is an outside company that installs the meters for FPL and they ended up paying for my problem after FPL denied my claim for them to pay for the damages.”

Fire Tears Through Cutlet Bay Home A family in Florida suspects a Smart Meter was the cause of their house fire. According to the article, ” Fire investigators have not released the cause of the blaze. A relative told Local 10 the family believes a recently installed Smart Meter may have started the fire. Florida Power and Light says the company will investigate the allegation…”

In Houston Texas, “Local 2 investigates Smart Meter fires” reports they looked into homeowners complaints of Smart Meter fires and found some people are left with no electricity and major damage to their homes, including burnt out appliances after a Smart Meter has been installed by the utility. See Video.
“Charles Phillips saw smoke coming from the transformer in his backyard one morning last November. When he went out to inspect the damage, he said he saw a CenterPoint Energy contractor at his meter box with a fire extinguisher. He told me it had caught on fire, Phillips said.”
“Inside Phillip’s home, two TVs were fried, his air conditioner and garage door opener stopped working, and all of the wires and cables hooked up to his electronics were melted from the jolt his electronics took when a fire sparked after the installer removed his old meter. Phillips was left with a total of about $2,500 in damages.”
According to the article, Centerpoint, the utility for Houston Texas, has admitted the connection between fire risk and Smart Meters, stating there has been less than 100 problems. “CenterPoint’s LeBlanc said the problem is mostly in older homes where wiring is not up to code or something has caused a strain on the wires running into the meter box.”

Powercor, a utility company in Australia recognizes the safety risk from Smart Meters, stating, “A defect notice is issued when a wiring safety issue is identified. The defect may be identified before or during the smart meter installation or during the testing that we must do before reconnecting the electricity supply. If you are given a defect notice, you will need a registered electrical contractor to rectify the defect and issue a Certificate of Electrical Safety.”

Texas Consumer Complaint: Three months ago, Centerpoint installed a smart meter at my home. Since then, I have been experiencing very frequent power outages in different parts of my home. I cannot even turn on my air condition since the power flow is not reliable. I am 64 years old and retired, living on a fixed income. I have called centerpoint numerous times and they have not admitted responsibility and tell me that I am responsible to fix the this issue which is a fire hazard as well. I have consulted with two different experienced electricians and they have told me that when a centerpoint technician installed the smart meter, the 4 prong male connection that plugs into the smart meter was not inserted correctly and he must of forced it in which caused one of the prongs to go bad and burn out. So I now know what is causing the so frequent power outages, but Centerpoint Reps will not take responsibilty for the problem that they created. I have been living in my home for 24 years and never have had this occur. This is not a coincidence, How come this problem surfaced once the new smart meter was installed? We all know the truth, I will keep calling centerpoint and I am in the process of filing a formal complaint with texas state regulators.

Oncor Changing Smart Meter Installation After Fires "The Chief Executive Officer of Oncor says the company has a new procedure for installation of smart meters after two house fires in Arlington last week. Robert Shapard says old wiring in two homes could not support the new smart meters. The company now cuts power to the house while the meters are being installed…then as the change is made…electricians check the wiring to make sure there aren't any problems."
Reader comment posted on the above story by (Renee Callahan) "My mother had the "new smart meter" installed about a month ago. Since then she has had trouble with the lights blinking on and off. So on this past Friday (sept 17) she called TXU about the problem.They sent Oncor out late that evening while she was gone. Imagine the suprise she had when she returned home late with groceries and NO POWER! A note was on her front door saying….lugs in meter base need to be replaced fire hazard call back when repairs are made we will restore serv[ice]. After several calls to TXU ,ONCOR(representatives were very rude)she was told that she needed to find an electrician to fix problem at her expense. My mother is disabled and elderly and my sister who also lives with her is disabled. Because this was after hours more fees were charged..a total of$1483.66 to fix this problem that was caused by ONCOR because they decided to put in "smart meter"If there was a problem with lugs,was this not noticed when they were installing "smart meter" or simply that problem didn't exist until installation of "smart meter"? So here it is 1:35 Monday afternoon and still no power. We are waiting for inspection then we can notify Oncor to have power restored. This is so wrong. These older homes are not equipped to handle these "smart meters". So why put them in homes that are older and most likely are senior citizens living there and they are on fixed incomes. Something is so wrong with this picture. …"

_____

5/31/2011 Some blame 'smart' meter for Portland restaurant fire
"PORTLAND, Maine— A small fire on May 25 at El Rayo, a York Street Mexican restaurant, was blamed on an electrical problem. But some people are saying there's more to the fire than a simple wiring issue. Central Maine Power Co.'s vendor had installed a "smart" electrical meter on the building in January. The fire broke out in the electrical box where the meter connects to the building. "Sorry for being closed at lunch. CMP's allegedly smart meter caught fire and shut us down all day," the restaurant posted May 25 on Facebook."

_____

Electrical fire causes power outage at Coddingtown JC Penney store
JC Penney closes after another electrical panel explodes in Santa Rosa Coddingtown mall, the third reported electrical panel fire in Santa Rosa within a few weeks. Although the newspaper article does not report it, the manager of the store confirmed these were smart meters involved in the explosion and fire. "The JC Penney store at Santa Rosa's Coddingtown shopping center remained closed on Thursday afternoon because of an early morning electrical explosion and fire that cut off power to the store, fire officials said… An electrical panel in a utility room had exploded and begun burning, sending smoke into the first and second floors of the building, fire officials said."

_____

3 PG&E Smart Meters Explode at Santa Rosa Mall
April 7, 2011 According to the incident report from the Santa Rosa Fire Department on April 7, firefighters found the electrical room at the Santa Rosa Mall "charged with smoke" and "upon investigation found 3 PG&E meters that had blown off the electrical panel causing damage to the interior wiring of the electrical panel. A fire was still smoldering.."
The cause of the fire is listed as equipment failure and arcing coming from the switchgear area, and transformer vault.

_____

El Cerrito Smart Meter Catches Fire El Cerrito CA Fire Dept Report
Smart Meter was reported to catch fire and was still sparking when the fire crew arrived.

_____

Commentary by electrical contractor Lance Houston Unknown: Safety of New Disconnect Switch in Smart Meters: CPUC Meter Safety Testing Confirmation Needed.

_____

Smart Meter Explodes in Oregon, comment from Stop Smart Meters.org "I didn't know that I had a smart meter until it blew up on 08/12/2010! I am an Oregon PG&E customer, now victim. I want to know if anyone else has seen a smart meter blow up. It threw flames out and black smoke was in the air for hours. I

called PG&E, but they said it wasn't possible for a meter to explode. I wrote letters, called many times, but they said that they were too busy to come look at meter. For five months it sat there black and the house black also from the blast. I had to be taken to the Dr. because the blast knocked me down onto the cement. My doctor has referred me to a specialist. I have never had health problems. Now I have severe pain running through the nerves of the right side of my body. I can only walk with crutches now and only sleep two to four hours per night. The bills continue to go higher each month, and my bill says "estimated usage." Anon, Oregon

_____

"VICTORIA'S [Australia] energy regulator has conceded smart meter contractors might lack required skills and is reviewing the qualifications of workers rolling out the $2 billion scheme.
The Sunday Age [newspaper] can also reveal that, in the course of their work, smart meter installers have identified dangerous and possibly life-threatening electrical hazards in 3500 Victorian homes. Smart Meter Shock: electrical hazards found in 3500 homes

_____

"When PG&E installed their SmartMeters on my duplex in Sunnyvale they almost burned the place down. All the power plugs had burned insulation and wires where the wires connected to the plug receptacle in one of the units. PG&E's SmartMeters are a safety hazard and any good judge would stop PG&E before more people are hurt and more property is damaged." Michael E. Boyd –President, CAlifornians for Renewable Energy, Inc.

_____

SPARKS in Oregon! On November 8th, 2010 Anonymous (not verified) says: "The smart meter that was installed two months ago sparked and made exploding noises. I am still getting a bill. However, after that last boom with fire sparks, I am sure it isn't running. I can't see inside the meter because the front of it is black now! I am going to let tit sit there for a while and see if the bill continues to rise drastically. I haven't seen anymore sparks since the last big one. I am assuming my rising PG&E bill is created by the "energy fairy" at PG&E!

_____

State of Maine Utility CMP Supervisor admits finding Smart Meter fire hazards Media report Russ Farwell, a CMP unit supervisor, said the technicians are actually discovering more possible fire hazards than the company anticipated, and informing customers of dangers they otherwise would not have known existed. He said, so far, they have discovered 70 to 80 electrical issues in the Portland area. "I didn't think they'd find that many," he said.
"Farwell said recently a customer's television was destroyed during a meter replacement because the man allegedly did not come to the door when a technician knocked and then left the television on during the meter change.

_____

Media Report: Danville (Virginia) Woman says meter is a fire hazard " Kari Pyrtle says the meter, provided by the city, actually exploded and that it could have set her whole house on fire. The incident happened back on October 8, 2010.
"We were getting up, getting ready for school and for work," said Kari Pyrtle, a Danville resident. "All of the sudden the lights started flickering on and off and we hit the breaker box. Go outside and we could smell electrical burning. And we looked and our whole smart meter was turning black."

_____

Fires Spark During Smart Meter Installations
ARLINGTON – Smart meter installations are being blamed for two house fires in Arlington this week.The problem isn't the meters themselves, but instead what's happening to electrical wiring.
The first fire happened Monday on Brook Hill Lane and the second happened Tuesday on Grants Parkway. Arlington fire investigator Morkita Anthony found that when the old meters were pulled out, the main electric feeds to the houses were accidentally pulled as well. "
What it's doing is making contact somehow with the electric box or the wiring inside and causing a short, which is causing a fire," Anthony said.

_____

Smart meter fire reported in Canada: " The smart meter on the side of my house caught fire and per the Fire Inspector said it was the cause of the fire. Hydro came and took the meter saying it was there property. Who is at fault and if there property burnt my house why should I have to pay my deductible and risk my insurance to go up? Will my insurance go after the Hydro company? Should I get a good Lawyer? "

_____

Media Report: Vacuum Shop Fire Raises Smart Meter Questions “There may have been warning signs that the electrical system wasn’t working properly before the 6:30 a.m. fire. Rawles and a friend of his, offshore crane operator Ty Allen, both said the remote meter appeared to have stopped working months before the fire. Rawles said calls to the utility went ignored.

Allen also described unusual marks on the meter before it caught fire. “It looked like it’d been hot or burned inside the meter,” he said.

“An incident report filed by the Bakersfield Fire Department the day of the fire appears to blame the meter. It said department personnel arrived at the scene and found “a problem with the electric service meter.” “The meter had appeared to failed and shorted out causing arcing,” according to a copy of the report.”

_____

Berkeley Fire Department Report: Smart Meter Fire It states, “Investigation revealed the newly installed PG&E Smart Meter in the kitchen was hot to touch and smoking, with a orange glow inside the meter housing”

The issue was turned over to PG&E.

The following scan of the Berkeley fire department report is a large file and may take a long time to load: Berkeley Smart Meter Fire

_____

The Utility Reform Network: Are Smart Meters a Better Way to do Business? “They have shorted out appliances, they’ve caught fire, they interfere with garage door openers or security systems.” said Mark Toney of the Utility Reform Network.

_____

Modesto Irrigation District Finally Comes Clean About Smart Meters | THE VOICE OF MODESTO. The original article has been removed. More info HERE.

Meters caused GFI problems-MID spent over $138,000.00 in overtime repairs to homes where the meters caused the GFI circuit breaker to trip causing service disruption for the homeowner. Modesto’s Head Electrical Inspector said while the people changing home wiring weren’t electricians, that it was the same as having a handyman in your home redoing the wiring so no inspection was needed, and that the homeowner assumed responsibility for the repairs. MID made the claim they weren’t aware of any homeowners paying for their own repairs, but if the homeowner didn’t know MID was at fault, they wouldn’t have contacted them.

_____

From New Zealand: Fire Prone Meter Boxes causing Concern

“Front line firefighters are concerned about the number of household power meter boxes that are bursting into flames.

There have been 67 callouts in Christchurch to electrical malfunctions so far this year, and new smart meters have been involved in three in the last five days. Graham Hobbs considers himself lucky. He was woken at 4:30am to find his smart meter on fire. ”I lifted this up it was still glowing and smoking, and slammed it shut to try and seal it off.” The following night Kelvin Dixon, who lives nearby, suffered a similar fate. ”I pulled into my drive way and found my meter box on fire great amounts of smoke.” Mr Dixon is a registered electrician and says the contactor that sits beneath the smart meter caught fire and melted.”

_____

PG&E Report: “During the second quarter of 2009, PG&E discovered a limited number of cases of SmartMeter™ radio interference with customer electronics, including ground fault circuit interrupters (GFCI) and arc fault circuit interrupters (AFCI). In response, PG&E implemented a policy to defer meter installations at customer premises that PG&E is aware could potentially be affected by radio frequency interference. PG&E plans to install an adjustable voltage meter to prevent potential interference at these recorded locations. These adjustable meters are currently in final acceptance testing at PG&E. Upon final acceptance and approval, a schedule will be developed to deploy these meters at the premises where installation was deferred.” Pages 6-7 Advanced Metering Infrastructure; January 2010 Semi-Annual Assessment Report and SmartMeter™

Program Quarterly Report (Updated), Pacific Gas and Electric Company. Updated Semi-Annual AMI Report_Jan_2010-12

Online reader comment: “As a newspaper editor in little ole Cleburne County, Alabama we come out tomorrow with a story on a house which may have burned down because of a smart meter, another incident of a meter apparently getting so hot it almost burned along with circuit panel inside the home and people being told either by installer or power co that if they did not replace all the wiring in their home that the meter would indeed cause a fire!!!! I am told by a commercial builder that some meters may be faulty and allow 300-440 volts in on a home’s 220 and 110 lines. We’re seeing problems out here of burn outs in appliances, meltdowns of hair dryers, kitchen appliance , and a number of high-end electronics getting zapped. Goodbye Bose radio, goodbye wide, wide screen tv and see if the utility cos are going to pay for those items – don’t think so!” Link to news article

Electrical Fires reported in Georgia 2009 http://stopsmartmeters.org/wp-content/uploads/2012/01/Electrical-fires-Georgia-Feb2009.pdf

Media report on a Smart Meter fire in Bakersfield. “Smart Meter Blows Up At Business”
“On Wednesday, a PG&E technician was called out to replace the meter after employees found the device burned up and lying on the ground. …”Basically it was an explosion. I saw the meter on the ground and the face plate was blew off and the whole meter was blackened. Even the breaker box that housed the meter was blackened by what seemed to be an electrical short,” said Vernon Nelson, an employee. Another employee wondered how safe the meters are in general, especially for residential families? ABC 23 contacted PG&E who said they are not aware of any smart meters catching fire or blowing up. However the PG&E technician told the employee as he was replacing the meter, that he had replaced at least 15 meters around town due to the same problem they had, said an employee.”

More Smart Meter Fires stories: Coalition to Stop Smart Meters

Wireless Smart Meters and Potential for Electrical Fires
Commentary by Cindy Sage, Sage Associates and James J. Biergiel, EMF Electrical Consultant July 2010
Typical gauge electrical wiring that provides electricity to buildings (60 Hz power) is not constructed or intended to carry high frequency harmonics that are increasingly present on normal electrical wiring. The exponential increase in use of appliances, variable speed motors, office and computer equipment and wireless technologies has greatly increased these harmonics in community electrical grids and the buildings they serve with electricity. Harmonics are higher frequencies than 60 Hz that carry more energy, and ride along on the electrical wiring in bursts. Radio frequency (RF) is an unintentional by-product on this electrical wiring.
It may be contributing to electrical fires where there is a weak spot (older wiring, undersized neutrals for the electrical load, poor grounding, use of aluminum conductors, etc.). The use of smart meters will place an entirely new and significantly increased burden on existing electrical wiring because of the very short, very high intensity wireless emissions (radio frequency bursts) that the meters produce to signal the utility about energy usage.
There have now been electrical fires reported where smart meters have been installed in several counties in California, in Alabama, and in other countries like New Zealand. Reports detail that the meters themselves can smoke, smolder and catch fire, they can explode, or they can simply create overcurrent conditions on the electrical circuits.
Electrical wiring it is not sized for the amount of energy that radio frequency and microwave radiation. These unintended signals that can come from new wireless sources of many kinds are particularly a worry for the new smart meters that produce very high intensity radio frequency energy in short bursts. Electrical fires are likely to be a potential problem.
Electrical wiring was never intended to carry this – what amounts to an RF pollutant – on the wiring. The higher the frequency, the greater the energy contained. It’s not the voltage, but it is the current that matters. RF harmonics on electrical systems can come from computers, printers, FAX machines, electronic ballasts and other sources like variable speed motors and appliances that distort the normal, smooth 60 hertz sine wave of electrical power and put bursts of higher energy RF onto the wiring.
Wireless smart meters don’t intentionally use the electrical system to send their RF signal back to the utility

(to report energy usage, etc). But, when the wireless signal is produced in the meter… it boomerangs around on all the conductive components and can be coupled onto the wiring, water and gas lines, etc. where it can be carried to other parts of the residence or building.
It is an over-current condition on the wiring. It produces heat where the neutral cannot properly handle it. The location of the fire does NOT have to be in close proximity to the main electrical panel where the smart meter is installed.
A forensic team investigating any electrical fire should now be looking for connections to smart meters as a possible contributing factor to fires. Every electrical fire should be investigated for the presence of smart meter installation. Were smart meters installed anywhere in the main electrical panel for this building? For fires that are 'unexplained'or termed electrical in nature, fire inspectors should check whether smart meters were installed within the last year or so at the main panel serving the buildings. They should question contractors and electricians who may have observed damage from the fire such as damage along a neutral, melted aluminum conductor or other evidence that would imply an overcurrent condition. They should also look for a scorched or burned smart meter, or burn or smoke damage to the area around the smart meter. Problems may be seen immediately, with a smart meter smoking or exploding. Or, it may be months before the right conditions prevail and a neutral circuit overloads and causes a fire. The fire may or may not be right at the smart meter. Some questions that should be asked include:
Were smart meters installed in the main electrical panel for this building? Problems may be seen immediately, with a smart meter smoking or exploding. Or, it may be months before the right conditions prevail and a neutral circuit overloads and causes a fire. The fire may or may not be at the smart meter. Any smart meter installed in a main panel might start an electrical fire in that building; it would not be necessary for the unit itself to have a smart meter. The RF emissions from any smart meter in the main panel might trigger an electrical fire at any location in the building served by this main panel because harmonics can and will travel anywhere on electrical wiring of that building.
Is there damage at the smart meter itself (burning, scorching, explosion)?
Was there fire damage, a source, or a suspicious area around the neutral where it connected to the main panel or at the breaker panel?
Was the damage around a lug at a connection on the neutral conductor in the attic at Xanadu? Was there any indication of heating or scorching or other thermal damage around the neutral in the area of the fire?
Was aluminum conductor present? Aluminum conductors that were installed in the '70s are today recognized as more of a problem for heating than copper wire. Was the aluminum, if present, showing heat damage or melting?
Even before smart meters were being installed widely in California, people who know something about EMF and RF were expressing concerns that this kind of thing would likely happen (electrical fires due to overcurrent condition from RF signal). What is already postulated, and of concern, is that the rising use of equipment that put RF harmonics onto the electrical wiring of buildings may overload that wiring. Faulty wiring, faulty grounding or over-burdened electrical wiring may be unable to take the additional energy load.

48 Responses to Smart Meter Fires and Explosions

Brian Dafferner says:
May 20, 2011 at 7:44 am
Smart meters fires are now occuring in Houston as well through Centerpoint. I had to pay $875 after a smart meter caused a fire at the meter box. A third party installer North Houston Pole Line did the installation work. According to Centerpoint, a hang tag is supposed to placed in situations where older electrical wiring is present. Apparently, older wiring can cause fires during the installation process. I was told by Centerpoint that the meter box needed to be up to date and they denied my claim. I also know of someone whose appliances burned out following a surge caused by a smart meter install. I wound up using an attorney who was able to recover my costs. He is now specializing in these cases since they are popping up all over the country causing property damage and physical harm. Contact Brad Leigh at the Leigh Law Firm (281) 419-3476.

Raymond velez says:
June 1, 2011 at 12:33 pm
i had problems with the smart meter too……..i live in Chicago after they installed the meter i had problems

with my lights going off and on in the house called Comed they send someone to look at it….they tightened up some screws said problem solved. Couple days later same probem called Comed again they said get an electrian to look at it ….Make a long story short it finally caught on fire the meter and my electric box lucky i was home to turn it off……they told me since it was in my house it was my problem i had to fix it….but it was there fault for installing the smart meter they should know better than to install them thing in houses that cant handle the outage….I wana know if i can sue them

Sandi says:
June 1, 2011 at 1:09 pm
Yes, you can sue-see the comment on this page where an attorney has sued and won a case.

NapervilleSmartMeterAwareness says:
June 12, 2011 at 9:03 pm
At Raymond Velez: Just read your post about your house fire. I'm sorry to read your problems about your Smart Meter that ComEd installed. I hope you seek a lawyer to assist you in getting your damages paid for. We are in Naperville and fighting our city's plan to install the Smart Meters. Talk to all your friends and neighbors. Try to keep ComEd from spreading these smart meters throughout Chicagoland. There is so much risk, even more than fire. Best of luck.

Linda Ferrari says:
June 19, 2011 at 9:34 am
They put a smart meter on bedroom wall of a cabin I have been renting for 18 years. It is partway into the wall, a board and batting wall. The first night I was awakened with a wave of energy going through my body. I could imagine my body, the internal rib cavity as it passed through and upwards through my head. I was scared. I have moved into the living room to sleep, it happened again. I have shrouded the smart meter with tinfoil to interfere with the microwaves. I have talked to three idiots reading from scripts at PG&E. The last one said, "It only lasts 45 seconds." I want to tell him to put his balls into a microwave for 45 seconds and see how it feels. Any other help?

Maryling Gonzalez says:
June 22, 2011 at 5:37 am
We had a Smartmeter installed in our home. On April 8th, at 5:3 AM, our lights started flickering, luckily my husband is an early riser. He hurried over to the inside electric box and saw it explode. The Smartmeter exploded as well. The rest of the family was able to get out safely, but our house is a total loss. An FPL representative arrived at our house before the fire department did!
I have heard several stories of people saying that their house caught fire after the Smartmeter was installed. Check out what my home looks like now.
Go to this link:
http://www.miamidade.gov/building/regulation.asp
PUT IN FOLIO NO.30-5912-002-0830, PRESS SUBMIT, THEN ON THE NEXT PAGE PRESS GO, SCROLL DOWN. Pretty sad, huh?

Jacqueline says:
July 11, 2011 at 11:23 pm
My old meter was defect and Portland General Electric replaced it with a "smart meter". It exploded two weeks later as I walked out my front door. It covered the porch with heavy black smoke and threw me down to the cement. I called PGE seven times and told them that the meter exploded. Each time I called the employees used the same phrase, "smart meters do not explode". They decided to come out and look at the black meter and burned wall on my house five months later because I complained about the extremely high bill. However, before they came to inspect meter they hit the "kill switch" and left me without electricity for eleven hours in 20 degree weather. I put up a barrier on the porch with a sign that said, "Warning. Do not pass this chair. Meter has Exploded". PGE is now blaming me for the explosion! Why? I don't know. There was a PGE inspector's business card on my front door last week that had a note on the back stating, "You will pay for all tampered meters. You will die." I called this man and asked why he would threaten my life. He said, I didn't mean to write "die". Yes, I have been threatened by Portland General Electric.

Evelyn Gray says:
August 11, 2011 at 4:58 pm
My son just lost everything He owned when his mobile home caught on fire. He had been living there for two months without electricity due to being laid off from his job and his unemployment running out. I signed for his power to be reconnected. I couldn't bear
to see him living like that any longer. Within less than an hour everything was gone, and his pit bull was

suffering from severe burns and smoke inhalation. We still don't know if Jedamiah (the dog) is going to make it. Audie (my son) was laid off his job that mourning, almost went to prison over $.50 still owed on his legal fees. The power company assumes no responsibility for the fire (Blue Ridge Electric). I don't know if the meter was a smart meter, but it was installed last year. My point being
that while the cause of the fire was undetermined because of structual damage,
it did not catch fire also had an explosion until the power was reconnected. You tell me. The power company now wants a $60.00 reconnect fee. FAT CHANCE!.
A ll this happened on August 10,2011. AUDIE TURNED 42 ON AUGUST10,2011.
Audie's Mom

Mia Nony says:
August 16, 2011 at 5:18 pm
Look at it this way. Your taxes paid for the meter that harmed you all. Special legislation does not exempt utility corps from illegal use of a frequency weapon to inflict trespass and harm.
Time to stand up for yourselves.
I hear that ebay and electricity shops are good places to buy an analog meter for about $60. And besides, given that smart meters are illegal, just go get the analog meter installed by any electrician who is willing and who already KNOWS these are illegal devices warned against by the WHO. Then immediately lock that analog meter up tight so thoroughly that no metal saw can get at or shear through the carriage bolts that go inside you home, that no bolt cutters can cut chains, padlocks. Just make it securitized so that no pry bar can remove the good old fashioned mechanical device that is good for 30 years instead of 8.

et says:
August 17, 2011 at 1:15 am
that happened to me at work one of my neighbors house caught on fire a day and a half after they installed it . got evacuated in the motor home park i work at as a in home nurses assistant.

ryan elson says:
August 27, 2011 at 2:15 pm
coming soon, debtors prisons, after the government makes sure everybody owes something.

goldberg says:
September 12, 2011 at 4:55 am
they are unsafe …….it is with suspicion that i view this implementation of these metrs….even a plan to stagger the emissions from these things to 1 in every 30 houses and on to every 2nd house every 30 days etc…but this is not to be as the rediculous ness of these things going off every minute for what ? …they only need to go on every 30 days for 10 seconds to transmit the months usage …what a bunch of bull shit that you get to logon to your meters usage site to see how you use electricity ,,,gee willacers ,really ,,,this is stupid and specious on the face of the damaging evidence of severe health problems associated with the meters….stalin could not have set up a better way to anhilate 10's of millions of people with radiation..on top of wifis,,cell towers ,cfl bulbs that emit 30,000 hertz noise waves, etc….yeah i cant wait to log onto my site so i can participate in my own demise ,,,,come up with a safer way to collect energy data or go straight to hell pg$e

Mississippi Coal says:
November 11, 2011 at 10:33 am
Smart Meter fire reported in Diamondhead Mississippi, November 4th, 2011. The Diamndhead fire department and Coast Electric reported to the scene. No injuries or house damage reported.

admin says:
November 11, 2011 at 6:08 pm
Thanks for posting. Can you obtain a copy of the fire dept report?

Keith says:
November 16, 2011 at 9:04 am
I am currently having trouble with the socket where electricity is supplied to the meter heating up and causing power surges. FPL and their subcontractor Wilco is denying it has anything to do with them installing a new smartmeter and the underground supply wire subsequently frying. I'm having trouble getting an electrician to work on it and Wilco will do nothing. Is there anything I can do?

admin says:
November 16, 2011 at 9:55 am

This is dangerous. If your utility will not do anything, there are places to purchase an analog meter as I suspect you did not have this problem before?
http://www.hialeahmeter.com/siphwame.html

Mar says:
December 19, 2011 at 2:49 pm
New smart meter explosion.
http://www.justicenewsflash.com/2011/12/19/electrical-explosion-at-naples-bay-resort-injures-1_201112199285.html

Burn Center says:
January 26, 2012 at 12:12 am
Grossman Burn Center 2615 Chester Avenue, Bakersfield, CA 93301-2014 (661) 869-6135 sjch.us

serena says:
February 22, 2012 at 3:38 pm
It happened to me.. and i don't have a right to sue because state farm is the ins. company and they decided not to persue it… they decided not to persue because there is no study proving these fires, just numerous reports.. and it would cost them more money now then they would get back.. what about the people who could die in each additional fire.

Molon Labe says:
February 25, 2012 at 11:42 am
I don't think these so called smart meters have Underwriter's Laboratories Certification. I think this may be a loop hole for the insurance companies to use to refuse a claim..

frank walker says:
February 27, 2012 at 4:18 pm
rincon georgia-feb 26th 2012 10pm, brother in laws house burns up, everyone got out alive. they heard loud popping sounds and smelled smoke. fire is out by 11 pm. strangely, in the commotion, no one saw georgia power come in, remove the meter and meter cover, and de-energise the incoming underground electrical line, and then leave, unanounced and unnoticed with the smart meter and cover plate. the next day, when called, they did admitt to being dispached and removing the equipment in question. no one there saw them, no one knew the power line was off comming into the line side of the meter base, and the meter base cover should have been left on the meter base. the fire started right in front of the meter, on the ground.

admin says:
February 27, 2012 at 5:13 pm
Did you you report this to the fire dept and fire inspector?

Edward Strine says:
March 1, 2012 at 10:35 am
We had a short in our smoke alarm and lost power to our master bedroom smoke alarm. My wife and I have also have had headaches at the same time, I rarely get headaches. This all started happening after our smart meter reader was installed.

Anonymous says:
March 5, 2012 at 11:35 am
THIS INFORMATION IS UNVERIFIED AND I DO NOT KNOW WHAT BRAND OF SMART METER NV ENERGY IN NEVADA IS ACTUALLY USING…BUT IF THIS INFORMATION I READ ON THE "NET" HAS ANY TRUTH TO IT WHAT-SO-EVER, IT WARRANTS FURTHER LOOKING INTO.
According to the Smart Meters I have seen they appear to be a Sensus brand smart meter. I do not know if these are the original smart meters or the current ones being installed by NV Energy…but I have learned that the Sensus brand smart meter does lacks UL Certification.
• From what I read online many of the smart meters being installed around the country also lack UL Certification.
According to Underwriter Laboratories the standard meter manufactured by Sensus are certified by Underwriter Laboratories but the Smart Meters are NOT! This has me concerned.
• I have read online that some people are learning after the fact that some of the home owner/renters policies and home warranty policies are NOT covering damage claims to in-home electrical systems, HVAC, appliances, electrical fires, etc. if an uncertified smart meter was already installed at the time of the damage.
This is way above my pay grade but it is an interesting information and makes one ponder if a

homeowner's policy or home warranty policy disallows a claim due to an uncertified smart meter, does that make the various electric companies culpable for any/all damages if they are in fact using uncertified smart meters??
If this is the case…how were uncertified meters ever approved by the Nevada PUC in the first place.

admin says:
March 14, 2012 at 10:07 am
A man from Red Bluff called today to talk about how he believes the smart meter, installed 6 weeks prior caused his house to burn down in May 2011. His insurance company, Nationwide, has paid for the damages, then Nationwide started a lawsuit against PG&E, but withdrew it in 3 months. Every breaker in the electric panel was tripped, and the meter may have exploded. (sounds like arcing) His house was built in 1985. He said PG&E has denied the smart meter caused the fire.

ANGE says:
April 1, 2012 at 1:38 am
Just recieved a new smartmeter. Not great lights have started to flicker the next day.
We really are being stooged. The people must revolt against all this injustice.

Jodi McCluskey says:
April 14, 2012 at 1:33 pm
I lived in Laguna Woods, CA until the house burned down on April 3, 2012. Absolutely caused by arcing from the new smart meter. This community of 12,000+ was built in the 60's and has wiring and breakers that are a half a century old!
Powerful high-tec meters on ancient wiring. The management company, PCM, is not warning the residents of the dangers. How many people are going to have to be injured or die before they finally take their heads out of the sand?

Concerned Daughter says:
June 23, 2012 at 10:07 pm
About 3 weeks ago my Mom who is 76 was at home, when power went out sporadically throughout the house, no breakers were blown. The lights in the living room tv had power. the small bedroom was without power, the bathroom, parts of my brothers room, her overhead light in her room and the appliances in the kitchen. That caused her fridge to stop working. The electic company came out took a look and said that the smart meter had a wire that had came loose or wasnt properly attached which caused this. He supposedly fixed the problem. twelve days later there was a popping noise and smoke shortly after fire. The electric company same man mind you came out for that as well. he is tryin to blame her wiring and box someone must have stuffed cotton down in it he said. The fire marshal told her it started at the smart meter. There have been 4 fires in a week in a small town of about 6000 that were far worse than hers. Which seems kinda high if you ask me. luckily she lives less than 2 miles from the fire station or her house would have been gone as well. Thankfully it was around 7:30 pm instead of the middle of the night. She lost everything that was in the room which was a lot to due smoke and water damage. Was without power for 6 days and lost all perishable food. Please due something about these smart meters before it is to late!

Bonnie Medd says:
July 31, 2012 at 2:41 pm
Our new smart meter exploded yesterday causing half our circuits to stop working. The men from the electric company asked if I had any work done recently and I told them the electric company had upgraded the meter. He rolled his eyes at me and said, "yeah, some people CALL it an upgrade" and preceded to tell me of other smart meters catching fire. He said we were extremely lucky our house did not go up in flames. Now, I'm going to be a hesitant activist in order to get the word out that these smart meters are DANGEROUS! I don't feel I have to put my family's lives in danger in order to make my electric company's job easier. There is NO opt-out program where I live and DTE told one woman who wanted to opt out that they would just shut her electricity off. Time to put the gloves on…

Mia Nony says:
August 6, 2012 at 11:54 pm
8/5/2012
Smart meter fire on Darwin Ave., Coquitlam, BC.
As with the Mission fire BC Hydro is blaming the smart meter base again.
Problem is that this is a brand new subdivision so how can they postulate that a brand new meter base is

cracked, or is an old crumbling meter base?
BC Hydro doubts smart meter to blame for Coquitlam fire
COQUITLAM/CKNW (AM980)
CKNW News Staff | Email news tips to nwnews@cknw.com
8/5/2012
Could a newly installed BC Hydro smart meter be partially to blame for an early morning fire in Coquitlam?
Hydro crews don't believe so, but they are investigating after a small fire broke out on the outside of a home on Darwin Avenue.
Spokesman Greg Alexis says it appears the cause was likely a faulty meter base.
"The meter base is the piece of the customer's equipment that we plug the smart meter into. The smart meter is the end of our grid and the meter base is the piece of customer equipment."
Alexis says damaged sockets are blamed for a series of recent electrical fires, but stresses the smart meter itself isn't the problem.

Mia Nony says:
August 7, 2012 at 1:20 am
BC Hydro says it's not yet clear what caused a fire at a Coquitlam home where a smart meter had been installed one month earlier.
http://bc.ctvnews.ca/2-home-fires-probed-where-new-smart-meters-were-set-up-1.905587
2 home fires probed where new smart meters were set up
Published Monday, Aug. 6, 2012 4:04PM PDT
BC Hydro says it's not yet clear what caused a fire at a Coquitlam home where a smart meter had been installed one month earlier.
The cause of the blaze that broke out early Sunday morning at the house on Darwin Avenue is under investigation.
BC Hydro says smart meters are safe and that inspections are carried out before the devices are set up.
"In the vast majority of cases we actually find problems when we actually pull the old meter off. It's extremely rare that there is any kind of incident after a meter is installed," BC Hydro spokesperson Cindy Verschoor said.
The Crown corporation also says it has repaired about 1,000 meter bases around the province.
In June, a fire also began at a home in Mission where a smart meter had recently been installed. BC Hydro says the BC Safety Authority is investigating that blaze.
Norm says:
August 18, 2012 at 8:53 pm
I strongly recommend that all those home owners and/or tenants who now have "smart meters" instead of the analog type to go to the meter area and give it a visual and physical check for any apparent discoloration or burning. Use the back of your hand to check the meter base for heat. (You don't want to suffer burns on your palms or fingers.)
Some of these installations of so called "smart meters"have resulted in fires almost immediately, or in a matter of months. There should be no heat! If there is, it could indicate a poor connection between the "lugs" of the base and the "stabs"of the meter.
A fire potential!
Jennie says:
August 20, 2012 at 5:31 pm
I had a really difficult day, the other day.
I woke up. The sun was shining. Life was good. I was heading out to take my dog for a walk, and I bumped into a nice PG&E man. We both spooked each other.
He told me that they were getting a "hot meter" alert from my "smart meter". Heard about those? They are new meters that are internet connected, and speak both to your appliances, and to the head office. Sounds spooky, huh?
Anyhow, he took the meter off, and the clips that I own with the house, were melting and were a fire hazard. Key word: The part "I own".
So, in all good faith, he couldn't walk away from my home, knowing that it was a fire danger, until "I" got it fixed! He put a jumper on it, so that I had at least 110 power, (but no 220) and left. He took my meter

with him, so that I had to get it fixed.

Good day: OVER.
I called my preferred electrician, and then realized I have First American Home insurance. So, I called them. They said, "Yes, it was a covered expense", and they were sending out their electrician to fix it. The electrician they sent out had a bad reputation on Angie's list.
Well, they couldn't come till Tuesday.
It is a fire hazard, and they can't come till Tuesday??? It was Friday! It is 100 degrees out, and I have no electricity!? So, my insurance called until they found someone that could do it, today.
RWE came out, (they had a better reputation on Angie's list, too!) and ordered the parts, and fixed it, (this, about 5 PM) and called PGE to shut down my main power on the street, and wait till it was fixed, to turn it back on. I had 5 large PGE trucks in front of my house! Yikes!
In the meantime, I found out that PGE had previously installed THREE (count em!) smart meters into my home, since Feb 2010 and all had failed. In March 2010, the house was not occupied. I bought the home in July of 2011.
All three "smart meters" had given out "hot socket" alarms and one had actually melted, and they had come out to change each one, without notifying anyone. Somehow, though, this fourth one is my fault?! I'm a little weird-ed out by this. I also found out that these smart meters are starting fires in homes, by doing the very same thing, this one did. I don't know if it's due to installing smart meters into older equipment, or what? But, I found some interesting links about them.
People aren't liking them at all. It's kind of a 1984 "big brother" thing.
Anyhow, when all was said and done, after the insurance company said they'd pay for it, well, the electrician called to make the claim and they ended up denying it! So, I paid $720.00 on my VISA for something I'm not thinking is my doing! Do you even know how long this will take for me to pay off? Wah. I'm a single disabled woman, and I live from paycheck to paycheck.
I mean, why, when the meter was giving out hot signals, did PG&E not tell me and instead, replace it three times…. but then not the fourth time? I have on record from Portland General that they replaced it once due to it being melted, once giving out a not socket alarm, and once again a hot socket alarm.
Why were my meter clips OK until they installed one of these new meters? Why did the insurance company say they'd pay for it, and then not? Do they do that, sometimes? Did they look up this problem like I did, and find the problems with these meters?
I'm new at this whole home ownership thing, but I think I'm going to be doing some research.
Thing is, I don't feel safe, even now, after having this thing get hot, melt, and then melt the clips. Is it going to happen again? While I'm out of town, or in town? What's worse?
I don't know, but I'm sure interested in doing something about all of this.
Jen

zeebo says:
August 31, 2012 at 5:07 pm
It is not the smart meter. It is the wiring and the meter-base that causes the fire.
I have been removing and installing electric meters for 30 years for a major utility and it is very common, up to 80 percent, to observe fatigue in older and rarely even new meter base wiring. When this fatigue is disturbed micro fractures occur in wire insulation and meter lugs and lug mounting brackets. Micro fractures do not sit and do nothing, electricity is a volatile product and seeks a path of least resistance to ground, these fractures expand according to severity and may last hours or years until ground is established then you have your flash. This is what causes the smoke and or fire not the meter, but the disruption of brittle or faulty equipment/wiring. This is fact. Been there done that.
admin says:
August 31, 2012 at 5:32 pm
Perhaps what you say is true…considering the unsuspecting homeowner is the victim of these fires, why aren't the utility companies ENSURING installation safety – instead of denying that there's a huge problem, or paying off insurance companies and not addressing the problem? What utility company do you work for? In California there's a major cover up happening.

John Edmonds says:
September 11, 2012 at 3:13 pm
About four weeks after ONCOR installed a SmartMeter at my home in Plano, Texas, one of the lugs in the meter base broke, causing half of my house to lose power. The lug was obviously corroded, and the new meter should not have been installed in the old base.
I was lucky, in that nothing was burned. The electrician that replaced the meter base for me pointed out that my circuit breaker box, a Federal Pacific Electric, showed signs of having been overheated. So I followed his recommendation, and had it replaced.

GIOVANNI DANIELLO says:
October 12, 2012 at 8:17 am
WOW WHERE DO I START.
I live in Edgewater Florida. i have 2 Rottweilers and a dutch Shepherd in my yard. i have 12 beware of dog signs. HONEYWELL STILL WENT IN MY YARD AND LET MY DOGS GO. whan i came home i had to search for my dogs. i found 2, but not the shepherd that will bite someone. HONEYWELL TOLD ME… SORY FOR YOUR LOST. WE CAN NOT HELP YOU. Fpl sent me a check for my lost dog, that check does not get me back my Guard Dog. HoneyWell did not care. i get my check in 3 weeks. IT GETS WORST. my air conditioner wires all melted and the condenser blew up out side. my refrigerator power just went out on a different line. my room power is out and wire are melting. some of my fuses are now poping. i do not know what to do. what next a house fire…….. i had no PROBLEMS UNTIL THE SMART METER……..
John Collier says:
November 13, 2012 at 9:29 pm
After a smart meter was installed at my home my dishwasher and 46 "Sony hd tv both went out . After being in house for 10 to 15 min started suffering from head aches but head aches go away after leaving home .I filed a claim with Honewell after 2 weeks still havent heard anything after theyr inspector came to check them both . But they waited till meter was changed before they came out to check the equipment . this is in Daytona Bch Florida
pat doran says:
November 14, 2012 at 3:31 am
i was afraid of smart meters so when i heard they were being installed in Houston, I wrote txu and centerpoint energy refusing them on health grounds–also called them several times. Then one day i was awakened one afternoon with a noise outside my bedroom window-i ran outside and found a man installing a smart meter-he had not rung doorbell even and was trespassing and refused to stop and refused to identify himself and when i demanded he put my old meter back and picked up the box with my old meter in it, he grabbed the box, threatened me and knocked me to the ground. When i told him he better leave now or i would call the police he laughed at me and said go ahead-that he would make sure i was the one that would be thrown in jail. Since he was so certain that he could assault a 64 year old woman with impunity, and knowing the reputation of Houston police, I believed him. He casually continued his tasks and then went back to his truck while I went inside to call txu-who just passed the buck to centerpoint who just passed it back to txu-just before driviing off, the monster that assaulted me did give me his bosses phone number. I called it immediately and that man was a true psychopath. After being mister nice and saying his employee should not have assaulted me (duh!), he told me he used to work for Centerpoint and that he had been awarded the contract to install all the smart meters in Houston and that I had no choice but to comply and that I was to believe everything he said BECAUSE HE WAS A CATHOLIC–I was so insulted by his arrogance and bizarre statements that I started complaining some more to Centerpoint and TXU–TXU immediately started sending me bills that were 3-4 times what they were before the installation, then when I complained about that, they threatened to cut off my electricity with no notice at all…and kept this up until I switched electric companies. THEN Centerpoint sent TWO thugs to my house to threaten and intimate me–when I complained the meter was making popping noises and when I came near any electric plug i felt heat and static electricity and the plug would short out, they said nothing was wrong with my meter and then said if I complained, they would say I was threatening THEM and have me thrown in jail. I told them to get out, and shame on them. THEN Centerpoint had someone else break into my yard without knocking and installed ANOTHER smart meter on my gas line. When I told that guy to leave-that he was trespassing and had no permission from me to install that second meter, he left. Then someone called me

from Centerpoint with more lies about how there are no problems with smart meters and then questioned my sanity again for objecting. They said the man had not installed the new smart gas meter…then sent ANOTHER man out who broke into my yard and installed a smart meter-easily observable by the different red tabs but Centerpoint insists i imagined the whole thing. The utility companies in this world are the ones that are quite mad-and murderous. Psychopaths-all of them. Since this attempted robbing and murder spree, half my hair has fallen out-I can't sleep at night, and i fear my house will burn down from what these meters are doing to my electrical system… and yet NOT ONE PERSON will stop them.

vickie says:
December 7, 2012 at 1:39 pm
My smart(DUMB)meter was installed on or around october12,2012-Nov 12,2012. The middle of November My $3,600.00 TV exhibited a snowy picture while me and my grandchildren were watching cartoons. I got up to check the TV, and suddenly the power in that part of the house went off. My grand-daughter and I went outside to check the breaker box and as I attempted to open the box, sparks started shooting from thee top of the box. After reading all of these complaints, I am now terrified to go to sleep at night. Because I know there is a short somewhere in the smart box. I never had any problems until this so-called smart-box was installed. Now I am out an expensive TV. I had to go and buy another cheaper model. GO FIGURE!! GOVERNMENT IS TAKING OVER. SO PEOPLE GET READY!!

Robert LaChance says:
January 8, 2013 at 7:59 pm
My 80 year old mom was dying, dizzy all the time, falling, tired, no color, headaches, sleepless, confused, chest pains and more ….. test after test but nothing….she even died but was revived during one test, all provided no answer. They put her on oxygen 24/7. Thankfully for people that are sharing information on these Death meters. I started searching and found others having the same issues and blaming the so-called smart meter, which is by the way, the greatest oxymoron of all times.
We ordered the removal of the death meter and mom's health started to improve with in two days. Now two months later, she is up and about, active and doesn't use the oxygen tank any more, she is nagging at me again, has great color, spunk, energy, no more headaches, dizziness, or seizers, she is no longer falling to the ground or confused and is sleeping well again.
We are not happy paying an extra $12 a month to opt out but if that is the price of life, it's a hell of a good deal.
PS my mom's pacemaker manufacture warns against smart meters and radiation/RF EMF…. however the utility company didn't not warn us about the possible effects of these death meters which they installed without our knowledge and the PUC doesn't seem to care. But that is not news.
Again thank you all for your input and everyone that is fighting this terrible device, as without this resource and the effort of those before me, my mom would have died by now; that is why I call IT the Death meter.

Ntheknow says:
April 9, 2013 at 7:06 am
As I read these frustrating posts sadly all of them miss the true target. It is NOT evil oil companies but the dolts that think "Green Energy" is the way of the future. There were NO problems until Mr. Green OBO, or Bush with his corn for fuel idea and all the Whacked Environmentalists, vehicles are being destroyed but idiots like Daryl Hannah, TBoon, et all continue. Too bad the face lift idiot did not fall out of the tree in South LA.
Live next to a windmill farm and see how noisy it is and enjoy the EMF it produces. Solar panel farms in the desert were broken panels are just allowed to fall to the sand and we don't have to speak of car companies like Fisker do we? Not to mention, the elite do not have them, only YOU do! I would say wake up, but you are living the nightmare. The only thing "green" about this energy is the money leaving YOUR account! I am for a clean planet out of common sense, however as they insert another ring in your nose with a leash how free are you. I have NEVER heard of an analog meter doing this, even SCE employees opted out, but clown organizations (CPUC) that are appointed are not beholding to the voter and let electo comps install SM so when they finally said. well you do not have to have them.. too late.. installed. Do some research on San Francisco residents wanting Green, now that Nanny Meters been put in people are mad, putting foil to stop the RF (tin hat syndrome) but too late.. In efforts to break a society that was decided over a century ago, they think ugly propeller driven generators and solar panels where <90% are not made here is smart. Chew that bitter pill up in small chunks gang and swallow, those that voted for this

ilk will NOW reap those rewards. Remember "As they fiddled while it burned.. well, now they text while Capt Edward Smith aims for the iceberg. Unfortunately, your stupid decision is taking us with you and there are not enough life boats.
USA the country that once dominated by power, intelligence and pride.. now they are just words.

tony teubert says:
June 3, 2013 at 9:00 am
I need help I have seen high elecrical field get pulled off power line at my house have been looking for the source for 6 monthes untill I read about smart meters all of my appliances have burnt up 4 times my ears ring high pitch when in house the water sofener doing electrolisis on sodium cloride water ph of 11 alklinity and hardness off the chart copper casing of phone line melt when ungrounde I saw a lithuium phone battery crack open 50 volts on all ground wires my hve lit led bulbs off them I. Get shocked so bad in my house it drops me to my knees I have had the power company and 2 electricians look at it now there just pointing fingers at each other with nothing geting fixed.

admin says:
June 4, 2013 at 2:48 pm
Where are your from? Who is your utility? Do you have a Smart Meter on your home?

Clare Donegan says:
June 15, 2013 at 8:54 am
Ontario Fire Marshall:
"Since May 2011, there have been seven reported incidents of smouldering fires and/or explosions involving either the electrical smart meter or the meter base to which it is mounted. Anecdotal information indicates that these incidents resulted from a meter base problem, an installation problem or a failed meter."

Michael Chambers says:
August 26, 2013 at 3:58 pm
On Sunday 8/25/13 at 5 am, asleep in bed, I awoke to explosions in my backyard. Seeing this I immediately went outside to investigate finding a fire was started coming from the smart meter on the back of the garage.
With explosions continuing, and fire getting bigger, eventually engulfing the garage, I quickly realized I was in over my head.
Electrical damage is severe. 200A service total trash. Line fuse on the pole never took out the service, so it kept burning. Guess smart meters aren't quite that smart.
The power company (Centerpoint Energy) was johnny on the spot. While the firefighters were putting out the fire, CNP replaced the line fuse and took the smart meter with no contact with anyone.

admin says:
August 26, 2013 at 4:54 pm
See this thread comments for the Texas attorney who's won a smart meter fire case already. If there was a news report on this fire, can you post it here? Good luck.

Susan says:
September 26, 2013 at 12:07 pm
I do not have a smart meter.
I have offered a Courtesy Notice (CN) (an offer to contract) to my local utility monopoly and we are now in contract because they called me on the phone to offer installation of a smart meter with their legal, but not lawful, new definition of the term "opt-out", a practice of slight-of-hand practiced by most utility monopolies these days. Under that plan, opt-out means you still get a smart meter, but supposedly it does not transmit, and extra fees and monthly charges are applied that no one else has to pay. I do not consent and would be therefore harmed, thus the CN. Meaning that they can put a smart meter in, but they would have to pay me. And BTW, I am prepared to move out if they install one or do a shut-off.
Last week they installed smart meters on all condos in my complex, but skipped mine. I suspect I have not heard the last of this.
I am energy sensitive and so are you, whether you know it or not. Your local utility monopoly knows of such toxicity, but they say they don't to keep peace with the cattle.

I suffered for 15 years with severe health problems before I found the reason was the non-ionizing radiation coming from the energy grid and certain electrical devices. I have filtered my complete condo for the toxic non-ionizing frequencies coming from the wires inside the walls for $300, have a meter, $100, and have added more filters of of new manufacturer, and have a small device that neutralizes frequencies such as WiFi. My computer is connected by wire, not WiFi. The day I put in the filters, all my health problems went away. Yes, on that very day. Never came back.

My local utility monopoly let out that they will not turn the smart meters on until all homes are thus metered. That makes me suspect that they get turned on a little when newly installed just to read the whole house usage, and in months or years is when they turn them on 'for real', metering each and every one of your appliances of any kind and boy will your usage go up (in flames).

Remember, it costs much less to read the old meter than the cost of metering with smart meter and they lie about that by reducing the real estimated cost in one community, $10 billion, reduced down to $2 billion for public consumption, to keep peace with the community cattle. I suggest that you are not cattle and should say so.

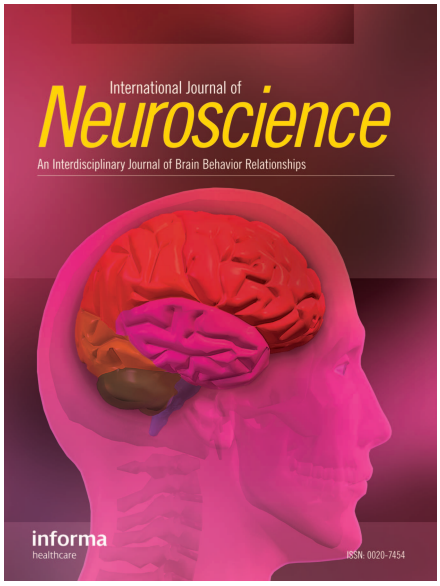
Quit respecting these people, but be friendly and nice to them, even though they are criminals. Lying to the public like that. Educate their paid agents as to the real story.

I made a rousing speech to my local Stop Smart Meters group. One symptom of 15 years of ill-health that I mentioned in the speech, but certainly not the worst symptom, was the 15 years of 'menopause from hell'. After my speech a woman certainly too young for menopause, and she said so, said to me that immediately after installation of her smart meter she went into menopause. And that is with the low dose, not the 'for real' dose.

They know about this and have known for decades, probably since the late 1800s at least, which is when the electric grid was first installed, and when cancer, heart disease, and diabetes rate began to rise. It got much worse after the snake-like fluorescent light bulbs were invented as a result of oil embargo in the 1970s. And all such toxic non-ionizing frequencies travel over the the utility lines. And surprise, surprise, is quite easy and cheap to fix.

But the smart meters are WiFi, and will use a lot of energy to spy on us, ruin our health, steal our money, and possibly other nefarious deeds.

informa
healthcare



Just Accepted by *International Journal of Neuroscience*

ELECTROMAGNETIC HYPERSENSITIVITY: EVIDENCE FOR A NOVEL NEUROLOGICAL SYNDROME

David E. McCarty, M.D., Simona Carrubba, Ph.D., Andrew L. Chesson, Jr., M.D., Clifton Frilot, II, Ph.D., Eduardo Gonzalez-Toledo, M.D., Andrew A. Marino, Ph.D.

doi:10.3109/00207454.2011.608139

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.

ELECTROMAGNETIC HYPERSENSITIVITY: EVIDENCE FOR A NOVEL NEUROLOGICAL SYNDROME

David E. McCarty, M.D.[a], Simona Carrubba, Ph.D.[a], Andrew L. Chesson, Jr., M.D.[a], Clifton Frilot II, Ph.D.[b], Eduardo Gonzalez-Toledo, M.D.[c], Andrew A. Marino, Ph.D.[a,*]

[a]*Department of Neurology, LSU Health Sciences Center, Shreveport, LA, USA*

[b]*School of Allied Health Sciences, LSU Health Sciences Center, Shreveport, LA, USA*

[c]*Department of Radiology, LSU Health Sciences Center, Shreveport, LA, USA*

*Corresponding author. Address: Department of Neurology, LSU Health Sciences Center, P.O. Box 33932, Shreveport, LA 71130-3932, USA. Tel.: 1-318-675-6177.

E-mail address: amarino@lsuhsc.edu

Running head: Electromagnetic Sensitivity

Keywords: Electromagnetic fields, Evoked potentials, Hypersensitivity, Provocation study, Sensory transduction, Sleep study.

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.

INTRODUCTION

Man-made electromagnetic fields (EMFs) such as those produced by cell phones, powerlines, or computers are ubiquitous in the general and workplace environments. About 3–5% of the population subjectively associates acute or subacute exposure to EMFs with departures from normal function or feeling (EMF hypersensitivity) [1, 2]. The prevalence of self-reported EMF hypersensitivity has usually been attributed to somatization disorders [3, 4].

A possible nonpsychological basis for EMF hypersensitivity was provided by the discovery of the ability of human beings to detect weak EMFs, as evidenced by the occurrence of field-onset and field-offset brain potentials [5], and the induction of steady-state changes in brain electrical activity that persisted during the presence of the field [6]. The underlying mechanism of field sensory transduction appears to be an electric-force-sensitive ion channel [7]. Animal studies suggest that the electroreceptor cells and/or afferent processing cells are located in the brain stem [8, 9].

Despite the physiological and biophysical evidence that could explain at least some cases of human somatic responses to EMFs without invoking psychological processes [5-9], direct evidence of nonpsychological EMF hypersensitivity is lacking. Our purpose was to determine whether EMFs could produce symptomatic responses in a putatively hypersensitive subject, while appropriately controlling for chance, confounders, and somatization.

METHODS

Subject

In the context of ongoing human, animal, and biophysical studies involving EMF sensory transduction in our laboratory, we were contacted by a 35-year-old female physician with multiple neurologic and somatic symptoms including headaches, hearing and visual disturbances, subjective sleep disturbances and nonrestorative sleep, and musculoskeletal complaints, all of which she reported could be precipitated by exposure to environmental EMFs and abated by withdrawal from the fields. Among the environmental triggering sources she identified were cell phones, computers, powerlines, and various common electrical devices. During extensive interviews she credibly explained the reasons for her belief that EMFs from common environmental sources could provoke her symptoms.

After she agreed to medical tests appropriate for evaluating her medical condition, she was admitted as a patient on the neurology service and underwent a physical exam including a comprehensive neurologic exam, a clinical electroencephalogram (EEG) exam, a noncontrast magnetic-resonance (MR) imaging of the brain, an overnight sleep study (with video and expanded EEG montage) in which the resulting polysomnogram was scored in accordance with standardized rules [10], a standard laboratory evaluation of serum electrolytes and blood chemistries, liver function tests, serum fasting cortisol, and complete blood count, and direct evaluations of her EMF sensitivity in a series of EMF provocation and behavioral studies (see below). The institutional review board at the LSU Health Sciences Center approved all experimental procedures, and the subject gave her written informed consent.

EMF Exposure

The subject sat in a comfortable wooden chair with her eyes closed, and uniaxial 60-Hz (unless noted otherwise) sinusoidal electric fields were generated by applying a voltage to parallel 49-cm square metal plates spaced 36 cm apart (Figure 1). The equipment that controlled the field was located outside the subject's view and emitted no visual or auditory stimuli. The background electric field (the field present irrespective of whether or not a voltage was applied to the parallel plates) was about 1 V/m throughout the region occupied by the subject (HI-3603, Holaday, Eden Prairie, MN, USA). The plate arrangement did not produce magnetic fields. The continuously-present background 60-Hz magnetic field was 0.1 mG, and the geomagnetic field was 599.8 mG, 68.4° below the horizontal component (component along the direction of the applied field, 360.5 mG) (MAG-03, Bartington, GMW, Redwood City, CA, USA). High-frequency signals from cell-phone towers and other distant antennae (1–10 GHz) were less than 0.1 $\mu W/cm^2$ (the background fields in the sleep-study room were similar) (Spectran, Aaronia, Euscheid, Germany).

In the provocation studies the electric field was applied for 100-s intervals with a duty cycle of 50% and a repetition rate of 10 Hz, which resulted in alternating field-on and field-off pulses of 100 ms (pulsed field); a continuous field (100% duty cycle) was used in one of the provocation studies. Duty cycle, pulse structure, and interval length were regulated by a microcontroller programmed to produce the desired signals. When the duty cycle was 50% the actual EMF stimuli consisted of: 1) 10 onset stimuli per second x 100 s = 1000 field-onset stimuli per interval; 2) an equal number of field-offset

stimuli; 3) the presence of the EMF for a total of 50 s. When the duty cycle was 100% there was only 1 field-onset stimulus and 1 field-offset stimulus, and the EMF was present for 100 s. In the behavioral studies the electric field was applied in trials consisting of a 2-s epoch when a pulsed field was applied (50% duty cycle, 10-Hz repetition rate) and a 10-s field-free control epoch.

Field Strength

The applied electric field was significantly distorted by the subject's body, resulting in strong inhomogeneities in the field surrounding the subject. To overcome the problem of measuring the external field, we used Maxwell's laws to calculate it at every point in the subject's vicinity. The subject was modeled as an electrically isolated composite of rectangular solids representing the trunk and lower extremities, and an ellipsoid representing the head. The assumed conductivity was 1 S/m. The total electric field at every point was determined for V_{AC} = 100 V using finite-element analysis consisting of approximately 10^6 elements; a more detailed mesh was automatically generated in the head region (Multiphysics, Comsol, Los Angeles, CA, USA). The peak external electric field was about 1000 V/m (Figure 1); the average field was about 300 V/m around the head, and less than 50 V/m around the body. The peak and average field strength and duration of exposure were far below the levels generally recognized as capable of producing physiological effects in human subjects [11].

The external electric field resulted in an induced internal electric field in the brain in accordance with physical law. The strength of the induced brain electric field was comparable to that induced by environmental-strength power-frequency electric and

magnetic fields [12, 13].

Somatic Responses

A pulsed field (50% duty cycle) was applied for 100 s in ten independent field-exposure intervals. The controls were ten 100-s sham-exposure intervals during which a field was not applied. The order of the field and sham intervals was determined randomly. The environmental conditions during the field-exposure and sham-exposure intervals were identical except that the wires carrying the plate voltage were disconnected during the sham-exposure intervals. At the end of each interval the subject was questioned by an interviewer blinded to whether or not the field had been applied and asked to describe any symptoms she developed during the interval, whether or not the symptoms had persisted into the interview period. She was queried using descriptive terms she had employed. Whenever she reported symptoms, commencement of the next interval was delayed until she reported that they had abated.

We used a pulsed field because we expected it would result in a stronger symptomatic response compared with a continuous field [9, 14]. To test this reasoning we performed a second study to assess whether the subject developed a differential symptomatic response to the pulsed and continuous fields. The subject was exposed or sham exposed for 100-s intervals, and immediately after each interval was interviewed as described above. A sham field (S), continuous field (C) (100% duty cycle), and pulsed field (P) (50% duty cycle, 10 Hz) were applied, and the SCP pattern was repeated five times. The subject was blinded regarding the use of different EMFs; from

her perspective the laboratory procedures were identical to those followed in the first study. The interviewer was aware that the effects of C and P fields were being compared, but was blinded regarding the actual sequence of the fields.

Behavioral Responses

We considered the possibility that any symptomatic response might be a result of the combined processes of conscious awareness of the EMF followed by a somatization reaction based on a fear that EMFs were harmful. We approached the issue by determining whether the subject could consciously perceive a field when it was presented in multiple independent trials. A field having the same strength and spatial distribution as previously (Figure 1) was applied in a series of trials each of which consisted of a 2-s epoch during which a pulsed field (50% duty cycle, 10-Hz repetition rate) was applied and a 10-s field-free control epoch. Eight independent sequences were employed, each with 30–50 trials. In three sequences the frequency was 60 Hz, in two it was 1 kHz, and in three others the respective frequencies were 10 kHz, 100 kHz, and 500 kHz.

The subject held a small plastic box that housed a buzzer, a button labeled YES and another button labeled NO. In the middle of each on and off epoch the buzzer emitted a 4-kHz tone at 60 dB which lasted 100 ms, and she was instructed to press the YES or NO button whenever she heard the tone, depending on whether or not she had any conscious sensation of a field at that moment. Employing a custom-designed virtual instrument (LabView, National Instruments, Austin, TX, USA), we determined the number of YES and NO responses in the presence and absence of the field in each

sequence. In addition, 4 sham sequences (minimum of 30 trials in each) were conducted in which a field was not applied. The subject had no knowledge that an off-on pattern was being used in the field sequences or that some sequences consisted of sham exposure.

Statistics

The frequencies of the somatic and behavioral responses in the presence and absence of the field were evaluated using the chi-square test (2 x 2 tables) or the Freeman-Halton extension of the Fisher exact probability test (2 x 3 tables) [15].

RESULTS

Clinical Studies

The patient's physical examination was unremarkable. The presence of frequent subjective awakenings from sleep, sometimes with unintended gross motor activity such as muscle twitching and leg jerking, prompted clinical concern for a sleep-related movement disorder, parasomnia, or nocturnal epilepsy. The polysomnogram revealed significant sleep fragmentation and discontinuity (Table 1), but no evidence of significant sleep-disordered breathing, nocturnal epilepsy, or abnormal REM-related atonia. Periodic limb movements were noted, but did not appear to be a major sleep-disrupting force.

Standard and 24-hour video-accompanied EEG recordings revealed normal-appearing background rhythms and no epileptiform activity. EEG performed in the presence of active cellular telephone use provoked a right-sided headache, but

produced no unusual EEG waveforms. The MR image revealed evidence of cortical dysplasia in the right temporal lobe, and right parietal polygyria, both without interval change when compared with a study performed 19 months earlier. Laboratory evaluation for common metabolic/endocrine problems and blood count abnormalities was unremarkable.

Somatic Responses

The sequence and characteristics of the symptomological and behavioral experiments are shown in Table 2.

The question of a relation between the presence of the field and the occurrence of symptoms was directly addressed by interviewing the subject immediately following 100-s field-exposure or sham-exposure intervals; both the interviewer and the subject were blinded regarding the exposure condition. During the interviews the subject reported a range of symptoms including localized pain in her jaw, ear, or the side of her head, a more diffuse head pain, and muscle pain or twitching in the hip, neck, and back. Sometimes she qualified the symptom as “strong” or “mild,” and sometimes she denied all symptoms. We grouped the symptoms related to localized head pain as “temporal pain,” those related to diffuse head pain as “headache,” and those related to muscle effects as “muscle pain/twitching.” Symptoms reported more rarely were indicated explicitly (Table 3a). The subject consistently reported pronounced symptoms that occurred during the field intervals, particularly in intervals 7, 13, 14, 15, and 18. In the sham intervals she reported no symptoms in intervals 4, 6, 8, 16, 20, weak temporal

pain in intervals 2, 3, 19, and a weak headache in intervals 10 and 12. The field and sham distributions of symptoms differed significantly ($P < 0.05$) (Table 3b).

In a second study, the relative role of EMF changes (number of onsets and offsets) and steady-state presence of the EMF was directly addressed by interviewing the subject immediately following 100-s exposure intervals in which either a pulsed field or a continuous field was presented. She was queried regarding her symptoms as previously and reported symptoms in both field intervals (Table 4a). The symptoms triggered by the pulsed field were more intense compared with the sham control ($P < 0.05$) (Table 4b); the symptoms triggered by the continuous field did not differ from the sham control ($P = 0.16$). The subject reported no symptoms in 4 of 5 sham intervals (intervals 1, 4, 10, 13).

Behavioral Responses

The possible influence of conscious awareness of the EMF on the development of symptoms was investigated by assessing whether the subject could consciously perceive the field. A total of 300 independent trials involving carrier frequencies of 60 Hz to 500 kHz were used; the controls consisted of 150 sham trials. The results did not depend on the carrier frequency, and consequently the data was combined for analysis (Table 5).

The subject failed to respond to the tone 7 times while the field was on and 7 times while it was off, resulting in a total of 293 responses for each of the two conditions. There were no missed responses in the sham trials. The overall yes response rate in the field trials was (51/586) x 100 = 8.7%. The occurrence of a yes

response was significantly associated with the presence of the field ($P < 0.05$) (Table 5a), but the sensitivity of the yes responses was low ([32/(32 + 261)] x 100 = 11%). The yes response rate in the sham trials was slightly higher than that seen in the field trials ([27/273 = 9.9%]) (Table 5b).

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 sham-exposure 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.

Declaration of Interest: The authors report no conflicts-of-interest. The authors alone are responsible for the content and writing of the paper.

REFERENCES

1. Levallois P, Neutra R, Lee G, Hristova L. Study of self-reported hypersensitivity to electromagnetic fields in California. Environ Health Perspect. 2002;110 Suppl. 4:619-23.

2. Schreier N, Huss A, Röösli M. The prevalence of symptoms attributed to electromagnetic field exposure: a cross-sectional representative survey in Switzerland. Soz Praventivmed. 2006;51:183-4.

3. Rubin GJ, Das Munshi J, Wessely S. Electromagnetic hypersensitivity: a systematic review of provocation studies. Psychosom Med. 2005;67:224-32.

4. Rubin J, Nieto-Hernandez R, Wessely S. Idiopathic environmental intolerance attributed to electromagnetic fields. Bioelectromagnetics. 2010;31:1-11.

5. Carrubba S, Frilot C, Chesson Jr. AL, Marino AA. Evidence of a nonlinear human magnetic sense. Neuroscience. 2007;144:356-67.

6. Marino AA, Carrubba S, Frilot II C, Chesson Jr. AL, Gonzalez-Toledo E. Simulated MR magnetic field induces steady-state changes in brain dynamics: implications for interpretation of functional MR studies. Magn Reson Med. 2010;64:349-57.

7. Marino AA, Carrubba S, Frilot C, Chesson Jr. AL. Evidence that transduction of electromagnetic field is mediated by a force receptor. Neurosci Lett. 2009;452:119-23.

8. Frilot II C, Carrubba S, Marino AA. Magnetosensory function in rats: localization using positron emission tomography. Synapse. 2009;63:421-8.

9. Frilot II C, Carrubba S, Marino AA. Transient and steady-state magnetic fields induce increased fluorodeoxyglucose uptake in the rat hindbrain. Synapse. 2011;65:617-23.

10. AASM. The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications: American Academy of Sleep Medicine; 2007.

11. International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields. Health Phys. 1998;74:494-522.

12. Carrubba S, Frilot II C, Chesson Jr. AL, Marino AA. Numerical analysis of recurrence plots to detect effect of environmental-strength magnetic fields on human brain electrical activity. Med Eng Phys. 2010;32(8):898-907.

13. Carrubba S, Frilot II C, Hart FX, Chesson Jr. AL, Marino AA. The electric field is a sufficient physical determinant of the human magnetic sense. Int J Radiat Biol. 2009;85:622-32.

14. Carrubba S, Frilot II C, Chesson Jr. AL, Marino AA. Method for detection of changes in the EEG induced by the presence of sensory stimuli. J Neurosci Meth. 2008;173:41-6.

15. Freeman GH, Halton JH. Note on exact treatment of contingency, goodness of fit and other problems of significance. Biometrika. 1951;38:141-9.

16. Hirshkowitz M, Moore CA, Hamilton 3rd CR, Rando KC, Karacan I. Polysomnography of adults and elderly: sleep architecture, respiration, and leg movement. J Clin Neurophysiol. 1992;9(1):56-62.

17. Chokroverty S, Thomas RJ, Bhatt M. Atlas of Sleep Medicine, 1st Ed. Philadelphia, PA: Elsevier; 2005.

18. Pressman MR. Primer of Polysomnogram Interpretation. Boston: Butterworth Heinemann; 2002.

19. Naifeh KH, Severinghaus JW, Kamiya J. Effect of aging on sleep-related changes in respiratory variables. Sleep. 1987;10(2):160-71.

20. Bonnet MH, Arand DL. EEG arousal norms by age. J Clin Sleep Med. 2007;3:275-6.

21. Nicolas A, Michaud M, Lavigne G, Montplaisir J. The influence of sex, age and sleep/wake state on characteristics of periodic leg movements in restless legs syndrome patients. Clin Neurophysiol. 1999;110:1168-74.

22. American Academy of Sleep Medicine. The International Classification of Sleep Disorders: Diagnostic and Coding Manual, 2nd Ed. Westchester, IL: American Academy of Sleep Medicine; 2005.

Table 1 Polysomnography Results. Comparison with usual night, per patient: “Same as usual.” No epileptiform activity noted during arousals associated with unintended gross motor activity. Normal REM-related atonia. REM, rapid eye movement; WASO, wake after sleep onset; PLM, periodic limb movement; AH, apnea/hypopnea.

	SUBJECT	NORMAL RANGE
Sleep latency	6 min	13.4 ± 10.1 [16]
Stage N1 sleep	13.8%	3–8% [17]
Stage N2 sleep	51.8%	44–55% [17]
Stage N3 sleep	23.6%	10–15% [17]
Stage R sleep	10.7%	20–25% [17]
REM latency	150.5 min	57–66 min [18]
WASO index	6/hr	1.3 ± 0.8 [16]
WASO total	40.5 min	10.7 ±11 min [19]
Total sleep time	340.5 min	340.0 ± 70 [16]
Sleep efficiency	88%	86.4% ± 11.6 [16]
Arousal index	34.2/hr	16.8 ± 6.2 [20]
PLM index	7.8/hr	< 5/hr [21]
AH index	0.2/hr	< 5/hr [22]

Table 2 Sequence and characteristics of experiments.

EXPERIMENT	ELECTRIC FIELD CONDITION	NO. OF TRIALS	TRIAL DURATION (sec)	RESPONSE
1	Pulsed	10	100	Symptoms
	Sham	10	100	
2	Pulsed	5	100	Symptoms
	Continuous	5	100	
	Sham	5	100	
3	Pulsed	300	1	Behavior
	Sham	150	1	

Table 3 Evaluation of the relation between presentation of a pulsed electric field and the development of symptoms. (a) Results from the individual 100-s exposure intervals. (b) Summary table.

(a)

INTERVAL NO.	CONDITION	RESULT
1	Pulsed Field	Temporal pain
2	Sham	Mild temporal pain
3	Sham	Mild temporal pain
4	Sham	No symptoms
5	Pulsed Field	Temporal pain; Headache
6	Sham	No symptoms
7	Pulsed Field	Skipped heartbeats; Feeling of unease
8	Sham	No Symptoms
9	Pulsed Field	Headache
10	Sham	Mild headache
11	Pulsed Field	Temporal pain
12	Sham	Mild headache
13	Pulsed Field	Muscle twitch; Feeling of unease
14	Pulsed Field	Strong headache
15	Pulsed Field	Strong headache
16	Sham	No symptoms
17	Pulsed Field	Stiff neck
18	Pulsed Field	Muscle twitch; temporal pain
19	Sham	Mild temporal pain
20	Sham	No symptoms

(b)

FIELD CONDITION	SYMPTOMS		
	NONE	MILD	> MILD
Sham	5	5	0
*Pulsed Field	0	0	10

*P < 0.05

Table 4 Evaluation of the comparative effect of continuous and pulsed fields relative to a sham field on the development of symptoms. (a) Results from individual 100-s exposure intervals. (b) Summary table.

(a)

INTERVAL NO.	CONDITION	RESULT
1	Sham	No symptoms
2	Continuous Field	No symptoms
3	Pulsed Field	Temporal pain
4	Sham	No symptoms
5	Continuous Field	No symptoms
6	Pulsed Field	Mild headache
7	Sham	Mild headache
8	Continuous Field	Muscle twitch
9	Pulsed Field	Severe pain
10	Sham	No symptoms
11	Continuous Field	Temporal pain
12	Pulsed Field	Headache; Muscle twitch
13	Sham	No symptoms
14	Continuous Field	Mild temporal pain
15	Pulsed Field	Mild temporal pain

(b)

CONDITION	SYMPTOMS		
	NONE	MILD	> MILD
Sham	4	1	0
Continuous Field	2	0	3
*Pulsed field	0	2	3

*P <0.05

Table 5 Evaluation of conscious perception of a pulsed electric field. Subject's responses during the presence (On) and absence (Off) of the field, respectively.

(a)

RESPONSE	PULSED FIELD	
	ON	OFF
Yes*	32	19
No	261	274

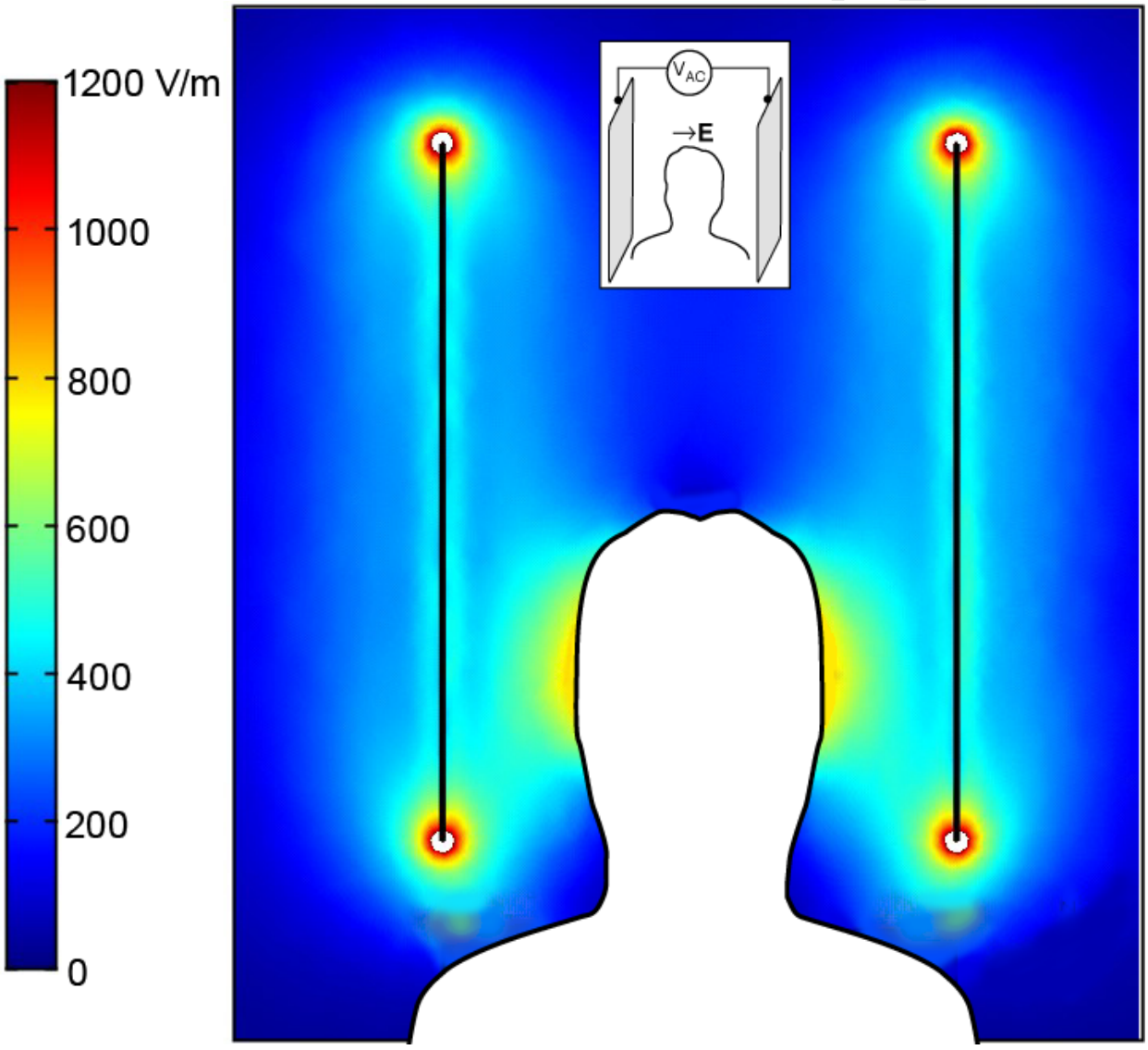
*P < 0.05

(b)

RESPONSE	SHAM	
	ON	OFF
Yes	15	12
No	135	138

Figure Legend

Figure 1. Spatial distribution of the external electric field (E) in the mid-sagittal plane. E was generated by applying V_{AC} = 100 volts to parallel metal plates while the subject was electrically isolated (insert), and calculated at all points in the subject's environment. Average E surrounding the head was about 300 V/m.



http://www.dmlawfirm.com/smart-meter-fire-death

Smart Meter Fire Death
July 9, 2013 # 1:59 pm # Corporatocracy Watch # 2 Comments

Call Toll Free
888-520-5202

The following summarizes a story from stopsmartmeters.org.
A wrongful death lawsuit filed against a Calif. utility, subcontractor and meter manufacturer – all of which had some responsibility for a so-called "smart meter" which killed a man by burning down his house – has been settled with the man's family for an undisclosed sum.
Larry Nikkel of 230 Arbor St. was killed by a Pacific Gas and Electric (PG&E) "smart meter" that caught fire in Vacaville, Calif., on July 9, 2010. A suspicious electrical fire consumed Mr. Nikkel's home the day after Wellington Energy, contractors for PG&E, installed a Landis & Gyr "smart" (read: "Not so much") electric meter.
Microwave radiation – like that emitted from so-called smart meters – usually kills slowly and insidiously after years of exposure, but the dramatic circumstances surrounding Mr. Nikkel's death show that "smart" meters can also kill quickly and violently, and his death is not an isolated incident.
On July 8, 2010, according to neighbors, Wellington Energy installed electric smart meters to houses all along Mr. Nikkel's street. Less than 48 hours later, Mr. Nikkel was killed by smoke inhalation and burns from an unexplained electrical fire that destroyed his house.
Stopsmartmeters.org writes: "According to his brother Walter, who had spent time with Larry at his house the morning before the fire (and only hours after the smart meter was installed), there were serious electrical problems in the house that day. Larry had tried to boot up his laptop to watch a DVD that evening, but the computer would not function. The cable box did not work either. Walter and Larry both heard a very loud, high pitched "snap" coming from the wall. Later that night, after Walter had returned home, he received a call from Larry, who said that the 'house was humming.' He regrets to this day not coming over immediately to investigate what was wrong."
According to electrical engineers, popping, humming and appliance damage are telltale signs of an electrical problem caused by arcing, possibly from a meter. Arcing can trigger fires and explosions. (As stopsmartmeters.org documented in late 2010 in interview with a whistleblower from Wellington Energy, workers were encouraged to ignore safety hazards and only had 20 hours of training, violating FCC requirements that smart meters be installed by a professional electrician). Mr. Nikkel's death appears to be a direct result of the kind of violations uncovered by the whistleblower, whose reports were summarily ignored by the Calif. Public Utilities Commission.
On June 10, 2012, the Nikkel family filed a lawsuit against Pacific Gas and Electric, Wellington Energy, and Landis & Gyr meter manufacturers, alleging negligence and wrongful death.
The case was settled out of court, showing that the utilities and meter manufacturers were alarmed about the potential to lose the case, as well as more bad publicity related to their meter program. The settlement is far from ideal as it avoids a verdict that might force the utilities to compensate others who have suffered smart meter fires, or even to recall the dangerous meters.
The number of smart meter fires meanwhile continues to grow. Last year, a Stamford, Conn., woman lost five members of her family to a fire she suspects was started by her so-called "smart" meter. Her home was suspiciously bulldozed and its contents inexplicably and quickly removed 24 hours later, eliminating evidence that could have shown exactly why the fire started, and perhaps preventing future fires.
In August 2012, Peco Energy of Pennsylvania was forced to suspend its deployment after at least 26 separate incidents where newly installed smart meters had caught fire or exploded. The EMF Safety Network has tracked many of these fires here. See others at stopsmartmeters.org.
A June 15 2012 presentation by the Ontario Fire Marshal analyzes smart meter fires being reported in Canada and abroad, stating:
"We encountered an unusual amount of fire incidents involving smart meters. . . prior to any proper investigation the utility company had removed and replaced the meters from the affected areas. . . New meters may have defects that cause electrical failures (or they may be caused by) careless installation

during change over. . . ”

So-called Smart Meters are neither smart nor safe. Let’s all take action on a local front and stop smart meters from doing any more damage than they have already. If they don’t kill us quickly by fire, they’ll kill us slowly with cancer, or at the least, if we are unlucky enough to live close to them, they can interrupt our sleep and wreak havoc on our human body’s own natural electrical grid. All of our impulses are electric, all the synapses firing in our brains are electric and affected by electricity and microwave. There is no question but that smart meters can overlay our own personal grids and affect us in harmful ways. These things have not been properly tested before being released on us, but at least 2,000 research pieces have shown the hazards of microwave radiation like that emitted from so-called smart meters.

2 Comments

- Seth says:

July 29, 2013 at 9:22 pm
great article
Reply to this comment »

- Chris Turner, Esq. says:

August 16, 2013 at 2:43 pm
News Video:
http://www.myfoxdc.com/story/22240644/fox-5-investigates-smart-meters-spark-controversy#axzz2c4CQZ6mU
http://www.wired.com/threatlevel/2012/09/self-combusting-smart-meters/
http://blogs.citypaper.com/index.php/2012/09/smart-meter-fires-yeah-they-happen/
http://www.napervillesmartmeterawareness.org/2012/12/28/2011-home-fire-results-in-5-deaths-and-questions/
http://www.networkworld.com/community/blog/cia-wants-spy-you-through-your-appliances

No, Your Patient Is Not Crazy

Radiofrequency Sickness: Symptoms, Causes, Mechanisms, Diagnosis, and Treatment

Catherine Kleiber, webmaster at www.electricalpollution.com

Radiofrequency Sickness

Radiofrequency sickness results from overexposure to radiofrequency radiation. Radiofrequencysickness is not a disease. It is an environmentally induced functional impairment. Radiofrequencysickness has real and disabling consequences. People with radiofrequency sickness experience illness(or even death) upon exposure to radiofrequency radiation.

1,2,3,4 The most common sources are electricalpollution – high frequencies that travel on building wiring or through the ground– and transmitters – allwireless devices. Radiofrequency sickness develops when the exposure overwhelms the body's abilityto compensate for the effects produced by the exposure, often within 3-5 years.Detrimental biological effects, distinct from tissue heating effects, have been extensively documented instudies at a range of different frequencies and at levels far below the current United States safetystandard.

5 **Our current safety regulations are not designed to protect people from the non-thermal hazardsposed by wireless devices and transmitting meters.**

The FCC "safety" guidelines are solely designedto protect a 6 ft 185 lb man from tissue heating during a short (6 minute) exposure. They are notdesigned to protect even a 6 ft man - never mind smaller men, women, pregnant women, children, andfetuses - from biological effects during a continuous exposure.

6,7 Population exposures fromtransmitting utility meters and other transmitters (wireless devices) are continuous, so these "safety"standards are meaningless. Transmitting devices compliant with current safety standards should not becharacterized as "safe". The fact that these transmitters are deemed "safe" because they comply withFCC guidelines is part of the reason that exposure is now ubiquitous and involuntary. Recent studiesand an extensive historical literature strongly support complying with the precautionary principle.

8 Enacting precautionary policy would require establishment of lower safety standards for chronicexposures to radio frequency radiation for the population as a whole.

Symptomatology

Microwave and radiofrequency radiation are now being associated with attention deficit disorder,autism, sleep disorders, multiple sclerosis, fibromyalgia, chronic fatigue syndrome, Alzheimer's disease,SIDS, epilepsy and chronic pain, as well as asthma, diabetes, malignant melanoma, breast cancer, andother illnesses that have become increasingly more common. Please see www.bioinitiative.org to read a2007 review of the peer-reviewed science on the long-term risks of exposure to transmitted microwaveand radio frequency radiation. Studies finding no health effects are predominantly industry funded.

9 Areport by Hallberg and Johansson

10 published recently in
Pathophysiology
asks the provocative questionabout whether the recent (1997 and later) increase in exposure to microwave frequencies may beresponsible for the recent decline in public health in Sweden. The data seem to say that public exposureto microwave frequencies is a likely culprit.Autism continues to be a puzzle. Robert Kane, PhD suggested a link between exposure to radiofrequencies and the rise in autism.
11 There are reasons to believe that Dr. Kane may be correct.
*
Sections of
The BioInitiative Report
was updated in 2009 and published in a special issue of the peer-reviewed journal
Pathophysiology

available at

:http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%235138%232009%23999839997%231345066%23FLA%23&_cdi=5138&_pubType=J&_auth=y&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=46db922ea4d2a2352e7490de7de6c785

The fact *that, despite the removal of mercury from vaccines, the rate of autism is continuing to increase and hasincreased more or less in parallel to the increasing rate of exposure to high frequencies and emf issuggestive, as is the fact that the Amish Community had not experienced a similar increase in the rate of autism. Some attribute this to the fact that the Amishdon't vaccinate. However, the Amish also have not hadthe radiofrequency and emf exposures now standard inmodern society. A large Danish (13,159 child) studylinkslinks high frequency exposure pre- and post-natally with behavior and learning difficulties.*

12 **Causes of Radiofrequency Sickness**
Electrical pollution and wireless technology expose people to radiofrequencies. Often the levels of exposure are high enough to cause chronic or severe illness. Exposure is often involuntary. For instance, exposure to radiofrequency radiation from neighbors often causes sensitive people in town to be chronically ill, unable to recover. Utility companies nationwide are moving toward installing transmitting electrical, gas, and water meter sat each customer's service. The new digital meters installed on electrical services are called "smart" meters because they can do time of day metering, keep very close track of energy usage, and potentially perform other functions. Many of these "smart" meters are **transmitting** *"smart" meters. The transmitting meters often send in the data by transmitting in strong microwave bursts every few seconds 24 hours per day 7days a week. In addition to transmitting in strong bursts, transmitting, "smart," or AMR meters can also overexpose the general population to high frequencies by putting high frequencies on home and building wiring, either deliberately through signaling or inadvertantly through poor engineering. High frequency signals on power lines are also biologically active. Milham and Morgan found a dose-response relationship between high frequencies present on building wiring and cancer*

Symptoms of Radio Wave Sickness
(excerpted from No Place To Hide April 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 pain, 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.*

13. Recent analysis of historical epidemiological data indicates a relationship to cancer, diabetes, heart disease, and suicide

14. Removing high frequencies on building wiring has improved MS symptoms, blood sugar levels, asthma, sleep quality, teacher health, student attentiveness, headaches, ADD, and numerous other health problems

15,16,17. Technical papers provide a solid electrical and biomolecular basis for these effects. A recent paper by Ozen showed that transients induce much stronger current density levels in the human body than does the powerline 60Hz signal

18. A technical paper by Vignati and Giuliani discusses the authors' findings that high frequency communication signals on power lines also induce much stronger electrical currents in the human body than a low frequency signal of the same strength

19. The induced currents disturb normal intercellular communications. This causes harmful short-term and long-term effects. Additional information can be found onwww.electricalpollution.com. Information necessary to properly measure the high frequencies causingthese health problems can be found on the Technical page. A simple meter is also available that canprovide accurate measurements of electrical pollution levels in most situations.

Mechanisms of action - A brief overview

A number of studies show that electromagnetic radiation, including radiofrequency radiation, alters heartrate variability, blood pressure (including inducing hypertension with microwave exposure – mostwireless devices transmit in the microwave range) and increases risk of arrhythmia-related heart diseaseand heart attack.
4,5
There is extensive documentation in the literature of alterations of Ca2+ homeostasis.
5
This is likely tobe responsible at least in part for the profound effects that radiofrequency radiation has on the heart andneurological function. Ca 2+ regulates gap junction opening. Gap junctions are key in many intercellularcommunications.Exposure to radiofrequency radiation also interferes with the action of enzymes, signaling pathways, andmakes the immune system simultaneously hyperactive and less effective.
5,20
Immune impairment resultsin part from the disruptive effect of radiofrequency radiation on calcium ion homeostasis. In addition toradiofrequency radiation-induced immune impairment increasing risk of various types of infection, it islikely to increase the risk of getting cancer from the DNA breakages that radiofrequency radiation iswell-documented to induce.
5
While radiofrequency radiation is non-ionizing, the metabolic changes itcan cause result in oxidative damage to DNA and subsequent breakage. Direct interactions betweenradiofrequency radiation and DNA can have similar results, as well as causing changes in genetranscription, through changes in electron flows induced by the radiation.
21
Neurological function can be seriously impaired by radiofrequency radiation. Ca2+ homeostasis and gap junction function are key to neurological function. Cholinesterase enzyme activity is impaired byexposure to radiofrequency radiation in a manner similar to impairment caused by organophosphatepesticides, often rendering a person with radiofrequency sickness particularly sensitive to small amountsof chemicals.
22
Radiofrequency radiation can lower the pain threshold, slow reaction times, causefatigue, muscle weakness, headaches, difficulty concentrating, short-term memory problems and evenmemory loss.
1,2,3,4
Radiofrequency radiation significantly decreases melatonin levels and decreases the ability of existingmelatonin to fight cancer.
5
Good sleep is essential for good mental and physical health. Good sleep isvery difficult, if not impossible to obtain with abnormally low melatonin levels. Sleep deprivation alongwith impaired neurological function, altered brain glucose metabolism, disruption of various enzymepathways, induction of the stress response and associated effects, and increased permeability of theblood-brain barrier (lasting as long as 50 days after exposure), are likely to be behind the brain fog andcognitive difficulties those with radiofrequency sickness experience.
4,5,22,23,24,25,26

In the book "The Brain that Changes Itself" the author, Norman Doidge M.D., discusses the research into brain plasticity by Michael Merzenich, PhD. Dr. Merzenich has found that many of the symptomsof autism can be explained by the developing brain getting locked into an undifferentiated brain map prematurely. The book cites a study that found that continuous exposure to white noise could contribute to this happening in susceptible children. The mechanism is unlikely to be specific to white noise and likely to be responsive to any exposure to large amounts of high frequencies (such as electrical pollution and transmitters - wireless devices). Dr. Merzenich has developed a treatment that is based on the premise of high frequency exposure. He has found it to be far more effective than originally hoped. The effectiveness would validate the link Dr. Kane suggested between autism and radiofrequency exposuresince it targets developmental damage caused by the effects of high frequency exposure in susceptibleindividuals. The treatment Dr. Merzenich has developed is a special computer program - Fast Forward.It simply aims at re-opening developmental windows and properly differentiating the portions of thebrain involved.

Radiofrequency exposure may cause or contribute to SIDS as well. Dr. William Sterner, chief medicalexaminer for the State of Rhode Island, found that babies that died of SIDS had lower melatonin levelsthan babies that died of other causes. He postulated that this caused depressed respiration
27
.Radiofrequency radiation exposures have been well documented to decrease melatonin levels.
4,5
Theyare also well documented to interfere with neurological function.
4,23
There has not been a consistentrigorous evaluation of this possibility in SIDS investigations. A thorough evaluation should includetransmitted high frequency readings, electrical pollution readings, and gauss readings, perhaps even on a24 hour basis for a period of time, as well as a check for proximity to various sources such as babymonitors, wireless internet modems, transformers for electronics, DECT phones, TVs, computers,including on the other side of the nursery wall.

Diagnosis

Diagnosis of radio frequency sickness remains a largely clinical diagnosis. Since it is anenvironmentally-induced functional impairment, the health of the whole family should be consideredwhen considering radiofrequency sickness as a diagnosis. Some previous diagnoses seem to stronglyindicate radiofrequency exposure as a causal agent or an aggravator, even without consideration of otherfamily members. These diagnoses are: multiple sclerosis, fibromyalgia, and chronic fatigue syndrome.Other diagnoses such as asthma, diabetes, headaches, migraines, allergies, rashes, sleeplessness, ADD/ADHD, GERD, autism, depression, nausea, and possibly chronic lyme disease warrant checking forassociation with radiofrequency sickness, especially when more than one family member has any of thediagnoses mentioned or has noticed changes in symptoms at different locations. For instance, the patientalways gets headaches at work, but not at home - or vice versa. Day of the week associations or time of year associations may also indicate an association with radiofrequency sickness.Bradycardia, tachycardia, sinus arrhythmia, and many other symptoms may relate to the neurologicallyexhausting effect of radiofrequency exposure. Changes in EKG and EEG were also noted.Radiofrequency sickness can also cause changes in the pain threshold and so should be considered inpatients with chronic pain of unknown etiology.

4,23

Treatment

The only "cure" for radiofrequency sickness is to end the exposure to radiofrequency radiation.

Eliminating exposure to radiofrequencies in this day and age can be a challenge. Patients will need tobegin in their own environments where they have the most control. A comprehensive list of steps to taketo eliminate exposure to radiofrequencies as much as possible is available atwww.electricalpollution.com/solutions.html.Many people can reduce their exposure enough in their own environments to enable them to improve.Others find that they have to move. Many will need your help to facilitate the changes necessary. Astheir physician, you may need to write letters of support to utility companies, landlords, employers, andothers with whom they must work so they can improve their environment to assist their recovery.In the literature, stage 3 radiofrequency sickness is taken very seriously, and hospitalization is recommended.

23

Unfortunately, hospitalization at this time in the U.S. would likely do more harm thangood with the wireless telephone headpieces, WiFi, and myriad other radiofrequency transmitterspresent in hospitals.(Previously exposure was primarily occupational, not society wide.) Your helpmay be necessary in order to get hospitals and clinics to create low RF environments for the sake of yourpatients. Many people with radiofrequency sickness have trouble accessing healthcare due to theextreme toxicity of highly electrically-polluted and transmitter-ridden environments for those whoalready have radiofrequency sickness.While those with full-blown radiofrequency sickness become ill quickly, often immediately, inenvironments highly polluted with radiofrequencies, healthy individuals also face the possibility of getting radiofrequency sickness from continued exposure. Radiofrequency sickness in healthyindividuals often develops within 3-5 years of beginning overexposure, although the onset and severityof the illness depends on how often the exposure occurs, the frequency and amplitude of the radiationsignal and the duration of the exposure.

23

Studies show pulsed microwaves, as utilized by moderncommunication devices, including transmitting electrical meters, are very potent biologically.

1,2,3,4,23

It is important to bear these risks in mind while instituting changes. The precautionary principle dictates that everyone should minimize their exposure to radiofrequenciesfrom both transmitters and electrical pollution. Continued exposure to radiofrequencies increaseseveryone's risk of developing cancer. Thus, people should keep their cellphones off, except during brief essential calls. They should use dedicated wired or fiber optic connections for everything, butemergency use. Even having your cellphone on to send and receive texts exposes your body on anongoing basis to pulsed microwave radiation as the phone communicates continuously intermittentlywith the cell tower. Wireless devices with transmitters that are continuously on (such as DECT phones)should be avoided. The installation of transmitting or poorly engineered "smart" utility meters shouldbe halted and rolled back. Only meters that do not increase public exposure to microwave andradiofrequency radiation and "dirty" power should be used while conservative standards to protect thehealth of the general population during continuous exposures to electrical pollution and radiofrequencyradiation are researched and established.More detailed information can be found in the following references, in

The BioInitiative Report

atwww.bioinitiative.org, atwww.magdahavas.com, atwww.electricalpollution.comand atwww.emrpolicy.org.

References

1)Johnson Liakouris AG. Radiofrequency (RF) sickness in the Lilienfeld study: An effect of modulated microwavesArchives of Environmental Health; May/Jun 1998; 53, 3.2)Santini R, Santini P, Le Ruz P, Danze JM, and Seignel M. 2003 Survey Study of People Living in the Vicinity of Cellular Fhone Base Stations. Electromagnetic Biology and Medicine Vol. 22, No. 1, pp. 4149.3)Hyland GJ. Physics and biology of mobile telephony. The Lancet, Vol 356, November 25, 2000.4)Marha K, Musil J, and Tuha H. Electromagnetic Fields and the Life Environment. Institute of Industrial Hygiene andOccupational Diseases, Prague, Czechoslovakia. English Translation 19715)Cherry, N. 2000 Criticism of the Health Assessment in the ICNIRP Guidelines for Radiofrequency and MicrowaveRadiation (100 kHz- 300 GHz)6)Letter from Norbert Hankin, Center for Science and Risk Assessment, Radiation Protection Division, EPA, regarding thelimitations and purpose of the FCC exposure standards. http://www.emrpolicy.org/litigation/case_law/docs/noi_epa_response.pdf 7)Identification of Research Needs Relating to Potential Biological or Adverse Health Effects of Wireless Communication,2008, National Academy of Science. http://www.nap.edu/catalog.php?record_id=12036#toc

8)Sage C, Carpenter DO. 2009. Public health implications of wireless technologies, Pathophysiology Aug; 16(2-3):233-46.9)Huss et al., "Source of Funding and Results of Studies of Health Effects of Mobile Phone Use: Systematic Review of Experimental Studies", Environmental Health Perspectives, 115(1): 1-4, 2007. http://www.ehponline.org/members/2006/9149/9149.pdf.10)Hallberg O, Johansson O, Apparent decreases in Swedish public health indicators after 1997 – Are they due to improveddiagnostics or to environmental factors? Pathophysiology Volume 16, Issue 1, June 2009, Pages 43-46.11)Kane RC. 2004. A Possible Association Between Fetal/neonatal Exposure to Radiofrequency Electromagnetic Radiationand the Increased Incidence of Autism Spectrum Disorders (ASD) Medical Hypotheses 62, 195-19712)Divan HA, Kheifets L, Obel C,

Olsen J Prenatal and Postnatal Exposure to Cell Phone Use and Behavioral Problems in Children Epidemiology 2008;19: 523–529.13)Milham S, Morgan L. A new electromagnetic exposure metric: High frequency voltage transients associated withincreased cancer incidence in teachers in a California school, American Journal of Industrial Medicine, Volume 51,Issue 8, Date: August 2008, Pages: 579-58614)Milham S. Historical evidence that electrification caused the 20th century epidemic of "diseases of civilization". Medical Hypotheses DOI: 10.1016/j.mehy.2009.08.03215)Havas M, Olstad A. Power quality affects teacher wellbeing and student behavior in three Minnesota Schools, Science of the Total Environment, Volume 402, Issues 2-3, 1 September 2008, pp. 157-162.16)Havas M. 2008. Dirty Electricity Elevates Blood Sugar Among Electrically Sensitive Diabetics and May Explain BrittleDiabetes. Electromagnetic Biology and Medicine, 27:135-146. http://www.informaworld.com/smpp/content~db=all?content=10.1080/15368370802072075 17) Havas M. 2006. Electromagnetic hypersensitivity: biological effects of dirty electricity with emphasis on diabetes andmultiple sclerosis. Electromagnetic Biology Medicine 25(4):259-68.18)Ozen, S. 2007. Low-frequency Transient Electric and Magnetic Fields Coupling to Child

Body, Radiation ProtectionDosimetry (2007), pp. 1–6. http://rpd.oxfordjournals.org/cgi/content/full/ncm31519)Vignati, M. and L. Giuliani, 1997. Radiofrequency exposure near high-voltage lines. Environ Health Perspect 105(Suppl6):1569-1573 (1997) http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=146991420)Johansson O. Disturbance of the immune system by electromagnetic fields—A potentially underlying cause for cellulardamage and tissue repair reduction which could lead to disease and impairment, Pathophysiology, Volume 16, Issues 2-3,August 2009, Pages 157-177.21)Blank M and Goodman R.Electromagnetic Fields May Act Directly on DNA, Journal of Cellular Biochemistry75:369-374 (1999)22)Grant L. Microwaves Imitate Pesticides. U.S. Department of Energy Risk Management Quarterly, Volume 5-323)Dodge C. Clinical and Hygienic Aspects of Exposure to Electromagnetic Fields. Biological Effects and HealthImplications of Microwave Radiation,Symposium Proceedings, Richmond, Virginia, September 17-19, 1969.24)Kwon MS, et.al. 2011. GSM mobile phone radiation suppresses brain glucose metabolism Journal of Cerebral Blood Flow & Metabolism 31, 2293–230125)Volkow ND, et. al. Effects of Cell Phone Radiofrequency Signal Exposure on Brain Glucose Metabolism JAMA2011;305(8):808-813.26)Salford et al, Nerve Cell Damage in Mammalian Brain after Exposure to Microwaves from GSM Mobile Phones.Environmental Health Perspectives, Vol. 111(7), June 2003.27)A Becker, RO "Cross Currents: The Promise of Electromedicine, The Perils of Electropollution" 1990, Tarcher/Putnam.

Symptoms of Radio Wave Sickness
(excerptedfrom No Place To Hide April 2001):

Neurological:
headaches, dizziness,nausea, difficulty concentrating, memoryloss, irritability, depression, anxiety,insomnia, fatigue, weakness, tremors,muscle spasms, numbness, tingling, alteredreflexes, muscle and joint pain, leg/footpain, "Flu-like" symptoms, fever. Moresevere reactions can include seizures,paralysis, psychosis and stroke.

Cardiac:
palpitations, arrhythmias, pain orpressure in the chest, low or high bloodpressure, 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 theeyes, pressure in/behind the eyes,deteriorating vision, floaters, cataracts.

Others:*digestive problems; abdominalpain; enlarged thyroid, testicular/ovarianpain; dryness of lips, tongue, mouth, eyes;great thirst;dehydration;nosebleeds;internalbleeding; altered sugar metabolism;immune abnormalities; redistribution of metals within the body; hair loss; pain in theteeth; deteriorating fillings; impaired sense of smell; ringing in the ears.*

these health problems can be found on the Technical page. A simple meter is also available that canprovide accurate measurements of electrical pollution levels in most situations.

Mechanisms of action - A brief overview

A number of studies show that electromagnetic radiation, including radiofrequency radiation, alters heartrate variability, blood pressure (including inducing hypertension with microwave exposure – mostwireless devices transmit in the microwave range) and increases risk of arrhythmia-related heart diseaseand heart attack.

4,5

There is extensive documentation in the literature of alterations of Ca

2+

homeostasis.

5

This is likely tobe responsible at least in part for the profound effects that radiofrequency radiation has on the heart andneurological function. Ca

2+

regulates gap junction opening. Gap junctions are key in many intercellularcommunications.Exposure to radiofrequency radiation also interferes with the action of enzymes, signaling pathways, andmakes the immune system simultaneously hyperactive and less effective.

5,20

Immune impairment resultsin part from the disruptive effect of radiofrequency radiation on calcium ion homeostasis. In addition toradiofrequency radiation-induced immune impairment increasing risk of various types of infection, it islikely to increase the risk of getting cancer from the DNA breakages that radiofrequency radiation iswell-documented to induce.

5

While radiofrequency radiation is non-ionizing, the metabolic changes itcan cause result in oxidative damage to DNA and subsequent breakage. Direct interactions betweenradiofrequency radiation and DNA can have similar results, as well as causing changes in genetranscription, through changes in electron flows induced by the radiation.

21

Neurological function can be seriously impaired by radiofrequency radiation. Ca

2+

homeostasis and gap junction function are key to neurological function. Cholinesterase enzyme activity is impaired byexposure to radiofrequency radiation in a manner similar to impairment caused by organophosphatepesticides, often rendering a person with radiofrequency sickness particularly sensitive to small amountsof chemicals.

22

Radiofrequency radiation can lower the pain threshold, slow reaction times, causefatigue, muscle weakness, headaches, difficulty concentrating, short-term memory problems and evenmemory loss.

1,2,3,4

Radiofrequency radiation significantly decreases melatonin levels and decreases the ability of existingmelatonin to fight cancer.

5

Good sleep is essential for good mental and physical health. Good sleep isvery difficult, if not impossible to obtain with abnormally low melatonin levels. Sleep deprivation alongwith impaired neurological function, altered brain glucose metabolism, disruption of various enzymepathways, induction of the stress response and associated effects, and increased permeability of theblood-brain

barrier (lasting as long as 50 days after exposure), are likely to be behind the brain fog andcognitive difficulties those with radiofrequency sickness experience.
4,5,22,23,24,25,26
In the book "The Brain that Changes Itself" the author, Norman Doidge M.D., discusses the researchinto brain plasticity by Michael Merzenich, PhD. Dr. Merzenich has found that many of the symptomsof autism can be explained by the developing brain getting locked into an undifferentiated brain mapprematurely. The book cites a study that found that continuous exposure to white noise could contributeto this happening in susceptible children. The mechanism is unlikely to be specific to white noise andlikely to be responsive to any exposure to large amounts of high frequencies (such as electrical pollutionand transmitters - wireless devices). Dr. Merzenich has developed a treatment that is based on thepremise of high frequency exposure. He has found it to be far more effective than originally hoped. Theeffectiveness would validate the link Dr. Kane suggested between autism and radiofrequency exposure

http://www.veteranstoday.com/2013/10/24/microwaves-smart-meters-and-the-use-of-electronics-for-mind-control/

Microwaves, Smart Meters and the use of electronics for 'mind control'

by Jim Fetzer, Barrie Trower and Deborah Taveres Thursday, October 24th, 2013

For those who have wondered about the use of electronic weapons for 'mind control', here is a most disturbing interview of an expert, where I am publishing portions of the transcript, which is here.
The interview was provoked by a document found on the White House website entitled, "Realizing the Full Potential of Government Held Spectrum to Spur Economic Growth", President's Council of Advisors on Science Technology (20 July 2012).
The complete interview may be found in the YouTube embedded below. This is about as disturbing as it gets.
Barrie Trower is a British physicist who was trained in microwave warfare by microwave experts. He looked at aspects of microwave warfare and, when he finished the time that he spent in the military, he had a lot of expertise in the microwave field and he was asked to carry on with this research. And it was a new cold war that he discovered with microwaves. Here is his personal warning in his own words:

> "In the very early 1960's I trained with the government microwave warfare establishment. I looked at all aspects of microwave warfare and when I finished my time in the military, because I had a lot of expertise in the microwave field, I was asked if I would carry on with this research. We are in a new Cold War and this is why countries are developing this. And this is why all the microwave transmitters are going up everywhere because somebody, if they wanted to, could use them for other effects. The system is up and running.
>
> Years ago our government said to our scientists when it comes to microwaves you will only talk about things to do with heat, and that is it. So they won't even discuss anything else. **They will deny anything that doesn't have anything to do with heat. They even deny all their 40 years of research leading up to this, although they've said that this can cause cancer and all the damage, they say no it can't. We're only looking at heat and heat is all that matters. So for the last 40 years the English government has been lying to the people.** And the American, the Canadian, the Australian, they have been lying. They have been lying to protect industry, to protect their profits, to protect themselves from lawsuits.
>
> So they are really just liars and it is provable, sanctioned by the World Health Organization, without a shadow of a doubt. It is the same people that sit on the ICNAP certificate, sit on our government health protection agencies, sit on the World Health Organization . . . . it is the same people. There are probably no more than 20 of them.
>
> But, yes, they are going to, in my opinion, commit the worst genocide this planet has ever known, not just people, but animals and plants.
>
> They are probably going to cause more destruction than a global war, and in several hundred years time, people will look back, whoever survives, and look at what we tried to do to stop them."

About gaining a foothold

Deborah Tavares: So as we go through this, Barrie, I would like for you to explain some of what you see in this document, if you would, because it's going through thirteen pages, and they're talking about what the purpose of the spectrum is and if we could just flip slowly each portion represents one page that is on our website.
Barrie Trower: One of the things you said, the universities, for instance, they may not be guilty. And I can give you an example. The government holds massive amounts of funds for research

and the universities apply for research grants. Now to give you one example in the United States, the government asked one university if it could devise a method whereby if you beamed microwaves into somebody's ears the vibrational frequencies in the cochlea, they would actually produce sound in the person head so nobody else around could hear, just the one person being beamed could hear the sound.

And the University was told this would aid the deaf enormously because people could talk into a device and they would just hear it straight through. It was also picked up by the super store manufacturers who said we could also use this for good because if we have shoplifters, we can beam the pulse frequencies to the shoplifters to say, "You're being watched. Put this down." We'll prevent crime, and that was used for good. It didn't take people very long, especially the military and other super stores to think, 'well, hang on, we can use this for our own devices'.

> So the military can now put voices into people's heads to do whatever deed they wish it to achieve, and the super stores have also realized that rather than say 'put that down, you're going to steal it' , if you're indecisive and you're shopping, they can say 'you really do want to buy this', and after nine months, and I got the figure from one of your calls, somebody took one of your super stores to court for beaming them. And they made a phenomenal profit in just nine months, phenomenal profit. But because your Federal Communications Committee says that microwaves were safe, the case fell.

So all I'm saying is that when you're reading out the universities, they may be acting totally innocently and it may be that the recipients, after the research is done, say now we will turn this to our advantage.

Deborah Tavares: And that's because so much is compartmentalized and that's how they keep this monster escalating to the degree that they are.

Barrie Trower: Yes. It's perception.

About the use of "Smart Meters"

Deborah Tavares: Would you say that as far as the microwave targeting of mass populationsnow, which is what this is showing (holds White House document up), is the intention where we were talking about more specific targeted people hundreds of thousands globally?

Barrie Trower: Yes.

Deborah Tavares: Now we're looking at a map that really does show a mass targeting particularly of the United States?

> **Barrie Trower**: Oh yes. Absolutely. Really this is one of the ideas behind the Smart Meter where they put them on everybody's homes. What they can do now. They can watch every single person in that house. They can watch you go to bed. They can watch what you're doing in bed. They can watch you on the toilet and in the bath. They can hear every single word you're saying. They have a machine which will measure your hormone levels. They have a machine, provided they're within a 150 feet, they can measure your brain activity and they can even tell what frame of mind you're in.
>
> Now, if they can do this to an entire population, most people would not like it done to them but would be unaffected, and from the government point of view is, we're really not interested in 98% of the population anyway, but we want the 2% that could be dangerous to the American citizens. But that doesn't' apply. They then do on to say, "Well hang on, there's a group there that are obstructing us doing this, demonstrators. We'll watch those." And then you get to people of specific religions, and people with long hair, and people who smoke cannabis, and the level comes down and down and down to the point where they're actually monitoring about 75% of the population and they have the computer
>
> technology to do this.

Mind Control and Behavior Shaping

Deborah Tavares: Well, that is what we're understanding is the intention of this (holding up the White House document). And what this is of course depicting is psychotronic weapons for mass

mind control and about quantum computers and mind control, mind theft, and invasion of the human brain with artificial intelligence. Could you explain to people what that means.

Barrie Trower: The first thing, with this (referring to the White House document) when you blanket a whole area, there are different reasons for monitoring populations, and right now in the United States there could be to my knowledge between 40 to 45 countries blanketing people with microwaves, and all you need is a few vehicles, blanketing people with microwaves for specific purposes. Now I grew up in the Cold War era with spies, and forget James Bond or anything silly like that, the main weapon of a spy, any spy from any country, the main weapon is blackmail. That is the main weapon. Because, for instance, if I'm from a country and I want to get a spy into the United States they're going to need documentation. To get a passport or a birth certificate or some form of documentation you need a professional person or two, like a lawyer, to sign an affidavit or something to say I have known this person since they were zero years old, they are now 22. I can identify them . . . everything.

> They are a person. To get a professional person like a lawyer, if you blanket an area with microwaves, you know every conversation they're having, you know where they go, what they're doing. For instance, if you have a person who is a pedophile, a person who has a mistress or two, a person who is a secret alcoholic or gambler and they would lose their job if it became known, all they have to do is go up to that person and say is this is what we have on you, and you're from another country obviously, this is what we have on you and we will give you a choice and you make your decision now. And this is what they do.

You make your decision now. Either this goes in your local press in the Sunday newspaper or you will lose your job, your children come out of university with disgrace, your wife will leave you and run away and hide, you will lose your house, everything, and you will never work again. You will be a beggar on the streets, if you're lucky. Or you can sign this piece of paper to say you know this individual. They're an upstanding person. They deserve the passport. They deserve a job reference because they should get this job. You'll highly recommend that. You will sign it and we will go away. You will never see us again. Most people, given ten seconds thought, will sign and walk away and breathe a sigh of relief. That is why I suspect this, the blanketing the whole area (points to the White House document). It may not be the United States. It could be up to 40 countries. And I can assure you there are at least 40 countries who would like to get spies in the United States. And when they're in, they're in. Then it goes on from there.

> I don't like the word 'mind control' because you don't really control the mind. You can change it to act in a different behavior, but you do not permanently control it. You can make people do things, and that's very easy. I could do it. I could do it to you in less than three days.

Deborah Tavares: Such as assassins?

Barrie Trower: I could turn you into an assassin in less than three days. That's easy. So there are lots, and lots and lots of different reasons for blanketing an area and watching people. And 98% of the population probably would not be affected, but it is the fact that you have no choice. And if you upset somebody in the government, they can abuse their authority and target you.

Whistleblowers and Death Threats

Deborah Tavares: There are many scientists who realize what their scientific experiments have now caused. They're not being used for the benefit of mankind and they now see how those are being used against their children, their families, and the world at large and they're coming out and they're letting this be known. And they're not being targeted microwaves and the inventions that they've created are now being used against many of these whistleblowers, would you say?

Barrie Trower: Yes. And I can give you a specific example from a chief scientific officer in England. But, if you're going to become a whistleblower you must realize first of all you're going to receive death threats and these are very serious death threats. You are going to lose your job. Your children are not going to get a job or go to university. It is a family sacrifice, as well as

yours.

> I can give you an example. I've received many cryptic and strange messages from senior persons. I received a message from a very, very senior scientist in the top secret experimental place in England. He said, "I need to talk to you, Barrie." I said okay and we met. He said I am going to give the perspective from where I am sitting. We have received a contract from the government to do research. I'm researching the effect of microwaves on the brain and the heart. I am one of the country's leading research scientists. What they have asked me to do is study the brain and the heart being exposed to various microwaves, a specific pulse frequency known to affect the brain and the heart.

I know and you know, because a part of my degree was experimental physics, that if we're going to do a study on the heart and the brain we're looking at about 15 years. It would take about ten years to do the study and another five years to tie up the loose ends, write it, have it peer reviewed, go to publication. You and I know, because if I said to you how long would it take to do these experiments, you would say ten to fifteen years, which is what the drug companies do when they're testing a new drug. It's always a minimum of ten years, maybe longer. They don't always get it right, but at least they have a go.

And he said to me there's a lot of money involved here. Do you know how long they've given me to do the experiments on the brain and the heart? One of them, ten minutes and the other one is 20 or 25 minutes. I can do them both in an hour and have time for a cup of coffee. He said now I know that when I do these, the results are going to show SAFE, SAFE, SAFE, SAFE, SAFE. And I know that they are going to use this with the stamp of my laboratory to say 'this is safe—sell it'. And this particular system has now been sold to 150 countries as safe.

> And he said to me, now I've done nothing wrong. I did the experiments. I produced the results, which are safe, but I know this is going to be abused. I know that people are going to die because this is going to be published. Women are going to get breast cancers, miscarriages; all sorts of things are going to happen. But they're going to do that—not me. He said now I am in a top government scientist job. I have a top salary. I have two children at university, one at college. I have a mortgage on a big beautiful house. If I spill the beans, I will lose everything today and I will never work again. My children will come out of university and my life will be a mess. What do I do? I said you only have two choices: you give up your family and your children's university educations and everything, or you keep quiet. And those were the only two choices, and he decided to keep quiet.

Deborah Tavares: Well, of course, we know in many of these decisions the dangers beyond the family, and the fact that the family is going to be assaulted and confronted by increased frequencies anyway, as well as all of his friends and the rest of the world.

Barrie Trower: So this is the dilemma that some of the scientists are put in. So even when you read up laboratories, it may be that the scientists did nothing wrong, he did nothing wrong. He did what he was asked to do. He gave the results he was asked to give. It was the other people who are doing something wrong. But again, I'm very, very wary of reading out lists of corporations and laboratories because the people responsible may not be responsible.

***Jim Fetzer**, a former Marine Corps officer, is McKnight Professor Emeritus at the University of Minnesota Duluth.*

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

Home → Health Effects → Live Blood Analysis – Observable Effects of RF/MW Radiation from 'Smart' Meter

The following clip 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.

Glucose metabolism changes within the brain are observable after just minutes of cell phone use.

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.

ISDE, IDEA: Statement on Electromagnetic [radio frequency] Radiation [EMR] and Health Risks

International Society of Doctors for the environment (ISDE) and Irish Doctors' Environmental Association (IDEA) state that there is sufficient scientific evidence to warrant more stringent controls on the level and distribution of electromagnetic radiation [EMR]. The joint statement and recommendations are part of a call by medical and scientific experts for safe technologies in schools.

The report aims to inform schools, Governing Bodies, Academy Trusts, School Boards, Education Authorities, teachers and parents of the professional, medical and scientific concerns about children using wireless technologies in schools. The information can be used to implement safe school policies, practices and guidance in order to safeguard the health and development of children and young people and to aid cognitive abilities, learning and achievement.

Download the report at: http://wifiinschools.org.uk/resources/safeschools2012.pdf

Originally posted on 9 July 2012

Irish Doctors' Environmental Association (IDEA)

The **Irish Doctors' Environmental Association (IDEA)** is an Irish organisation established by health professionals seeking to promote the right to health and peaceful co-existence worldwide.

The main objective of the IDEA is to foster and promote, through education, publications and seminars, a concept of health as a state of physical, psychological and social well-being, which acknowledges the potential impact of environmental conditions, violent conflict, and inequalities within and between nations on that well-being.

Contact details

Raheny, Dublin 5, Ireland
Tel.: [+353] 01 8314065
Email: info@ideaireland.org
http://www.ideaireland.org

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3341445/

Effect of electromagnetic field exposure on the reproductive system

Myung Chan Gye and Chan Jin Park

Author information ► Article notes ► Copyright and License information ►

Go to:

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

Go to:

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.

Go to:

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.

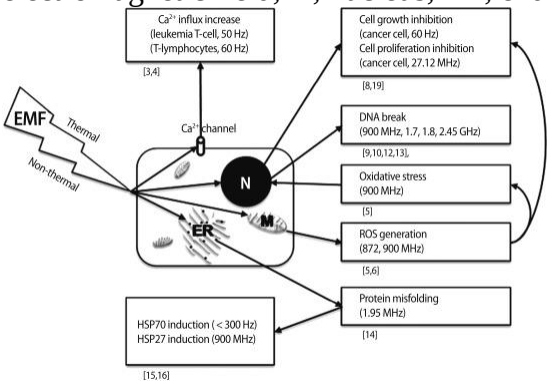
Go to:

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.



Go to:

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].

Go to:

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].

Go to:

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].

Go to:

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.
Go to:

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.

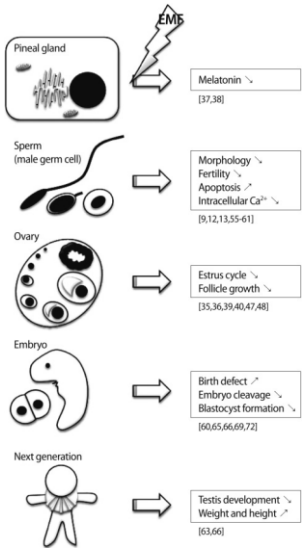


Table 1

Effects of EMF on mammalian endocrine system and reproduction

Table 1

Effects of EMF on mammalian endocrine system and reproduction

Type of EMF[a]		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.

Go to:

References

1. Dawson BV, Robertson IG, Wilson WR, Zwi LJ, Boys JT, Green AW. Evaluation of potential health effects of 10 kHz magnetic fields: a rodent reproductive study. Bioelectromagnetics. 1998;19:162–171.[PubMed]
2. Hydro-Québec. Electricity in the air. Montreal: Hydro-Québec; 1989.
3. Lindström E, Mild KH, Lundgren E. Analysis of the T cell activation signaling pathway during ELF magnetic field exposure, p56lck and [Ca2+]i-measurements. Bioelectrochem Bioenerget. 1998;46:129–137.
4. Liburdy RP. Calcium signaling in lymphocytes and ELF fields. Evidence for an electric field metric and a site of interaction involving the calcium ion channel. FEBS Lett. 1992;301:53–59.[PubMed]
5. Zeni O, Di Pietro R, d'Ambrosio G, Massa R, Capri M, Naarala J, et al. Formation of reactive oxygen species in L929 cells after exposure to 900 MHz RF radiation with and without co-exposure to 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone. Radiat Res. 2007;167:306–311.[PubMed]
6. Luukkonen J, Hakulinen P, Maki-Paakkanen J, Juutilainen J, Naarala J. Enhancement of chemically induced reactive oxygen species production and DNA damage in human SH-SY5Y neuroblastoma cells by 872 MHz radiofrequency radiation. Mutat Res. 2009;662:54–58.[PubMed]
7. Guney M, Ozguner F, Oral B, Karahan N, Mungan T. 900 MHz radiofrequency-induced histopathologic changes and oxidative stress in rat endometrium: protection by vitamins E and C. Toxicol Ind Health. 2007;23:411–420.[PubMed]
8. Koh EK, Ryu BK, Jeong DY, Bang IS, Nam MH, Chae KS. A 60-Hz sinusoidal magnetic field induces apoptosis of prostate cancer cells through reactive oxygen species. Int J Radiat Biol. 2008;84:945–955.[PubMed]
9. Sarkar S, Ali S, Behari J. Effect of low power microwave on the mouse genome: a direct DNA analysis. Mutat Res. 1994;320:141–147.[PubMed]
10. Diem E, Schwarz C, Adlkofer F, Jahn O, Rüdiger H. Non-thermal DNA breakage by mobile-phone radiation (1800 MHz) in human fibroblasts and in transformed GFSH-R17 rat granulosa cells in vitro. Mutat Res. 2005;583:178–183.[PubMed]
11. 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 Xue Za Zhi. 2006;40:149–152.[PubMed]
12. Aitken RJ, Bennetts LE, Sawyer D, Wiklendt AM, King BV. Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline. Int J Androl. 2005;28:171–179.[PubMed]
13. Nikolova T, Czyz J, Rolletschek A, Blyszczuk P, Fuchs J, Jovtchev G, et al. Electromagnetic fields affect transcript levels of apoptosis-related genes in embryonic stem cell-derived neural progenitor cells. FASEB J. 2005;19:1686–1688.[PubMed]
14. Mancinelli F, Caraglia M, Abbruzzese A, d'Ambrosio G, Massa R, Bismuto E. Non-thermal effects of electromagnetic fields at mobile phone frequency on the refolding of an intracellular protein: myoglobin. J Cell Biochem. 2004;93:188–196.[PubMed]
15. Leszczynski D, Joenväärä S, Reivinen J, Kuokka R. Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: molecular mechanism for cancer- and blood-brain barrier-related effects. Differentiation. 2002;70:120–129.[PubMed]

16. Goodman R, Blank M. Insights into electromagnetic interaction mechanisms. J Cell Physiol. 2002;192:16–22.[PubMed]
17. Lin H, Blank M, Goodman R. A magnetic field-responsive domain in the human HSP70 promoter. J Cell Biochem. 1999;75:170–176.[PubMed]
18. Lin H, Blank M, Rossol-Haseroth K, Goodman R. Regulating genes with electromagnetic response elements. J Cell Biochem. 2001;81:143–148.[PubMed]
19. Zimmerman JW, Pennison MJ, Brezovich I, Yi N, Yang CT, Ramaker R, et al. Cancer cell proliferation is inhibited by specific modulation frequencies. Br J Cancer. 2012;106:307–313. [PMC free article][PubMed]
20. Cameron IL, Sun LZ, Short N, Hardman WE, Williams CD. Therapeutic Electromagnetic Field (TEMF) and gamma irradiation on human breast cancer xenograft growth, angiogenesis and metastasis. Cancer Cell Int. 2005;5:23. [PMC free article][PubMed]
21. Brainard GC, Kavet R, Kheifets LI. The relationship between electromagnetic field and light exposures to melatonin and breast cancer risk: a review of the relevant literature. J Pineal Res. 1999;26:65–100.[PubMed]
22. Preece AW, Hand JW, Clarke RN, Stewart A. Power frequency electromagnetic fields and health. Where's the evidence? Phys Med Biol. 2000;45:R139–R154.[PubMed]
23. BioInitiative report: a rationale for a biologically-based public exposure standard for electromagnetic fields (ELF and RF) [Internet] BioInitiative. 2010. [cited 2012 Feb 26]. Available from: http://www.bioinitiative.org.
24. London SJ, Thomas DC, Bowman JD, Sobel E, Cheng TC, Peters JM. Exposure to residential electric and magnetic fields and risk of childhood leukemia. Am J Epidemiol. 1991;134:923–937.[PubMed]
25. Bastuji-Garin S, Richardson S, Zittoun R. Acute leukaemia in workers exposed to electromagnetic fields. Eur J Cancer. 1990;26:1119–1120.[PubMed]
26. Harrington JM, McBride DI, Sorahan T, Paddle GM, van Tongeren M. Occupational exposure to magnetic fields in relation to mortality from brain cancer among electricity generation and transmission workers. Occup Environ Med. 1997;54:7–13. [PMC free article][PubMed]
27. Johansen C, Olsen JH. Mortality from amyotrophic lateral sclerosis, other chronic disorders, and electric shocks among utility workers. Am J Epidemiol. 1998;148:362–368.[PubMed]
28. Verkasalo PK, Kaprio J, Varjonen J, Romanov K, Heikkilä K, Koskenvuo M. Magnetic fields of transmission lines and depression. Am J Epidemiol. 1997;146:1037–1045.[PubMed]
29. Reichmanis M, Perry FS, Marino AA, Becker RO. Relation between suicide and the electromagnetic field of overhead power lines. Physiol Chem Phys. 1979;11:395–403.[PubMed]
30. Sobel E, Dunn M, Davanipour Z, Qian Z, Chui HC. Elevated risk of Alzheimer's disease among workers with likely electromagnetic field exposure. Neurology. 1996;47:1477–1481.[PubMed]
31. Johansson O. Disturbance of the immune system by electromagnetic fields-A potentially underlying cause for cellular damage and tissue repair reduction which could lead to disease and impairment. Pathophysiology. 2009;16:157–177.[PubMed]
32. Stevens RG, Davis S, Thomas DB, Anderson LE, Wilson BW. Electric power, pineal

function, and the risk of breast cancer. FASEB J. 1992;6:853–860.[PubMed]
33. Reiter RJ. Static and extremely low frequency electromagnetic field exposure: reported effects on the circadian production of melatonin. J Cell Biochem. 1993;51:394–403.[PubMed]
34. Kato M, Honma K, Shigemitsu T, Shiga Y. Circularly polarized 50-Hz magnetic field exposure reduces pineal gland and blood melatonin concentrations of Long-Evans rats. Neurosci Lett. 1994;166:59–62.[PubMed]
35. Rodriguez M, Petitclerc D, Burchard JF, Nguyen DH, Block E, Downey BR. Responses of the estrous cycle in dairy cows exposed to electric and magnetic fields (60 Hz) during 8-h photoperiods. Anim Reprod Sci. 2003;77:11–20.[PubMed]
36. Rodriguez M, Petitclerc D, Burchard JF, Nguyen DH, Block E. Blood melatonin and prolactin concentrations in dairy cows exposed to 60 Hz electric and magnetic fields during 8 h photoperiods. Bioelectromagnetics. 2004;25:508–515.[PubMed]
37. Yellon SM. Acute 60 Hz magnetic field exposure effects on the melatonin rhythm in the pineal gland and circulation of the adult Djungarian hamster. J Pineal Res. 1994;16:136–144.[PubMed]
38. Stevens RG, Davis S. The melatonin hypothesis: electric power and breast cancer. Environ Health Perspect. 1996;104(Suppl 1):135–140. [PMC free article][PubMed]
39. Lincoln GA, Maeda KI. Reproductive effects of placing micro-implants of melatonin in the mediobasal hypothalamus and preoptic area in rams. J Endocrinol. 1992;132:201–215.[PubMed]
40. Malpaux B, Daveau A, Maurice F, Gayrard V, Thiery JC. Short-day effects of melatonin on luteinizing hormone secretion in the ewe: evidence for central sites of action in the mediobasal hypothalamus. Biol Reprod. 1993;48:752–760.[PubMed]
41. Burchard JF, Nguyen DH, Block E. Progesterone concentrations during estrous cycle of dairy cows exposed to electric and magnetic fields. Bioelectromagnetics. 1998;19:438–443.[PubMed]
42. Bortkiewicz A. A study on the biological effects of exposure mobile-phone frequency EMF. Med Pr. 2001;52:101–106.[PubMed]
43. Black DR, Heynick LN. Radiofrequency (RF) effects on blood cells, cardiac, endocrine, and immunological functions. Bioelectromagnetics. 2003;(Suppl 6):S187–S195.[PubMed]
44. Pourlis AF. Reproductive and developmental effects of EMF in vertebrate animal models. Pathophysiology. 2009;16:179–189.[PubMed]
45. Nelson JF, Karelus K, Bergman MD, Felicio LS. Neuroendocrine involvement in aging: evidence from studies of reproductive aging and caloric restriction. Neurobiol Aging. 1995;16:837–843.[PubMed]
46. Tappa B, Amao H, Ogasa A, Takahashi KW. Changes in the estrous cycle and number of ovulated and fertilized ova in aging female IVCS mice. Jikken Dobutsu. 1989;38:115–119.[PubMed]
47. Jung KA, Ahn HS, Lee YS, Gye MC. Effect of a 20 kHz sawtooth magnetic field exposure on the estrous cycle in mice. J Microbiol Biotechnol. 2007;17:398–402.[PubMed]
48. Cecconi S, Gualtieri G, Di Bartolomeo A, Troiani G, Cifone MG, Canipari R. Evaluation of the effects of extremely low frequency electromagnetic fields on mammalian follicle development. Hum Reprod. 2000;15:2319–2325.[PubMed]

49. Aydin M, Cevik A, Kandemir FM, Yuksel M, Apaydin AM. Evaluation of hormonal change, biochemical parameters, and histopathological status of uterus in rats exposed to 50-Hz electromagnetic field. Toxicol Ind Health. 2009;25:153–158.[PubMed]
50. Yamashita H, Hata K, Yamaguchi H, Tsurita G, Wake K, Watanabe S, et al. Short-term exposure to a 1439-MHz TDMA signal exerts no estrogenic effect in rats. Bioelectromagnetics. 2010;31:573–575.[PubMed]
51. Oral B, Guney M, Ozguner F, Karahan N, Mungan T, Comlekci S, et al. Endometrial apoptosis induced by a 900-MHz mobile phone: preventive effects of vitamins E and C. Adv Ther. 2006;23:957–973.[PubMed]
52. Lee HJ, Pack JK, Kim TH, Kim N, Choi SY, Lee JS, et al. The lack of histological changes of CDMA cellular phone-based radio frequency on rat testis. Bioelectromagnetics. 2010;31:528–534.[PubMed]
53. Ozguner M, Koyu A, Cesur G, Ural M, Ozguner F, Gokcimen A, et al. Biological and morphological effects on the reproductive organ of rats after exposure to electromagnetic field. Saudi Med J. 2005;26:405–410.[PubMed]
54. Imai N, Kawabe M, Hikage T, Nojima T, Takahashi S, Shirai T. Effects on rat testis of 1.95-GHz W-CDMA for IMT-2000 cellular phones. Syst Biol Reprod Med. 2011;57:204–209.[PubMed]
55. Saygin M, Caliskan S, Karahan N, Koyu A, Gumral N, Uguz A. Testicular apoptosis and histopathological changes induced by a 2.45 GHz electromagnetic field. Toxicol Ind Health. 2011;27:455–463.[PubMed]
56. Lee JS, Ahn SS, Jung KC, Kim YW, Lee SK. Effects of 60 Hz electromagnetic field exposure on testicular germ cell apoptosis in mice. Asian J Androl. 2004;6:29–34.[PubMed]
57. Kim YW, Kim HS, Lee JS, Kim YJ, Lee SK, Seo JN, et al. Effects of 60 Hz 14 microT magnetic field on the apoptosis of testicular germ cell in mice. Bioelectromagnetics. 2009;30:66–72.[PubMed]
58. Fabra I, Roig JV, Sancho C, Mir-Labrador J, Sempere J, García-Ferrer L. Cocaine-induced ischemic colitis in a high-risk patient treated conservatively. Gastroenterol Hepatol. 2011;34:20–23.[PubMed]
59. Bernabò N, Tettamanti E, Pistilli MG, Nardinocchi D, Berardinelli P, Mattioli M, et al. Effects of 50 Hz extremely low frequency magnetic field on the morphology and function of boar spermatozoa capacitated in vitro. Theriogenology. 2007;67:801–815.[PubMed]
60. Bernabò N, Tettamanti E, Russo V, Martelli A, Turriani M, Mattoli M, et al. Extremely low frequency electromagnetic field exposure affects fertilization outcome in swine animal model. Theriogenology. 2010;73:1293–1305.[PubMed]
61. Roychoudhury S, Jedlicka J, Parkanyi V, Rafay J, Ondruska L, Massanyi P, et al. Influence of a 50 hz extra low frequency electromagnetic field on spermatozoa motility and fertilization rates in rabbits. J Environ Sci Health A Tox Hazard Subst Environ Eng. 2009;44:1041–1047.[PubMed]
62. Iorio R, Scrimaglio R, Rantucci E, Delle Monache S, Di Gaetano A, Finetti N, et al. A preliminary study of oscillating electromagnetic field effects on human spermatozoon motility. Bioelectromagnetics. 2007;28:72–75.[PubMed]
63. Tenorio BM, Jimenez GC, Morais RN, Torres SM, Albuquerque Nogueira R, Silva Junior VA. Testicular development evaluation in rats exposed to 60 Hz and 1 mT

electromagnetic field. J Appl Toxicol. 2011;31:223–230.[PubMed]
64. Chung MK, Lee SJ, Kim YB, Park SC, Shin DH, Kim SH, et al. Evaluation of spermatogenesis and fertility in F1 male rats after in utero and neonatal exposure to extremely low frequency electromagnetic fields. Asian J Androl. 2005;7:189–194.[PubMed]
65. 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. 2011;30:246–252.[PubMed]
66. Kowalczuk CI, Robbins L, Thomas JM, Butland BK, Saunders RD. Effects of prenatal exposure to 50 Hz magnetic fields on development in mice: I. Implantation rate and fetal development. Bioelectromagnetics. 1994;15:349–361.[PubMed]
67. Ohnishi Y, Mizuno F, Sato T, Yasui M, Kikuchi T, Ogawa M. Effects of power frequency alternating magnetic fields on reproduction and pre-natal development of mice. J Toxicol Sci. 2002;27:131–138.[PubMed]
68. Kim SH, Song JE, Kim SR, Oh H, Gimm YM, Yoo DS, et al. Teratological studies of prenatal exposure of mice to a 20 kHz sawtooth magnetic field. Bioelectromagnetics. 2004;25:114–117.[PubMed]
69. Goldhaber MK, Polen MR, Hiatt RA. The risk of miscarriage and birth defects among women who use visual display terminals during pregnancy. Am J Ind Med. 1988;13:695–706.[PubMed]
70. McDonald AD, McDonald JC, Armstrong B, Cherry N, Nolin AD, Robert D. Work with visual display units in pregnancy. Br J Ind Med. 1988;45:509–515. [PMC free article][PubMed]
71. Schnorr TM, Grajewski BA, Hornung RW, Thun MJ, Egeland GM, Murray WE, et al. Video display terminals and the risk of spontaneous abortion. N Engl J Med. 1991;324:727–733.[PubMed]
72. Bergqvist UO. Video display terminals and health. A technical and medical appraisal of the state of the art. Scand J Work Environ Health. 1984;10(Suppl 2):1–87.[PubMed]
73. Bryant HE, Love EJ. Video display terminal use and spontaneous abortion risk. Int J Epidemiol. 1989;18:132–138.[PubMed]

Articles from Clinical and Experimental Reproductive Medicine are provided here courtesy of **Korean Society for Reproductive Medicine**

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2203969/

Effects of whole body exposure to extremely low frequency electromagnetic fields (ELF-EMF) on serum and liver lipid levels, in the rat

Patricia V Torres-Duran,[1] Aldo Ferreira-Hermosillo,[2] Marco A Juarez-Oropeza,[1] David Elias-Viñas,[3] and Leticia Verdugo-Diaz[4]
Author information ► Article notes ► Copyright and License information ►

Go to:

Abstract

Backgound

The effects of extremely low-frequency electromagnetic fields (ELF-EMF) on the blood serum and liver lipid concentrations of male Wistar rats were assessed.

Methods

Animals were exposed to a single stimulation (2 h) of ELF-EMF (60 Hz, 2.4 mT) or sham-stimulated and thereafter sacrificed at different times (24, 48 or 96 h after beginning the exposure).

Results

Blood lipids showed, at 48 h stimulated animals, a significant increase of cholesterol associated to high density lipoproteins (HDL-C) than those observed at any other studied time. Free fatty acid serum presented at 24 h significant increases in comparison with control group. The other serum lipids, triacylglycerols and total cholesterol did not show differences between groups, at any time evaluated. No statistical differences were shown on total lipids of the liver but total cholesterol was elevated at 24 h with a significant decrease at 96 h ($p = 0.026$). The ELF-EMF stimulation increased the liver content of lipoperoxides at 24 h.

Conclusion

Single exposures to ELF-EMF increases the serum values of HDL-C, the liver content of lipoperoxides and decreases total cholesterol of the liver. The mechanisms for the effects of ELF-EMF on lipid metabolism are not well understand yet, but could be associated to the nitric oxide synthase EMF-stimulation.

Go to:

Background

Some recent epidemiologic studies have suggested that the exposure to extremely low frequency (ELF) electromagnetic fields (EMF) affect human health, because of the incidence of certain types of cancer, depression, and miscarriage have been increased among individuals living or working in environments exposed to such fields [1-3]. Some of these studies have shown associations between exposure to power-frequency (50–60 Hz) magnetic fields and increased health risk [4,5], but other studies have not shown such a link [6]. The results described above are not completely conclusive, since in several cases they are contradictory.

Extremely low-frequency electromagnetic fields exposure is generally believed to be

innocuous for human health due to their low-level energy exposition, which is of a magnitude well below that required to affect the metabolic rate of the human body [3,7,8]. However, an increasing number of studies have reported that ELF-EMF exposure is capable to eliciting *in vivo* and *in vitro* bioeffects [9-12]. ELF-EMF exposure has shown to increase oxidative-stress in some models like chick embryos [13], mammalian cultured cells [14], and human erythrocytes [15]. The increased oxidative-stress involves oxidative DNA damage, lipid peroxidation [16], and may cause a number of systemic disturbances [17].

Spreading evidence suggests that environmental and artificial magnetic fields have significant impact on cardiovascular systems of animals and humans [18-21]. Recent studies showed that static magnetic fields decreased arterial baroreflex sensitivity in rabbits [22]. Under pharmacologically induced hypertensive conditions, the exposure to nonuniform MF to rabbits, significantly attenuated the vasoconstriction and suppressed the elevation of blood pressure [23]. In contrast, microwaves increase skin temperature and therefore cause vasodilatation in normal subjects exposed during 30 minutes [24]. Also, human blood platelets exposed *in vitro* to microwaves produced by mobile phones (operating at 900 MHz), increased the thiobarbituric acid reactive substances (TBARS) production and significantly depleted the superoxide dismutase-1 activity [17]. Recently, it has been studied the possibility that heat generation and the activation of the inducible form of nitric oxide (NO) synthase may be the possible causes of the biological effects of EMF exposure [25-27].

On the other hand, beneficial effects of ELF-EMF have also been reported. In diet-induced hypercholesterolemic rabbits, pulsed of EMF lowers total cholesterol and triacylglycerols levels [28]; similar results have been found in rats [29] and mice [30], both fed on control diets. Despite the above mentioned studies, there are not enough data to know the time-course effects of ELF-EMF on lipid and lipoperoxide levels in biological models. Then, the aim of the present study was to investigate, in the rat, the time-course effects of a single ELF-EMF stimulation on serum and liver lipid concentrations, as well as liver lipoperoxide production.

Go to:

Results

Serum lipid concentrations

There were no significant differences between experimental and control groups for triacylglycerols and total cholesterol serum levels, at any time analyzed. However, 48 h after beginning the treatment, HDL-C concentrations were higher in stimulated rats (48.2 ± 4.3 mg/dL) than those observed in control group (38.7 ± 7.1 mg/dL); however, a significant decrease on HDL-C levels was observed at 96 h in ELF-EMF stimulated rats (24 h 46.1 ± 8.1 mg/dL and 96 h 29.24 ± 2.20 mg/dL) (Fig. (Fig.1).1). On the other hand, FFA serum levels increased at 24 h (20 ± 2.25 mg/dL) with a statistically significant difference respect control (16.6 ± 3 mg/dL; $p = 0.026$) but no differences were found at 48 or 96 h (Fig. (Fig.22).

Figure 1

High density lipoprotein cholesterol serum levels in control group and 24, 48 and 96 h after ELF-EMF exposure. * Values significantly different in comparison with control group by ANOVA. A significant decrease was observed at 96 h in comparison with 24 **...**

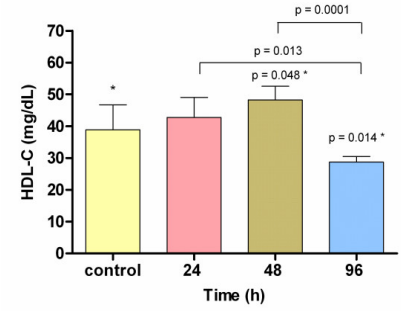
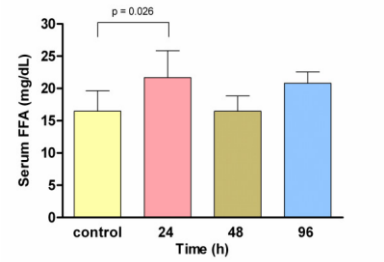


Figure 2

Free fatty acid serum levels in control group and 24, 48 and 96 h after ELF-EMF exposure. A significant increase was observed at 24 h in comparison with control group by ANOVA.



Liver analyses

There were no significant differences, in total lipids, triacylglycerols and protein values at any time (24, 48 and 96 h, data not shown). Liver total cholesterol showed a transient increase level at 24 h (48.6 ± 8.3 mg/dL) that decreased at 96 h (32.8 ± 6.1 mg/dL; p = 0.026) (Fig. (Fig.3).3). Furthermore, liver TBARS concentration was the variable where the ELF-EMF exposure induced major increases 24 h after beginning the treatment (198.80 ± 56.9 vs. control group 102.18 ± 27.8 ng/mg total lipids) meanwhile no significant differences were found at 48 or 96 h (Fig. (Fig.44).

Figure 3

Total cholesterol liver levels in control group and at 24, 48 and 96 h after ELF-EMF exposure. A significant decrease was observed at 96 h in comparison with 24 h by ANOVA.

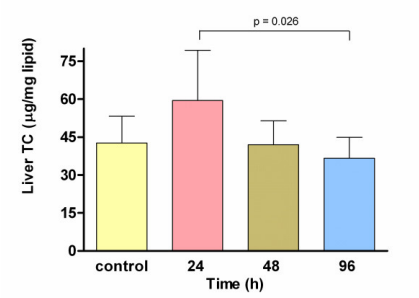
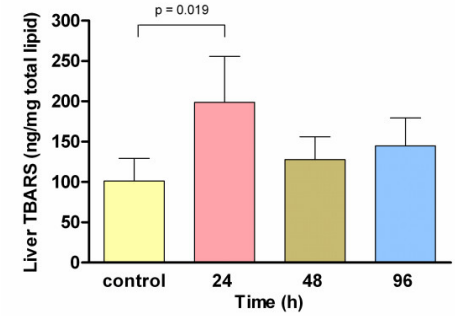


Figure 4

Thiobarbituric acid reactive substances liver levels in control group and 24, 48 and 96 h after ELF-EMF exposure. A significant increase was observed at 24 h in comparison with control group by ANOVA.



Discussion

Extremely low frequency electromagnetic fields interact with an animal by inducing electric fields inside the body. These induced fields represent the internal exposure or "dose" [31]. In living animals, a variety of natural endogenous electric fields also exist internally. These fields arise from normal physiological activity, and extend into adjacent tissues throughout the body. The endogenous fields will combine by simple addition with any field induced by external exposure to electromagnetic fields.

Some studies about biological effects due to 50–60 Hz electromagnetic fields exposure have been performed with rodents and other animal models [32,33]. Assessment of possible human health effects has been to a certain extent supports on these studies. It has been recognized that induced electric field in rodents are much lower than in humans for the same exposure field [34], this is a direct result of differences in size [35].

Since *in situ* measurement of induced field cannot be performed in humans, dosimetric models and animal studies are used. Comparisons of all dosimetric models are agreed within 2% or less; however, differences dues of size, shape, postural and individual organ have been observed [36].

In the present study, we use the rodent model to test the time-course effects of a single exposure to ELF-EMF (60 Hz, 2.4 mT, by two hours) on serum and liver lipids, as well as liver lipoperoxide content. The whole body exposure approach could stimulate any tissue; however, among the most susceptible tissues to EMF exposure are brain, blood and liver [37]. No changes were observed in total cholesterol and triacylglycerol serum levels. But HDL-C and free fatty acids, were higher at 48 and 24 hours, respectively, in

stimulated group than in sham-stimulated; however, only HDL-C showed lower levels at 96 hours after beginning the exposure. Our results are partially in accordance with previous studies showing that a single one hour exposure to a 12 Hz, 1.5–12 mT pulsed magnetic fields decreased, in a reversible way, cholesterol and triacylglycerol plasma levels in male rats 24 hours after their exposure [29,38]. Furthermore, when hyperlipidemic diet-induced female rabbits were exposed to a 15 Hz, 0.4 mT, 10 hours/day by 8 weeks, both cholesterol and triacylglycerols were significantly decreased, while HDL-C values were increased [28]. Harakawa and colleagues [37] observed that the exposition for 14 days to ELF-electric fields of ischemic rats significantly decreased free fatty acids and triacyglycerol plasma levels. The fact that total cholesterol and triacylglycerol serum levels did not change in our study could be explained in part by the frequency and length of stimulation used, as well as the basal lipemia of animals. Because of changes in serum free fatty acid concentration under our experimental conditions were observed at 24 h, it can be proposed that ELF-EMF have early effects on adipocytes lipolysis, at least after a single EMF stimulation.

On the other hand, TBARS levels were also increased in experimental group at 24 hours after the exposure. Because of the nitric oxide (NO) synthase may be stimulated by the EMF exposure [25-27], and this compound has been involved in the stimulation of lipid peroxidation during the initial states of ischemia-reperfusion injury [39], it is possible that increased free fatty acid deposition in the liver after ELF-EMF could occur as a consequence of the NO production. This hypothesis could explain also the increased TBARS production in stimulated group.

Lipid peroxidation products have been accepted as biomarkers for oxidative stress in biological systems [40]. Furthermore, few studies have been focused on the involvement of oxidative stress in the action mechanism of EMF exposure [41,42]. Some authors have showed that exposition to electric fields (50 Hz) of Sprague-Dawley rats did not change the antioxidant activity and lipid peroxide level of unstressed animals but decreased the plasma peroxide level in stressed rats [43]. The authors suggest that the electric fields might have some influence on lipid peroxide metabolism. In the present study we also obtained changes in liver peroxide level when Wistar rats were exposed to electromagnetic fields. Recently, Zwirska-Korczala and colleagues [44] using preadipocytes, showed a diminution in the activity of superoxide dismutase after 24 and 48 h of EMF exposition (180–195 Hz). The early increase in the liver TBARS concentration observed in our study after 24 h of EMF stimulation could be the result of the reduction in the activity of antioxidant enzymes or/and the increase of free radical production.

No differences were observed in cholesterol content of the liver between both groups studied. This result contrast with those finding in other studies [28,29], but could be explained by the different stimulation conditions used in that studies.

On the other hand, reduction in serum total lipids has also been observed in human beings. The most pronounced changes were found in steelworkers with the longest exposure (over 10 years) to electromagnetic fields [45].

Go to:

Conclusion

In conclusion, the results described here demonstrate the adaptative temporary response on lipid metabolism after the single exposure to ELF-EMF. The increased TBARS level

after a single exposure to ELF-EMF deserves more research in other ELF-EMF conditions. Although the mechanisms for the effects of ELF-EMF are not well understand yet, the effects described above could be useful in the comprehension of lipid changes observed during chronic exposure to ELF-EMF.

Go to:

Methods

Reagents

All reagents and chemicals used were of analytical grade (Sigma-Aldrich, México). Solvents were purchased from Merck (México). Total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), triacylglycerols (TAG), and free fatty acids (FFA) were assessed by enzymatic kits (Roche, México).

Animals

Forty male rats of the Wistar strain, weighing 220–250 g were used. All animals were housed per group (five animals per acrylic cage) with free access to food and water, in a room with controlled temperature (25 ± 2°C) and light-dark cycles (07:00 – 19:00 h, light on). All experiments were conducted during the light phase of the cycle, between 09:00 and 15:00 h.

All procedures were performed in strict accordance with the international guidelines for care of experimental animals.

The rats were either exposed to a single stimulation of ELF-EMF (experimental groups) or sham-stimulated (control groups). The time-course effects of the single ELF-EMF exposure on serum and liver lipid concentrations, as well as liver lipoperoxides (measured as TBARS) were assessed at 24, 48 and 96 h after beginning the treatment (five rats per group at each time).

ELF-EMF exposure

Electromagnetic field exposure was applied with a device used previously in our laboratory [46]. Electromagnetic fields were generated inside the exposure chamber with a pair of circular Helmholtz coils (30 cm internal diameter) composed of 18-gauge copper wire (350 turns). The two coils were connected in parallel to minimize the total impedance of the wire and to map the magnetic field. Coils were connected to a 120 V adjustable transformer (Staco Energy Products, Dayton, OH, USA). An oscilloscope (Tektronix, 5103N, USA) was coupled to the system for monitoring the 60 Hz sinusoidal MF waveform. Magnetic flux density was measured using a hand-held Gauss/Tesla Meter (Alpha-Lab). The sinusoidal magnetic flux density was 2.4 mT. Helmholtz coils provide a very uniform field over a relatively large volume in the space between the coils. Coils were spaced apart at a distance equal to their radii in the upper and lower face of the plastic exposure chamber (30 × 30 × 15 cm). A single stimulation was applied during 2 h from 09:00 to 11:00 h. The exposure chamber housed five rats each experimental session. Sham-stimulated animals were maintained simultaneously to experimental animals for an equal period of time inside of another chamber with the coils turned off. The magnetic field ambient background level was <0.04 mT. Inside the exposure chamber the temperature was 25.4 ± 0.4°C and illumination intensity was 17 ± 2 Lux.

Serum analyses

The animals were fasted twelve hours previously to the end of experimental period. The rats were anesthetized with diethyl ether and killed by cervical dislocation. The serum

was obtained by blood centrifugation and stored at -78°C until triacylglycerols, total cholesterol and free fatty acids were assessed. HDL-C was determined using aliquots of fresh serum.

Liver analyses

The liver was excised, weighed and stored at -78°C. For each liver, a sample of fresh tissue was obtained for lipid analyses.

Total lipids were extracted with chloroform-methanol (3:1 v/v) by a modified Folch's method [47]. For liver samples, 1.0 g of fresh tissue was homogenized in 4 volumes of 0.05 M phosphate buffer, pH 7.2 containing 0.025% butylated hydroxytoluene (BHT), as antioxidant. Then, the pH was adjusted to 6.0 by the addition of HCl solution and this suspension was extracted three times with 3 volumes each of the chloroform-methanol mixture. The extract was washed with 10 mL of water, the organic fraction was evaporated under a nitrogen stream, then weighed (for total lipids), and stored at -78°C until cholesterol, triacylglycerol, and TBARS analyses were performed. Liver lipoperoxides were measured by determining TBARS as previously described [48]. Total protein content was determinated in homogenate aliquots, using Bradford's method [49].

Statistical analyses

Results were evaluated by one way analysis of variance (ANOVA) except those from serum and liver triacylglycerols (Kolmogorov-Smirnov). Differences among groups were assessed by Tukey and Mann Withney-U tests, using SPSS software v. 12. A statistical *p* value less than 0.05 was considered significant.

Go to:

Competing interests

The author(s) declare that they have no competing interests.

Go to:

Authors' contributions

PVTD participated in the collection, design, analysis and interpretation of data and writing of the manuscript; AFH participated in the collection and analysis of data and performed the statistical analysis; MAJO participated in the design, analysis and interpretation of data and writing of the manuscript; DEV participated in the design of equipment; LVD participated in the analysis and interpretation of data and writing of the manuscript. All authors read and approved the final manuscript.

Go to:

Acknowledgements

This work was supported in part by a grant from PAPIIT-UNAM (IN218107, MAJO).

Go to:

References

- Lacy-Hubert A, Metcalfe JC, Hesketh R. Biological responses to electromagnetic fields. FASEB J. 1998;12:395–420.[PubMed]
- Ahlbom A, Feychting M. Electromagnetic radiation. British Medical Bull. 2003;68:157–165. doi: 10.1093/bmb/ldg030.[PubMed] [Cross Ref]
- Feychting M, Ahlbom A, Kheifets L. EMF and health. Annu Rev Public Health. 2005;26:165–189. doi: 10.1146/annurev.publhealth.26.021304.144445.[PubMed] [Cross Ref]

- Valberg PA, Kavet R, Rafferty CN. Can low-level 50/60 Hz electric and magnetic fields cause biological effects? Radiation Research. 1997;148:2–21. doi: 10.2307/3579533.[PubMed] [Cross Ref]
- Wertheimer N, Savitz DA, Leeper E. Childhood cancer in relation to indicators of magnetic fields from ground current sources. Bioelectromagnetics. 1995;16:86–96. doi: 10.1002/bem.2250160204.[PubMed] [Cross Ref]
- Preece AW, Hand JW, Clarke RN, Stewart A. Power frequency electromagnetic fields and health. Where's the evidence? Phys Med Biol. 2000;45:139–154. doi: 10.1088/0031-9155/45/9/201.[PubMed] [Cross Ref]
- Adey WR. Tissue interactions with nonionizing electromagnetic fields. Physiol Rev. 1981;61:435–514.[PubMed]
- Habash RW, Brodsky LM, Leiss W, Krewski D, Repacholi M. Health risks of electromagnetic fields. Part I: Evaluation and assessment of electric and magnetic fields. Crit Rev Biomed Eng. 2003;31:141–195. doi: 10.1615/CritRevBiomedEng.v31.i3.10.[PubMed] [Cross Ref]
- Litovitz TA, Montrose CJ, Wang W. Dose-response implications of the transient nature of electromagnetic-field-induced bioeffects: theoretical hypotheses and predictions. Bioelectromagnetics. 1992:237–246. doi: 10.1002/bem.2250130721.[PubMed] [Cross Ref]
- Repacholi MH, Greenebaum B. Interaction of static and extremely low frequency electric and magnetic fields with living systems: health effects and research needs. Bioelectromagnetics. 1999;20:133–160. doi: 10.1002/(SICI)1521-186X(1999)20:3<133::AID-BEM1>3.0.CO;2-O.[PubMed] [Cross Ref]
- Foster KR. Mechanisms of interaction of extremely low frequency electric fields and biological systems. Radiat Prot Dosimetry. 2003;106:301–310.[PubMed]
- Juutilainen J. Developmental effects of extremely low frequency electric and magnetic fields. Radiat Prot Dosimetry. 2003;106:385–390.[PubMed]
- Di Carlo AL, White NC, Litovitz TA. Mechanical and electromagnetic induction of protection against oxidative stress. Bioelectrochemistry. 2000;53:87–95. doi: 10.1016/S0302-4598(00)00116-1.[PubMed] [Cross Ref]
- Hook GJ, Spitz DR, Sim JE, Higashikubo R, Baty JD, Moros EG, Roti JL. Evaluation of parameters of oxidative stress after *in vitro* exposure to FMCW and CDMA modulated radio frequency radiation fields. Radiat Res. 2004;162:497–504. doi: 10.1667/RR3251.[PubMed] [Cross Ref]
- Dachà M, Accorsi A, Pierotti C, Vetrano F, Mantovani R, Guidi G, Conti R, Nicolini P. Studies on the possible biological effects of 50 Hz electric and/or magnetic fields: evaluation of some glycolitic enzymes, glycolitic flux, energy and oxido-reductive potentials in human erythrocytes exposed in vitro to power frequency fields. Bioelectromagnetics. 1993;14:383–391. doi: 10.1002/bem.2250140410.[PubMed] [Cross Ref]
- Yokus B, Cakir DU, Akdag MZ, Sert C, Mete N. Oxidative DNA damage in rats exposed to extremely low frequency electromagnetic fields. Free Radic Res. 2005;39:317–323. doi: 10.1080/10715760500043603.[PubMed] [Cross Ref]
- Stopezyk D, Gnitecki W, Buczynski A, Markuszewski A, Buczynski J. Effect of electromagnetic field produced by mobile phones on the activity of superoxide (SOD-1) and the level of malonyldialdehyde (MDA) *in vitro* study. Med Pr.

2002;53:311–314.[PubMed]
- Sastre A, Graham C, Cook MR. Brain frequency magnetic fields alter cardiac autonomic control mechanisms. Clin Neurophysiol. 2000;111:1942–1948. doi: 10.1016/S1388-2457(00)00438-7.[PubMed] [Cross Ref]
- Szmigielski S, Bortkiewicz A, Gadzicka E, Zmyslony M, Kubacki R. Alteration of diurnal rhythms of blood pressure and heart rate to workers exposed to radiofrequency electromagnetic fields. Blood Press Monit. 1998;3:323–330.[PubMed]
- Graham C, Sastre A, Cook MR, Kavet R. Heart rate variability and physiological arousal in men exposed to 60 Hz magnetic fields. Bioelectromagnetics. 2000;21:480–482. doi: 10.1002/1521-186X(200009)21:6<480::AID-BEM8>3.0.CO;2-J.[PubMed] [Cross Ref]
- Jauchem JR, Frei MR, Ryan KL, Merritt JH, Murphy MR. Lack of effects on heart rate and blood pressure in ketamine-anesthetized rats briefly exposed to ultra-wideband electromagnetic pulses. IEEE Trans Biomed Eng. 1999;46:117–120. doi: 10.1109/10.736767.[PubMed] [Cross Ref]
- Gmitrov J, Ohkubo C. Artificial static and geomagnetic field interrelated impact on cardiovascular regulation. Bioelectromagnetics. 2002;23:329–338. doi: 10.1002/bem.10020.[PubMed] [Cross Ref]
- Okano H, Ohkubo C. Anti-pressor effects of whole body exposure to static magnetic field on pharmacologically induced hypertension in conscious rabbits. Bioelectromagnetics. 2003;24:139–147. doi: 10.1002/bem.10092.[PubMed] [Cross Ref]
- Paredi P, Kharitonov SA, Hanazawa T, Barnes PJ. Local vasodilator response in mobile phones. Laryngoscope. 2001;111:159–162. doi: 10.1097/00005537-200101000-00027.[PubMed] [Cross Ref]
- Kavaliers M, Choleris E, Prato FS, Ossenkopp KP. Evidence for the involvement of nitric oxide and nitric oxide synthase in the modulation of opiod-induced antinociception and the inhibitory effects of exposure to 60-Hz magnetic fields in the land snail. Brain Res. 1998;809:50–57. doi: 10.1016/S0006-8993(98)00844-0.[PubMed] [Cross Ref]
- Kim SS, Shin HJ, Eom DW, Huh JR, Woo Y, Kim H, Ryu SH, Suh PG, Kim MJ, Kim JY, Koo TW, Cho YH, Chung SM. Enhanced expression of neuronal nitic oxide synthase and phospholipase C-gamma1 in regenerating murine neuronal cells by pulse electromagnetic field. Esp Mol Med. 2002;34:53–59.[PubMed]
- Seaman RL, Parker JE, Kiel JL, Mathur SP, Grubbs TR, Prol HK. Ultra-wideband pulses increase nitric oxide production by RAW 264.7 macrophages incubated in nitrate. Bioelectromagnetics. 2002;23:83–87. doi: 10.1002/bem.100.[PubMed] [Cross Ref]
- Luo EP, Jiao LC, Shen GH, Wu XM, Cao YX. Effects of exposing rabbits to low-intensity pulsed electromagnetic fields on levels of blood lipid and properties of hemorheology. Chinese J Clin Rehabilitation. 2004;8:3670–3671.
- Bellossi A, Pouvreau-Quillien V, Rocher C, Ruelloux M. Effect of pulsed magnetic fields on triglyceride and cholesterol levels in plasma of rats. Panminerva Med. 1998;40:276–279.[PubMed]
- Kumosani TA, Qari MH. The effect of magnetic field on the biochemical

parameters of mice blood. Pak J Med Sci. 2003;19:36–40.
- Miller DL, Creim JA. Comparison of cardiac and 60 Hz magnetically induced electric fields measured in anesthetized rats. Bioelectromagnetics. 1997;18:317–323. doi: 10.1002/(SICI)1521-186X(1997)18:4<317::AID-BEM4>3.0.CO;2-5.[PubMed] [Cross Ref]
- Babbit JT, Kharazi AI, Taylor JM, Boods CB, Mirell SG, Frumkin E, Zhuang D, Hahn TJ. Hematopoietic neoplasia in C57BL/6 mice exposed to split-dose ionizing radiation and circularly polarized 60 Hz magnetic fields. Carcinogenesis. 2000;21:1379–1389. doi: 10.1093/carcin/21.7.1379.[PubMed] [Cross Ref]
- Morris JE, Sasser LB, Miller DL, Dagle GE, Rafferty CN, Ebi KL, Anderson LE. Clinical progression of transplanted large granular lymphocytic leukemia in Fischer 344 rats exposed to 60 Hz magnetic fields. Bioelectromagnetics. 1999;20:48–56. doi: 10.1002/(SICI)1521-186X(1999)20:1<48::AID-BEM7>3.0.CO;2-8.[PubMed] [Cross Ref]
- NIEHS Assessment of health effects from exposure to power-line frequency electric and magnetic fields NIH Publication No 98. 1998.
- Dawson TW, Caputa K, Stuchly MA. Electric fields induced in humans and rodents by 60 Hz magnetic fields. Phys Med Biol. 2002;47:2561–2568. doi: 10.1088/0031-9155/47/14/313.[PubMed] [Cross Ref]
- Caputa K, Dimbylow PJ, Dawson TW, Stuchly MA. Modelling fields induced in humans by 50/60 Hz magnetic fields: reliability of the results and effects of model variations. Phys Med Biol. 2002;47:1391–1398. doi: 10.1088/0031-9155/47/8/311.[PubMed] [Cross Ref]
- Harakawa S, Inoue N, Hori T, Tochio K, Kariya T, Kunihito Takahashi K, Doge F, Martin ED, Saito A, Suzuki H, Nagasawa H. Effects of exposure to a 50 Hz electric field on plasma levels of lactate, glucose, free fatty acids, triglycerides and creatine phosphokinase activity in hind-limb ischemic rats. J Vet Med Sci. 2005;67:969–974. doi: 10.1292/jvms.67.969.[PubMed] [Cross Ref]
- Bellossi A, Pouvreau-Quillien V, Rocher C, Ruelloux M. Effect of pulsed magnetic fields on cholesterol and triglyceride levels in rats study of field intensity and length of exposure. Z Naturforsch. 1996;51:603–606.[PubMed]
- Jaeschke H. Molecular mechanism of hepatic ischemia-reperfusion injury and preconditioning. Am J Physiol Gastrointest Liver Physiol. 2003;284:G15–G26.[PubMed]
- Laval J. Role of DNA repair enzymes in the cellular resistence to oxidative stress. Pathol Biol. 1996;44:14–24.[PubMed]
- Moustafa YM, Moustafa RM, Belacy A, Abou-El-Ela SH, Ali FM. Effects of acute exposure to the radiofrequency fields of cellular phones on plasma lipid peroxide and antioxidase activities in human erythrocytes. J Pharm Biomed Anal. 2001;26:605–608. doi: 10.1016/S0731-7085(01)00492-7.[PubMed] [Cross Ref]
- Simko M, Droste S, Kriehuber R, Weiss DG. Stimulation of phagocytosis and free radical production in murine macrophages by 50 Hz electromagnetic fields. Eur J Cell Biol. 2001;80:562–566. doi: 10.1078/0171-9335-00187.[PubMed] [Cross Ref]
- Harakawa S, Inoue N, Hori T, Tochio K, Kariya T, Takahashi K, Doge F, Suzuki H, Nagasawa H. Effects of a 50 Hz electric field on plasma lipid peroxide level

and antioxidant activity in rats. Bioelectromagnetics. 2005;26:589–594. doi: 10.1002/bem.20137.[PubMed] [Cross Ref]

- Zwirska-Korczala K, Jochem J, Adamcczyk-Sowa M, Sowa P, Polaniak R, Birkner C, Latocha M, Pilc K, Suchanek R. Effect of extremely low frequency electromagnetic fields on cell proliferation, antioxidative enzyme activities and lipid peroxidation in 3T3-L1 preadipocytes-an *in vitro* study. J Physiol Pharmacol. 2005;56:101–108.[PubMed]
- Kula B, Sobczak A, Grabowska-Bochenek R, Piskorska D. Effect of electromagnetic field on serum biochemical parameters in steelworkers. J Occup Health. 1999;41:177–180.
- Vázquez-García M, Elías-Viñas D, Reyes-Guerrero G, Domínguez-González A, Verdugo-Díaz L, Guevara-Guzmán R. Exposure to extremely low-frequency electromagnetic fields improves social recognition in male rats. Physiol Behav. 2004;82:685–690. doi: 10.1016/j.physbeh.2004.06.004.[PubMed] [Cross Ref]
- Torres-Durán PV, Miranda-Zamora R, Paredes-Carbajal MC, Mascher D, Ble-Castillo J, Díaz-Zagoya JC, Juárez-Oropeza MA. Studies on the preventive effect of *Spirulina maxima* on fatty liver development induced by carbon tetrachloride, in the rat. J Ethnopharmacol. 1999;64:141–147. doi: 10.1016/S0378-8741(98)00120-2.[PubMed] [Cross Ref]
- Torres-Durán PV, Paredes-Carbajal MC, Mascher D, Zamora-González J, Díaz-Zagoya JC, Juárez-Oropeza MA. Protective effect of *Arthrospira maxima* on fatty acid composition in fatty liver. Arch Med Res. 2006;37:479–483. doi: 10.1016/j.arcmed.2005.08.005.[PubMed] [Cross Ref]
- Bradford MM. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Anal Biochem. 1976;72:248–254. doi: 10.1016/0003-2697(76)90527-3.[PubMed] [Cross Ref]

http://www.falloutreport.com/special-issue-on-the-risks-of-exposure-to-low-level-radiation#more-983

Special issue of The Bulletin of the Atomic Scientists on the risks of exposure to low-level radiation
Comments Off
Posted by admin on Jul 9, 2012 in Health News, International Sites, Japan | Comments Off
http://bos.sagepub.com/content/68/3/10.full
Jan Beyea
Every time a release of radioactivity occurs, questions arise—not only about the true exposures, but also about the health risk at low doses. Predictably, debates unfold in the news media and galvanize social media networks. Sometimes these conversations enlighten the public, but often times they only exacerbate the confusion and fear about the significance and reality of exposure. Fukushima is the latest example of this warped communications strategy.
This special issue of the Bulletin examines what is new about the debate over radiation risk, specifically focusing on areas of agreement and disagreement, including quantitative estimates of cancer risk as a function of dose. In this issue, we don't pretend to put the questions about the scientific jigsaw puzzle to rest, but we do hope to provide a sophisticated update for you, presented by people whose work has increased understanding within the field. For example, social scientist Paul Slovic updates his classic work on perception of radiation risk. Roger Kasperson, another social scientist, writes on the intriguing framework that he and colleagues developed about the social amplification of risk, which helps to explain public reactions to events like Fukushima and Chernobyl. By implication, Kasperson's analysis raises a challenge for those who communicate risk information, whether professionally or informally. To provide information needed in a democracy, these communicators may amplify risks to the point where needless fear is generated, or they may attenuate the risks to a degree that desirable responses are avoided.
Today, the scientific and medical establishment of most countries (with the exception of France, where the public strongly supports nuclear power) accepts a default hypothesis on the effects of radiation at doses below the range where epidemiologic data are conclusive. This is the so-called linear non-threshold theory (LNT), which the review committee of the US Institute of Medicine and the National Academy of Scientists refers to in these words: 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)
Radiation protection organizations, such as the International Commission on Radiation Protection, also use the LNT to justify minimizing future exposures; however, they have a tendency to focus on the uncertainties of the hypothesis and oppose its use to estimate consequences from releases such as Fukushima and Chernobyl—no doubt out of concern that such estimates may amplify the perception of risk. Whether or not avoiding predictions of low-dose consequences really attenuates risk perception or, in fact, amplifies it by increasing public suspicion about a cover-up is an interesting question. Technical and policy analyst Gordon Thompson, in his contribution to this issue of the Bulletin, discusses some aspects of this dilemma from the perspective of a scientist who often works with community groups.
Whatever the use of the LNT, the data from the one-time exposures of the Japanese atomic-bomb survivors provide most of the quantitative data on the linear slope, meaning the magnitude of the dose response. Epidemiologist David Richardson, whose work with these data has provided much new information about risks of low-dose radiation, writes on the history of this most important studied population, discussing its strengths and limitations. Radiobiologist Colin Hill examines some of the new biological research, particularly, on genomic instability, bystander effects, and adaptive response—effects that may lead to a better understanding of responses at very low doses and may help quantify any deviations from the LNT.
An important question is whether or not any of the epidemiologic evidence has been interpreted properly. Answering no to that question is biostatistician Sander Greenland, who writes that misleading interpretations of low-dose epidemiologic data result in an underestimate of the full health impacts, because of failure to account for diseases with accelerated onsets.
Quantitative perspectives on risk at low doses have changed dramatically over the last 40 years, back when I first engaged in public debates on the subject. Has it made any difference outside political campaigns and in the culture wars? In particular, how do quantitative risk estimates affect rules and regulations? Terry Brock and Sami Sherbini from the US Nuclear Regulatory Commission examine the role that risk estimates of health effects play in regulating nuclear power in the United States.
In my own contribution to this special issue, I survey data, arguments, and debates surrounding low-level

radiation risks. Historically—in the absence of human epidemiologic data—biologic arguments and cell data, fiercely debated, were used to convert risk estimates derived from the atomic-bomb data to protracted exposures. My article explores the new, large-scale epidemiologic studies that are directly relevant—not to one-time exposures received at Hiroshima and Nagasaki, but to the protracted exposures that are received from continuous decay of radioactive isotopes associated with releases from Fukushima or from the Soviet and US weapons complexes.

I also analyze contrasting data that suggest that dose responses might be higher or lower than predicted by the LNT. Some researchers believe that the dose response is higher than the LNT at low doses (supralinear response), while others maintain the dose response drops rapidly below the range covered by epidemiologic data (quasi-threshold); both groups can find some support in recent epidemiologic studies demonstrating the complexity of the scientific jigsaw puzzle that researchers face. There are other researchers who believe that the dose response turns around at some point as dose is decreased, actually reducing the risk of cancer (hormesis theory); this evidence can be found in data collected from home radon measurements correlated to county lung-cancer rates—albeit in contradiction to more standard epidemiologic studies of the same association, which do show the expected dose response.

If our efforts in this issue of the Bulletin are successful, the reader will be ready to join the debate armed with a broad-based view of the epidemiologic evidence and its differing interpretations, along with an awareness of the stakeholder and researcher landscape.

Reference

National Research Council (2006) Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2. Washington, DC: National Academies Press.

The scientific jigsaw puzzle: Fitting the pieces of the low-level radiation debate

Jan Beyea

Bulletin of the Atomic Scientists 2012 68: 13
DOI: 10.1177/0096340212445025

Bulletin of the Atomic Scientists

IT IS 5 MINUTES TO MIDNIGHT

Feature

Bulletin of the Atomic Scientists
68(3) 13–28

DOI: 10.1177/0096340212445025
http://thebulletin.sagepub.com

SAGE

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

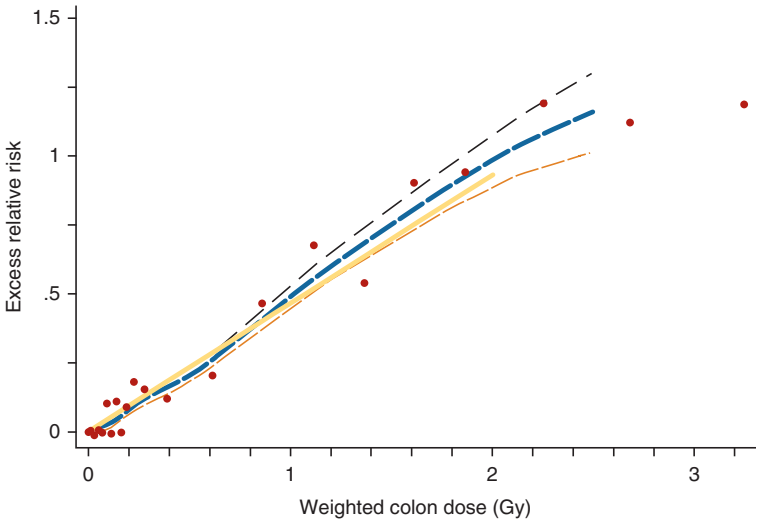


Figure 1. Solid cancer-incidence dose response for atomic-bomb survivors.
Source: Preston et al. (2007). This figure is reproduced with permission from the Radiation Research Society.
Notes: This figure shows excess relative risk versus "weighted colon dose" in units of gray (Gy)—these units are equivalent 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

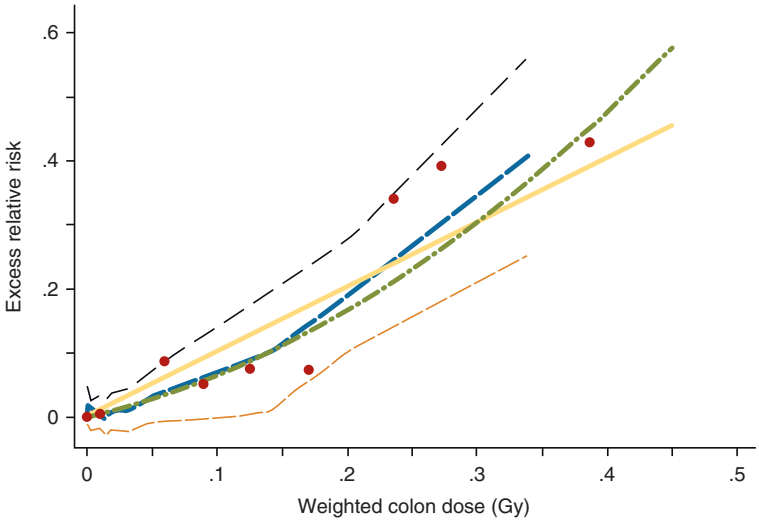


Figure 2. Solid cancer-incidence dose response for the Techa River cohort.
Source: Krestinina et al. (2007). This figure is reproduced with permission from the authors; © Oxford University Press.
Notes: This figure shows excess relative risk versus weighted dose in units of Gy (equivalent to Sv for the 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.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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.

References

Ashmore JP, Norman EG, and Richard VO (2010) Incomplete data on the Canadian cohort may have affected the results of the study by the International Agency for Research on Cancer on the radiogenic cancer risk among nuclear industry workers in 15 countries. *Journal of the Society for Radiological Protection* 30(2): 121–129.

Aurengo A, Averbeck D, Bonnin A, et al. (2005) Dose-effect relationships and estimation of the carcinogenic effects of low doses of ionizing radiation: The Joint Report of the Académie des Sciences (Paris) and of the Académie Nationale de Médecine. Available at: http://www.academie-medecine.fr/Upload/anciens/rapports_227_fichier_lie.rtf.

Boice Jr JD (2010) Uncertainties in studies of low statistical power. *Journal of Radiological Protection* 30: 115–120.

Boice Jr JD, Hendry JH, Nakamura N, et al. (2010) Low-dose-rate epidemiology of high background radiation areas. *Radiation Research* 173(6): 849–854.

Brock TA and Sherbini SS (2012) Principles in practice: Radiation regulation and the NRC. *Bulletin of the Atomic Scientists* 68(3). Doi: 10.1177/0096340212444869.

Cardis E, Vrijheid M, Blettner M, et al. (2005) Risk of cancer after low doses of ionising radiation: Retrospective cohort study in 15 countries. *BMJ* 331(7508): 77.

Chomentowski M, Kellerer AM, and Pierce DA (2000) Radiation dose dependences in the atomic bomb survivor cancer mortality data: A model-free visualization. *Radiation Research* 153(3): 289–294.

Darby S, Hill D, Auvinen A, et al. (2005) Radon in homes and risk of lung cancer: Collaborative analysis of individual data from 13 European case-control studies. *BMJ* 330(7485): 223.

Einstein AJ (2009) Medical imaging: The radiation issue. *Nature Reviews Cardiology* 6(6): 436–438.

EPRI (2009) *Program on Technology Innovation: Evaluation of Updated Research on the Health Effects and Risks Associated with Low-Dose Ionizing Radiation*. Palo Alto, CA: Electric Power Research Institution. Available at: http://my.epri.com/portal/server.pt?space=CommunityPage&cached=true&parentname=ObjMgr&parentid=2&control=SetCommunity&CommunityID=404&RaiseDocID=000000000001019227 &RaiseDocType=Abstract_id.

Greenland S (2012) Underestimating effects: Why causation probabilities need to be replaced in regulation, policy, and the law. *Bulletin of the Atomic Scientists* 68(3). Doi: 10.1177/0096340212444873.

Healy JR (1981) Commitment, equivalent and collective. *Health Physics* 41(7): 379–381.

Hendry JH, Simon SL, Wojcik A, et al. (2009) Human exposure to high natural background radiation: What can it teach us about radiation risks?

Journal of Radiological Protection 29(2A): A29–A42.
Hill CK (2012) The low-dose phenomenon: How bystander effects, genomic instability, and adaptive responses could transform cancer-risk models. *Bulletin of the Atomic Scientists* 68(3). Doi: 10.1177/0096340212444874.
Hoffman FO, Kocher DC, and Apostoaei AI (2011) Beyond dose assessment: Using risk with full disclosure of uncertainty in public and scientific communication. *Health Physics* 101(5): 591–600.
Jacob P, Ruhm W, Walsh L, et al. (2009) Is cancer risk of radiation workers larger than expected? *Occupational & Environmental Medicine* 66(12): 789–796.
Kasperson RE (2012) The social amplification of risk and low-level radiation. *Bulletin of the Atomic Scientists* 68(3). Doi: 10.1177/0096340212444871.
Kocher DC, Apostoaei AI, Henshaw RW, et al. (2008) Interactive Radioepidemiological Program (Irep): A web-based tool for estimating probability of causation/assigned share of radiogenic cancers. *Health Physics* 95(1): 119–147.
Krestinina LY, Davis F, Ostroumova E, et al. (2007) Solid cancer incidence and low-dose-rate radiation exposures in the Techa River cohort: 1956–2002. *International Journal of Epidemiology* 36(5): 1038–1046.
Krewski D, Lubin JH, Zielinski JM, et al. (2006) A combined analysis of North American case-control studies of residential radon and lung cancer. *Journal of Toxicology & Environmental Health: Part A* 69(7/8): 533–597.
Locke PA (2009) Incorporating information from the U.S. Department of Energy low-dose program into regulatory decision-making: Three policy integration challenges. *Health Physics* 97(5): 510–515.
Lubin JH (2002) The potential for bias in Cohen's ecological analysis of lung cancer and residential radon. *Journal of Radiological Protection* 22(2): 141–148.
Lyon JL, Alder SC, Stone MB, et al. (2006) Thyroid disease associated with exposure to the Nevada nuclear weapons test site radiation: A reevaluation based on corrected dosimetry and examination data. *Epidemiology* 17(6): 604–614.
Marshall E (1990) Academy panel raises radiation risk estimate. *Science* 247(4938): 22–23.
Morgan WF and Sowa MB (2009) Non-targeted effects of ionizing radiation: Implications for risk assessment and the radiation dose response profile. *Health Physics* 97(5): 426–432.
Nair RRK, Rajan B, Akiba S, et al. (2009) Background radiation and cancer incidence in Kerala, India-Karanagappally cohort study. *Health Physics* 96(1): 55–66.
NCRP (2009) *Ionizing Radiation Exposure of the Population of the United States, Report 160*. Bethesda, MD: National Council on Radiation Protection and Measurements. Available at: http://www.ncrppublications.org/reports/160.
National Research Council (2006) *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2*. Washington, DC: National Academies Press. Available at: http://www.nap.edu/openbook.php?record_id=11340.
Ozasa K, Shimizu Y, Suyama A, et al. (2012) Studies of the mortality of atomic bomb survivors, report 14, 1950–2003: An overview of cancer and noncancer diseases. *Radiation Research* 177(3): 229–243.
Preston DL (2011) From epidemiology to risk factors, aka DDREF: Light and shadows. Multidisciplinary European Low Dose Initiative. Presented at the Third Melodi workshop, Rome. Eureka, CA: Hirosoft International. Available at: www.melodi-online.eu/Preston.pdf.
Preston DL, Ron E, Tokuoka S, et al. (2007) Solid cancer incidence in atomic bomb survivors: 1958–1998. *Radiation Research* 168(1): 1–64.
Reissland JA (1981) BEIR III: The effects on populations of exposure to low levels of ionising radiation. *Journal of the Society for Radiological Protection* 1(2): 17. Available at: http://iopscience.iop.org/0260-2814/1/2/002.
Richardson D (2012) Lessons from Hiroshima and Nagasaki: The most exposed and most vulnerable. *Bulletin of the Atomic Scientists* 68(3). Doi: 10.1177/0096340212444876.
Shimizu Y, Kodama K, Nishi N, et al. (2010) Radiation exposure and circulatory disease risk: Hiroshima and Nagasaki atomic bomb survivor data, 1950–2003. *British Medical Journal* 340: b5349.
Slovic P (2012) The perception gap: Radiation and risk. *Bulletin of the Atomic Scientists* 68(3). Doi: 10.1177/0096340212444870.
Standring WJF, Dowdall M, and Strand P (2009) Overview of dose assessment developments and the health of riverside residents close to the "Mayak" PA facilities, Russia. *International Journal of Environmental Research and Public Health* 6(1): 174–199.
Tao Z, Akiba S, Zha Y, et al. (2012) Cancer and non-cancer mortality among inhabitants in the high background radiation area of Yangjiang, China (1979–1998). *Health Physics* 102(2): 173–181.
UNSCEAR (2006) *Effects of Ionizing Radiation*. Report to the General Assembly, with Scientific Annexes. New York: UN Scientific Committee on the Effects of Atomic Radiation.

Wing S, Shy CM, Wood JL, et al. (1991) Mortality among workers at Oak Ridge National Laboratory. *JAMA: Journal of the American Medical Association* 265(11): 1397–1402.

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.

Chapter 22

Aspects of DNA Damage from Internal Radionuclides

Christopher Busby

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/53942

1. Introduction

In this chapter, there is insufficient space to exhaustively review the research which has been carried out on internal radionuclide effects. I hope only to highlight evidence which shows that internal radionuclides cannot be assessed by the current radiation risk model, and to suggest some research directions that may enable a new model to be developed, one which more accurately quantifies the real effects of such exposures. The biological effects of exposure to ionizing radiation have been studied extensively in the last 70 years and yet very little effort has gone into examining the health effects of exposure to internal incorporated radionuclides. This is curious, since the biosphere has been increasingly contaminated with novel man-made radioactive versions of naturally occurring elements which living creatures have adapted to over evolutionary timescales, and intuition might suggest that these substances could represent a significant hazard to health, one not easily or accurately modelled by analogy with external photon radiation (X-rays and gamma rays).

The question of the health effects of internal radionuclide exposures began to be asked in the early 1950s when there was widespread fallout contamination of food and milk from atmospheric nuclear tests. It quickly became the subject of disagreements between two committees of the newly formed International Commission on Radiological Protection (ICRP)[1]. The questions of the equivalence of internal and external radiation exposure, which were the basis of these disagreements, have still not been resolved. In the West, up to very recently, the whole spectrum of health effects from internal incorporated radionuclides has focused on animal studies of Radium, Plutonium and Strontium-90 and human retrospective studies of those individuals exposed to Radium-226 and Thorium-232 in the contrast medium "Thorotrast". These studies suffer from a number of problems which will be discussed.

Soviet scientists were more interested in internal radiation effects from fission-product radionuclides, but unfortunately their valuable studies have been difficult to access since they are published in Russian. In 1977 Gracheva and Korolev published a book summarising work in this area which was translated in India in 1980 as *Genetic Effects of the Decay of Radionuclides in* Cells [2]. This presented a wealth of interesting data relating to beta emitter genetic effects in various systems and drew attention to the distinction that must be made between external and internal radiation. This is important since the whole assessment of radiation in terms of health has been through the quantity "absorbed dose" and what can be called the bag-of-water model.

In this bag of water model, illustrated in Fig 1, the total energy transferred by the radiation to living tissue is diluted into a large mass, greater than a kilogram, as if the effects were uniform throughout the tissue being considered. In Fig 1 the tissue mass A represents an external irradiation by X-rays or gamma rays and here the effects are uniform across the tissue. But in the case B, for internal irradiation, it is clear that it is possible, for certain kinds of exposure, for tissue local to the source to receive very large amounts of radiation energy at the same overall energy transfer to the tissue mass.

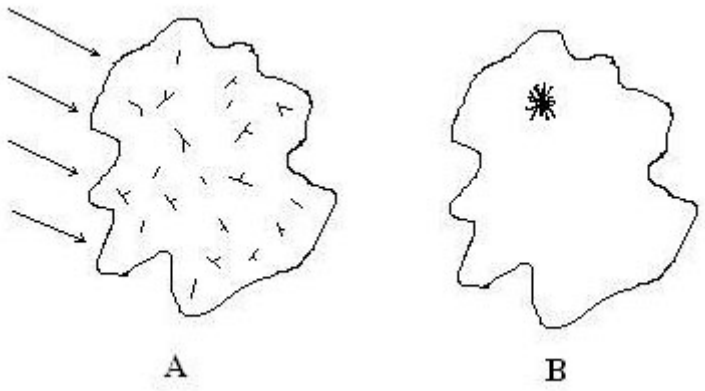


Figure 1. Comparing external and internal irradiation: the ICRP/ ICRU bag of water model. In case A, external radiation (X-rays or gamma rays) there are 20 events uniformly spaced throughout the tissue and the "absorbed dose" (see text) at any microscopic point is evenly distributed. In case B, for internal irradiation (here from a radioactive particle) there is a very large transfer of energy to a small tissue volume and the concept of "absorbed dose" does not apply.

Thus, in the historic and also the current system of radiation protection, those experts who assess radiation risk, who are termed *Health Physicists*, calculate the cumulative absorbed dose in Grays, i.e. in terms of the total energy in Joules imparted by the beta electron or alpha particle decays of the internal radionuclide contamination to one kilogram of tissue. For this calculation, the tissue is modelled as water. For example, those whose body contains 100 Bq of Strontium-90 are assessed, for the purposes of radiation protection, as having received a cumulative absorbed dose of 100 x w where w is the "cumula-

tive (absorbed) dose coefficient", obtained from measurements of the biological half life of the Strontium in the body and the decay energy of each decay in Joules. This number **w** is to be found in a Table published by the ICRP. In the case of the Strontium-90 contaminated individual, if the person weighed 50 kg, then the mean activity concentration would be 2 Bq/kg. The resulting absorbed dose would then be 2 x 2.8 x 10^{-8} (this is the ICRP 72 dose coefficient [3]). In other words, the committed dose is 5.6 x 10^{-8} Sv (0.056 μSv). But can this be safely compared with a dose from a chest X-ray (40 μSv) or from natural background radiation (2500 μSv) or from a high dose acute exposure to gamma rays from an atomic bomb linearly scaled to zero dose (the current way of modelling radiation effects)? This chapter explores this question. It is one which has become increasingly necessary as serious health effects, including cancer and leukemia, have been reported in those exposed to internal radioactivity in areas contaminated by radionuclides released from nuclear sites, weapons testing fallout and accidents like Chernobyl and Fukushima, at very low conventionally calculated "absorbed doses".

The matter has been discussed in some detail since 1998 by the independent European Committee on Radiation Risk (ECRR) whose reports [4, 5] provide a methodology for assessing health effects through a system of weighting factors based on available data. As more and more evidence emerged after 1995 that something was very wrong with the ICRP absorbed dose approach to internal radiation, the UK government set up a Committee Examining Radiation Risk from Internal Emitters (CERRIE). Since there were (and are) political dimensions to the issue, the committee was composed of scientists and experts from the nuclear industry and the official radiation protection organisations in the UK. Unfortunately the 4-years process ended in acrimony, legal threats to member of the committee, and failure to agree a final report. Two reports were issued [6, 7]. However, there was agreement that there were reasonable concerns about the safety of employing "absorbed dose" for certain internal radionuclide situations, and similar concerns about the safety of the ICRP model were made in 2005 by the French IRSN [8]. The error factor that these discussions led to was believed by different ends of the CERRIE process to be between 10-fold and 1000-fold. More recently, the value put on this error factor by the retired Scientific Secretary of the ICRP at a meeting in Stockholm in 2009 was "two orders of magnitude". What this means, in our Strontium-90 case above, is that the dose from 100Bq contamination to the whole body is no longer 0.056μSv but may now be between 0.56μSv and 56μSv and the risk of fatal cancer is proportionately increased. To put this in perspective, the mean Sr-90 dose over the period 1959-1963 to individuals in the northern hemisphere was given as about 1 mSv [9]. The ICRP risk model gives a 0.45% per Sievert excess lifetime cancer risk. Epidemiological studies suggest that the cancer "epidemic" which began in the 1980s in areas of high rainfall and fallout is a consequence of the earlier fallout exposures [10]. The weighting of dose necessary to explain this is greater than 300 if calculated from the ICRP absolute risk factor of 0.05/Sv [5, 11]. Many other instances of anomalous health effects from exposure to internal radionuclides require hazard weighting factors of between 100-fold and more than 1000-fold, and these are consequences of mechanisms which will be presented.

2. Fundamental principles

Ionising radiation, however it is delivered, creates harmful effects by causing mutations in genetic material both at the somatic level (cellular DNA) and germ cell level (heritable mutations). The mutations are caused by alterations in the cellular DNA in the nucleus and in mitochondria. These are brought about by three mechanisms:

a. Direct ionisation of the DNA and subsequent chemical alteration of the bases to molecules which are not recognised as a coding signal.

b. Indirect ionisation of the DNA by reactive species produced by ionisation of water (called Reactive Oxygen Species ROS).

c. A mechanism termed "Genomic Instability" which is an inducible cell-cell signal consequence of the production of ROS in the cytoplasm (non-DNA region) of an irradiated cell. This process is communicable between cells in some way and even between individuals and has been termed the "bystander effect".

These mechanisms are well described in the literature and in textbooks, and the processes described here can be found in the reports of radiation protection agencies e.g. [12].

Ionising radiation always transfers its energy to matter in the form of structured tracks of charged particles. Photon radiation (gamma and X-radiation) is absorbed by matter mainly through Compton Effect, Photoelectron, and Pair-production. All these cause the creation of tracks of energetic electrons which carry the energy of the original photon and collide with molecules in the absorbing medium causing ionisation. The ionised fragments (in the case of living tissue mainly of water) then recombine or react with local molecular entities causing chemical changes in the molecular structure. Various chemical reactions take place e.g.

H_2O (radiation) → $H_2O^+ + e^-$

$H_2O^+ + H_2O \rightarrow OH^* + H_3O^+$

The free radical OH* has an unpaired electron and is highly reactive; it will combine with local species including DNA if that is close to the track. If it reacts again with water species the result is a range of highly reactive fragments which are collectively described as Reactive Oxygen Species. The process can be written:

H_2O (radiation) → e_{aq}, H*, H_2O_2, H_2, OH*.

The relative concentrations of the main ROS are [12]:

e_{aq} (hydrated electron) 45%

OH* (hydroxyl radical) 45%

H* (hydrogen radical) 10%

These reactive species attack molecules in the cell and cause damage; because it is an oxidising agent the OH* radical is likely to be the most effective DNA damaging agent, abstracting

a hydrogen atom from the deoxyribose moiety of DNA yielding a highly reactive DNA radical. This will then rearrange or react with local molecules to produce a new molecule in the DNA coding sequence, the gene, a molecule which is unrecognizable to the coding transfer process and alters the message of the gene.

It seems that evolution has recognised the dangers of high levels of cellular ROS and has developed a process to deal with the threat to the species or to the organism. At the organism level the process involves firstly the existence of double strands of DNA which permit repair of ionisation damage to a base located on one strand by copying from the opposite strand. This type of lesion, termed a "point mutation" is a more likely result for chemical mutagenesis or random attack by ROS species present in the cell at some background concentration (as a by product of other chemical processes in the cell). In some cells, the result of DNA damage is programmed cell suicide, termed apoptosis. But at the organism level, one response is the induction of genomic instability, whereby a signal is switched on in the DNA resulting in increased levels of random mutagenesis built into cell replication of the damaged cell and also bystander cells. The exact purpose of this process, which is well documented, is uncertain [13]. If the damage is more extensive, involving locally multiply damaged sites (LMDS) or both strands, it becomes more difficult to accurately repair the material and either a fixed mutation or cell death results.

Internal exposure results from the radioactive decay of radionuclides incorporated into tissue through inhalation or ingestion. There are three principle types of decay which represent the majority of all internal exposures. Gamma decay, which produces fast electron tracks, β decay which also produces fast electron tracks, and alpha decay. In addition there are also short range electron tracks from Auger decays. The main internal nuclides of environmental and radiobiological importance are listed in Table 1.

Apart from effects at the nuclide (recoil, transmutation) β decay is indistinguishable from the fast (photoelectron) electron tracks produced from gamma and X-ray interactions. With β-decay, unstable elements change into elements with one greater atomic number Z and emit an electron in the process; they may also emit a gamma ray. Sometimes the daughter nuclide is also unstable and may further decay. An example is Strontium-90 which emits a β-particle of endpoint energy 546 keV (kiloelectron volts) and transmutes into Yttrium-90 which further emits a β−particle of endpoint energy 2280 keV and transmutes into stable Zirconium-90. There are several series decay sequences in which ten or more unstable nuclides are formed, one from another. An example is the natural α-emitter Uranium-238 which decays through twelve sequential unstable radionuclides until the sequence stops at stable Lead-206. Transmutation involving α-decay involves the change of the chemical element to one with Atomic Number Z four places lower on the Periodic Table. Thus U-238 emits an α-particle and decays to Thorium-234.

There is strong evidence that damage to DNA is the cause of the effects of ionising radiation. For example, experiments have been carried out with nuclides which have short range electron emissions (Auger emissions) or Tritium chemically incorporated into DNA precursors so that these elements become covalently bonded to the DNA. The measured harmful effects are up to 100-times greater than would be predicted from the "absorbed dose" showing that

it is the ionisation in the DNA that is key to the destruction of the cell [14, 15]. Another argument is based on the effects of the weak β-emitter Tritium, as tritiated water HTO. The measured effects of Tritium exposure are not too different from that expected on the basis of the absorbed dose (although it may be higher, see below). But clearly the Tritium will be evenly distributed throughout the cell. Since the beta energy of Tritium is only 6 keV the electron track range will be less than 0.5 μ and the ionisations will occur in clusters, uniformly distributed in the cell but with no overlap. It is clear that only those clusters which are close to the DNA will have an effect on the DNA, and the great majority of the energy will be "wasted" in the cytoplasm. Thus for a Tritium dose modelled by ICRP as 1 mSv, only a very small fraction of the Tritium decays will contribute to the effect.

The main target DNA, in the cell nucleus, represents a very small fraction of the total material in the cell. In a 10 μ diameter cell (mass 520 pg) there is 6 pg of DNA made up of 2.4 pg bases, 2.3 pg deoxyribose, 1.2 pg phosphate. In addition, associated with this macromolecule are 3.1 pg of bound water and 4.2 pg of inner hydration water [16]. Since absorbed dose is given as Joules per kilogram, if it were possible to accurately target the DNA complex alone, a dose to the cell (mass 520 pg) of 1 milliJoule per kilogram (one milliGray, one milliSievert) would, if absorbed only by the DNA complex (6 pg), represent a dose of 520/6 = 87 mSv to the DNA. It is possible to imagine the DNA as an organ of the body, like the thyroid gland or the breast. If this is done, then there should be a weighting factor for its radiobiological sensitivity of 87 which would be based on spatial distribution of dose alone. Of course, for external photon irradiation, to a first approximation, tracks are generated at random in tissue. Therefore only a small proportion of these tracks will intercept the DNA but the interception will be mainly uniform, and the health effects from such external exposure may be assumed to be described by the averaging approach of "absorbed dose". This is not the case for internal exposures from radionuclide decays in a number of quite specific circumstances which will be described below (see [5]).

The calculations of "absorbed dose" also assume that the medium irradiated has uniform isotropic qualities with an absorption coefficient roughly equivalent to that of water. However the absorption of gamma radiation is proportional to the 4^{th} power of the atomic number Z. It follows that the probability of absorption of gamma radiation will be location specific, and this is highly relevant to a number of high Z elements, either biologically necessary (Iodine, Z=53) or as contaminants (Uranium Z=92) [17].

Radionuclides are primarily chemical elements with the affinities and reactivities of the non-radioactive forms of these elements. They will therefore have quite specific biochemical pathways in the body and may accumulate at positions in cells as a result of their chemical group, valency, ionic volumes, charge etc. This will result in high local doses at sites where they accumulate. In addition, the decay of a nuclide attached to some cell structure or macromolecule will result in the alteration of the radionuclide into a different element with a different charge, with resultant recoil energy. This will always break the chemical bond and result in ionisation. Thus there will be local ionisation and this may be on some critical macromolecule like DNA. These localisation and transmutation effects were studied in the 1960s but no attempt has been made to incorporate them for radiation protection purposes.

http://dx.doi.org/10.5772/53942

The decay of a radionuclide attached chemically to the DNA is illustrated schematically in Fig 2.

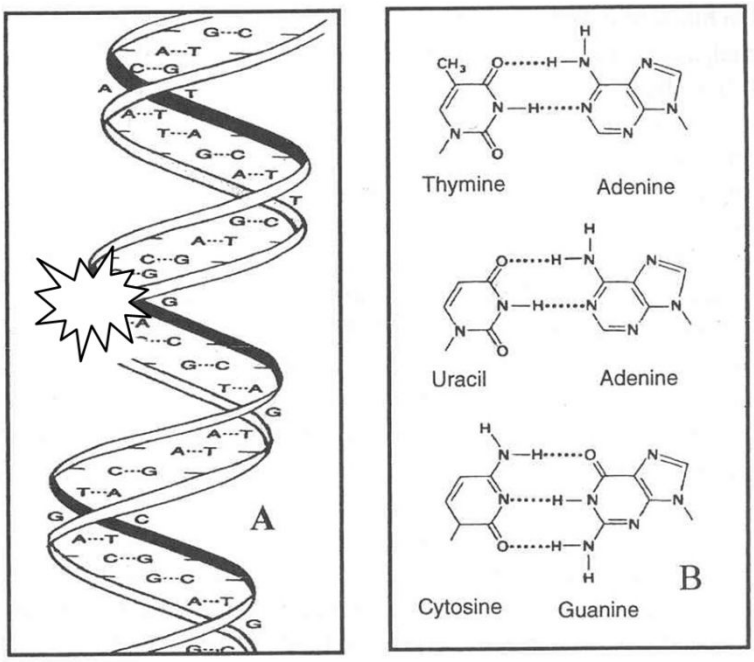


Figure 2. Certain radionuclides (Sr-90, Uranium) bind to DNA and when they decay cause (a) transmutation ionisation and (b) local electron emission ionisation (Auger, β particle) on or close to the critical target for radiation effects.

Cells have two phases of activity during their lifespan. They are mostly in a quiescent phase where DNA is not localised spatially. For a short period at the end of their lifespan, when they replicate, they are in a cell cycle phase. In this phase they are much more sensitive to irradiation. Therefore this repair replication phase represents a critical window for mutagenesis if it can be engineered. The radiation sensitivity of the repair replication phase has been studied extensively and it was suggested [18, 19] that two irradiation events separated by about 10-12 hours could represent an enhanced hazard since the first pushed quiescent cells into repair replication and the second damaged them during the sensitive 12 hour period. The idea is termed the Second Event theory. There is some evidence for it from work with split doses of X-rays. It will be discussed below.

3. Concerns about internal radionuclides

To summarise, the position is that the current assessment of harm from radiation exposure is based on a quantity which does not assume any structure in the tissue being irradiated. It does not

distinguish between different radionuclides on the basis of their chemical properties except at the organ level (Iodine/ thyroid) and it does not include any weighting for chemical affinities for DNA, nor for transmutation effects. It does not consider the fractionation of doses within cell cycle repair times. Risk factors are based almost entirely on acute external gamma ray exposures. The main concerns are for radionuclides which are significant environmental contaminants and which are listed in Table 3.

3.1. Proximity effects on local doses

Since the genotoxic effects of radiation are mediated by ionisation and the local concentration of reactive oxygen species, it is firstly this local ionization density that is the proper measure of the effectiveness of a radiation exposure. The current risk model acknowledges this by weighting the highly ionizing α particle tracks by an arbitrary factor of 20. But of concern is the overlap of such tracks, and of electron tracks from β−decays or Auger electron showers with active DNA in the nucleus, and especially at the time when this is in some critical state, as in cell repair/division. For externally delivered photon radiation, it can be assumed (in the absence of high-Z photoelectron effects) that ionization is uniform across tissue. Under these circumstances it is only a matter of probability whether a cell is intercepted by a track or not. It has been calculated [20] that, at normal Natural Background levels, each cell in the body will, on the basis of probability, receive one hit per year (a hit being the traversal of the cell by an electron track). Of these hits, some small proportion will involve a track that intercepts the DNA and may cause damage. This damage, if it results in a point mutation, will be repaired before cell division. The ionisation density in a photoelectron track is assumed to be low. Therefore, for external exposure, a dose of 1 mSv to the whole body can be assumed to provide a dose of 1 mSv to the cell on average. At the cell level, this is not the case. A cell can be intercepted by a track or not. If not, then the cell dose is zero and there is no ionisation. If so, then the cell dose can be greater than 1 mSv. The dose to the DNA from such processes will again be either zero or some dose greater than 1 mSv.

For internal exposures, the probability of interception of the track is clearly a function of the distance of the nuclide from the DNA. In addition, internal exposures may be to α tracks which carry significantly more ionisation density. The range of most α tracks (which carry about of 5 MeV energy) is about 4 cell diameters and so, theoretically, the track dose to the cell from one decay is in the region of 500 mSv. The matter becomes serious when the nuclide is an alpha emitter but also has a high chemical affinity for DNA. This is the case for Uranium. Anomalous effects from internal nuclides have been known for a long time. Early studies of cell doses from Tritium were carried out by Apelgot [21] and Robertson and Hughes [22] and reviews of Tritium and of S-35 and P-32 studies are found in ref [2]. In order to emphasise the profound effects which can be identified in internal exposures, the case of Carbon-14 will be examined in greater detail below.

The cell dose from any decay is fairly simple to approximate on the basis of a continuous slowing down approximation and the assumption that the energy delivered along a track is a constant function of the track length. Electron track lengths in tissue for a range of energies

are given in Table 1. These apply also to photoelectrons which have energies almost equal to the gamma photons that produced them. Assuming a cell diameter of 10 μ, the energy deposited in the cell is merely the decay energy divided by the track length in the cell. This is then converted into Joules (1 keV = 1.6 x 10^{-19} J) and divided by the mass of the cell in kg. For a 10 μ diameter cell this is 5.2 x 10^{-13} kg. For the Strontium-90 example, a single decay track will deposit approximately 1 mSv in each cell traversed by the track.

Energy (keV)	Range (cms)	*Linear energy transfer keV/μ	Examples (maximum β–energy, keV)
5	1.2 E-4	4	Tritium (5.7)
15	5.2 E-4	2.9	
20	8.6 E-4	2.3	
150	2.8 E-2	0.53	Sulfur-35 (167);Carbon-14 (155)
500	1.78 E-1	0.28	Strontium-90 (546) Caesium-137 (514) Iodine-131 (607) Caesium-134 (658) Barium-140 (168)
1000	4.42 E-1	0.22	Iodine-132 (1610,1210,1040) Barium-140 (1020,1010)
2000	9.92 E-1	0.201	Yttrium-90 (2280) Iodine-132 (2160)

* this is simply the loss of energy of the particle over unit distance

Table 1. Continuous slowing down range in muscle tissue for electrons in g cm^{-2} (values very similar to range in water) (from ICRU Report 35 Table 2.5 [23])

3.2. Calculating the spatial effect enhancement

The spatial effect enhancement is the probability of an ionisation track from an internal nuclide intercepting the DNA at some given level of ionisation density, compared with the probability of this happening from external radiation.

Thus we take the mutagenic event of interest to be associated with absorbed dose (energy per unit mass) in a volume element of a track which is coincident with active DNA in space and time. For nuclides with chemical affinity for DNA this ratio is clearly very large. In the limiting case of covalent binding it can be assumed that approximately half of the decays of the bound nuclide traverse the DNA, and in addition the *transmutation* of the nuclide causes a point ionisation at its position. In the limit this probability will be 1; for example, C-14 which is incorporated into one of the DNA bases will decay and change into Nitrogen. This will immediately destroy the purine or pyrimidine base which it is part of and will introduce a mutation which may or may not be repaired.

The probability of the interception of a charged particle track intercepting the DNA depends on the distance of the point source and the dimensions of the DNA target employed. The cross sectional diameter of one strand is about 0.3 nm but, in mitosis, various much larger

condensed targets exist. The principle is the same, however: the probability of intercepting the target falls off rapidly with distance. The result for a condensed DNA target of cross section 0.1 x 1 μ is given in Fig 3. The calculation is given in Appendix A. The result confirms what is intuitively obvious: the effect of radionuclide decay in the cytoplasm is much less harmful than for nuclides bound to DNA. This is particularly significant for the α-emitters which have chemical affinity for DNA, Uranium (as UO_2^{++}) and, possibly, Plutonium.

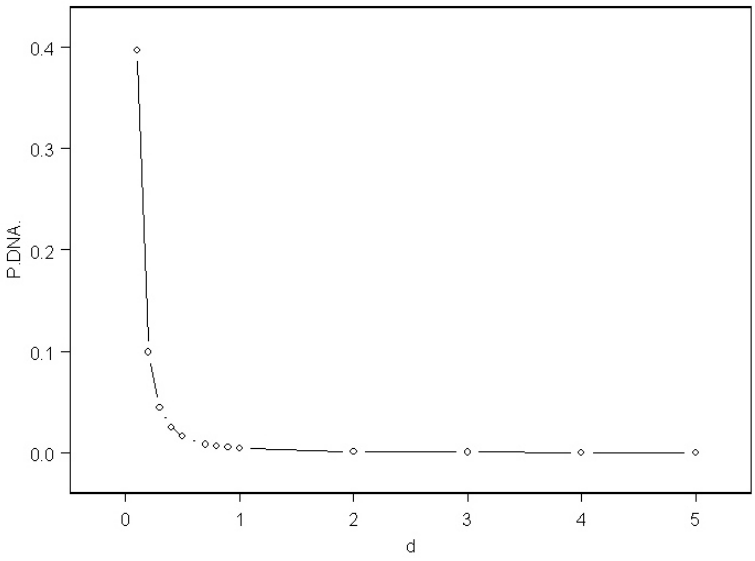


Figure 3. Approximate probability of a track interception of a DNA target modelled as a strip of 0.1 x 1 μ by distance in μ from target. In this model, the maximum probability is 0.5 for a nuclide located on the surface of a flat strip.

One other simple way to illustrate this spatial effect is merely to consider the tissue as two compartments, an organ A which may be called "DNA" and one B which may be called "everything else". The current ICRP risk model calculates the absorbed dose of any internal exposure by dividing the total decay energy by the mass. This would not distinguish between compartments A and B; both would receive the same dose. But as far as cancer is concerned (or other consequences of genetic damage) all the ionisation in compartment B is wasted. It has no effect. Therefore it is the dose to compartment A that is the cause of the effect. This would suggest that the spatial enhancement is at minimum the ratio MassB/MassA or about 90-fold. This assumes that *all* the DNA in the cell is a critical target which is unlikely to be the case. If the critical DNA represented even $1/10^{th}$ of the total cellular DNA, the spatial enhancement from track interception alone would be 900-fold.

3.3. Double strand breaks

At natural background radiation levels, where there is one "hit" per cell per year, the Poisson probability of multiple tracks across the DNA strand is low. Most of the "hits" are repairable and the biological response is proportional to the dose. But it is believed on the basis of good evidence that genetic mutations result from multiply damaged sites [12]. If two adjacent DNA strands are broken, then repair is not possible since there is no template from which to copy the correct sequence. Ward et al. (1988) [16] compare DNA damage necessary to inactivate exposed cells between radiation and chemical mutagens. Table 2 lists some of the results:

Agent	DNA lesion	No of lesions per cell
Ionizing radiation	SSB	1000
	DSB	40
	Total LMDS	440
Benzo[a]pyrene 4,5 oxide	Carcinogenic adduct	100,000
methylnitrosourea	7-methylguanine	800,000
Aflatoxin	Carcinogenic adduct	10,000

Table 2. Yields of DNA damage necessary to kill 63% of exposed cells [16]

From Table 2 it is clear that ionizing radiation is more effective than the most powerful chemical carcinogens in causing genetic lesions to the DNA, but it is the double strand breaks (DSBs) and LMDS which are the most efficient processes. From simple kinetic theory it is clear that the probability of inducing double strand breaks or LMDS will increase as the number of tracks per unit time increases. At low background external doses this is very unlikely. But as the dose rate increases, so the likelihood of multiple tracks increases (for a discussion see [18]). This is not true for a number of internal exposure situations where multiple tracks can occur at very low doses, conventionally assessed. The first is exposure to particulates.

Radioactivity from releases from nuclear explosions, e.g. accidents like Chernobyl, or from weapons tests or Uranium weapons is partly in the form of sub-micron particulates which are respirable and can be translocated from the lung. Tissue near such particles will receive multiple tracks even though the dose, as assessed as energy per unit mass may be very low. Similar multiple track effects can occur close to high Z element particles whether they are intrinsically radioactive or not, e.g. platinum (catalysers), bismuth, gold (prostheses), due to secondary photoelectron conversion from natural background gamma radiation [7, 17]. The second is where a relatively immobilised nuclide has a sequential decay pathway and so there is more than one decay from approximately the same position. This situation is more genotoxic when the decays occur within the repair replication cycle; the Second Event [7] and this situation will be discussed separately.

Radionuclide	Half life (Decay product)	Decay	Reasons for concern	Other remarks
Tritium H3	12.32 y Helium-3	Low energy β	Ubiquitous; Discharged in large amounts by all nuclear sites and weapons tests; present as tritiated water and easily incorporated into body. Can be present as organically bound tritium which may accumulate in the body.	Evidence of serious genetic effects in invertebrate development at very low doses; short range of β decay causes high ionisation density.
Carbon-14	5730 y Nitrogen	β emitter	Discharged by nuclear sites, particularly reprocessing sites (Sellafield) and weapons tests. Incorporated into the carbon of the body	Doses by ingestion mainly of vegetables, milk, fish. Both Carbon and hydrogen (Tritium) make up the structure of living systems. Transmutes to a gas, nitrogen.
Sulphur-35	87 days Chlorine	β emitter	Discharged from nuclear sites. Concentrates in foods.	Sulphur also a part of internal macromolecules in living systems. Transmutes to a reactive gas, Chlorine
Strontium-90	28.9 y Yttrium-90	β emitter	Globally Widespread. Atmospheric test fallout, nuclear sites, accidents (Chernobyl, Fukushima); Group 2 affinity for DNA	Second event nuclide with daughter Y-90 of concern since it binds to DNA
Krypton-85	10.7 y Rubidium-85	β emitter	Very large amount routinely released from nuclear sites is building up in atmosphere.	Very soluble in fats and therefore can build up in body fat (beast tissue, lymphatic tissue) following inhalation
Barium-140	12 d Lanthanum-140	β emitter	Large quantities from nuclear weapons tests; Group 2 affinity for DNA	Second event emitter binds to DNA. Of concern in assessing effects of nuclear atmospheric tests and accidents
Iodine-131	8 days Xenon-131m	βγ emitter	Large amounts from accidents, licensed releases. Affinity for Thyroid and Thyroxine in circulating blood	Second event emitter with daughter Xe-131m short half life. Transmutes to a gas.
Tellurium-132	3.25 d Iodine-132	βγ emitter	Released in large amounts from accidents; daughter is Iodine 132	Second event series
Caesium-134	2 y Barium-134	βγ emitter	Released from nuclear explosions, accidents	Binds to muscle
Caesium-137	30 y Barium-137m	βγ emitter	Released from nuclear explosions, accidents, nuclear sites under licence	Binds to muscle; concerns over effects on heart in Chernobyl contaminated areas.

Radionuclide	Half life (Decay product)	Decay	Reasons for concern	Other remarks
Radium-226	1599 y Radon-222	α emitter	NORM Contamination near oil and gas processing sites; widely studied but problems with the studies (see text). Decays to Radon gas.	Group 2 Calcium seeker. Binds to DNA. Evidence of non-cancer reduction in lifespan in human studies.
Polonium-210	139d Lead-204	α emitter	Releases from nuclear sites; daughter of Lead 201 which can build up in environment as a result of contamination from NORM	
Uranium-238	4.5 x 10^9y Series	α emitter	Releases from nuclear sites; contamination from mining and processing; from weapons fallout and accidents; from battlefield weapons usage and testing. Widespread in the environment but generally not measured near nuclear sites	High Z photoelectron effects; binds to DNA; considerable evidence for its anomalous genotoxicity
Plutonium-239	2.4 x 10^4 y Uranium-235	α emitter	Releases from nuclear sites, weapons test fallout, widespread environmental contaminant	Binds to DNA (?) evidence for anomalous genotoxicity

Table 3. Internal radionuclides of concern

Third, if an alpha emitting nuclide is either randomly positioned near or chemically attracted to the DNA, there is a significant probability that the highly ionising track will traverse the two strands of the DNA and damage multiple sites. This is the origin of the high efficiency of alpha emitters which resulted in their being weighted by ICRP. Fourth, there are situations where dose is delivered by very low energy beta emitters; the best example is Tritium. Because dose is assessed as energy per unit mass, the very low decay energy of Tritium means that there is a large number of decays from different atoms of Tritium (90 tracks) to deliver the same dose as one 500 keV β decay from Caesium-137 or from the traversal of a cell by a 500 keV photoelectron track. This would suggest a mechanism backing the evidence (see below) that Tritium represents a greater mutagenic hazard than is calculated on the basis of its absorbed dose.

3.4. Summary of enhancement mechanisms; caveats over high dose studies

The target for radiation effects is the DNA, the nuclear DNA and the sensitivity to radiation varies depending on whether the cell is in quiescent phase or in repair replication. Within the 12 hour repair replication period there are other sensitive windows. The end point for radiation damage to the DNA can be genetic mutation leading to heritable damage (in germ cells) or cancer, but if the ionisation density is too great, or the sequential hits to close to-

gether then the cell will die. The interesting thing then is that this will *decrease the fixed mutation rate* and therefore *will decrease the cancer rate*. Thus we would not expect studies of high dose and high dose rate to elicit information which informs on low dose and low dose rate.

The dose/ dose rate response in cancer studies will inevitably have a complex character for this reason. This is clear from the results of retrospective studies of Radium and Thorotrast contamination, studies which have been influential in supporting the current radiation risk model, an issue with will be discussed further below. The key point is that, for certain internal exposure regimes, the ionisation density at the DNA and the damage to the DNA can be extremely high even though the absorbed dose, as calculated by the current methodology, may be extremely low.

The regions of internal and external dose, are illustrated in Fig 4.

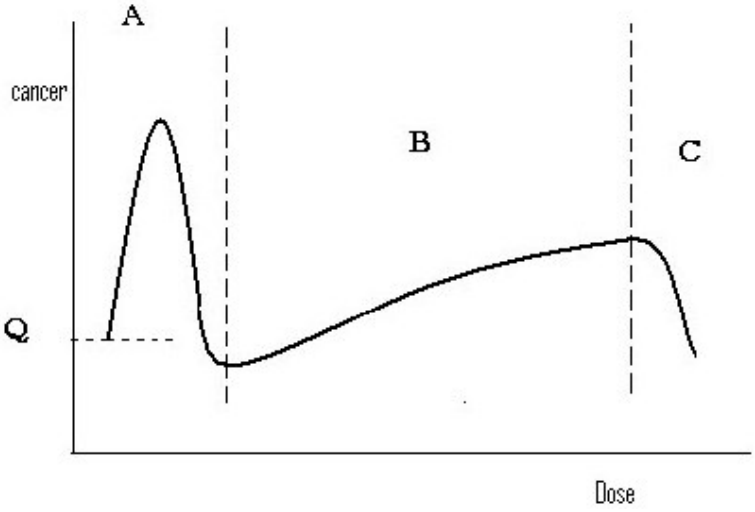


Figure 4. Regions of interest in a theoretically predicted dose response relation (see text and ECRR2010). Exactly this dose response is seen in infant leukemia rates after Chernobyl in Greece, Germany (3 dose regions) Wales, Scotland and Belarus (see [25]).

The analysis from ECRR 2010 [5] is described in Fig 4, the end point is assumed to be cancer rate. Q is the background rate. There are three regions. In the first region A, sensitive cells in repair replication are first mutated (positive slope) and then overwhelmed (negative slope). Next, in region B the cells in quiescent phase are mutated and eventually overwhelmed in C. This is also the organism response since at high doses C the organism suffers from non cancer causes of death which affect the cancer rates, reducing them as the dose increases. These responses are seen in many epidemiological and animal studies but are generally misinterpreted. Burlakova has made a special study of dose response relationships and has shown the type AB response for a wide range of objective markers of DNA damage and also whole organism end-points [24].The dose response is seen in, and most easily explained in, infant

leukemia after internal radiation exposures. As the exposure increases, foetal death ensues at some point, and the leukemia rate in the infant falls [25]. If the dose response is assumed to be linear, and the low dose data points assumed to be data scatter, a line drawn between the background cancer rate Q and the peak in region B cuts the response line in such a way as to suggest that radiation is actually reducing cancer rate, the so-called hormesis theory. The analysis in ECRR2010 points out that this is a misinterpretation of the data.

From what has been discussed, it is possible to summarise the mechanisms that may lead to increased risk of damage to DNA, and indeed to decreased risk in the case of high local doses which will kill rather than fix mutations. The mechanisms are listed in Table 4 where enhancements from alpha emitters with affinity for DNA may deliver such high local doses as to inactivate the cell.

Mechanism	Range	Examples
Spatial location		
DNA affinity	0.1-100	Uranium, Strontium, Barium, Radium Plutonium?
Membrane affinity	?	Caesium, Potassium, Rubidium, Chlorine, Sodium
DNA incorporation	Very high	Tritium, Carbon-14
Particulates	10-1000	Uranium. Plutonium
Protein incorporation	?	Sulphur-35, Tritium, Carbon-14
Transmutation	5-100	All covalently bound internal nuclides e.g. Sulphur-35, Tritium, Carbon-14
Temporal location		
Critical cell lifespan phase interception by immobilised source	0.01-100	Strontium-90 , Tellurium-132, Tritium, Radium-226, particulates
Critical repair replication window interception	0.01-1000	Strontium-90 , Tellurium-132, Tritium, Radium-226, particulates
Fat soluble noble gases	?	e.g. Kr-85
High Atomic Number photoelectron amplification	U-238 100-1000	Uranium, Platinum, Gold, Bismuth, potentially all elements with Z"/>53

Table 4. Main mechanisms of enhancement of genetic hazard from internal irradiation (see ECRR2010).

4. Specific concerns and new research directions

4.1. Location enhancement and chemical affinity

Concern has been shown since the 1950s that radionuclides of Group 2 in the Periodic Table, notably Strontium-90 and Barium-140, may have high affinity for DNA. These ele-

ments exist in solution as dipositive ions which are known to concentrate in organs (bones, teeth) which have high phosphate concentrations. Calcium and Magnesium are also known to bind electrostatically to the DNA Phosphate backbone and to stabilise its conformation. It is therefore likely that Strontium, Barium and Radium also have such affinity. The concentration of the radiation risk establishment on Radium epidemiology has been based on an end-point of bone cancer because the nuclide concentrates in bone. The affinity for DNA has been overlooked.

In the 1960s, for the reason that it was believed that Strontium would bind to DNA, and because some experiments showed that this was the case, there was significant concern about Strontium-90 contamination of milk. Mouse experiments demonstrated effects on intrauterine foetal death [26], and studies on rats showed development effects from Sr-90 [27]. There were effects at very low doses from Sr-90 [28], and by 1970 the director of the UK Medical Research Council suggested that further interest be taken in research on Sr-90 [29]. However nothing was done. In 2004, the CERRIE committee unanimously called for there to be further research into the effects of exposure to Sr-90 [6]. Also classified with these Group 2 is Uranium which exists in solution as the dipositive ion UO_2^{++} the Uranyl ion. This has very high affinity for DNAP [30] which led to its introduction as a chromosome stain for electron microscopy as early as 1960 [31].

The most necessary research is to measure the affinity of Strontium, Radium and Uranyl ion for chromosomes *in vivo*. Owing to the high opacity of Uranium there are certainly potential electron microscope methods for examining its location in cells *in vivo*. It might be possible to employ autoradiography to measure the affinity constants in vivo for Ra-226, Sr-90 and Ba-140. Affinity constants for DNAP can be easily measured *in vitro* for Strontium, Barium and Radium but this does not appear to have been done.

Animal studies of Radium and Uranium have assumed that the end point must be bone cancer or leukemia, and that only high doses will cause cancer. Effects at low doses have been assumed to be random scatter. It is suggested that low dose animal studies be undertaken with lifespan observation of all possible conditions to resolve this issue.

1. *There is the question of membrane affinity. If certain ions congregate at certain* membranes, the local ionisation density from radioactive decay will be higher than if these were uniformly distributed in cytoplasm. Experiments with the nuclide Sodium-22 by Petkau showed a supralinear dose response and effects at very low doses as calculated by using the total solution volume as a denominator [32]. If such effects occur *in vivo* there are a number of critical membranes which might be destroyed from internal radionuclide ions. Experiments *in vitro* might involve K-40, and Cs-137.

2. *DNA is made from Carbon, Oxygen, Hydrogen and Nitrogen. Carbon-14 and* Tritium can both therefore become covalently bonded into the molecule, and Tritium can easily exchange with labile hydrogen atoms on -SH, -OH and –NH moieties. The resultant decay will result in the total internal rearrangement or local reaction resulting in permanent alteration of the molecule. This will produce a point mutation with 100% efficiency. The electrons from the decay or reactive species created during the trans-

mutations through abstraction of protons from water may damage other local DNA leading to LMDS or DSBs. In the case of C-14, the transmutation to N-14 will totally destroy the molecule since the two elements have different valency, outer electron structure, and reactivity. Owing to the long half-life of C-14, experiments on its genetic effects have been difficult to carry out. Nevertheless, some studies have been published which show that these transmutation effects dominate the hazards of C-14 and Tritium incorporation (see below).

4.2. Particulates

The problem of the anisotropy of dose from internal "hot particles" was raised by Tamplin in the 1980s [33]. It was discussed by CERRIE and was the subject of a review by Charles et al in 2003 [34]. Since the 1950s, there has been a new class of internal radionuclide exposure which has not existed throughout evolution. This is the sub-micron or nanometre diameter radioactive particle. Particles below 1μ diameter can be inhaled and translocated from the lung to the lymphatic system. They are created in nuclear explosions, from power station accidents, from nuclear site releases and from Uranium weapons on battlefields. Depending on their nuclide composition they can produce very high local doses to tissue in which they become immobilised, but may also, depending on their diameter and composition, produce lower doses. Two concerns are Uranium and Plutonium oxide particles. Both contaminated large areas of land in Europe after Chernobyl. Both are resuspended from coastal sediments where contamination exists e.g. the Baltic Sea and the Irish Sea and plutonium from this latter source has been measured in coastal autopsy specimens [35], sheep faeces, and childrens teeth [36]. The well known Seascale child leukemia cluster [37] was discussed by the authorities [40] who dismissed the idea that the leukemia was caused by inhalation of plutonium and uranium on the basis that the doses to the lymphatic system were below natural background [38, 39]. However, the methodology employed diluted the particulate energy into a lymphatic system modelled as several kilograms of tissue [38] rather than the tracheobronchial lymph nodes which weigh about then grams and which are known to be the origin of leukemia in some animals.

The problem with the hot particle issue is that there will be a range of local energies (local dose) which will have either little effect (A), a genetic effect (B) or a killing effect (C). This was pointed out in 1986 following Chernobyl [41] and the idea is illustrated in Fig 5. Regions A to C will have dimensions resulting (a) from the activity and composition of the particle and (b) from its diameter. A particularly interesting case is that of a weakly radioactive particle like U-238 produced from battlefield use of Uranium weapons, so called depleted Uranium. Such a particle may be more carcinogenic than the much more radioactive plutonium particles found in the Irish Sea and epidemiology seems to bear this out. Of interest also is the photoelectron amplification of natural background radiation by internal high atomic number particles like Uranium-238, but also other elements (see below). It is not sufficient to dispute the hazards from particulates by pointing out that they will have such high activities that cells will be killed rather than mutated e.g. [34, 6].

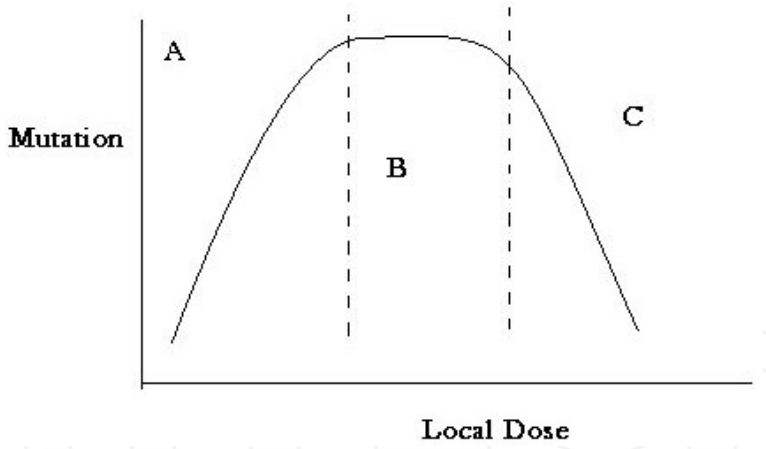


Figure 5. Effects in cells local to "hot particles" (see text).

4.3. Protein and DNA incorporation and transmutation

The inactivation of key enzymes or DNA by incorporation through biosynthesis of radionuclide substituted precursors is a matter that seems to have been entirely overlooked in radioprotection. The environmental contamination nuclides which will inactivate biological molecules are those from which they are constituted, namely Carbon (C-14), Hydrogen (Tritium), and Sulfur (S-35). Some results for C-14 and Tritium will be briefly presented. There is an important experiment which shows the contribution of transmutation to the lethal effects of C-14. Apelgot and Latarjet [42, 43] incorporated C-14 into the cells of the bacteria *e.coli* by culturing in a medium containing 2-14C-thymidine. The samples were stored at -196 C, The specific activity of the 2-^{14}C thymidine was 166 MBq/milliMol. The experiments continued for a year. To evaluate the role of the β-radiation, a control non-radioactive bacteria sample was stored in the presence of 2-^{14}C thymidine in such a way that the radioactivity per cm^3 of this suspension was the same as the study sample. From a comparison of the results, the authors concluded that the predominant lethal effect was from transmutation with an efficiency of 160-times that which would be obtained from the β-radiation. Similar results have been obtained from studies of C-14 by Anderson and Person [44, 45] who put the hazard coefficient relative to β−radiation at 10-fold. These authors studied the mutagenic effect of C-14 and compared transmutation with external X-ray doses. Pluchennik [46, 47] studied the mutagenic effect of C-14 decay in *Chlorella* grown in a medium containing a single carbon source with different fractions of C-14. The number of mutants from the C-14 rose rapidly at low fractions and quickly saturated due to killing effects; the data showed that the mutagenic effect considerably exceeded that due to external radiation. Other research carried out in the 1960s has largely confirmed this generalisation [2].

The genetic effects of incorporation of C-14 are of concern since the atmospheric nuclear tests in the 1950s and 1960s greatly increased the C-14 in the atmosphere. The genetic hazard

to man was first pointed out by Totter et al [48] in 1958 and also by Pauling [49]. A number of studies were carried out on different systems. These include onion bulbs [50, 51] grown in an atmosphere of $^{14}CO_2$ resulting in chromosome aberrations, micronuclei and elongated cells. Onion bulbs were also studied by Friedkin and Atchison [52] who compared chromosome aberration in the roots between labelled thymidine (incorporated in DNA) and thymine (not incorporated). The frequency of aberrations was 3.95% for the thymidine but only 0.43% for the thymine, showing that the effect of transmutation was 9-times that of the β −radiation. A study of the effect of the C-14 position in the thymidine [53] showed quite clearly that it was transmutation that was the cause of the effects.

Kuzin et al [54, 55] compared the transmutational component of C-14 incorporation with external γ radiation in the broad bean. The amount of chromosomal aberration in 2 days was found to be 25-times per rad for the transmutational component. Other studies on drosophila [56, 57] give results which suggest that the mutagenic efficiency of C-14 is about three times that of chronic external γ radiation. Valuable reviews of effects from Tritium and Sulphur-35 are presented in [2].

Tritium has been increasing in the biosphere since the nuclear atmospheric testing. The main form in which it exists is tritiated water (HTO) but the nuclide also is incorporated into carbon compounds e.g. CH_3T and this is termed organically bound Tritium. Tritium is also employed for radioactively labelling compounds in chemical, medical and biochemical research. Tritium has a half-life of 12.6 years and radiates low energy β-particles (0-18 keV) and when incorporated in a molecule it transmutes to Helium with molecular restructuring and ionisation and realises a recoil energy of 0-3 keV. These events convey a high probability of destruction or inactivation of the parent molecule. If this is a macromolecule, local restructuring may alter the tertiary folding structure and inactivate the entire molecule. Thus the effects of Tritium are amplified in the ratio of the molecular mass to the Tritium mass, which may be by orders of magnitude. The question of whether these results show enhancement of effect relative to externally calculated absorbed dose does not seem to have been addressed either for lethality or mutation. Experiments with very low dose exposures of Tritium to invertebrates have identified significant developmental effects [58]. Tritium is also of interest as a pseudo-second event nuclide (see below) owing to the fact that the number of events associated with unit dose is far greater than the mean event number associated with background gamma radiation.

4.4. Temporal location: The second event theory

It is well known that dividing cells are more sensitive to radiation than quiescent cells. Once cells are committed to division, they enter the active part of the cell cycle, during which DNA repair takes place followed by cell division. It is therefore clear that any damage or signal which moves cells from quiescence into the repair replication sequence puts the cells into a condition where a second damaging event will carry an enhanced risk of mutation or lethality. This is the basis of the Second Event Theory [18, 19]. This postulates that split doses to the cell DNA, separated by 10-12 hours, will represent an enhancement of hazard. The sequence is vanishingly unlikely for external natural back-

ground irradiation but exceedingly likely for a number of specific internal sequential emitters. These include exposure regimes involving Sr-90/Y-90, Te-132/I-132 and various others. They include hot particles (since there are continuous releases of tracks from these) and also Tritium which, due to its very low decay energy, produces many more tracks per unit dose than natural background radiation.

The probabilities of second event processes occurring can be calculated but depend on basic assumptions. A paper by Cox and Edwards of the UK National Radiological Protection Board [59] concluded that the cell dose enhancements were finite but low. However it was pointed out that there were major faults in the cell dimensions employed in this study [60]. Clearly, the enhancement is a function of the location of the Second Event nuclide, the factor increasing sharply as the critical volume is reduced. For location on the DNA the potential enhancement becomes enormous. Table 5 shows results for Sr90/Y90. A number of studies have indeed shown anomalous genetic hazard from Sr-90/Y-90 [7, 18]. However, since Strontium also binds to DNA it carries enhancement from other mechanisms. An interesting experiment which suggests that there are 2nd event effects from Sr-90/Y90 was a comparison of the genetic damage effectiveness of Sr-90 and the singly decaying Sr-89 on yeast suspensions at the same doses. The results showed that the Sr90 was four-times as genetically damaging as the Sr89 for the same dose [61]. Further support comes from cell culture experiments with split doses of X-rays which show an enhancement of effect for split dose regimes during the repair replication period [18, 62, 63]. In view of the important implications this has for medical X-ray and radiology the question should be examined by further research. Such research might include (a) split dose research on living animals, e.g drosophila, zebra fish, (b) comparison of sequential decay effects from indentical elements with different decay sequences e.g. Sr-90/Y-90 vs. Sr-89.

External dose comparison	2nd Event enhancement probability [19]	Cox and Edwards (2000)[59] Cox Edwards and Simmonds (2004) [6]
1 mGy	30	1.3
0.1 mGy	200	*8.6*
0.01 mGy	1900	*82*
0.001 mGy	9400	*407*
1 atom per g of tissue	5×10^9	

Table 5. Second Event Enhancements for Sr-90/Y-90 (From Busby 1998 [19])

4.5. Secondary photoelectron effects

The quantity employed in radiation protection, *absorbed dose*, is defined as D = ΔE /ΔM. Hitherto, the mass into which the energy has been diluted is that of living tissue; ICRU provide tables of absorption coefficients for different living tissue, adipose, bone, muscle etc. which can be employed for calculations involving doses, but generally all these denominator quantities have the absorption characteristics of water (H_2O) (ICRU35 1984). The absorption of electromagnetic (photon) radiation is due to a number of processes, the main three being pair-production, Compton scattering and photoelectron production. For elements of atomic number greater than about 30, and for photon energies of less than about 500 keV, the photoelectric effect predominates. Even for the low atomic number elements that make up living systems, there is fairly quantitative conversion of incident photon radiation below 200 keV (and induced photon radiation from second order and third order processes) into photoelectrons. These are fast electrons which are indistinguishable from beta radiation and have the energy of the incident photon minus their binding energy (which is generally far less than the incident photon energy and can be ignored). The absorption of photon radiation by elements is proportional to the fourth or fifth power of the atomic number Z. Thus the predominant absorber in water is the Oxygen atom Z=8 and it is reasonable to give the effective atomic number of water as 7.5. Of course, there are elements in tissue with higher atomic numbers, but interestingly, apart from Iodine (Z=53) few elements with Z>26 (Iron, Fe).The incorporation of high Z elements into living systems would generally be harmful since it would increase the radiation dose, and therefore such developments have been lost though evolutionary selection. Iodine is an exception, but it should be noted that the main sites for radiation damage in terms of sensitivity are the main sites for Iodine concentration, the thyroid gland and the blood. It has been suggested that the metabolic and cell repair status controls exercised by the thyroid gland are the reason why Iodine has been incorporated into living systems and is employed as a kind of radiation-repair control mechanism [17].

A problem in radiation protection arises when high Z elements are incorporated into living tissue, since the enormously greater absorption of photon radiation by such material will result in enhanced doses to tissues adjacent to the high Z material. The problem was first addressed in 1947 in relation to X-rays of bone [64] and has been studied in the past in relation to prostheses. More recently, interest has shifted to the use of high Z material to enhance photon radiotherapies for tumour destruction where it has been shown to be effective. Gold nanoparticles have been successfully employed (and patented) for radiotherapy enhancement [65].

Despite this knowledge, the enhancement of photon radiation by high Z contaminants has not been addressed in radiation protection. The situation may have arisen out of the fact that prosthetic materials are not intrinsically radioactive and contamination from high Z elements like Lead (Z=82) are considered under the heading of chemical toxicity. The issue was raised in 2005 [66, 67]. It was pointed out that there are two circumstances where the Secondary Photoelectron Effect (SPE) would have significant radiological implications. These are (a) for high Z elements that bind to DNA and (b) for internal high Z particulates. In the latter case, the effect will increase as the particle size is reduced, since for massive high Z con-

tamination e.g. prostheses, most of the photoelectrons are wasted inside the bulk material. The emergence of the photoelectrons into tissue is a function of the mean electron path in the material, and the absorbed dose in local tissue is a function of the electron range and thus its energy.

The radiological implications of the idea emerged in considering the anomalous health effects of Depleted Uranium weapons and were presented to the CERRIE Committee in 2003 and the UK Ministry of Defence in 2004 although nothing was done. More recently there have been attempts to quantify the effects for particles through Monte Carlo modelling [68, 69], but these have not generally been very credible treatments or able to cope with the small volumes of complex media involved, and the results have been far removed from the few experimental data published [70, 65].

The particular concern is for the element Uranium, since this has been employed since 1991 as a weapon; the Depleted Uranium (DU) penetrators, used from the 1991 Persian Gulf War onward, produce a fallout comprising sub-micron Uranium Oxide particles which are environmentally mobile and respirable. Uranium has another quality which makes it of interest in SPE; as the uranyl ion UO_2^{++} it has a very high affinity for DNA phosphate: some 10^{10} M^{-1} [30]. This affinity has been known since the 1960s when it was first employed as an electron microscope stain for imaging chromosomes [31].

The SPE is therefore likely here to cause enhanced photoelectron ionization at the DNA due to enhanced absorption of natural background radiation (or medical X-rays). A similar process occurs with the Platinum chemotherapeutic agent cisplatin which binds to the DNA and acts as an antenna for background radiation and radiotherapy beams.

For SPE phantom radioactivity in other elements of high atomic number, the tissue doses are enhancements of the incident photon dose at the point of the atom or particle being considered. Due to the complex interactions these local doses must be determined by experiment. However, these experiments are straightforward and involve X-irradiation of high Z element contaminated tissue at different doses. In principle, this development suggests that the internalization of any high Z particle which is biologically long-lived will cause continuous irradiation of local tissue cell populations, which would represent a carcinogenic hazard. This has implications for those employing prosthetic materials and also for the dispersion of high Z particles (Tungsten, Platinum, Bismuth, Lead) in the environment. It also suggests that it may be of interest to examine tumours for the presence of high Z particles at their centre. Table 6 lists a number of potentially hazardous SPE elements.

Finally it should be pointed out that physical modelling through Monte Carlo codes is unlikely to establish useful data and certainly should not be employed as an attempt to dismiss the importance of the proposed mechanism.

Nevertheless, a FLUKA Monte Carlo model of the absorption by nanoparticles of Gold and Uranium carried out by [71] Elsaesser *et al* 2007 graphically confirmed the effect. The results for photoelectron track production following absorption of 100 keV photons is shown in Fig 6 below. Enhancement factor in this calculation for the 10nm Uranium particle relative to water was approximately 8000.

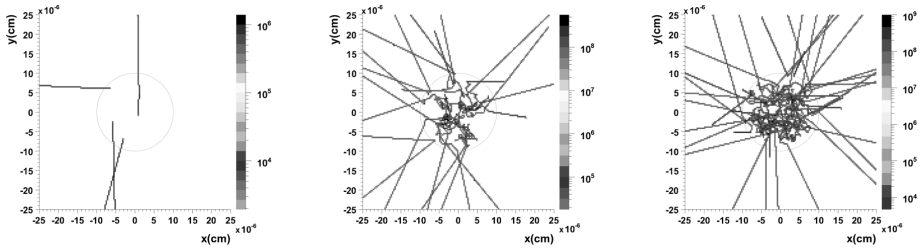


Figure 6. Photoelectron tracks emerging from (left to right) 10 nm particles of water (Z=7.5), Gold (Au; Z =79) and Uranium (U;Z=92) after irradiation with 100keV photons. Monte Carlo (FLUKA code) analysis. Track numbers are in proportion to the 4th power Z law (tracks are shown as projections on a flat plane). Note that the model uses 1000 incident photons for Au and U but 10,000 for water [71]

Material	Z	Z^4/tissue	Source	Note
U	92	22642	Weapons particles, nuclear fuel cycle, atomic and thermonuclear bomb tests	Binds to DNA; known to cause cancer in animals and genomic damage at very low concentrations
Th	90	20736	Incandescent mantles Contrast media	Highly insoluble
Bi	83	14999	General contaminant	Insoluble
Pb	82	14289	General contaminant	Toxic; SH binding
Hg	80	12945	General contaminant	Toxic; enzyme binding
Au	79	12310	Prostheses; colloid used for rheumatism	Friction particles may travel in body; inert and insoluble
Pt	78	11698	Vehicle catalysers, general contaminant	Inert and insoluble
W	74	9477	Weapons; general particle contaminant	Associated with child leukemia cluster Fallon Nevada; known to cause genomic damage and cancer in animals.
Ta	73	8975	Capacitors	
I	53	2493	Thyroid, blood plasma	Radiation sensitivity

Table 6. Biologically significant environmental contaminants and materials exhibiting phantom radioactivity through the Secondary Photoelectron Enhancement (SPE) of natural background and medical X-rays

4.6. Fat soluble radioactive noble gases

The nuclide Krypton-85 has been released to the biosphere continuously since 1945 and increasingly from nuclear energy processes. With a half-life of 10.7 y and a β decay of 672 keV

the concentration in the atmosphere has been building up to the extent that liquid air is now significantly radioactive. The assessment of harm from Kr-85 has generally been associated with skin doses from β decays in air. However Krypton (and Radon) are far more soluble in fats than in water and this water/oil partition driven equilibrium might cause build up of these nuclides in lymphatic tissue as a result of equilibria in the lung.

5. Conclusions and recommendations.

5.1. Epidemiology: Uranium effects

The current radiation risk position, that of the ICRP and its associated organisations, has been adequately reviewed by Harrison and Day [72]. With regard to the questions raised in the present overview, the only useful discussion in this paper, as in the CERRIE majority report [6], is the belief that the application of external risk models to internal exposures is supported by epidemiological studies of Thorotrast and Radium. It is therefore worth briefly looking more closely at these.

5.2. Radium and thorotrast studies: Re-examining the data

The increasing pressure brought to bear on the ICRP risk model focuses intensely on the arguments about internal and external radiation exposure rehearsed in the previous section. The ICRP and the radiation protection agencies have to concede much of the science, but fall back on the epidemiology. The problem is, very little human epidemiologic research has been done on internal radionuclide exposures. There are, however, two sets of studies which are said to broadly support the arguments that the current risk model is correct. These are the studies of individuals medically treated with Radium and Thorotrast. The studies originally were carried out because of doubt over the use of the external based risk model to deal with internal radionuclide exposures at a time when internal exposures from alpha emitters like plutonium were increasing in proportion to the development of the A-Bombs and H-Bombs. All of these studies were of roughly the same type. A group of individuals was formalised and then records were traced, or the individuals themselves were traced to see what the number of cancers were. The end point was always cancer, since the project was to see if the ICRP cancer risk model was accurate for these internal exposures. The medical and other (e.g. laboratory) exposures to Radium had been largely before 1960; e.g radium clock dial painters, and there were many of these who had survived from the period when they were employed. In addition there were individuals who had been exposed to Ra-224 as a treatment for various illnesses. There had been a fashion to treat syphilis, hypertension, gout, infectious polyarthritis, “muscular rheumatism”, anaemia, epilepsy and multiple sclerosis [29] with radium. Then there were many individuals who had been injected with the substance Thorotrast, an X-ray contrast medium based on the nuclide Th-232, the daughter of which is Ra-228. So these are all internal radium exposures. What was reported in studies was that the cancer yields, mainly of liver cancer, bone cancer, and leukaemia could be roughly related to the exposures and that the yield was not too far away from the yield predicted by the

ICRP external type of risk model, i.e. the A-Bomb survivors. These studies are the last remaining defence that the current risk agencies can mobilise. There are a number of fatal problems with all the radium studies:

- The study groups were assembled long after the exposures and so not all those who had been exposed were in the study group: only the survivors. Many were dead. This biased the samples.
- A number of published studies give sufficient data to show that there was a high rate of death in the early period before the groups were assembled.
- The doses were not isotropic; for Thorotrast, the material was stored in depots in parts of the body where cells were quite resistant to radiation.

In addition, the doses were very large, so these studies were not of low dose chronic exposure but were in fact high dose internal chronic exposure.

Some of these problems were raised in 1970 in relation to the pioneering work by Robley Evans. Evans was a physicist and was concerned with the question of physical dosimetry of small quantities of internal emitters. Writing in the *British Journal of Cancer* in 1970, JF Loutit [29] took issue with the methodology of the Radium studies and pointed out that the massive bone marrow damage resulting from Radium exposure (which had been reported by many authors before Evans) would result in a very large excess death rate from a range of diseases. Loutit wrote that the limiting hazard from internally retained radium acquired occupationally being bone cancer needed to be reconsidered. He pointed out that evidence already existed in the 1930s from the work of Martland that those with substantial body burdens of radium had considerable life shortening and that the associated pathology had not been clarified. Loutit re-examined the radium dial case reports and found that internal radium had a profound effect on the bone marrow, best described as leukopenic anemia. This identifies one source of increased risk from non cancer illness and death which would have removed individuals from Radium and Thorotrast study groups. Indeed, the problem with all these studies is that they exclude about half of the exposed population who may have been lost to the researchers but are very likely to have died of cancer or a range of non cancer illnesses. In the better reported studies, where more data is made available, it is possible to see that this is indeed the case. An example is Wick et al. (1983) who examined cancer in Ra-224 patients. I have reduced the data from a diagram in this paper to produce the graph in Fig 7 which shows the percentage dead in the age group at exposure by the period between exposure and death. It is clear from the trend that for all the groups, the most deaths will have occurred in the first five years in individuals that were not in the study group.

This Ra-224 study by Wick et al. [73] is of the exposure group of German patients who were treated between 1948 and 1975 with Ra-224 for ankylosing spondylitis. There were 1501 total patients, among them 69 were missing and 433 were dead. What did they die of? We don't hear. But 3 of them developed bone cancer, 5 developed leukemia, and 6 bone marrow failure (cf Loutit above). This tiny cancer yield may approximate to the range predicted by the ICRP model (assuming that the dose could be accurately descri-

bed) but what about the missing people? What about the 433 who died? If they died of conditions caused by the stress on their immune system (bone marrow failures and silent bone marrow problems) then the cancer yield is not a proper representation of the effects of the radium exposures on this group. And the cancer yield to produce an approximation to the ICRP risk predictions for leukemia is lower than in the control group. Addition of a handful of cases from the missing individuals or a handful of pre-leukemic immune-compromised individuals from the 633 dead would have a profound effect on the outcome of the study.

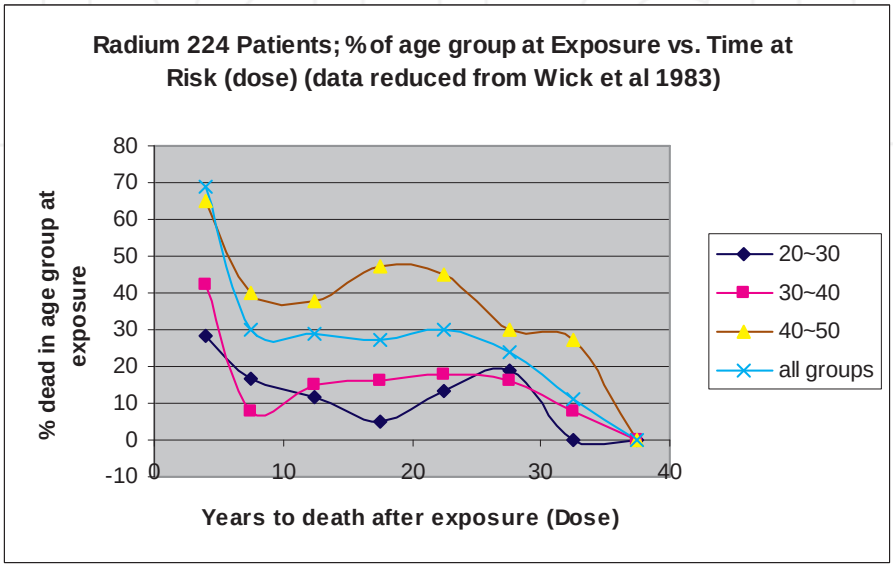


Figure 7. Percentage of each age group at exposure plotted against years to death from exposures in the Ra-224 study of Wick et al 1983. [73]

A similar picture is found in the thorotrast studies, where it is possible to see enough data. For example, in the paper by Mori et al 1983, 282 Japanese war wounded ex-servicemen thorotrast cases are followed up [74]. There were deaths from liver cancer, cirrhosis of the liver and also blood diseases. But in 170 deaths in the group, 42% were from cancer and 37% from other causes. There was no dose response for the cancers and the cancer yield was about 20-times greater than expected from ICRP. But the most interesting aspect is that from analysis of this group, the death rate was very high and the age at death very low compared with all Japanese populations. This is missed in the report since the method employed was to choose sick pathology controls from a hospital pathology records sample. I have compared their age specific death rates with all-Japan. Plots of the survival curves in the females in this group show that 100% were dead by age 75 compared with 65% for the equivalent all-Japan population. Results are given in Fig 8.

Of course, about 40% of these study group women died of cancer: the effects of the thorotrast. But note that the others died from something else; they didn't live to a ripe old age nor did they live as long as the all Japan population. This is clear from the survival curves in Figure 8 which show almost a 20 years age effect in the women. For men, the shift was about 9 years (my unpublished results, not shown).

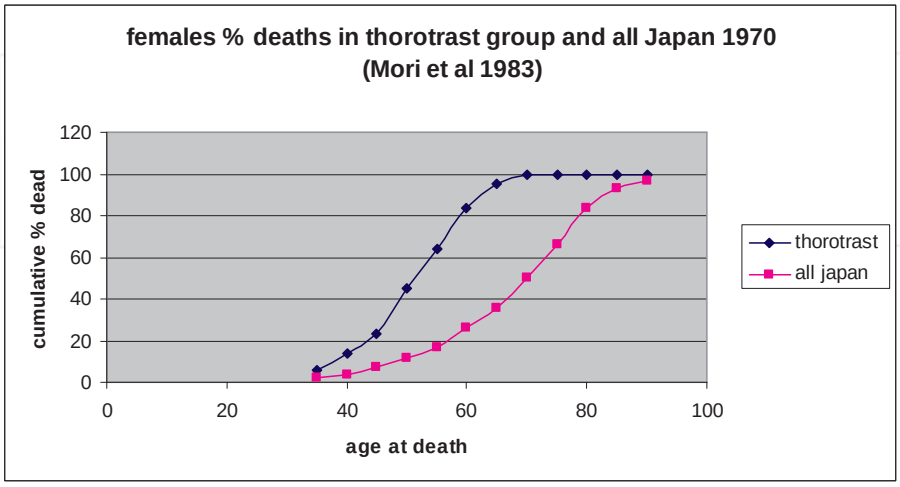


Figure 8. Survival curves for female thorotrast patients studied by Mori et al 1983 compared with all Japan. Data reduced from tables in Mori et al 1983 [74] and Japanese government publications.

The conclusions of this brief account of the re-examinations of the radium and thorotrast studies show that they cannot be used as indicators for low dose chronic risk to internal radionuclides. Apart from the fact that the doses were (like the A-Bomb doses) very large, the main fatal flaw was and is that confounding causes of death make the cancer yield conclusions unsafe. Loutit 1970 makes the point that the damage to the bone marrow would be likely to occur in the case of the weapons-fallout component Strotium-90, and he urged the research community to concentrate on examining risk from that nuclide, an exhortation which the research community entirely failed to take notice of. Loutit was a Medical Research Council MRC (Harwell) director.

5.3. Uranium

The anomalous health effects of exposure to Uranium, especially in the form of particulates, have been increasingly clear in the last 10 years. The radiobiological evidence is reviewed in ECRR2009 [75] and there is insufficient space here to do more than note that the current risk external radiation based model cannot begin to explain or predict what is found empirically. Despite the massive evidence including studies by nuclear industry and military scientists, the agencies ICRP, UNSCEAR, BEIR et al persist in their assertions that the observed effects

cannot be due to Uranium. Most recently there have been studies of French Uranium workers showing leukemia and lymphoma excess, lung cancer excess and heart disease at doses which are too low by some 2000-times to explain them on the basis of current risk models [76, 77, 78]. There is an urgent need to carry out research into this issue. The effects of photoelectron amplification can easily be examined by studies involving varying external X-ray doses at different concentrations of Uranium particulates and molecular Uranyl ion in cell culture and animal studies. There is no routine measurement of Uranium in the vicinity of nuclear sites. This should also be remedied.

5.4. other epidemiological evidence

5.4.1. Childhood cancer near nuclear installations

There have been reports in peer reviewed journals of increased risk of childhood leukemia and non Hodgkin lymphoma near many nuclear sites in Europe. A list and discussion may be found in ECRR2010. Child leukemia excesses are found near nearly all the sites that have been examined [5]. e.g the reprocessing sites at Sellafield [37] Dounreay UK [79] and La Hague (France) [80] near the Atomic Weapons Establishment Aldermaston (UK) [81], the Atomic Energy Research Establishment Harwell (UK) [82], near Hinkley Point nuclear power station (UK) [83] and recently near all the combined nuclear sites in Germany (KiKK study) [84] and near all the combined nuclear sites in France [85], GB, and Switzerland.

The radiation risk community [86, 87] basing calculations on the ICRP risk model have worked out the dose ranges and say they cannot be more than a few microSieverts, well below Natural Background. The ICRP risk model predicts an excess risk of 0.05 cancers per Sievert. 100 microSieverts is 1/10,000 th (10^{-4} of a Sievert). An Excess Absolute Risk of 0.05/Sv is Excess Relative Risk (ERR) of 5E-8 per μSv. This, divided by the spontaneous risk of 3E-4 for 0-4 y old children, is 1E-3 per 6 microSv. But there are twice as many child leukemias as are expected: a doubling of risk: the ERR observed in the KiKK study was ~ERR=1. So ICRP predicts a 1000-fold lower risk than found in the KiKK study.)

The ICRP does not give a risk factor for childhood leukaemia but to define a difference between external and internal exposure we can employ the Excess Relative Risk based on the obstetric X-ray studies analysed by Wakeford and Little [88]. This gives an Excess Relative Risk of 50/Sv and based on the 40/Sv Obstetric X-rays results of Alice Stewart.

Stewart found a 40% excess risk after an X-ray dose of 10 mSv [88]. That would suggest a 4% increase after 1 mSv, 0.4% after 100 μSv. But we are seeing a 100% increase at this level. The error is now 100/0.4 = 250-fold.

5.4.2. Infant leukemia after Chernobyl

Five different groups [89-93] reported a statistically significant increase in infant leukemia in 5 different countries of Europe in those children who were in the womb at the time of the Chernobyl Caesium-137 fallout as measured by whole body monitoring. The effect was also reported from the USA [94]. Thus the Chernobyl exposure is the only explanation for the in-

crease. This occurred and was reported from Greece, Germany, Scotland, Wales, Belarus, USA and the error this shows in the ICRP model was the subject of two peer reviewed papers in 2000 [92] and 2009 [25]. Using the Alice Stewart relation between dose and leukemia above, the error is about 400-fold (depending on the country) [25]. Using the ICRP model it is upwards of 1000-fold. This analysis is most relevant since it unequivocally supports the causal relation revealed by the nuclear site child leukemias yet in this case fission product internal radiation can be the only cause.

5.4.3. Cancer following Chernobyl in Northern Sweden

The study by Martin Tondel found a 11% increase in cancer for every 100 kBq/sq metre of Cs-137 from Chernobyl [95]. It is possible to calculate that 100 kBq/m^2 Cs-137 including a further 100kBq/ m^2 of Cs-134 if reduced exponentially due to rain washout to rivers and lakes with half life of 6 months would give a committed effective dose of about 1 mSv. The ICRP model [96] predicts an Excess Relative Risk of 0.45 per Sv, so the ICRP expected excess relative risk, including a Dose Rate Reduction Factor of 2 (as used by ICRP) is 0.0225%. The error in ICRP model defined by Tondel's result is thus 490-fold.

5.4.4. Human sex ratio at birth perturbed by low doses of internal fission-product ionising radiation

Studies by Hagen Scherb and Kristina Voigt [97] show clear and highly statistically significant alterations in the human sex ratio at birth (the number of boys born to girls) after (a) atmospheric bomb testing, (b) Chernobyl and (c) near nuclear facilities. Effects are shown to be local, European (several countries were studied) and global, supporting earlier evidence of increases in infant mortality during the period of atmospheric weapons testing [98, 99]. Sex ratio has been accepted as a measure of genetic damage with the preferential killing of one or other sex depending on the type of exposure (mothers or fathers). According to Scherb and Voigt, millions of babies were killed *in utero* by these effects [100]. A recent reanalysis of the sex ratio effect in Hiroshima reveals the effect in those populations also [101], evidence which was overlooked by the USA researchers through poor epidemiology and questionable decisions. This evidence objectively confirms the serious genotoxic effect of internal ionising radiation on germ cells and the exquisite sensitivity of humans and other living creatures to releases from Uranium fission. The ICRP does not consider such effects nor are they included in any assessment of harm.

5.4.5. Cancer and genotoxic effects in Iraq following DU exposure

A series of studies of the population of Fallujah Iraq shown [102- 104] to have been exposed to Uranium following the 2003-2004 battles have revealed extremely high rates of congenital malformations at birth and cancer and leukemia/lymphoma in adults. The studies also draw attention to significant sex ratio effects at birth beginning after 2004. These results, and the increases in genotoxic effects in the offspring of Gulf veterans support and are supported by the other sets of observations reviewed above which show that inhaled Uranium nanoparticles represent a very serious hazard which is entirely overlooked by ICRP.

5.4.6. Chernobyl effects as reported in the Russian peer-reviewed literature

The effects of the Chernobyl accident exposures have been reported in the Russian language peer review literature since 1996. These results have been reviewed by Busby and Yablokov 2006 [105] Yablokov et al 2010 [106] and Busby et al 2011 [107] but have been largely ignored by ICRP. They constitute a very large body of peer reviewed work which show that the effects of the Chernobyl accident exposures are massive and extremely serious [108]. They range from cancer and leukemia to heart disease especially in children together with a range of illnesses which can be best described by the term premature ageing [108]. They include congenital transgenerational diseases and are reported in animals and plants which cannot be affected by the kind of psychological processes (radiophobia) which have been employed by the radiation risk establishment to account for the early reports coming out of the affected territories. In addition, there are objective measurements of serious biological harm to humans and other living creatures affected by the exposures. The germline mutations found by minisatellite tests [109] in humans were also associated with real morphological effects and fitness loss in birds [110] and were shown to have caused significant sex ratio changes in the birds and also population loss [111] which is in agreement with the findings of Scherb and Voigt and the infant mortality findings [98, 99]. The implications for the understanding of the historic effects of the nuclear project on human health are alarming.

5.5. Summary and conclusions

The current radiation risk model is insecure for internal radionuclide effects. Massive evidence exists from epidemiology and also published studies of the effects of internal radionuclide exposures that the effects of location, chemical binding or affinity, temporal decay patterns and transmutation of internal radionuclides can have much greater genetic or lethal effects on cells than are predicted by the absorbed dose model. These data have been published since the 1950s but ignored for the purpose of radioprotection. Many critical research issues should have been pursued but have not been. It is recommended that those issues and research studies highlighted in this contribution are seen as a priority.

Appendix

Calculating the probability of a track interception with DNA as a function of distance of the point source

The model is given in Fig 9 and Fig 10. It locates the source at the centre of a sphere S radius r distance d from the DNA which is modelled as a cylinder of length 2R. We put r<D. Any decay which intercepts an infinitesimal strip of area A on the DNA cross section can be mapped onto a small area B on the surface of the sphere S. The required probability assumes that the decay can be in any direction. It is thus equal to the area B / total area of the sphere.

http://dx.doi.org/10.5772/53942

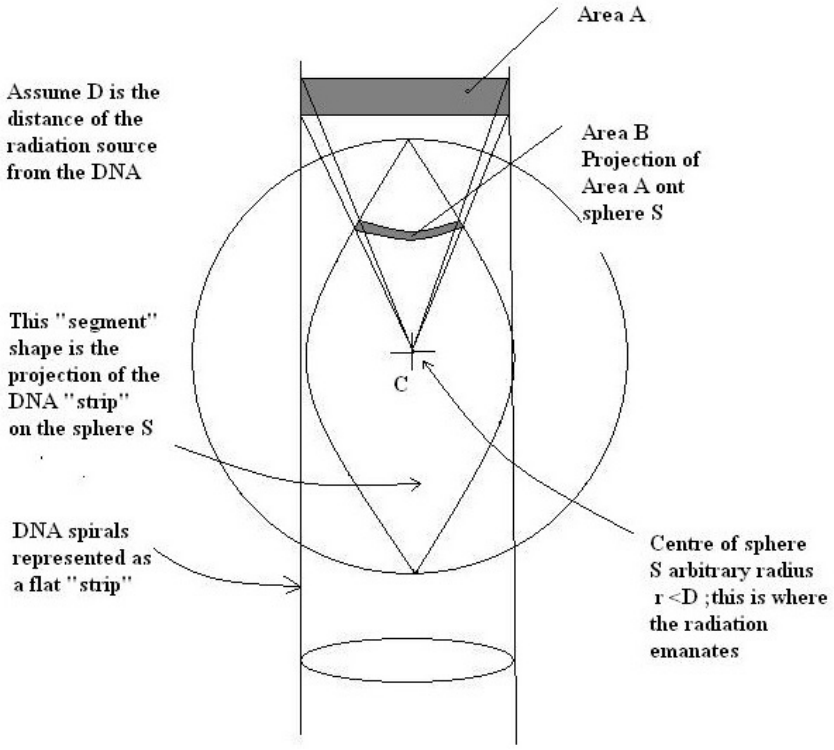


Figure 9. Model

From Fig 2, tan θ = R/d; θ = arctan (R/d)

Length of arc A = 2rθ = 2arctan (R/d)

d′ = d/cos θ; θ = arctan (R/d′) = arctan ((Rcos α)/d)

Area B (Fig 1) = 2rθ. rdα = $2r^2$ arctan((Rcos α)/d)

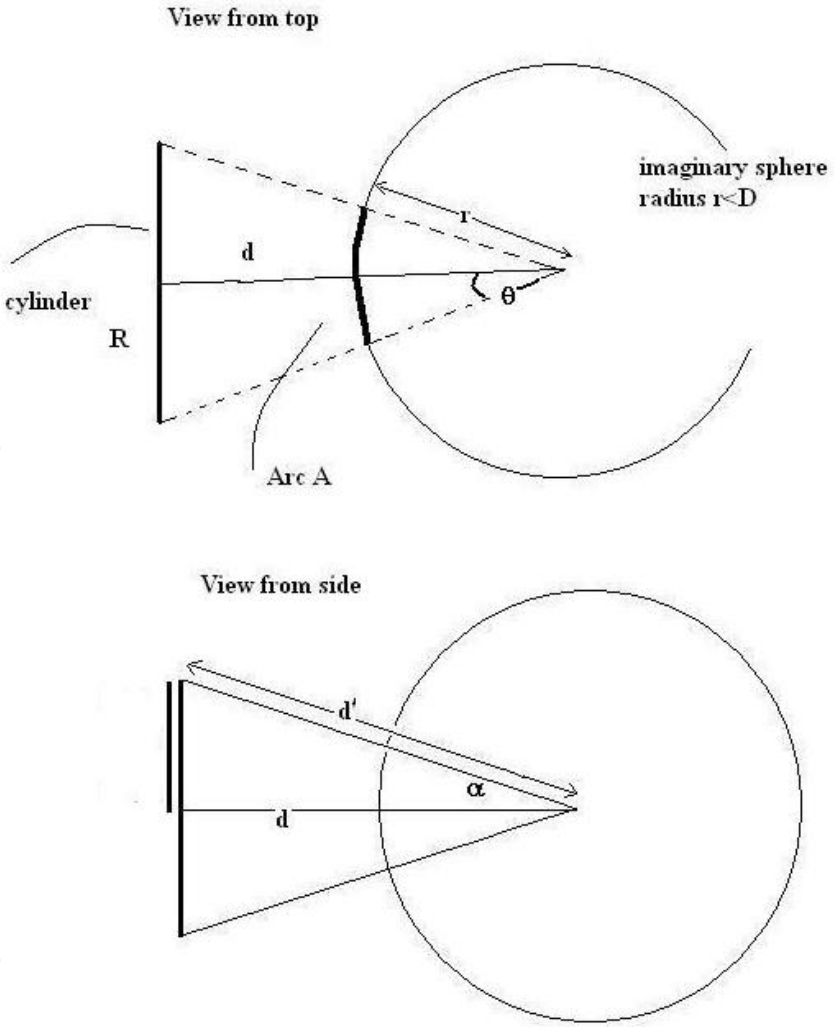


Figure 10. Model from top and side

Area B (Fig 1) = $2r\theta$. $rd\alpha = 2r^2 \arctan((R\cos\alpha)d)$

Whole area of segment =

$$4r^2\int_0^{\pi/2} \arctan((R\cos\alpha)/d)d\alpha$$

And the required probability is this divided by the surface area of the sphere $4\pi r^2$

$$P\ (DNA) = \frac{1}{\pi}\int_0^{\pi/2} \arctan((R\cos\alpha)/d)d\alpha$$

Author details

Christopher Busby

Jacobs University, Bremen, Germany

References

[1] Caufield, K. (1989), *Multiple Exposure: Chronicles of the Radiation Age* (London: Secker and Warburg).

[2] Gracheva LM and Korolev VG (1980) *Genetic effects of the decay of radionuclides in cells.* Edited by I.A.Zacharov. Calcutta: Oxonian Press PVT

[3] ICRP Publication 72 (1996) Age-dependent Doses to the Members of the Public from Intake of Radionuclides Part 5, Compilation of Ingestion and Inhalation Coefficients. Amsterdam: Elsevier

[4] ECRR2003 (2003) *2003 recommendations of the European Committee on Radiation Risk-The health effects of ionizing radiation at low dose--Regulator's edition*. Busby C.C editor with Bertell R, Yablokov A, Schmitz Feuerhake I and Scott Cato M (Brussels: ECRR-2003) Translations of the above into French Japanese Russian and Spanish (see www.euradcom.org for details)

[5] ECRR2010 (2010) *The 2010 Recommendations of the European Committee on Radiation Risk. The Health Effects of Ionizing Radiation at Low Doses and Low Dose Rates*. Eds. Busby C, Yablolov AV, Schmitz Feuerhake I, Bertell R and Scott Cato M Brussels: ECRR; Aberystwyth Green Audit

[6] CERRIE (2004) Report of the Committee Examining Radiation Risk from Internal Emitters (CERRIE) *Chilton, UK: National Radiological Protection Board*

[7] Busby CC, Bramhall R and Dorfman P (2004) *CERRIE Minority Report 2004: Minority Report of the UK Department of Health/ Department of Environment (DEFRA) Committee Examining Radiation Risk from Internal Emitters (CERRIE)* Aberystwyth: Sosiumi Press

[8] IRSN (2005) Les consequences sanitaire des contaminations internes chroniques par les radionucleides. Ed:-F.Paquet Rapport DRPH/2005-20 Fontenay aux Roses: Institut de Radioprotection et de Surete Nucliare

[9] UNSCEAR, (1977) *Sources and Effects of Ionising Radiation*, Report to the General Assembly, with annexes, (New York, United Nations).

[10] Busby, C. (1994), Increase in Cancer in Wales Unexplained, BMJ, 308: 268.

[11] Busby C.C (2002). 'High Risks at low doses.' Proceedings of 4th International Conference on the Health Effects of Low-level Radiation: Keble College Oxford, Sept 24 2002. (London: British Nuclear Energy Society).

[12] BEIR V (1990) BEIR (Committee on Biological Effects of Ionising Radiation), (1990) The Health Effects of Exposure to Low Levels of Ionising Radiation, BEIR V, (Washington: National Academy Press).

[13] Mothershill C and Seymour C (2012) Human and environmental health effects of low doses of radiation. In *Fukushima—What to expect. Proceedings of the 3rd International Conference of the European Committee on Radiation Risk, Lesvos, Greece May 5/6 2009* Eds Busby C, Busby J, Rietuma D and de Messieres M. Brussels, Belgium: ECRR

[14] Baverstock, K.F. & Charlton, D.E. 1988. *DNA Damage by Auger Emitters*. Taylor and Francis, London

[15] Hofer KG (1998) Biophysical aspects of Auger Processes- a review. *Acta Oncol*.35 798-96

[16] Ward, J.F., Limoli, P., Calabro-Jones, P. & Evans, W.F. 1988. Radiation vs.chemical damage to DNA. In: Nygard, O.F., Simic, M. & Cerutti, P. (eds.), Anticarcinogenesis and Radiation Protection. Plenum, New York.

[17] Busby Chris and Schnug Ewald (2008) Advanced biochemical and biophysical aspects of uranium contamination. In: (Eds) De Kok, L.J. and Schnug, E. *Loads and Fate of Fertilizer Derived Uranium.* Backhuys Publishers, Leiden, The Netherlands, ISBN/EAN 978-90-5782-193-6.

[18] Busby, C.C. (1995), *Wings of Death: Nuclear Pollution and Human Health* (Aberystwyth: Green Audit)

[19] Busby, C.C.(1998), 'Enhanced mutagenicity from internal sequentially decaying beta emitters from second event effects.' In 'Die Wirkung niedriger Strahlendosen- im kindes-und Jugendalter, in der Medizin, Umwelt ind technik, am Arbeitsplatz'. Proceedings of International Congress of the German Society for Radiation Protection. Eds: Koehnlein W and Nussbaum R. Muenster, 28 March 1998 (Bremen: Gesellschaft fur Strahlenschutz)

[20] Goodhead DT (1991) Biophysical features of radiation at low dose and low dose rate. In CB Seymour and C Mothershill (Eds) New Developments in fundamental and applied radiobiology London: Taylor and Francis.

[21] Apelgot S and DBuguesne M (1963) Energie dissipee par le Tritium dans les microorganisms. *Int.J.Radiation Biol.* 7 (1) 65-74

[22] Robertson JS and Hughes WL (1959) Intranuclear irradiation with Tritium labeled thymidine. In: Proc 1st National Biophysical Conference Columbus Ohio 278-283

[23] ICRU 35 (1984) Radiation Dosimetry: Electron Beams with energies between 1 and 50MEv. Bethesda MD USA: ICRU

[24] Burlakova E B; Goloshchapov A N, Zhizhina G P, Konradov A A, (2000) New aspects of regularities in the action of low doses of low level irradiation. In Low Doses of Ra-

diation—Are They Dangerous? Burlakova E B, Ed.; Nova Science Publishers: New York, NY, USA,

[25] Busby C.C. (2009) Very Low Dose Fetal Exposure to Chernobyl Contamination Resulted in Increases in Infant Leukemia in Europe and Raises Questions about Current Radiation Risk Models. International Journal of Environmental Research and Public Health.; 6(12):3105-3114. http://www.mdpi.com/1660-4601/6/12/3105

[26] Luning, K. G., Frolen, H., Nelson, A., and Ronnbaeck, C. (1963), `Genetic Effects of Strontium-90 Injected into Male Mice', Nature, No 4864 197: 304-5.

[27] Smirnova, E. I. and Lyaginska, A. M. (1969), `Heart Development of Sr-90 Injured Rats', in Y. I. Moskalev and Y. I. Izd (eds.), Radioaktiv Izotopy Organizs (Moscow: Medizina), 348

[28] Stokke, T., Oftedal, P. and Pappas, A. (1968), `Effects of Small Doses of Radioactive Strontium on the Rate Bone Marrow', Acta Radiologica, 7: 321-9.

[29] Loutit J F (1970), Malignancy from Radium. Brit.J.Cancer 24(2) 17-207

[30] Nielsen, P.E, Hiort, C., Soennischsen, S.O., Buchardt, O., Dahl, O. & Norden, B. 1992. DNA binding and photocleavage by Uranyl VI salts. J. Am. Chem. Soc. 114: 4967-4975.

[31] Huxley, H.E. & Zubay, G. 1961. Preferential staining of nucleic acid containing structures for electron microscopy. Biophys. Biochem. Cytol. 11: 273.

[32] Petkau A (1980) Radiation carcinogenesis from a membrane perspective *Acta Physiologica Scandinavica* suppl. 492. 81-90

[33] Tamplin AR and Cochran TB (1974) Radiation standards for hot particles. A report on the inadequacy of existing radiation standards related to exposures of man to insoluble particles of plutonium and other alpha emitting hot particles. Washington, USA: Natural Resources Defence Council

[34] Charles MW, Mill AJ and Darley P (2003) Carcinogenic risk from hot particles. J.Radiol.Prot. 23 5-28

[35] Popplewell, DS, Ham GJ, Dodd NJ, Shuttler SD (1988) 'Plutonium and Cs-137 in autopsy tissues in Great Britain' Sci. Tot. Environment 70 321-34

[36] Priest, N. D., O'Donnell, R.G., Mitchell, P. I., Strange, L., Fox, A., Henshaw, D. L., and Long, S. C. (1997), 'Variations in the concentration of plutonium, strontium-90 and total alpha emitters in human teeth collected within the British Isles', Science of the Total Environment, 201, 235-243.

[37] Beral V E. Roman, and M. Bobrow (eds.) (1993), Childhood Cancer and Nuclear Installations (London: British Medical Journal).

[38] Independent Advisory Group (1984), Investigation of the Possible Increased Incidence of Cancer in West Cumbria, The Black Report, (London: HMSO).

[39] Royal Society (2001) The Health Effect of Depleted Uranium Weapons Vol 1 London: Royal Society

[40] COMARE, (1996) The Incidence of Cancer and Leukaemia in Young People in the Vicinity of the Sellafield Site in West Cumbria: Further Studies and Update since the Report of the Black Advisory Group in 1984, COMARE 4th Report (Wetherby: Department of Health).

[41] Hohenemser C, Deicher M, Hofsass H, Lindner G, Recknagel E and Budnick J (1986) Agricultural impact of Chernobyl: a warning. *Nature* 321 817

[42] Apelgot S (1968) Effect letal de la disintegration des atomes radioactifs (3H, 14C, 32P) incorpres dans bacteria. In: Biological Effects of Transmutation and decay of incorporated Radioisotopes. Vienna: IAEA 147-163

[43] Apelgot S and Latarjet R (1962) Marquage d'un acide deoxyribonucleique bacterien par le radiophosphore, le radiocarbone at le tritium: comparison des effets letaux. Biochim et Biophys Acta 55(1) 40-55

[44] Andersen FA and Person S (1971) Incorporation of 14C labeled precursors into *e.coli* The lethal and mutagenic effects. *Radiation Res.* Abstr. 47 (1) p261

[45] Andersen FA and Person S (1973) Incorporation of 14C labeled precursors into *e.coli* The lethal and mutagenic effects. *Radiation Res.* Abstr. 21 (1) p4

[46] Pluchnnik G (1965) Mutagenyii protsess u khorelly pri assimilatsii radioaktivnoi uglekiskoty (mutagenic process in Chlorella during assimilation of radioactive carbon dioxide) *Genetika* 1(5) 19-25)

[47] Pluchennik G (1966) Comparative study of mutagenic effects of incorporated isotopes of the most important organogenic elements. Report 1. Mutagenic effects of incorporated 14C from the example of reversion to autotrophy of diploid yeasts that are homozygous in relation to mutations for adenine requirement. (Russian) *Genetika* 2(5) 117-124

[48] Totter IR, Zerle MR and Hollister H (1958) Hazards to man of Carbon-14. *Science* 128 1490-1495

[49] Pauling L (1958)Genetic and somatic effects of Carbon-14 *Science* 128 1183-1186

[50] Beal JM (1950) Chromosome aberrations in onion roots from plants grown in an atmosphere containing 14-CO_2. *Amer.J.Botany* 37 660-661

[51] Beal M and Scully NJ (1950) Chromosome aberrations in onion roots from plants grown in an atmosphere containing 14-CO_2. *Botan.Gas*112 232-235

[52] McQuade HA, Friedkin M and Atchison AA (1956) Radiation effects of thymidine 2-^{14}C. 1. Uptake of thymidine 2-^{14}C and thymine 2-^{14}C in the onion root tip. 2. Chromosomal aberrations caused by thymidine 2-^{14}C. and thymine 2-^{14}C in the onion root tip. *Expt.Cell.Res.* 11 (2) 249-264

[53] McQuade HA and Friedkin M (1960) Radiation effects of thymidine ^{3}H and thymidine ^{14}C. *Expt.Cell.Res.* 21(1) 118-125

[54] Kuzin AM (1962) Biological effects of increased concentrations of ^{14}C in the atmosphere (Russian) in *Radiation Genetics* Izd-vo AN SSSR Moscow 274-278

[55] Kuzin AM (1962) Effectiveness of biological action of ^{14}C when incorporated in live cells. In *Radionatsionnaya Genetika* Izd-vo AN SSSR Moscow 267-273

[56] Purdom CE (1965) Genetic effect of incorporated ^{14}C in *D.MelanogasterMutation Res.* 2(2) 156-167

[57] Kuzin AM, Glembotskii Ya M, Lapkin Yu A (1964) Mutagenic efficiency of incorporated Carbon 14. (Russian) *Radiobiologiya* 4(6) 804-809

[58] Jha AM, Dogra Y, Turner A and Millward GE (2005) Impact of low doses of tritium on the marine mussel *myrtilis edulis*. Genotoxic effects and tissue specific bioconcentrations. *Mutat.Res* 56(1) 47-57

[59] Cox R and Edwards A (2000) Commentary on the Second Event Theory of Busby *Int.J.Radiat.Biol* 76(1) 119-125

[60] Busby C.,(2000), 'Response to Commentary on the Second Event Theory by Busby' *International Journal of Radiation Biology* 76 (1) 123-125

[61] Gracheva LM and Shanshiashvili TA (1983) Genetic effects of decay of radionuclide products of fission of nuclear fuel II.Lethal and mutagenic effects on the mutation of cells of the yeast *saccharomyces cerevisiae* induced by Sr-90 and Sr-89. *Genetika* (Moscow) 9/4 532-5

[62] Miller RC and Hall EJ (1978) X-ray dose fractionation and oncogenic transformations in culture mouse embryo cells. *Nature* 272 58-60

[63] Borek C and Hall EJ (1974Rffects of split doses of X-rays on Neoplastic transformation of single cells *Nature* 252 499-501

[64] Speirs, F.W. 1949. The influence of energy absorption and electron range on dosage in irradiated bone. *Brit. J. Radiol*. 22: 521-533.

[65] Hainfeld, J.F., Slatkin, D.N. & Smilowitz, H.M. 2004. The use of gold nanoparticles to enhance radiotherapy in mice. *Phys. Med. Biol*. 49: N309-N315.

[66] Busby CC (2005) Does uranium contamination amplify natural background radiation dose to the DNA? *European J. Biology and Bioelectromagnetics*. 1 (2) 120-131

[67] Busby CC (2005) Depleted Uranium Weapons, metal particles and radiation dose. *European J. Biology and Bioelectromagnetics*. 1(1) 82-93

[68] Pattison J E, Hugtenburg R P, Green S, (2009) Enhancement of natural background gamma-radiation dose around uranium micro-particles in the human body. J.Royal http://rsif.royalsocietypublishing.org/content/early/2009/09/23/rsif.2009.0300.abstract

[69] Eakins, JS, Jansen J. Th. M. and Tanner R. J. (2011) A Monte Carlo analysis of possible cell dose enhancements effects by Uranium microparticles in photon fields Radiation Protection Dosimetry (2011), Vol. 143, No. 2–4, pp. 177–180 doi:10.1093/rpd/ncq398

[70] Regulla, D.F., Hieber, L.B. & Seidenbusch, M. 1998. Physical and biological interface dose effects in tissue due to X-ray induced release of secondary radiation from metallic gold surfaces. *Radiat. Res*. 150: 92-100

[71] Elsaesser A, Busby C, McKerr G and Howard CV (2007) Nanoparticles and radiation. EMBO Conference: Nanoparticles. October 2007 Madrid

[72] Harrison J and Day P (2008) Radiation doses and risks from internal emitters. *J Radiol.Prot.* 28 137-159

[73] Wick RR, Chmelevsky,D and Goessner W (1984) Risk to bone and haematopoetic tissue in ankylosing spondilitis patients. In W.Goessner, GB Gerber , U Hagen and A Luz. Eds *The radiobiology of radium and thorotrast.* Munich Germany: Urban and Schwartzenberg

[74] Mori T, Kumatori T, Kato Y, Hatakeyama S, Kamiyama R, Mori W, Irie H, Maruyama T and Iwata S (1983) Present status of medical study of thorotrast patients in Japan. Pp123-135 . In W.Goessner, GB Gerber , U Hagen and A Luz. Eds *The radiobiology of radium and thorotrast.* Munich Germany: Urban and Schwartzenberg

[75] ECRR2009 (2009) The health effects of exposure to Uranium. Brussels: ECRR (www.euradcom.org)

[76] Guseva Canu I, Laurier D, Caër-Lorho S, Samson E, Timarche M, Auriol B, Bérard P, Collomb P, Quesned B, Blanchardone E (2010) Characterisation of protracted low-level exposure to uranium in the workplace: A comparison of two approaches. *International Journal of Hygiene and Environmental Health* 213 (2010) 270–277

[77] Guseva Canu, Irina, Garsi, Jerome-Philippe, Cae°r-Lorho Sylvaine, Jacob SophieCollomb, Philippe, Acker Alain, Laurier Dominique (2012) Does uranium induce circulatory ? First results from a French cohort of uranium workers *Occup. Envir. Med*. OEM Online First, published on March 3, 2012 as 10.1136/oemed-2011-100495

[78] Guseva Canu I, Jacob S Cardis E, Wild P Cae°r –Lorho S, Auriol B, Garsi JP, Tirmarche M, Laurier D (2010) Uranium carcinogenicity in humans might depend on the physical and chemical nature of uranium and its isotopic composition: results from pilot epidemiological study of French nuclear workers. Cancer Causes Control DOI 10.1007/s10552-011-9833-5

[79] Urquhart T D, Black R T, Muirhead M T, et al., (1991) Case-control study of leukaemia and non-Hodgkins lymphoma in children in Caithness near the Dounreay nuclear installation. British Medical Journal; 302:687-692.

[80] Viel J-F, Poubel D, Carre A, (1995) Incidence of leukaemia in young people and the La Hague nuclear waste reprocessing plant: a sensitivity analysis. Statistics in Medicine, 14, 2459-2472.

[81] Busby C, and M. Scott Cato, (1997)`Death Rates from Leukemia are Higher than Expected in Areas around Nuclear Sites in Berkshire and Oxfordshire', *British Medical Journal*, 315 (1997): 309

[82] Busby C, and M. Scott Cato, (1997)`Death Rates from Leukemia are Higher than Expected in Areas around Nuclear Sites in Berkshire and Oxfordshire', British Medical Journal, 315 (1997): 309

[83] Bowie C, Ewings P D, (1988) Leukaemia incidence in Somerset with particular reference to Hinkley Point, Taunton: Somerset Health Authority.

[84] Kaatsch P, Spix C, Schulze-Rath R, Schmiedel S, Blettner M, (2008) Leukaemias in young children living in the vicinity of German nuclear power plants. Int J Cancer 122 , pp. 721-726.

[85] Sermage-Faure Claire, Laurier Dominique, Goujon-Bellec Stéphanie, Chartier Michel, Guyot-Goubin, Aurélie, Rudant Jérémie, Hémon Denis, Clavel Jacqueline (2012) Childhood leukemia around French nuclear power plants—The geocap study, 2002–2007 International Journal of Cancer Volume 131 (5) E769–E780 DOI: 10.1002/ijc.27425

[86] COMARE (Committee on Medical Aspects of Radiation in the Environment), (1986) The Implications of the New Data on the Releases from Sellafield in the 1950s for the Conclusions of the Report on the Investigation of a Possible Increased Incidence of Cancer in West Cumbria, COMARE 1st Report (London: HMSO).

[87] NRPB, (1995) Risks of leukaemia and other cancers in Seascale from all sources of ionising radiation NRPB R-276 (Chilton: NRPB).

[88] Wakeford R and Little MP (20030) Risk coefficients for childhood cancer after intrauterine irradiation. A review. Int.J.Rad.Biol. 79 293-309

[89] Michaelis J, Kaletsch U, Burkart W and Grosche B, (1997) Infant leukaemia after the Chernobyl Accident Nature 387, 246.

[90] Petridou E, Trichopoulos D, Dessypris N, Flytzani V, Haidas S, Kalmanti M, Koliouskas D, Kosmidis H, Piperolou F, Tzortzatou F, (1996) Infant Leukaemia after in utero exposure to radiation from Chernobyl, Nature, 382:25, 352.

[91] Gibson B E S, Eden O B, Barrett A, et al., (1988) Leukaemia in young children in Scotland, The Lancet, 630

[92] Busby, C. C. and Cato, M. S. (2000), 'Increases in leukemia in infants in Wales and Scotland following Chernobyl: evidence for errors in risk estimates' Energy and Environment 11(2) 127-139 92 Busby C.C. and Cato M.S. (2001) 'Increases in leukemia in infants in Wales and Scotland following Chernobyl: Evidence for errors in statutory risk estimates and dose response assumptions'. International Journal of Radiation Medicine 3 (1) 23

[93] Busby C.C. (2009) Very Low Dose Fetal Exposure to Chernobyl Contamination Resulted in Increases in Infant Leukemia in Europe and Raises Questions about Current

Radiation Risk Models. International Journal of Environmental Research and Public Health.; 6(12):3105-3114. http://www.mdpi.com/1660-4601/6/12/3105

[94] Mangano J, (1997) Childhood leukaemia in the US may have risen due to fallout from Chernobyl, British Medical Journal, 314: 1200.

[95] Tondel M, Hjalmarsson P, Hardell L, Carisson G, Axelson A, (2004) Increase in regional total cancer incidence in Northern Sweden. *J Epidem. Community Health.* 58 1011-1016.

[96] ICRP, (2007) *The 2007 recommendations of the International Commission on Radiological Protection*. ICRP 103 Orlando USA: Elsevier

[97] Scherb H and Voigt K (2010) The human sex odds ratio at birth after the atmospheric bomb tests, Chernobyl, and in the vicinity of nuclear facilities. Env.Sci.Pollut.Res. Int 18 (5) 697-707

[98] Sternglass E J, (1971) Environmental Radiation and Human Health, in Proceedings of the Sixth Berkeley Symposium on Mathematical Statistics and Probability, ed. J. Neyman (Berkeley, Calif.: University of California Press).

[99] Whyte R K, (1992) First Day Neonatal Mortality since 1935: A Re-examination of the Cross Hypothesis, *British Medical Journal*, 304: 343-6.

[100] Scherb H and Voigt K (2011) in Busby C, Busby J, Rietuma D and de Messieres M Eds. (2011) Fukushima: What to Expect. Proceedings of the 3rd International Conference of the European Committee on Radiation Risk May 5/6th Lesvos Greece. Brussels: ECRR; Aberystywth UK: GreenAudit

[101] Padmanabhan VT (2011) in Busby C, Busby J, Rietuma D and de Messieres M Eds. (2011) Fukushima: What to Expect. Proceedings of the 3rd International Conference of the European Committee on Radiation Risk May 5/6th Lesvos Greece. Brussels: ECRR; Aberystywth UK: GreenAudit

[102] Alaani Samira, Tafash Muhammed, Busby Christopher, Hamdan Malak and Blaurock-Busch Eleonore (2011) Uranium and other contaminants in hair from the parents of children with congenital anomalies in Fallujah, Iraq Conflict and Health 2011, 5:15 doi:10.1186/1752-1505-5-15

[103] Busby, Chris; Hamdan, Malak; Ariabi, Entesar. (2010) Cancer, Infant Mortality and Birth Sex-Ratio in Fallujah, Iraq 2005–2009. Int. J. Environ. Res. Public Health 7, no. 7: 2828-2837. doi:10.3390/ijerph7072828

[104] Alaani S, Al Fallouji M, Busby C and Hamdan M (2012) Pilot study of congenital rates at birth in Fallujah, Iraq, 2010 *J. Islam. Med. Assoc. N. Amer*. Sept 1st 2012

[105] Busby C, Yablokov A V (2006, 2009) *ECRR 2006. Chernobyl 20 years On. The health Effects of the Chernoby lAccident* Aberystwyth: Green Audit

[106] Yablokov A V, Nesterenko V B, Nesterenko A V, (2009) Chernobyl: Consequences of the Catastrophe for people and the environment. Annals of the New York Academy of Sciences. Vol 1181 Massachusetts USA: Blackwell

[107] Busby C, Busby J, Rietuma D and de Messieres M Eds. (2011) Fukushima: What to Expect. Proceedings of the 3rd International Conference of the European Committee on Radiation Risk May 5/6th Lesvos Greece. Brussels: ECRR; Aberystwyth UK: Green-Audit

[108] Malko M V, (1998) Chernobyl accident: the crisis of the international radiation community in Imanaka T: Research activities about the radiological consequences of the Chernobyl NPS accident and social activities to assist the sufferers of the accident. (Kyoto University: Research Reactor Institute).

[109] Dubrova Y E, Nesterov V N, Jeffreys A J et al., (1997) Further evidence for elevated human minisatellite mutation rate in Belarus eight years after the Chernobyl accident. Mutation Research 381 267-278.

[110] Ellegren H, Lindgren G, Primmer C R, Moeller A P, (1997), Fitness loss and Germline mutations in Barn Swallows breeding in Chernobyl, *Nature* 389/9, 583-4.

[111] Møller AP, Bonisoli-Alquati A, Rudolfsen G, Mousseau TA (2012) Elevated Mortality among Birds in Chernobyl as Judged from Skewed Age and Sex Ratios. PLoS ONE 7(4): e35223. doi:10.1371/journal.pone.0035223

INTECH

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.

American Academy of Environmental Medicine

6505 E Central • Ste 296 • Wichita, KS 67206
Tel: (316) 684-5500 • Fax: (316) 684-5709
www.aaemonline.org

January 19, 2012

Decision Proposed Decision of Commissioner Peevy (Mailed 11/22/2011)
BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA
On the proposed decision 11-03-014

Dear Commissioners:

The Board of the American Academy of Environmental Medicine opposes the installation of wireless "smart meters" in homes and schools based on a scientific assessment of the current medical literature (references available on request). Chronic exposure to wireless radiofrequency radiation is a preventable environmental hazard that is sufficiently well documented to warrant immediate preventative public health action.

As representatives of physician specialists in the field of environmental medicine, we have an obligation to urge precaution when sufficient scientific and medical evidence suggests health risks which can potentially affect large populations. The literature raises serious concern regarding the levels of radio frequency (RF - 3KHx – 300 GHx) or extremely low frequency (ELF – 0Hx – 300Hx) exposures produced by "smart meters" to warrant an immediate and complete moratorium on their use and deployment until further study can be performed. The board of the American Board of Environmental Medicine wishes to point out that existing FCC guidelines for RF safety that have been used to justify installation of "smart meters" only look at thermal tissue damage and are obsolete, since many modern studies show metabolic and genomic damage from RF and ELF exposures below the level of intensity which heats tissues. The FCC guidelines are therefore inadequate for use in establishing public health standards. More modern literature shows medically and biologically significant effects of RF and ELF at lower energy densities. These effects accumulate over time, which is an important consideration given the chronic nature of exposure from "smart meters". The current medical literature raises credible questions about genetic and cellular effects, hormonal effects, male fertility, blood/brain barrier damage and increased risk of certain types of cancers from RF or ELF levels similar to those emitted from "smart meters". Children are placed at particular risk for altered brain development, and impaired learning and behavior. Further, EMF/RF adds synergistic effects to the damage observed from a range of toxic chemicals. Given the widespread, chronic, and essentially inescapable ELF/RF exposure of everyone living near a "smart meter", the Board of the American Academy of Environmental Medicine finds it unacceptable from a public health standpoint to implement this technology until these serious medical concerns are resolved. We consider a moratorium on installation of wireless "smart meters" to be an issue of the highest importance.

The Board of the American Academy of Environmental Medicine also wishes to note that the US NIEHS National Toxicology Program in 1999 cited radiofrequency radiation as a potential carcinogen. Existing safety limits for pulsed RF were termed “not protective of public health” by the Radiofrequency Interagency Working Group (a federal interagency working group including the FDA, FCC, OSHA, the EPA and others). Emissions given off by “smart meters” have been *classified by the World Health Organization International Agency for Research on Cancer (IARC) as a Possible Human Carcinogen*.

Hence, we call for:

- An immediate moratorium on “smart meter” installation until these serious public health issues are resolved. Continuing with their installation would be extremely irresponsible.

- Modify the revised proposed decision to include hearings on health impact in the second proceedings, along with cost evaluation and community wide opt-out.

- Provide immediate relief to those requesting it and restore the analog meters.

Members of the Board
American Academy of Environmental Medicine

http://stopsmartmeters.org/frequently-asked-questions/faq-legal-issues/#classaction

Federal Energy Act of 2005 states clearly that “smart” meters are to be OFFERED to residential customers, not mandated or forced. Read this letter from a US representative clarifying the matter.

http://www1.eere.energy.gov/femp/regulations/epact2005.html

Energy Policy Act of 2005

The Energy Policy Act of 2005 (EPAct 2005) established a number of energy management goals for Federal facilities and fleets. It also amended portions of the National Energy Conservation Policy Act (NECPA).

EPAct 2005 sets Federal energy management requirements in several areas, including:

- Metering and Reporting
- Energy-Efficient Product Procurement
- Energy Savings Performance Contracts
- Building Performance Standards
- Renewables Energy Requirement
- Alternative Fuel Use

This content is intended as a reference only. You should refer to the full text of EPAct 2005 for more details or other sections relevant to your work (PDF 3.2 MB). Download Acrobat Reader.

Please note, the Energy Independence and Security Act of 2007 (EISA 2007) and Executive Order (E.O.) 13423 have been issued subsequent to the passage of EPAct 2005. These authorities update many of the energy management requirements of EPAct 2005.

Some of the following documents are available as Adobe Acrobat PDFs.

Metering and Reporting

Section 103 of EPAct 2005 includes the following requirements surrounding energy use measurement and accounting:

- Directs that all Federal buildings be metered "...for the purposes of efficient energy use and reduction in the cost of electricity used in such buildings..." by October 1, 2012. Advanced meters or metering devices must provide data at least daily and measure the consumption of electricity at least hourly. These devices must be used to the maximum extent practicable.
- Directs the Secretary of Energy to develop guidelines for implementation. The Guidance for Electric Metering in Federal Buildings (PDF 2.7 MB) was published on February 3, 2006.
- Requires Federal agencies to submit to the Department of Energy (DOE) an implementation plan identifying personnel responsible for achieving the requirements, and any determination by the agency that advanced meters or metering systems are not practicable in their specific situation.

Back to top

Energy-Efficient Product Procurement

Section 104 of EPAct 2005 requires that each agency incorporate energy efficiency criteria consistent with ENERGY STAR® and FEMP-designated products for "...all procurements involving energy consuming products and systems, including guides specifications, project specifications, and construction, renovation, and services contracts that include provision of energy consuming products and systems, and into the factors for the evaluation of offers received for the procurement."

For more information, read:

- Proposed Rules (10 CFR Part 436): Federal Procurement of Energy-Efficient Products (PDF 123 KB)
- Rulemaking Comments (RIN Number 1904-AB68): Federal Procurement of Energy-Efficient Products (PDF 2.4 MB)
- Also see the listing of FEMP-designated energy-efficient products

Back to top

Energy Savings Performance Contracts

Section 105 extends energy savings performance contracts (ESPCs) from October 1, 2003, through September 30, 2016.

For more information about ESPCs, see Energy Savings Performance Contracts.

Back to top

Building Performance Standards

Section 109 of EPAct 2005 includes the following requirements surrounding Federal building performance standards:

- Directs new Federal buildings—commercial or residential—to be designed 30% below ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) standards or the International Energy Code.
- Includes the application of sustainable design principles for new buildings.
- Requires Federal agencies to identify new buildings in their budget requests and those that meet or exceed the standards, which DOE must include in its annual report.

For more information, read:

- Final Rule (10 CFR Parts 433-435): Energy Conservation Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings and New Federal Low-Rise Residential Buildings
- Environmental Assessment for Final Rule: DOE/EA-1463, 2007 (PDF 515 KB)
- Rulemaking Comments: Docket EE-RM/STD-02-112 (PDF 3 MB)

Back to top

Renewable Energy Requirement

Section 203 of EPAct 2005 includes the following requirements surrounding the purchasing and use of renewable energy by Federal agencies:

- Requires that the Federal Government's renewable electricity consumption meet or exceed 3% from fiscal years 2007-2009, with increases to at least 5% in fiscal years 2010-2012 and 7.5% in 2013 and thereafter.
- Establishes a double credit bonus for Federal agencies if renewable electricity is produced on-site at a Federal facility, on Federal lands, or on Native American lands.
- Defines "renewable energy" as electric energy generated from solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project.

Section 204 of EPAct 2005 includes the following requirements surrounding photovoltaic (PV) energy use in public buildings:

- Establishes PV energy commercialization program in Federal buildings.
- Requires the installation of 20,000 solar energy systems in Federal buildings by 2010.

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.

---

[1] The author holds a Ph.D. in Applied Physics from Harvard University, 1975.

[2] BioInitiative Working Group, Cindy Sage and David O. Carpenter, Editors, BioInitiative Report: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation, December 31, 2012 (http://www.bioinitiative.org).

(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.

Other observations:

(1) Most biological effects of RF exposure cannot be sensed by human beings. Examples are the onset of cancer, DNA damage, and fertility effects. One category of effects that can often be sensed includes neurological effects on sleep, memory, learning, and behavior.

(2) Unborn and very young children may be more affected by RF exposure than adults.

This document provides background information, an explanation of each feature of the Biological Effects Chart, and a detailed discussion of each of the conclusions and observations summarized above. That discussion begins on page 11.

Figure 1, on page 9 in this document, and the Biological Effects Chart, at the end of this document, are in color, and are most easily understood when viewed in color. But they can also be understood in black and white. To make that possible, key lines in Figure 1 and in the Biological Effects Chart are identified not only by color but also by line thickness and line style (solid versus dashed).

Terminology for Parts of the Electromagnetic Spectrum

Electromagnetic fields occur over a wide range of frequencies, referred to as the electromagnetic spectrum.[3] But the terms used for parts of that spectrum are not consistently named or defined. The BioInitiative 2012 Report uses the following definitions for two key parts of the electromagnetic spectrum:

extra low frequency (ELF): electromagnetic fields with frequencies from 1 to 300 Hz[4]
radiofrequency (RF): electromagnetic fields with frequencies from 100 kHz to 300 GHz[5]

Within the *radiofrequencies* lie the *microwave* frequencies. Microwaves, too, are variously defined. Here are two common definitions:

microwaves: electromagnetic fields with frequencies from 300 MHz to 300 GHz[6]
microwaves: electromagnetic fields with frequencies from 1 GHz to 100 GHz[7]

This document focuses on the biological effects of the frequencies at which the following devices operate. Those frequencies are shown in round numbers.

---

[3] Explanation of units of measure for frequency: 1 hertz is 1 cycle per second. 1 kilohertz is equivalent to 1000 hertz. 1 megahertz is equivalent to 1000 kilohertz and to 1,000,000 hertz. 1 gigahertz is equivalent to 1000 megahertz and to 1,000,000 kilohertz and to 1,000,000,000 hertz. These units are abbreviated as follows: hertz (Hz), kilohertz (kHz), megahertz (MHz), and gigahertz (GHz).

[4] BioInitiative 2012 Report cited in footnote 2 on page 1, Section 26, Glossary of Terms and Abbreviations, page 3. The Report notes that the term Extremely Low Frequency is used in Europe and the term Extra Low Frequency is used in the United States. Wikipedia uses the term Extremely Low Frequency to refer to 3 to 300 hertz (http://en.wikipedia.org/wiki/Extremely_low_frequency).

[5] BioInitiative 2012 Report cited in footnote 2 on page 1, Section 26, Glossary of Terms and Abbreviations, page 5.

[6] (http://en.wikipedia.org/wiki/Microwaves)

[7] (http://en.wikipedia.org/wiki/Microwaves)

cell towers[8]	300, 400, 700, 800, 900, 950, 1800, 1900, 2100 MHz
Wi-Fi (most common type of WLAN)[9]	2400, 2500 MHz (predominant) 2600, 3600, 5000 MHz (emerging)
wireless laptops[10]	2400 MHz (predominant) 5000 MHz (emerging)
Smart Meters[11]	900, 2400 MHz (Smart Meters and Collector Smart Meters) 850 MHz (Collector Smart Meters only)
Smart Appliances[12]	2400 MHz

Note that that all of these devices operate at frequencies between 300 MHz and 5000 MHz. The frequencies at which Smart Meters and Smart Appliances operate are right in the middle of this range. According to one or more of the definitions given above, all of these frequencies may be referred to as either *radiofrequencies (RF)* or *microwaves*. Since the BioInitiative 2012 Report refers to these frequencies as *radiofrequencies* (*RF*), that term will be used here. But the term *microwaves* could have been used just as well.

The BioInitiative 2012 Report

The BioInitiative 2012 Report was developed by an international group of 29 individuals with expertise on the biological effects of electromagnetic fields, or on the related public-health issues.[13] As a group, these experts hold 20 PhD degrees, one DrSc degree, 9 MD degrees, one DVM degree, and four degrees of MSc, MA, MPH, or MSPAS. These experts come from ten countries, each with the following number of participants:

USA	10	India	2
Sweden	6	Italy	2
Austria	2	Denmark	1
Canada	2	Russia	1
Greece	2	Slovak Republic	1

The goal of the BioInitiative Report is to present "a solid scientific and public health policy assessment that is evidence-based." The report was prepared "independent of governments, existing bodies and industry professional societies that have clung to old standards."[14]

---

[8] (http://en.wikipedia.org/wiki/Cellular_network), (http://en.wikipedia.org/wiki/GSM_frequency_bands), and (http://en.wikipedia.org/wiki/UMTS_frequency_bands)

[9] (http://en.wikipedia.org/wiki/WI-FI) and (http://en.wikipedia.org/wiki/List_of_WLAN_channels)

[10] (http://en.wikipedia.org/wiki/Wireless_LAN)

[11] Both the Landis-Gyr FOCUS AXR-SD and the General Electric I-210+c Smart Meters, being installed in Maryland, have FCC ID OWS-NIC514. They send and receive information in two microwave frequency ranges: (1) 902.3 to 926.9 MHz, and (2) 2405.8 to 2480.9 MHz (http://stopsmartmeters.org/wp-content/uploads/2012/01/OWS-NIC514-FCC-specifications.pdf). Collector Smart Meters have a third transmission frequency of 850 MHz (http://sagereports.com/smart-meter-rf/?page_id=210). They receive and retransmit the signals from Smart Meters to assure that those signals reach the antennas of the electric power company. It is not clear to me at this time whether Collector Smart Meters are employed in all installations of Smart Meters.

[12] The most likely transmitter/receiver in the Smart Appliances is the so-called ZigBee device. ZigBee devices operate at 865 MHz (in Europe) and 915 MHz (in the USA and Australia) as well as 2.4 GHz (worldwide) (https://en.wikipedia.org/wiki/ZigBee). But the Smart Meters first observed in installations in Maryland seem to require that the ZigBee devices operate at 2.4 GHz.

[13] BioInitiative 2012 Report cited in footnote 2 on page 1, cover page of the full report, as a single PDF file.

[14] BioInitiative 2012 Report cited in footnote 2 on page 1 , Section i, Preface 2012, page 2.

The Scope of the BioInitiative 2012 Report

The 1479-page BioInitiative 2012 Report considers the "content and implications of about 1800 new studies" since the last BioInitiative Report was published in 2007.[15] The 2012 Report contains 16 chapters that address key categories of biological effects. The 2012 Report also contains several chapters that address key public policy issues, such as the nature and shortcomings of the current exposure standards, and the bases for sufficient argument for changing those standards. Emphasized is the importance of weighing the magnitude of potential harm against the evidence of potential harm, to determine when protective action should be triggered.[16] Since Smart Meters are being mandated for entire populations in the United States, the magnitude of potential harm is considerable, so prudence dictates serious consideration of the increasing evidence of harm.

The Data Source for the Biological Effects Chart

The data for the appended Biological Effects Chart were drawn from the so-called RF Color Charts in the BioInitiative 2012 Report.[17] The RF Color Charts contain two charts:

> The first chart describes 67 studies of the biological effects of radiofrequency (RF) radiation.[18] Each study represents one or more biological effects found at a one value of the RF power density (RF power per unit area) or within a range of such values. These data are especially useful when considering whole-body exposure, which is the type of exposure that human beings receive from Smart Meters at a distance of 1 meter or more.[19] These data form the basis for the appended Biological Effects Chart.
>
> The second chart describes 68 studies of the biological effects of radiofrequency (RF) radiation.[20] In this chart, each study represents one or more biological effects found at one Specific Absorption Rate, or SAR value, or within a range of such values. A SAR value is the RF power absorbed per unit mass of the biological entity being irradiated. These data are especially useful when less than the entire body is irradiated, and at very close distances, such as when a cell phone irradiates the head.

---

[15] BioInitiative 2012 Report cited in footnote 2 on page 1 , Section 1, Summary for the Public and Conclusions, 2012 Supplement: Summary for the Public – Ms. Sage, page 3.

[16] BioInitiative 2012 Report, cited in footnote 2 on page 1, Table 1-1, Section 23: The Precautionary Principle, 2012 Supplement: The Precautionary Principle – Mr. Gee, page 2.

[17] BioInitiative 2012 Report, cited in footnote 2 on page 1, Section 1, Summary for the Public and Conclusions, Table 1-2 Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure 2012, no page numbers.

[18] Each study in the first chart derives from one publication. But three publications contributed two studies, and one publication contributed three studies. As a result, the 67 studies derive from 62 publications. So the terms *studies* and *publications* have slightly different meanings as used here.

[19] More specifically, the power density values used in the first table are valid in the "far field" (also called the "radiative field") of the Smart Meter. For the type of antenna in a Smart Meter or a Collector Smart Meter, the far field should begin about two wavelengths from the meter (http://en.wikipedia.org/wiki/Far_field). A Collector Smart Meter transmits on three frequencies (850, 900, and 2400 MHz). The longest wavelength transmitted by a Collector Smart Meter is determined by the lowest frequency which it transmits, which is 850 MHz. That wavelength is 0.35 meters (about 1 foot). A Smart Meter transmits on two frequencies (900 MHz and 2400 MHz), so the lowest frequency transmitted by a Smart Meter is 900 MHz, and the longest wavelength it transmits is 0.33 meters (again about 1 foot). Smart Appliances are expected to transmit at 2400 GHz, with has a wavelength of 0.13 meters (about 5 inches). So for all three devices, the far field begins about 0.7 meters (about 2 feet), or less, from them. This document addresses distances from 1 meter (about 3 feet) up, so all such distances are in the far field for all three devices.

[20] Each study in the second chart derives from one publication. But two publications contributed two studies each. As a result the 68 studies derive from 66 publications. So the terms *studies* and *publications* have slightly different meanings as used here.

This is not the usual case for RF exposure from Smart Meters, so these data were not used for the appended Biological Effects Chart.

Criteria for Selection of the Studies in the RF Color Charts

The criteria used in the BioInitiative 2012 Report to select the studies for the RF Color Charts, and thus for the appended Biological Effects Chart, were the following:[21]

(1) A selection of good examples only. Not intended to be comprehensive.
(2) Peer-reviewed and published studies only.
(3) Good exposure data (numeric).
(4) Author(s) have clear methods and conclusions.
(5) Cover wide range of topics, such as genotoxicity, neurological, immune, cancers, behavior, attention, memory, sleep, etc.
(6) Cover wide range of exposure levels, with an emphasis on the lowest levels and the more recent studies.

Every study in the first chart of the RF Color Charts, and thus every study in the appended Biological Effects Chart based on that first chart, except one (Dumansky, 1974), was published after 1986. 1986 is the year of publication of the document on which the current FCC Maximum Permitted Exposure (MPE) limits are principally based.[22] That was 27 years ago, which is one factor in explaining why the current FCC MPE limits are out of date. The references for the studies in the RF Color Charts, and thus for the biological effects data in the appended Biological Effects Chart, are included in the reference list that immediately follows the RF Color Charts in the PDF file of the full BioInitiative 2012 Report.[23]

Explanation of the Appended Biological Effects Chart

The Horizontal Axis of the Biological Effects Chart

The studies are presented in order of increasing RF power density along the horizontal axis of the Biological Effects Chart. That order facilitates comparing effects observed at similar RF power densities. Each position along the horizontal axis of the Biological Effects Chart represents one study whose principal author and date of publication are written under that axis. The studies could just as well have been ordered alphabetically by the authors' last names, or numerically by the publication dates.

The Vertical Axis of the Biological Effects Chart

The vertical axis represents the RF power densities at which each study was conducted. These power densities cover a wide range of values, so a logarithmic vertical axis was employed. This approach permitted displaying 11 orders of magnitude on the Biological Effects Chart.[24] The units of measure

---

[21] The criteria were provided by Cindy Sage, co-editor of BioInitiative 2012, in a private communication, April 23, 2013.
[22] The current FCC exposure limits are based principally on a 1986 publication of the National Council on Radiation Protection and Measurements (NCRP). That publication is "Report No. 086 - Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields". The NCRP was chartered by the U.S. Congress in 1964, but is not a Government agency and is not subject to oversight by the Congress.
[23] BioInitiative 2012 Report cited in footnote 2 on page 1, Reported Biological Effects from Radiofrequency Radiation (RFR) at Low-Intensity Exposure Levels, sequential pages 112-121 in the 1479-page PDF version of the full Report.
[24] Each order of magnitude is a factor of 10.

selected for the vertical axis are milliwatts per square meter (mW/m^2).[25] These units work well for the wide range of power densities required for the vertical axis, making the length of the smallest number, 0.000001, not too much longer than the length of the largest number, 10000.

The selected units for the vertical axis also work well for relating the RF power density shown to the total RF power that an adult human would receive. The surface area of an adult human is about 2 square meters (m^2).[26] So the surface area that an adult human presents to an RF wave arriving from the front, or from the back, is about 1 square meter (m^2). So when an adult human faces an oncoming wave of radiation with a power density of, say, 10 milliwatts per square meter (mW/m^2), that human will receive a total of 10 milliwatts (mW) of radiation over the entire body. That is, the number describing the power density will be the same as the number describing the total power received, even though the units of measure are different in the two cases. So, when examining the vertical axis of the attached Biological Effects Chart, each number on that axis may be taken to mean *both* the power density (in mW/m^2) of the oncoming wave of RF radiation *and* the total RF power (in mW) received by an adult human when standing with the front, or the back, facing the direction from which the radiation is coming.

The Round Red Dots on the Biological Effects Chart

Each round **red** dot • on the attached Biological Effects Chart indicates the RF power density at which the study named on the horizontal axis, directly below the dot, was conducted. Some studies were conducted over a range of power densities. In such cases, the average value of the high and low ends of the range determines the location of the dot on the vertical axis. The range of power densities applicable is shown as a black vertical line through the dot. The top of the vertical line marks the high end of the range, and the bottom of the vertical line marks the low end of the range. On those vertical lines, the dots appear higher than the middle. That effect results from the logarithmic vertical axis, even though the dots are located at the true average value of the high and low ends of the range.

The Alphabetic Codes above the Dots on the Biological Effects Chart

A one- or two-letter code appears just above each of the dots on the Biological Effects Chart. Each code, such as "CB", identifies the category into which the biological effects found by a given study fall. Those one- and two-letter codes are translated in the table on the Biological Effects Chart, first into the one or two words represented by the letters of the codes, and then into a fuller description of the category, as reported in the RF Color Charts of the BioInitiative 2012 Report. For example, the code "CB" stands for the words "Cancer, Brain" and represents a category that contains "Brain tumors and blood-brain barrier".[27] Similarly, the code "CO" stands for the words "Cancer, Other" and represents a category that contains "Cancer (other than brain), cell proliferation".

The Thick Horizontal Blue Line at the Top of the Biological Effects Chart

The thick horizontal blue line, which appears at the top of the Biological Effects Chart, represents the Maximum Permitted Exposure (MPE) limits of the Federal Communications Commission (FCC). These are the limits applicable to the general population for uncontrolled exposure for the frequencies that Smart

---

[25] 1 milliwatt (mW) is one-thousandth of a watt (W).

[26] The surface area of a man is about 1.9 square meters (m^2); and the surface area of a woman is about 1.6 square meters (m^2), both according to Wikipedia (http://en.wikipedia.org/wiki/Body_surface_area).

[27] The reference to blood-brain barrier refers to the weakening of the barrier that the body erects between the blood and the brain to prevent harmful entities circulating in the blood from entering the brain.

Meters, Collector Smart Meters, and Smart Appliances use: 2400 MHz, 900 MHz, and 850 MHz. The top edge of the blue line is the limit applicable to 2400 MHz. The bottom edge of the blue line is the limit applicable to 850 MHz. The limit applicable to 900 MHz falls in between.

Frequency (MHz)	**FCC Maximum Permitted Exposure (MPE) Limits**[28] (mW/m^2)	
2400	10,000	(Smart Meters, Collector Smart Meters, and Smart Appliances)
900	6000	(Smart Meters and Collector Smart Meters)
850	5700	(Collector Smart Meters)

However, those FCC limits apply to the time-average RF power density over a period of 30 minutes. So, pulsed signals, like those issued by Smart Meters and Smart Appliances, are permitted to assume even higher peak values, as long as the time-average over a period of 30 minutes is below the FCC limits shown.

The Thick Horizontal Yellow Line on the Biological Effects Chart

The thick horizontal yellow line, which appears about one-third from the bottom of the Biological Effects Chart, shows the new RF exposure limits proposed in the BioInitiative 2012 Report for chronic exposure to pulsed radiation. Pulsed radiation is the type of radiation that Smart Meters and Smart Appliances emit. The top of this line is located at 0.006 milliwatts per square meter (mW/m^2). The bottom of this line is located at 0.003 milliwatts per square meter (mW/m^2).[29]

New Biologically Based RF Exposure Limits Proposed in the BioInitiative 2012 Report[30]
(as expressed, equivalently, in various units of measure)

0.3 to 0.6	nanowatts per square centimeter (nW/cm^2)	(units used in BioInitiative 2012)
0.003 to 0.006	milliwatts per square meter (mW/m^2)	(units used in appended Chart)
3 to 6	microwatts per square meter ($\mu W/m^2$)	

The data from the 67 studies in the Biological Effects Chart indicate why this level might have been judged appropriate by the authors of the BioInitiative 2012 Report: This level would protect against the biological effects found by all but five of the 67 studies. The BioInitiative 2012 Report indicates that these proposed new limits "may need to change in the future, as new and better studies are completed." [31] Note that this level, which can also be expressed as 3 to 6 microwatts per square meter ($\mu W/m^2$), is in agreement with the level of 5 microwatts per square meter ($\mu W/m^2$) proposed by Dietrich Klinghardt, M.D., Ph.D., in his detailed video treatment of the health hazards of Smart Meters.[32]

---

[28] Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields, OET (Office of Engineering and Technology) Bulletin 56, Fourth Edition, Federal Communications Commission, August 1999. See Table 1(B), Limits for General Population/Uncontrolled Exposure, page 15.
(http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet56/oet56e4.pdf)

[29] BioInitiative 2012 Report cited in footnote 2 on page 1 , Section 1, Summary for the Public and Conclusions, 2012 Supplement: Summary for the Public – Ms. Sage, pages 25-26.

[30] 1 milliwatt (mW) is one thousandth of a watt (W). 1 microwatt (μW) is one millionth of a watt (W). 1 nanowatt (nW) is one billionth of a watt (W). 1 centimeter (cm) is one hundredth of a meter (m). So, 1 square centimeter (cm^2) is one ten thousandth of 1 square meter (m^2).

[31] See footnote 29 above.

[32] Dr. Klinghardt's video, and further information about him, can be found on the following web sites:
(http://marylandsmartmeterawareness.org/smart-meter-news/dr-dietrich-klinghardt-smart-meters-emr-the-health-crisis-of-our-time) and (http://www.klinghardtacademy.com/BioData/Dr-Dietrich-Klinghardt.html).

The Thin Horizontal Green Lines on the Biological Effects Chart

The four thin horizontal **green** lines show the power density of the RF radiation emitted by a Smart Meter at four different distances. To determine these levels, I assumed that the Smart Meter is the type being installed in Maryland, as described in footnote 11 on page 3:

P = RF power output = 1 watt
g = antenna gain = 4 dBi = 2.5 (a pure number, a ratio)[33]

This Smart Meter has an RF power output, P, of approximately 1 watt. The antenna used in the Smart Meter is a variation of a vertical dipole antenna which provides a gain, g, of 4 dBi, or 2.5, in the horizontal direction. I have not accounted for absorption by obstructions, such as walls and other objects, which can lower RF power density levels. Nor have I accounted for reflections from walls or other objects, which can raise or lower RF power density levels. So the actual power densities would likely fall somewhere between the two extremes that could apply if these other factors had been considered. The RF power density, P_D, in watts per square meter (W/m^2) can be calculated from this equation:

$$P_D = g\left[\frac{P}{4\pi r^2}\right]$$

In the above equation, r is the distance, in meters, from the Smart Meter, in the horizontal direction. This equation can be understood this way: The radiation from the Smart Meter travels outward from the meter and is initially regarded as spreading uniformly over the surface of a sphere (centered on the Smart Meter) which has a radius, r, and thus a surface area of $4\pi r^2$. So the part of the equation in square brackets [ ] indicates the power density that would be produced, at a distance, r, if the radiation from the Smart Meter spread uniformly over the surface of that sphere. The antenna used in the Smart Meter increases the power density in the horizontal direction, at the expense of a decrease in the power density in the vertical direction, because all receivers of interest are in the horizontal direction. Those receivers include the antennas of the electric power company and the antennas of other Smart Meters in the area with which a given Smart Meter communicates. The antenna gain, g, accounts for this characteristic of the antenna and causes P_D to represent the power density in the horizontal direction.

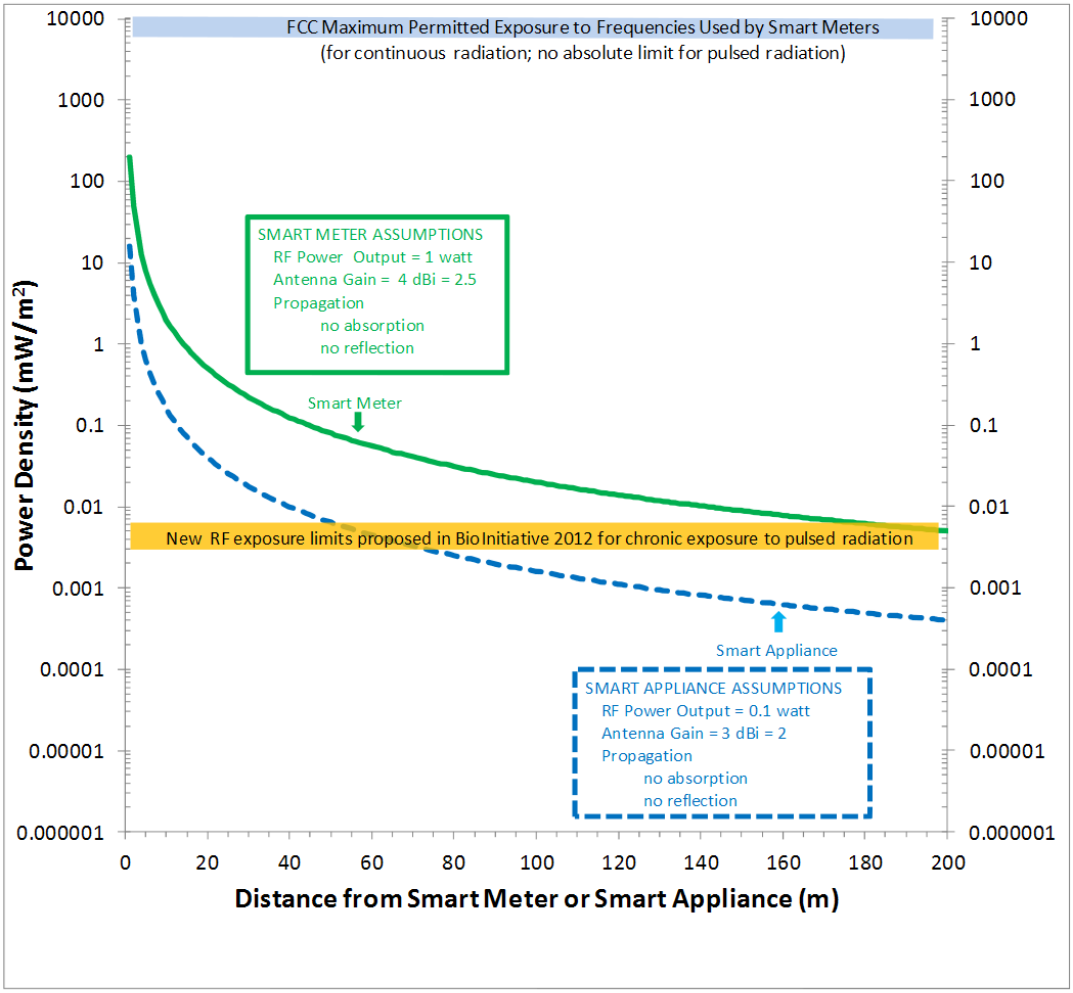
The RF power density, P_D, computed from the above equation is plotted in Figure 1 on page 9 as a function of the distance from the Smart Meter. The power density is expressed in units of milliwatts per square meter (mW/m^2) to match the units in the Biological Effects Chart under discussion. A logarithmic vertical axis is used for the power density, again to match the logarithmic vertical axis of the Biological Effects Chart. The vertical axis appears on both sides of Figure 1 to facilitate easier reading.

The power density is strongest near the Smart Meter and falls off quickly with increasing distance, but persists at lower levels to great distances. The power density of the Smart Meter drops to the maximum

[33] The antenna gain, g, is usually specified in dBi, which means the gain, in decibels, relative to an ideal isotropic antenna, which is an idealized antenna that radiates equally in all directions. The gain of the antenna in a Smart Meter (with FCC ID OWS-NIC514) is 4 dBi and translates to a factor of 2.5. That is, the power density in the horizontal direction is 2.5 times greater than it would be if the antenna radiated equally in all directions. In the case of Smart Meters, the power density in the vertical direction is reduced in favor of increased power density in the horizontal direction where all intended receivers are located. To access the reference, start at (http://transition.fcc.gov/oet/ea/fccid). In the box Grantee Code, enter OWS. In the box Product Code, enter –NIC514 (including the hyphen), press Search, click on the first entry Detail, and click on Test Report. This should take you to this location (https://apps.fcc.gov/eas/GetApplicationAttachment.html?id=1174749) which you cannot address directly. Then see page 3 of 66 of the document found.

exposure level proposed in the BioInitiative 2012 Report at a distance of about 180 meters. On the appended Biological Effects Chart, the four thin horizontal green lines show the power densities, taken from Figure 1, for distances of 1 meter (3 feet), 5 meters (16 feet), 20 meters (66 feet), and 100 meters (328 feet).

Figure 1: Smart Meter and Smart Appliance RF Power Densities versus Distance



The Thin Dashed Horizontal Blue Lines on the Biological Effects Chart

Smart Meters are designed to communicate wirelessly with new Smart Appliances that are now becoming available. The Smart Appliances contain RF transmitters and receivers of their own. Through the Smart Meters, the Smart Appliances can report, to the electric power company, data sufficient to identify the specific appliances and to indicate when they were installed or removed, and how much power they are

consuming throughout the day and the night, every day of the year. Less certain is whether the electric power company will be able to turn off the Smart Appliances by sending a wireless signal to them through the Smart Meter. (For example, the electric power company might want to turn off appliances that draw a lot of electricity at certain times of day, and in certain seasons, when the load on the electric power system is high. An example would be turning off the air-conditioner at midday in midsummer.)

Such Smart Appliances will increase the RF radiation inside each home. Verifiable data on the actual RF power output of the transmitters that will be used in the Smart Appliances is hard to find at present; but a likely value is 0.1 watt, since that is a common value used for other short-range wireless devices.[34] The antenna gain is assumed to be 3 dBi or 2.[35] The frequency of operation is assumed to be 2.4 GHz to communicate with the Smart Meters.[36]

The RF power density for Smart Appliances is calculated with the same equation used for Smart Meters above but with the different values for *P* and *g* just cited:

P = RF power output = 0.1 watt
g = antenna gain = 3 dBi = 2 (a pure number, a ratio)

The result for a single Smart Appliance is shown by the dashed blue line in Figure 1 on page 9. Once again, I have not accounted for absorption and reflection during propagation. Absorption can lower the power density. Reflection can lower or raise the power density. So the power densities shown in Figure 1 would likely fall somewhere between the two extremes that could apply if these other factors had been considered. The patterns of absorption and reflection inside homes vary greatly, so many different situations are possible.

The power density from a single Smart Appliance does not fall to the new maximum exposure level proposed in the BioInitiative 2012 Report until a distance of 50 meters (164 feet) from the Smart Appliance has been reached. So there will be no location within the typical home that will be that far from a Smart Appliance. Of course, over time, many such Smart Appliances may be purchased for a home, multiplying the total exposure produced.

In the appended Biological Effects Chart, the thin dashed blue lines show the RF power density, taken from Figure 1, for a single Smart Appliance at three distances: 1 meter (3 feet), 3 meters (10 feet), and 10 meters (33 feet) from the Smart Appliance. 10 meters is about at far from a Smart Appliance as a person can get inside the typical home with a single centrally located Smart Appliance.

---

[34] The most likely transmitter/receiver in the Smart Appliances is the so-called ZigBee device. These devices have RF outputs ranging from 0.001 watt to 0.1 watt, which is equivalent to a range of 1 milliwatt (mW) to 100 milliwatts (mW). (https://en.wikipedia.org/wiki/ZigBee)

[35] The assumed gain, *g*, in this case, is 3 dBi, which is based on the performance of an ordinary vertical dipole antenna. That is, the power density in the horizontal direction is 2 times greater than it would be if the antenna radiated equally in all directions.

[36] ZigBee devices operate at 865 (in Europe) and 915 MHz (in the USA and Australia), as well as 2.4 GHz (worldwide); but the design of the Smart Meters installed in Maryland seems to require that the ZigBee devices operate at 2.4 GHz. (https://en.wikipedia.org/wiki/ZigBee)

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.

Comparison of RF Exposure Limits

BioInitiative 2012 Report (RF)	FCC MPE (850 to 2400 MHz)	Ratio (FCC/BioInitiative 2012)
.003 to .006 mW/m^2	5700 to 10,000 mW/m^2	950,000 to 3,000,000

As shown in the appended Biological Effects Chart, the new RF exposure limits in the BioInitiative 2012 Report are low enough to protect against the biological effects found in nearly all of the 67 studies covered by that Chart.

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.

As shown in Figure 1, the RF power density from a Smart Meter does not drop down to the level of the proposed new RF exposure limits until distances of 180 to 200 meters from the Smart Meter are reached. In most residential communities, whether composed of single-family homes, townhomes, or apartments, it will not be possible to get sufficiently far away from *all* of the Smart Meters present in that community.

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.

When these Smart Appliances are installed in a home, they will significantly increase the radiation levels in that home for several reasons:

They will begin transmitting, and from distances very close to the residents.

The number of Smart Appliances in the home may increase with time as the residents gradually replace their old appliances with new Smart Appliances, increasing the total radiation level.

The Smart Meters will transmit more frequently, in order to communicate with the Smart Appliances.

Even a single Smart Appliance can produce RF power densities of concern. An inspection of the appended Biological Effects Chart indicates the following:

The power density at 1 meter (3 feet) from a Smart Appliance is higher than the power density that triggered biological effects in 32 of the 67 studies.

The power density at 3 meters (10 feet) from a Smart Appliance is higher than the power density

that triggered biological effects in 21 of the 67 studies.

The power density at 10 meters (33 feet) from a Smart Appliance is higher than the power density that triggered biological effects in 10 of the 67 studies.

These observations do not bode well for having 5, 10, or 15 Smart Appliances in a home. The RF radiation from even a few Smart Appliances, because they will be so close to the residents, may rival that of a home's more distant Smart Meter. And the RF radiation from a large number of Smart Appliances may exceed that of a home's Smart Meter.

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.

Fortunately, some states have offered an individual OPT OUT from the installation of a Smart Meter.[37] While such an OPT OUT is very helpful, and is definitely the ***vital first step***, the data on biological effects discussed here suggest the limitations of such an OPT OUT in resolving the problem of excess radiation from Smart Meters. There is no substitute for a roll back of all Smart Meters at the community level, or higher.

Most Biological Effects of RF Radiation Cannot be Sensed by Human Beings

Most biological effects of RF radiation cannot be sensed by human beings. This fact is evident from an inspection of the categories of biological effects from the RF Color Charts in the BioInitiative 2012 Report, as shown below. For example, humans cannot sense the onset of cancer, DNA damage, or fertility effects.

[37] Maryland, through the Maryland Public Service Commission, currently offers a temporary OPT OUT, with the future of that OPT OUT yet to be decided. And the Maryland House of Delegates is currently considering legislation (HB1038) that would make the OPT OUT permanent and would provide other protections for Maryland homeowners.

Categories of Biological Effects in the RF Color Charts of the BioInitiative 2012 Report

Code	Code Translation	Biological Effects Category
CB	Cancer, Brain	Brain tumors and blood-brain barrier
CO	Cancer, Other	Cancer (other than brain), cell proliferation
H	Heart	Cardiac, heart muscle, blood-pressure, vascular effects
MC	Metabolism, Calcium	Disrupted calcium metabolism
OD	Oxidation, DNA	Oxidative damage/ROS/DNA damage/DNA repair failure
R	Reproduction	Reproduction/fertility effects
S	Sleep	Sleep, neuron firing rate, EEG, memory, learning, behavior
SI	Stress, Immune	Stress proteins, HSP,[38] disrupted immune function

The principal category of biological effects that humans *can* often sense is the S (or Sleep) category. This category includes neurological effects on sleep, memory, learning, and behavior, among others. Unfortunately, not sensing these particular effects does not guarantee that other biological effects are not occurring.

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.*[41]

---

[38] HSP stands for Heat Shock Proteins. BioInitiative 2012 Report, cited in footnote 2 on page 1, Section 1, Summary for the Public and Conclusions, Table 1-2 Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure 2012, no page numbers.

[39] BioInitiative 2012 Report cited in footnote 2 on page 1, Section 1: Summary for the Public and Conclusions, 2012 Supplement: Summary for the Public – Ms. Sage, pages 8-10.

[40] Summary of H.R. 6358 can be found here: (http://marylandsmartmeterawareness.org/smart-meter-news/ask-your-congressional-rep-to-co-sponsor-h-r-6358). Full copy of H.R. 6358 can be found here: (http://thomas.loc.gov/home/gpoxmlc112/h6358_ih.xml).

[41] (http://ehtrust.org/wp-content/uploads/2012/12/aap_support_letter_cell_phone_right_to_know_act.pdf)

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 one-fifth 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.

Device	RF Power Output				
Smart Meter[42]	1.115	watts	which is	1115	milliwatts
Typical leakage from a microwave oven[43]	1	watt	which is	1000	milliwatts
Typical cell phone[43]	0.5	watt	which is	500	milliwatts
Wireless LAN (802.11a)[43]	0.251	watt	which is	251	milliwatts
Wireless LAN (802.11n)[43]	0.250	watt	which is	250	milliwatts
Cordless phone[44]	0.230	watt	which is	230	milliwatts
Smart Appliance[45]	0.100	watt	which is	100	milliwatts
Wireless LAN (802.11 b, g)[43]	0.100	watt	which is	100	milliwatts
Typical laptop wireless LAN (Wi-Fi)[43]	0.032	watt	which is	32	milliwatts

A Final Note

The Smart Meter is the first source of RF exposure that is mandated for installation in every home in an entire region without the informed consent, or any consent, of the residents, and that is not under the control of the residents.

For other sources of RF exposure in the home, the residents have a choice to use them, or not to use them, and how often, and how long. Some of those other sources are included in the table above.

The Smart Appliances, while not mandated, will be the second source of RF exposure in a home that is not under the control of the residents -- if manufacturers of the Smart Appliances provide no way of turning off the RF transmitters in those appliances.

The only solution for the individual homeowner, at present, is the removal of the Smart Meter and the avoidance of the Smart Appliances. This is a vital first step; but it is only a partial solution for a given home, because the radiation from the neighbors' Smart Meters and Smart Appliances will cross property boundaries. Collaboration with the neighbors on reducing exposure levels is needed; and a solution at the community level, or higher, will be even more effective.

---

[42] The Landis+Gyr FOCUS AXR-SD and the General Electric I-210+c, being installed in Maryland, have FCC-ID OWS-NIC514 which indicates that they send and receive information in two microwave frequency ranges: (1) 902.3 to 926.9 MHz, and (2) 2405.8 to 2480.9 MHz. The RF power output in the first frequency range is 0.968 watts. The RF power output in the second frequency range is 0.147 watt. These values sum to the 1.115 watts shown here, to provide an indication of the total RF power output capability of a Smart Meter. I have used an approximate value of 1 watt for the RF power output of a Smart Meter throughout this document (http://stopsmartmeters.org/wp-content/uploads/2012/01/OWS-NIC514-FCC-specifications.pdf).

[43] The RF power output levels come from this web site: (http://en.wikipedia.org/wiki/DBm). 1 watt equals 1000 milliwatts.

[44] Panasonic specifies the power output of its DECT 6.0 cordless telephone Model KXTG1061 as 115 milliwatts for the handset and another 115 milliwatts for the base station, for a total capability of 230 milliwatts.

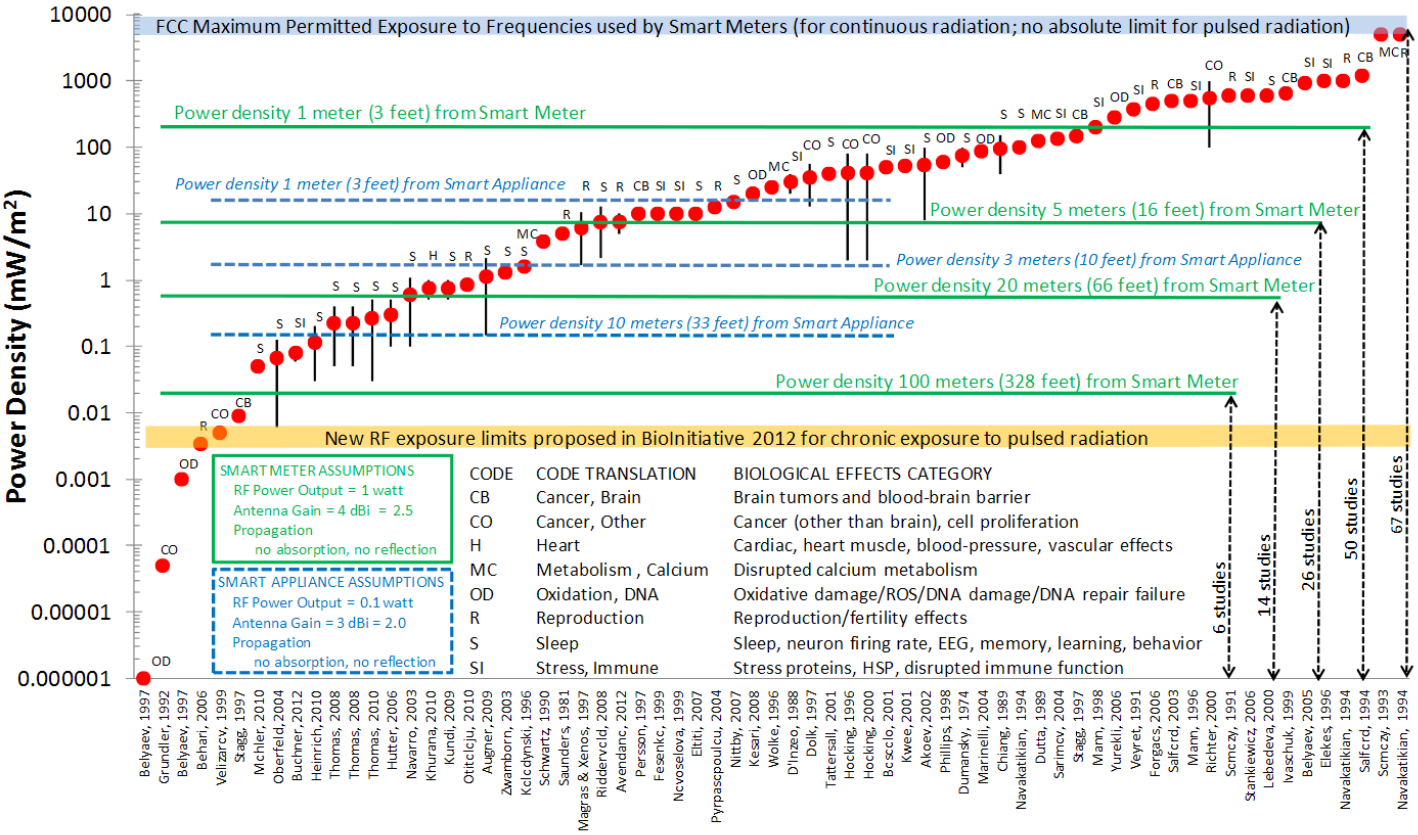
[45] For a reference, see footnote 34 on page 10.

June 11, 2013

Reported Biological Effects from RF Radiation at Low-Intensity Exposure in Each of the 67 Studies Referenced in the "BioInitiative 2012" Report (Cell Tower, Wi-Fi, Wireless Laptop, and Smart Meter Power Densities)

Ronald M. Powell, Ph.D.

Reference for data dots (red), data range indicators (vertical black lines through red dots), biological effects categories for the red dots, and new proposed limits (yellow line): BioInitiative Working Group, Cindy Sage and David O. Carpenter, Editors. BioInitiative Report: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation at www.bioinitiative.org, December 31, 2012. For references for other information on this chart, including the FCC Maximum Permitted Exposure limits, and the power densities of Smart Meters and Smart Appliances, see accompanying paper.



DEPARTMENT OF THE ARMY
UNITED STATES ARMY INTELLIGENCE AND SECURITY COMMAND
FREEDOM OF INFORMATION/PRIVACY OFFICE
FORT GEORGE G. MEADE, MARYLAND 20755-5995

REPLY TO
ATTENTION OF:

DEC 13 2006

Freedom of Information/
Privacy Office

Mr. Donald Friedman
Confidential Legal Correspondence
1125 Third Street
Napa, California 94559-3015

Dear Mr. Friedman:

References:

a. Your Freedom of Information Act (FOIA) request dated May 25, 2006, to the Department of the Army, Freedom of Information/Privacy Act Division (DA FOIA/PA DIV), for all documents pertaining to the microwave auditory effect, microwave hearing effect, Frey effect, artificial telepathy, and/or any device/weapon which uses and/or causes such effect; and any covert or undisclosed use of hypnosis. On September 5, 2006, the DA FOIA/PA DIV referred a copy of your request to this office. Your request was received on September 11, 2006.

b. Our letter of September 13, 2006, informing you of the search for records at another element of our command and were unable to comply with the 20-day statutory time limit in processing your request.

As noted in our letter, the search has been completed with another element of this command and the record has been returned to this office for our review and direct response to you.

We have completed a mandatory declassification review in accordance with Executive Order (EO) 12958, as amended. As a result of this review, it has been determined that the Army information no longer warrants security classification protection and is releasable to you. A copy of the record is enclosed for your use.

Fees for processing your request are waived.

If you have any questions concerning this action, please feel free to contact this office at (301) 677-2308. Refer to case #614F-06.

Sincerely,

Susan J. Butterfield
Director
Freedom of Information/Privacy Office
Investigative Records Repository

Enclosure

Bioeffects of Selected Nonlethal Weapons(fn 1)

This addendum to the Nonlethal Technologies--Worldwide (NGIC-1147-101-98) study addresses in summary, some of the most often asked questions of nonlethal weapons technology, the physiological responses observed in clinical settings of the biophysical coupling and susceptibility of personnel to nonlethal effects weapons. These results identify and validate some aspects of maturing nonlethal technologies that may likely be encountered or used as nonlethal effectors in the future including:

- Laser and other light phenomena.
- Radiofrequency directed energy.
- Aural bioeffects.

The study of electromagnetic fields and their influence on biological systems is increasing rapidly. Much of this work is taking place because of health concerns. For example, increased concern has arisen regarding the effects of operator exposure to the electromagnetic fields associated with short-wave diathermy devices, high power microwave ovens, radar systems, magnetic resonance imaging units, etc. In addition, much concern has arisen about extremely low frequency (60 Hz power frequency) electric and magnetic fields that originate from high-voltage transmission lines, industrial equipment, and residential appliances. Both occupational and residential long-term exposure have been the focus of epidemiological studies. The studies have suggested possible adverse effects on human health (e.g., cancer, reproduction, etc.). Laboratory research is still being pursued to identify possible mechanisms of interaction. However, other than thermal heating for microwave frequencies, there is no yet agreed-upon mechanism of action. As a consequence, our knowledge base is developed entirely with phenomenological observations. Because of this fact, it is not possible to predict how nonthermal biological effects may differ from one exposure modality to another. It is especially difficult, because of the small data base for fast pulses, to predict biological effects that might be associated with high-power pulses of extremely short duration.

There is, however, a growing perception that microwave irradiation and exposure to low frequency fields can be involved in a wide range of biological interactions. Some investigators are even beginning to describe similarities between microwave irradiation and drugs regarding their effects on biological systems. For example, some suggest that power density and specific absorption rate of microwave irradiation may be thought of as analogous to the concentration of the injection solution and the dosage of drug

administration, respectively. Clearly, the effects of microwaves on brain tissue, chemistry, and functions are complex and selective. Observations of body weight and behavior revealed that rats, exposed under certain conditions to microwaves, eat and drink less, have smaller body weight as a result of nonspecific stress mediated through the central nervous system and have decreased motor activity. It has been found that exposure of the animals to one modality of radiofrequency electromagnetic energy substantially decreases aggressive behavior during exposure. However, the opposite effects of microwaves, in increasing the mobility and aggression of animals, has also been shown for a different exposure modality. Recent published data implicates microwaves as a factor related to a deficit in spatial memory function. A similar type of effect was observed with exposure to a "resonance tuned" extremely low frequency magnetic field. Thus, the data base is replete with phenomenological observations of biological systems "affected" by exposure to electromagnetic energy. (The fact that a biological system responds to an external influence does not automatically nor easily translate to the suggestion of adverse influence on health.) The objective of the present study was to identify information from this developing understanding of electomagnetic effects on animal systems that could be coupled with human biological susceptibilities. Situations where the intersection of these two domains coexist provide possibilities for use in nonlethal applications.

Incapacitating Effect: Microwave Heating

Body heating to mimic a fever is the nature of the RF incapacitation. The objective is to provide heating in a very controlled way so that the body receives nearly uniform heating and no organs are damaged. Core temperatures approximately 41° C are considered to be adequate. At such temperature a considerably changed demeanor will take place with the individual. Most people, under fever conditions, become much less aggressive; some people may become more irritable. The subjective sensations produced by this buildup of heat are far more unpleasant than those accompanying fever. In hyperthermia all the effector processes are strained to the utmost, whereas in fever they are not. It is also possible that microwave hyperthermia (even with only a 1° C increase in brain temperature) may disrupt working memory, thus resulting in disorientation.

Biological Target/Normal Functions/Disease State

The temperature of warm-blooded (homeothermic) animals like the human remains practically unchanged although the surrounding temperature may vary considerably. The normal human body temperature recorded from the mouth is usually given as 37° C, with the rectal temperature one degree higher. Variation between individuals is typically between 35.8° C and 37.8° C orally. Variations also occur in any one individual throughout the day--a difference of 1.0° C or even 2.0° C occurring between the maximum in the late afternoon or early evening, and the minimum between 3 and 5 o'clock in the morning. Strenuous muscular exercise causes a temporary rise in body temperature that is proportional to the severity of the exercise; the level may go as high as 40.0° C.

Extreme heat stress, such that the body's capacity for heat loss is exceeded, causes a pathological increase in the temperature of the body. The subjective sensations produced by this buildup of heat are far more unpleasant than those accompanying fever. In hyperthermia all the effector processes are strained to the utmost, whereas in fevers they are not. The limiting temperature for survival, however, is the same in both cases--a body temperature of 42° C. For brief periods, people have been known to survive temperatures as high as 43 ° C.

In prolonged hyperthermia, with temperatures over 40° C to 41° C, the brain suffers severe damage that usually leads to death. Periods of hyperthermia are accompanied by cerebral edema that damage neurons, and the victim exhibits disorientation, delirium, and convulsions. This syndrome is popularly referred to as sunstroke, or heatstroke, depending on the circumstances. When the hyperthermia is prolonged, brain damage interferes with the central thermoregulatory mechanisms. In particular, sweat secretion ceases, so that the condition is further exacerbated.

Mechanism to Produce the Desired Effects

This concept builds on about 40 years of experience with the heating effects of microwaves. Numerous studies have been performed on animals to identify characteristics of importance to the understanding of energy deposition in animals. As a result of the physics, the relationship between the size of the animal and the wavelength of the radiofrequency energy is most important. In fact, the human exposure guidelines to radiofrequency radiation are designed around knowledge of the differential absorption as a function of frequency and body size. The challenge is to minimize the time to effect while causing no permanent injury to any organ or the total body and to optimize the equipment function. The orientation of the incident energy with respect to the orientation of the animal is also important.

In a study of the effect of RF radiation on body temperature in the Rhesus monkey, a frequency (225 MHz) is purposely chosen that deposits energy deep within the body of the animal. A dose rate of 10 W/kg caused the body temperature to increase to 42° C in a short time (10-15 min). To avoid irreversible adverse effects, the exposure was terminated when a temperature of 42° C was reached. A lower dose rate of 5 W/kg caused the temperature to increase to 41.5° C in less than 2 hours. The reversible nature of this response was demonstrated by the rapid drop in body temperature when RF exposure was terminated before a critical temperature of 42° C was reached. It is estimated for rats that the absorbed threshold convulsive dose lies between 22 and 35 J/g for exposure durations from less than a second to 15 minutes. For 30-minute exposure, the absorbed threshold dose for decrease in endurance is near 20 J/g, the threshold for work stoppage approximately 9 J/g, and the threshold for work perturbation ranges from 5 to 7 J/g. All of the above measures, except convulsions, are types of nonlethal incapacition.

A rough estimate of the power required to heat a human for this technology is on the order of 10 W/kg given about 15 to 30 minutes of target activation. Actual power levels

depend on climatic factors, clothing, and other considerations that affect the heat loss from the individual concerned. A method for expressing dose rate in terms of body surface area (i.e., watts per square meter) rather than body mass (i.e., watts per kilogram) would permit a more reliable prediction of thermal effects across species. However, there are large uncertainties in the ability to extrapolate thermoregulatory effects in laboratory animals to those in human beings.

This technology is an adaptation of technology which has been around for many years. It is well known that microwaves can be used to heat objects. Not only is microwave technology used to cook foods, but it is also used as a directed source of heating in many industrial applications. It was even the subject of the "Pound Proposal" a few years ago in which the idea was to provide residential heating to people, not living space. Because of the apparently safe nature of body heating using microwave techniques, a variety of innovative uses of EM energy for human applications are being explored. The nonlethal application would embody a highly sophisticated microwave assembly that can be used to project microwaves in order to provide a controlled heating of persons. This controlled heating will raise the core temperature of the individuals to a predetermined level to mimic a high fever with the intent of gaining a psychological/capability edge on the enemy, while not inflicting deadly force. The concept of heating is straightforward; the challenge is to identify and produce the correct mix of frequencies and power levels needed to do the remote heating while not injuring specific organs in the individuals illuminated by the beam.

A variety of factors contribute to the attractiveness of this nonlethal technology. First, it is based on a well-known effect, heating. Every human is subject to the effects of heating; therefore, it would have a predictability rating of 100%. The time to onset can probably be engineered to between 15 and 30 minutes; however, timing is the subject of additional research to maximize heating while minimizing adverse effects of localized heating. The onset can be slow enough and/or of such frequency to be unrecognized by the person(s) being irradiated. Safety to innocents could be enhanced by the application and additional development of advanced sensor technologies. Incapacitation time could be extended to almost any desired period consistent with safety. (Given suitable R&D, temperature or other vital signs could be monitored remotely, and temperature could be maintained at a minimum effective point).

Time to Onset

The time to onset is a function of the power level being used. Carefully monitored uniform heating could probably take place in between 15 and 30 minutes. Time to onset could be reduced but with increased risk of adverse effects. Minimum time is dependent on the power level of the equipment and the efficiency of the aiming device.

Duration of Effect

Assuming that the heating is done carefully, reversal of elevated body temperature would begin as soon as the source of heat is removed.

Tunability

This concept is tunable in that any rate of heating, up to the maximum capacity of the source, may be obtained. Thus it is suitable for use in a gradual force or "rheostatic" approach. If the situation allows, and the source is sufficiently powerful, there is the possibility to use this technology in a lethal mode as well. Prolonged body temperature above 43° C is almost certain to result in permanent damage to the brain and death.

Distribution of Human Sensitivities to Desired Effects

No reason has been identified to suggest that anyone would be immune to this technology. Individuals with compromised thermoregulatory mechanisms would be susceptible with a lower incident energy density. This would include people with organic damage to the hypothalamus, the part of the brain that integrates the autonomic mechanisms which control heat loss as well as people with compromised somatic features of heat loss (e.g., respiration, water balance, etc.).

The technologies needed for the thermal technology concept are relatively well developed because of the known biophysical mechanism, the universal susceptibility of humans to the mechanism of heating, and because of a well developed technology base for the production of radiofrequency radiation. Because the human body is inhomogeneous, certain organs are, by virtue of their size and geometry, more easily coupled with one radiofrequency wavelength than another. Therefore, to avoid permanent damage to the suspect or to innocent bystanders, it may be necessary to vary the frequency to avoid localized heating and consequent damage to any organ. Additionally, it will be necessary to avoid the conditions thought to be associated with the induction of cataracts. Thus, while the technology of microwave heating in general is mature, adaptation as a nonlethal technology will require sophisticated biophysical calculations to identify the proper regimen of microwave frequencies and intensities; it will also be necessary to optimize existing hardware to meet the biophysical requirements.

Possible Influence on Subject(s)

If the technology functions approximately as envisioned, the targeted individual could be incapacitated within 15 to 30 minutes. Because this technology is focused on a relatively slow onset, it should only be used in situations where speed is not important. The very uncomfortable nature of a high body temperature may be useful in negotiations or possibly for controlling crowds. It would be equally useful on single persons or crowds. Evidence also indicates a disruption of working memory, thus disorientation may occur because of an inability to consolidate memory of the recent (minutes) past.

Technological Status of Generator/Aiming Device

Equipment needed to explore this concept in the laboratory is available today. Design and construction of the RF/microwave generator will depend on the constraints posed by the calculations, potential generation devices, and energy-directing structures. A variety of

options exist for both of these equipment needs. The use of advanced frequency and modulation-agile RF generation and amplification circuitry will be required to assess fully the frequency/power/time envelope of RF heating profiles required. Although much equipment is commercially available, it is likely that custom hardware and software will be necessary because available equipment has not been designed with the need for frequency/intensity variability, which will probably be needed for safety purposes. In addition, the design of antennas and other energy-directing structures will almost certainly involve unique configurations. Since this technology utilizes radiofrequency energy, it can be defeated by the use of shielding provided by conductive barriers like metal or metal screen.

Incapacitating Effect: Microwave Hearing

Microwave hearing is a phenomenon, described by human observers, as, the sensations of buzzing, ticking, hissing, or knocking sounds that originate within or immediately behind the head. There is no sound propagating through the air like normal sound. This technology in its crudest form could be used to distract individuals; if refined, it could also be used to communicate with hostages or hostage takers directly by Morse code or other message systems, possibly even by voice communication.

Biological Target/Normal Functions/Disease State

This technology makes use of a phenomenon first described in the literature over 30 years ago. Different types of sounds were heard depending on the particulars of the pulse characteristics. Various experiments were performed on humans and laboratory animals exploring the origin of this phenomenon. At this time, virtually all investigators who have studied the phenomenon now accept thermoelastic expansion of the brain, the pressure wave of which is received and processed by the cochlear microphonic system, to be the mechanism of acoustic perception of short pulses of RF energy. One study (in 1975) using human volunteers, identified the threshold energy of microwave-auditory responses in humans as a function of pulse width for 2450 MHz radiofrequency energy. It is also found that about 40 J/cm^2 incident energy density per pulse was required.

Mechanism to Produce the Desired Effects

After the phenomenon was discovered, several mechanisms were suggested to explain the hearing of pulsed RF fields. Thermoelastic expansion within the brain in response to RF pulses was first studied and demonstrated in inert materials and was proposed as the mechanism of hearing of pulsed RF fields. A pressure wave is generated in most solid and liquid materials by a pulse of RF energy--a pressure wave that is several orders of magnitude larger in amplitude than that resulting from radiation pressure or from electrostrictive forces. The characteristics of the field-induced cochlear microphonic in guinea pigs and cats, the relationship of pulse duration and threshold, physical measurements in water and in tissue-simulating materials, as well as numerous theoretical calculations--all point to thermoelastic expansion as the mechanism of the hearing phenomenon.

Scientists have determined the threshold energy level for human observers exposed to pulsed 2450-MHz fields (0.5-to 32 micron pulse widths). They found that, regardless of the peak of the power density and the pulse width, the per-pulse threshold for a normal subject is near 20 mJ/kg. The average elevation of brain temperature associated with a just-perceptible pulse was estimated to be about $5x10^{-6}$° C.

Time to Onset

The physical nature of this thermoelastic expansion dictates that the sounds are heard as the individual pulses are absorbed. Thus, the effect is immediate (within milliseconds). Humans have been exposed to RF energy that resulted in the production of sounds.

Duration of Effect

Microwave hearing lasts only as long as the exposure. There is no residual effect after cessation of RF energy.

Tunability

The phenomenon is tunable in that the characteristic sounds and intensities of those sounds depend on the characteristics of the RF energy as delivered. Because the frequency of the sound heard is dependent on the pulse characteristics of the RF energy, it seems possible that this technology could be developed to the point where words could be transmitted to be heard like the spoken word, except that it could only be heard within a person's head. In one experiment, communication of the words from one to ten using "speech modulated" microwave energy was successfully demonstrated. Microphones next to the person experiencing the voice could not pick up the sound. Additional development of this would open up a wide range of possibilities.

Distribution of Human Sensitivities to Desired Effects

Because the phenomenon acts directly on cochlear processes, the thermoelastic pressure waves produce sounds of varying frequency. Many of the tests run to evaluate the phenomenon produced sounds in the 5 kHz range and higher. Because humans are known to experience a wide range of hearing loss due to cochlear damage, it is possible that some people can hear RF induced sounds that others with high frequency hearing loss cannot. Thus, there is a likely range of sensitivity, primarily based on the type of pulse and the condition of the cochlea. Bilateral destruction of the cochlea has been demonstrated to abolish all RF-induced auditory stimuli.

Recovery/Safety

Humans have been subjected to this phenomenon for many years. The energy deposition required to produce this effect is so small that it is not considered hazardous experimentation when investigating responses at the just-perceptible levels.

Possible Influence on Subject(s)

Application of the microwave hearing technology could facilitate a private message transmission. It may be useful to provide a disruptive condition to a person not aware of the technology. Not only might it be disruptive to the sense of hearing, it could be psychologically devastating if one suddenly heard "voices within one's head."

Technological Status of Generator/Aiming Device

This technology requires no extrapolation to estimate its usefulness. Microwave energy can be applied at a distance, and the appropriate technology can be adapted from existing radar units. Aiming devices likewise are available but for special circumstances which require extreme specificity, there may be a need for additional development. Extreme directional specificity would be required to transmit a message to a single hostage surrounded by his captors. Signals can be transmitted long distances (hundreds of meters) using current technology. Longer distances and more sophisticated signal types will require more bulky equipment, but it seems possible to transmit some type of signals at closer ranges using man-portable equipment.

Range

The effective range could be hundreds of meters.

Incapacitating Effect: Disruption of Neural Control

The nature of the incapacitation is a rhythmic-activity synchronization of brain neurons that disrupts normal cortical control of the corticospinal and corticobulbar pathways; this disrupts normal functioning of the spinal motor neurons which control muscle contraction and body movements. Persons suffering from this condition lose voluntary control of their body. This synchronization may be accompanied by a sudden loss of consciousness and intense muscle spasms.

Biological Target/Normal Functions/Disease State

The normal function of the brain is to control all forms of behavior, voluntary control of body, and the homeostatic parameters of the organism. In normal conditions, all the brain structures, neuron populations, networks, and single units function with specific rhythmic activity depending on the incoming sensory information, information from mnemonic structures, and signals from visceral organs. Each single neuron provides specific processing of information it receives and forms a specific pattern of impulse firing as outgoing information. Synchronization of neuron activity is a natural mechanism of the brain function that uses such controlling processes as motivation, attention and memory (experience) in order to organize behavior. For example, motivational processes are considered as activating ascending signals that synchronize the neuron activity of specific brain structures and neuron networks; this activation/synchronization in turn activates specific forms of behavior such as sexual, aggressive, ingestive activities.

In normal functioning the degree of neuronal synchronization is highly controlled. From experiments that record the neuronal activity in different brain areas simultaneously in animals, it is known that correlation of spike activity between neurons (measured by the correlation level of synchronization) changes depending on the stage of behavior, motivation, attention, or activation of the memory processes. However, under some conditions, such as physical stress, heat shock, or strong emotional stress, the level of synchronization may become higher, involving nonspecific large populations of brain neurons and the synchronization may become uncontrollable.

Depending on at which frequency the synchronization rhythm occurs and how many neurons are involved, it may produce different physical effects; muscle weakness, involuntary muscle contractions, loss of consciousness, or intense (tonic) muscle spasms. The higher level of synchronization takes place in persons affected with epilepsy when they experience periodic seizures since they have a pathologic source (e.g., from injury to the brain) of rhythmic synchronization. Because the neurophysiological mechanisms of epileptiform synchronization are better documented, this incapacitating technology is described in terms of epileptogenesis.

The neurophysiological mechanisms active in epileptogenesis involve changes in membrane conductances and neurotransmitter alterations as they affect neuronal interaction. In the process of epileptogenesis, either some neurons are discharging too easily because of alterations in membrane conductances or there is a failure of inhibitory neurotransmission. The actual discharges have been recognized to result from a neuronal depolarization shift with electrical synchrony in cell populations related in part to changes in membrane conductances. The ionic basis and biochemical substrate of this activation have been areas of considerable study but still leave many questions unanswered. What are the basic cellular properties, present in normal cells and tissue, that could contribute to the generation of abnormal activity? What parts of the systems are low threshold and function as trigger elements?

One of the current hypotheses is involved with microcircuitry, particularly local synaptic interactions in neocortical and limbic system structures. In the hippocampus, the role of the trigger element has been long attributed to the CA3 pyramidal cells--a hypothesis based on the fact that spontaneous synchronous burst discharge can be established in CA3 neurons Some studies describe an intrinsically bursting cell type in the neocortex that plays a role similar to that of CA3 cells in the hippocampus and that of deep cells in the pyriform cortex. The intrinsic nature of these cells appears to be an important contributor to the establishment of synchronized bursting in these regions. Another apparent requirement in such a population is for a certain degree of synaptic interaction among neurons, such that discharge of even one cell enlists the activity of its neighbors. Given the presence of these bursting cells and the occurrence of excitatory interactions among them in normal tissue, it may actually be the morphologic substrate for epileptiform discharges.

Another hyptothesis has focused particularly on the role of N-methyl-D-aspartate (NMDA) receptors. Various factors regulate the efficacy of NMDA receptors: their

voltage-dependent blockade by magnesium and modulation by glycine and polyamines. For example, in the low magnesium model, spontaneous synchronous burst discharge in hippocampal pyramidal cell populations is sensitive to NMDA antagonists. That finding suggests that it is the opening of NMDA channels, by relieving the magnesium blockade, that facilitates epileptiform activity.

Significant attention in the literature is also being given to gamma-amino butyric acid (GABA) receptors for the potential role in control of excitability. Changes in GABA inhibitory efficacy can lead to important effects on the excitability of the system. GABAergic inhibitory post-synaptic potentials (IPSPs) have been shown to be quite labile in response to repetitive activation of cortical cell populations, as may occur during epileptiform discharge. Scientists have shown that even a small percentage change in GABA inhibition can have profound effects on neocortical epileptogenesis. These changes in GABAergic inhibition may be the key to an explanation of how repetitive discharge patterns give rise to ictal discharge. Further, there appears to be a significant increase in excitatory postsynaptic potential (EPSP) frequency prior to seizure initiation an observation that is consistent with loss of IPSP efficacy prior to ictal onset.

The above hypotheses describe different mechanisms of epileptogenesis, but it is quite possible that all of these mechanisms take place, and they reflect large variety of types of epileptic seizures. The common principle of the mechanisms proposed is the change of membrane properties (i.e., conductance, permeability etc.) of certain neurons which results in depolarization and burst discharging. Some factors (e.g., trauma) can affect these specific neurons and initiate synchrony for neurons that control internal communication and communication with various muscle systems not associated with vital functions (i.e., heart beating, breathing). High strength pulsed electric fields could also be such a factor.

Mechanism to Reproduce the Desired Effects

Application of electromagnetic pulses is also a conceptual nonlethal technology that uses electromagnetic energy to induce neural synchrony and disruption of voluntary muscle control. The effectiveness of this concept has not been demonstrated. However, from past work in evaluating the potential for electromagnetic pulse generators to affect humans, it is estimated that sufficiently strong internal fields can be generated within the brain to trigger neurons. Estimates are that 50 to 100 kV/m free field of very sharp pulses (~ 1 nS) are required to produce a cell membranic potential of approximately 2 V; this would probably be sufficient to trigger neurons or make them more susceptible to firing.

The electromagnetic pulse concept is one in which a very fast (nanosecond timeframe) high voltage (approximately 100 kV/m or greater) electromagnetic pulse is repeated at the alpha brain wave frequency (about 15 Hz). It is known that a similar frequency of pulsing light can trigger sensitive individuals (those with some degree of light-sensitivity epilepsy) into a seizure and it is thought that by using a method that could actually trigger nerve synapses directly with an electrical field, essentially 100% of individuals would be susceptible to seizure induction. The photic-induced seizure phenomenon was borne out

demonstrably on December 16, 1997 on Japanese television when hundreds of viewers of a popular cartoon show were treated, inadvertently, to photic seizure induction (figure 31). The photic-induced seizure is indirect in that the eye must receive and transmit the impulses which initially activate a portion of the brain associated with the optic nerve. From that point the excitability spreads to other portions of the brain. With the electromagnetic concept, excitation is directly on the brain, and all regions are excited concurrently. The onset of synchony and disruption of muscular control is anticipated to be nearly instantaneous. Recovery times are expected to be consistent with, or more rapid than, that which is observed in epileptic seizures.

Time to Onset

No experimental evidence is available for this concept. However, light-induced seizures latency onset in photosensitive epileptics varies from 0.1 to about 10 seconds. Because of the fact that the electrical impulses triggered by light must spread to other parts of the brain, photic-induced seizures are expected to have a generally slower onset than neural synchrony induced by high-strength pulsed electric fields.

Duration of Effect

For epileptic individuals, the typical duration of a petit mal event or a psychomotor event is 1 minute or 2, possibly longer, while the duration of a grand mal seizure is 1 to 5 minutes. In a non-epileptic individual who is induced by electromagnetic means, the durations of the different events are expected to be roughly the same as the epileptic individual's events after the external excitation is removed.

Tunability

There are many degrees of epileptic seizure in diseased persons, and it seems reasonable that electromagnetic stimulation of neural synchrony might be tunable with regard to type and degree of bodily influence, depending on the parameters associated with the chosen stimulus. Because there are no actual data to build on, these statements must be considered tentative. It is known that in the study of photic-induced seizures, parameters can be varied so that the individual under study does not actually undergo a grand mal seizure. This knowledge gives confidence that the proposed technology would be tunable.

Distribution of Human Sensitivities to Desired Effects

It is anticipated that 100% of the population would be susceptible. The mechanism is one that could act on many individual neuronal cells concurrently and hence does not depend on spreading regions of electrical activity as in the disease state.

Possible Influence on Subjects(s)

If the technology functions approximately as envisioned, the targeted individual could be incapacitated very quickly. Because there have been no reported studies using the

conditions specified, experimental work is required to characterize onset time. Different types of technologies could be employed to influence wide areas or single individuals. Because this technology is considered to be tunable, the influence on subjects could vary from mild disruption of concentration to muscle spasms and loss of consciousness. The subject(s) would have varying degrees of voluntary control depending on the chosen degree of incapacitation.

Technological Status of Generator/Aiming Device

An electric field strength of roughly 100 Kv/m over a time period of 1 nanosecond is approximately the condition thought to be necessary to produce the desired effect when provided to an overall repetition rate of 15 Hz. Such a field may be developed using a radar-like, high-peak-power, pulsed source or an electromagnetic pulse generator operated at 15 Hz. These technologies exist today sufficient to evaluate the disabling concept. Power requirements are not high because the duty factor is so low. Aiming devices are currently available, but a high degree of directionality at long distances will require development. It may be necessary to provide bursts of these nanosecond pulses in order to stimulate the desired effect. As the duty time increases so does the average power requirement for power source. Because there were no open literature reports from which to make inferences, there is some uncertainty about the power levels required.

Range

The effective range could be hundreds of meters.

Defeat Capabilities/Limitations

Shielding can be provided by conductive barriers like metal or metal screen. There are a number of drugs that are capable of inducing convulsive seizures and others, like phenobarbital, diphenyllhydantoin, trimethadione, 2-4 dinitrophenol, and acetazolamide, which are anticonvulsive. Anticonvulsive drugs are known to be helpful in reducing the effect of seizures in epileptic patients, but their ability to reduce the effect of the proposed technology is unknown (possibly no effect) but expected to be less than for photic-induced seizures.

Incapacitating Effect; Acoustic Energy

The nature of the incapacitation consists of severe pressure sensations, nystagmus (a spasmodic, involuntary motion of the eyes), and nausea caused by high intensities of 9140-155 dB). Nystagmus occurs when convection currents are produced (cupula movement) in the lateral ear canal. This cupula movement causes the eyes to move involuntarily; hence, the external world is interpreted as moving. The subject "sees" his surroundings turning round him and at the same time experiences a sensation of turning. Persons exposed to these levels of sound experience nausea.

Biological Target/Normal Functions/Disease State

The two lateral semicircular canals, one located in each inner ear, alert a person to the fact that his upright head is experiencing angular acceleration. Within the ampulla of the canal are several so called hair cells. The cilia of these cells protrude into the lumen of the ampulla where they are encased in a mass of jelly-like material (the cupula) which is attached to the opposite wall of the canal. As the head accelerates, the cilia are bent by an inertial force of the cupula and the viscous liquid in the canal lumen. The bending of the cilia excites hair cells which in turn excite afferent neurons; these then alert the brain that a change of position of the head has occurred. Similar events occur when the head stops moving. The result of a strong hair cell stimulus to the brain is a rapid eye movement, call nystagmus, a feeling of dizziness and disorientation, and a possibility of nausea and vomiting.

Normal hearing is in the range between the frequencies of 20,000 to 16,000 Hz with the optimal sensitivity for most people between the frequencies of 500 to 6000 Hz.

Mechanism to Produce the Desired Effects

Because the end organs for acoustic and vestibular perception are so closely related, intense acoustic stimulation can result in vestibular effects. The hypothesis is that the sound of normal intensity produces oscillations of the endolymph and perilymph, compensated for by oscillations of the round window. High intensity sound produces eddy currents, which are localized rotational fluid displacements. High intensity sound can also produce nonlinear displacement of the stapes, causing a volume displacement, the result of which can be a fluid void in the labyrinth. To fill the void, fluid may be displaced along the endolymphatic duct and/or block capillary pathways, which, in turn, could stimulate vestibular receptors. Stimulation of the vestibular receptors may lead to nausea and vomiting if the sound pressure level is high enough. Conclude that both eddy currents and volume displacement serve to stimulate vestibular receptors in humans, when exposed to high levels of noise.

One study found nystagmum in guinea pigs exposed to high levels of infrasound via stimulation of the vestibular receptors. However, the same lab was unable to produce nystagmus in human subjects at 5- and 10-second exposures to a pure tone at 135 dB, broadband engine noise, or a 100 Hz tone at 120 dB, pulsed three times/s or 2 minutes. The same research was unable to elicit nystagmus at levels up to 155 dB, and also equally unable to produce nystagmus using infrasound levels of 112-150 dB in guinea pigs, monkeys, and humans. However, research with audible components in the sound spectrum with guinea pigs and monkeys produced nystagmus. Other researchers report other vestibular effects in addition to nystagmus at the following thresholds: 125 dB from 200-500 Hz, 140 dB at 1000 Hz, and 155 dB at 200 Hz. Decrements in vestibular function occur consistently for broadband noise levels of 140 dB (with hearing protection).

Human subjects listened to very high levels of low-frequency noise and infrasound in the protected or unprotected modes. Two-minute duration as high as 140 to 155 dB produced a range of effects from mild discomfort to severe pressure sensations, nausea, gagging,

and giddiness. Effects also included blurred vision and visual field distortions in some exposure conditions. The nature and degree of all effects was dependent on both sound level and frequency with the most severe effects occurring in the audible frequency range (as opposed to infrasound), at levels above about 145 dB. The investigators found no temporary threshold shift (TTS) among their subjects, and the use of hearing protectors greatly alleviated the adverse effects.

Since the early days of jet-engine testing and maintenance, anecdotal evidence has appeared linking exposure to intense noise, with such complaints as dizziness, vertigo, nausea, and vomiting. As a result of siren noise at 140 dB, subjects consistently reported a feeling of being pushed sideways, usually away from the exposed ear, and one subject reported difficulty standing on one foot.

These effects were not as dramatic as from the jet-engine (broadband) noise at 140 dB. This research concludes that the threshold of labyrinthine dysfunction is about 135 to 140 dB and that these effects occur during, but not after, exposure.

Time to Onset

No times to onset of nausea or nystagmus were identified in the literature but is presumed to be relatively immediate based on effects to the labyrinth system occurring during, but not after, exposure to sound pressure levels of 135 to 140 dB.

Duration of Effect

The incapacitation lasts only as long as the incapacitating sound is present.

Tunability

Based on the data presented above, it is unclear whether the degree of nausea or nystagmus is tunable, but similar symptoms caused by other stimuli are variable in degree.

Distribution of Human Sensitivities to Desired Effects

It is most probable that all individuals will be susceptible to this stimulus with the exception of those with a disease or defect (i.e., deaf mutes) of some part or parts of the vestibular system. Data showed no consistent decrease in vestibulo-ocular reflects with increased age.

Recovery/Safety

Normal subjects are likely to recover immediately and experience no or unmeasurable changes in hearing unless well known frequency-intensity-time factors are exceeded. This is based on studies which found no temporary threshold shift in hearing of subjects tested at low frequency. Occupational safety personnel generally recognize that 115

dB(A) is to be avoided and that 70 dB(A) is assumed safe. Is believed that the noise energy with predominating frequencies above 500 Hz have a greater potential for hearing loss than noise energy at lower frequencies. Occupational standards for noise state that a person may be exposed continuously for 8 hours to 90 dB(A) or 15 minutes to 115 dB(A).

Possible Influence on Subject(s)

Induction of nystagmus and nausea will have variable effects on individuals. Effects may be sufficiently incapacitation to allow offensive advantage; the perception of sickness may make a subject susceptible to persuasion. It would be difficult to target single individuals at the present level of sound directing technology. This technology may be better suited for groups of people.

Technological Status of Generator/Aiming Device

Sound generating technology is well developed but not highly portable. Aiming devices are poorly developed.

Range

Under normal circumstances the sound pressure level decreases 6 dB(A) when the distance from the source is doubled. For example if the sound is 100 dB(A) at 100 ft, at 200 ft the sound would be 94 dB(A). At very high sound levels, certain conditions may lead to nonlinear effects in propagation and greatly increase range accuracy.

Defeat Capabilities/Limitations

Negative effects of audible sound are greatly decreased if hearing protection is worn. High frequency sound is more easily blocked than low frequency sound due to wavelength effects.

Laser-Induced Biological Effects

Their are three basic damage mechanisms associated with exposure to laser radiation: chemical, thermal, and mechanical or acoustic-mechanical.

The laser-induced, chemical alterations in irradiated tissue are referred to as photochemical damage. The likelihood of laser radiation in the blue-light portion of the electromagnetic spectrum (.380 to .550 microns) inducing photochemical reactions progressively decreases with increasing wavelength. Photochemical effects are not observed upon exposure to radiation with wavelengths exceeding .550 to .650 microns because the kinetic energy associated with these photons is insufficient to initiate a photochemical change.

On the other hand, the thermal effect is a primary mechanism for laser-induced injury. The extent of the injuries induced depends upon the wavelength and energy of the incident radiation, duration of exposure, and the nature of the exposed tissue and its absorption characteristics. Generally, this mechanism predominates in the visible and the near-infrared (.760 to 1.4 microns) portions of the electromagnetic spectrum and for almost all CW and pulsed exposures between 0.1 milliseconds and 1 to 5 seconds.

The third injury mechanism associated with exposure to laser radiation is the mechanical or acoustical-mechanical effect. The radiant energy is absorbed into the tissue and, as a result of rapid thermal expansion following a short (1 nanosecond to 0.1 millisecond) laser radiation pulse, a pressure wave is generated that may result in explosive tissue injury.

Generally, all three mechanisms operate concurrently in an irradiated animal. Thermal effects currently predominate for continuous wave (CW) lasers, while mechanical effects are of increased significance for pulsed-mode lasers. With even higher power, one must also consider nonlinear phenomena such as multiphoton absorption and electromagnetic field effects.

The organs most susceptible to external laser radiation are the skin and eyes. The severity of injury is affected by the nature of the target, the energy density delivered to the target, the frequency and power of the laser, atmospheric attenuation of the beam, and the use of filtering or amplifying optics by the target, etc.

The primary effect on the skin is thermal damage (burns). The severity varies from slight erythema or reddening to severe blistering or charring, depending on such factors as total energy deposition, skin pigmentation, and the tissue's ability to dissipate heat.

The eye is particularly susceptible to intense pulse of laser radiation because of its unique sensitivity to light. The focusing effect is similar to that of a magnifying lens, which focuses the energy on a particular spot. Since the cornea and lens of the eye amplify the intensity of the light incident upon the retina, the retina is extremely sensitive to visible and near-infrared light, and damage to the retina may result in temporary or permanent loss of visual acuity. Laser eye injuries vary according to incident power, spot size, beam angle, temporal mode (CW or pulsed), and pulse repetition frequency. Reported effects include corneal lesions, burns, cataracts, and retinal lesions.

Some high-power lasers can cause antipersonnel effects by the deposition of thermal energy. These lasers must operate at a wavelength that is readily absorbed by the skin or the cornea. These generally include the far- and mid-IR regions (10 to 12 microns and 3 to 5 microns) as well as the ultraviolet region (<0.4 microns). However, ultraviolet wavelengths generally do not propagate well in the atmosphere, so the primary threat wavelengths to be considered are between 3 and 12 microns. Although relatively modest amounts of far-IR laser power are required to produce superficial burns on the skin at short ranges, and efforts to design rheostatically lethal laser weapons are on going.

Nonlethal blinding laser weapons generally use collimated beams with very low beam divergence, and the energy contained in the beam diminishes relatively slowly over great distances. Imaging systems such as eyes and EO vision systems have focusing optics that bring the incident plane wave of light to focus at the sensor plane. This results in a high optical gain (greater than 100,000 for eyes), which makes the associated sensor vulnerable to relatively low fluences of laser energy.

The effects of lasers on eyes are threefold:

- Dazzling or induced glare.
- Flashblinding or loss of night adaptation.
- Permanent or semipermanent blinding.

The severity of laser eye injuries varies according to the incident power, spot size, beam angle, pupil diameter (ambient light conditions), temporal mode (CW or pulsed), and PRF of the laser. Reported effects include corneal burns, cataracts (a permanent cloudiness of the lens), and retinal burns and perforations. Low-energy laser weapons are capable of causing the latter.

Exposure to relatively low laser energies can produce temporary changes in the ability to see without producing permanent injury. Exposure to laser light can produce an effect called glare or dazzle, which is similar to the temporary loss of vision experience when viewing the headlights of an oncoming car. The visual effects last only as long as the light is present in the field of view (FOV). At slightly higher energy exposures, the same laser radiation can saturate or flashblind the photoreceptor cells, resulting in after images that fade with time after exposure. Only visible radiation will induce veiling glare or after images; near-IR radiation will not produce these effects even though the radiant energy reaches the photoreceptor cells. Flashblindness and dazzle, while not permanent injuries, can cause discomfort and temporary loss of vision. Some studies have shown that dazzle and flashblindness can seriously impact mission performance, especially in highly visual tasks such as piloting an aircraft or aiming.

Blinding is the permanent or semipermanent loss of visual acuity. The effect can last from several hours onward and generally is evidenced by a dark spot in the field of vision. This spot is called a scotoma. The impact of the scotoma on visual acuity will vary with the size and position of the injury. Human vision is greatly affected when the laser damage is to the central vision area of the retina called the fovea. Nonfoveal laser damage may be less severe or even go unnoticed because it affects only the peripheral vision. The most serious retinal injuries occur when the incident light is so intense that a perforation in the retina is formed, resulting in a hemorrhage into either the subretinal layer or, in the most severe cases, the vitreous humor of the eye. Less severe exposures result in lesions on the retina.

Footnote:

1-(U) This appendix is classified FOR OFFICIAL USE ONLY in its entirety.

Information Cutoff Date: 17 February 1998

~~**Derived from: Multiple Sources**~~
~~**Declassify on: Source marked "OADR"**~~
~~**Date of Source: 17 February 1998**~~

~~*SECRET*~~
~~*NOFORN*~~

Karolinska Institutet
Department of Neuroscience
Experimental Dermatology Unit

Stockholm, July 9, 2011

California Public Utilities Commission
Cc Susan Brinchman, Director, Center for Electrosmog Prevention, P.O. Box 655, La Mesa, CA 91944-0655, USA

To: The California Public Utilities Commission,

I understand that you at present are concerned about the fast deployment of smart meters on homes in California, without adequate sharing of information with the public.

I work as an associate professor at the Karolinska Institute; we are world-famous for our Nobel Prize in Physiology or Medicine, which we many times have awarded to your fellow countrymen and –women. I also uphold a professorship at the Royal Institute of Technology; it being closely tied to the Nobel Prizes in Physics and Chemistry. For many years I have been studying health effects of wireless gadgets, such as Smart Meters.

Wireless communication is now being implemented in our daily life in a very fast way. At the same time, it is becoming more and more obvious that the exposure to electromagnetic fields may result in highly unwanted health effects. This has been demonstrated in a very large number of studies and includes cellular DNA-damage (which may lead to an initiation of cancer as well as mutations that carry down generations), disruptions and alterations of cellular functions like increases in intracellular stimulatory pathways and calcium handling, disruption of tissue structures like the blood-brain barrier (which may allow toxins to enter the brain), impact on vessel and immune functions, and loss of fertility. It should be noted that we are not the only species at jeopardy, practically all animals and plants may be at stake.

Because the effects are reproducibly observed and links to pathology can not be excluded, the precautionary principle should be in force in the implementation of this new technology within the society. Therefore, policy makers immediately should strictly control exposure by defining biologically-based maximal exposure guidelines also taking into account long-term, non-thermal effects, and including especially vulnerable groups, such as the elderly, the ill, the genetically and/or immunologically challenged, children and fetuses, and persons with the functional impairment electrohypersensitivity (which in Sweden is a fully recognized functional impairment, and therefore receives an annual governmental disability subsidy).

Prompted by all this, a group of international experts recently published a very important paper, The Seletun Scientific Statement (2011). Among its points are:

1) Low-intensity (non-thermal) bioeffects and adverse health effects are demonstrated at levels significantly below existing exposure standards.

2) ICNIRP/WHO and IEEE/FCC public safety limits are inadequate and obsolete with respect to prolonged, low-intensity exposures.

3) New, biologically-based public exposure standards are urgently needed to protect public health world-wide.

Mailing address
Experimental Dermatology Unit
Department of Neuroscience
Karolinska Institutet
171 77 Stockholm
Sweden

Visiting address
Retziuslaboratoriet
Retzius väg 8
Solna

Telephone
Direct 468-52 48 70 58
Switchboard 468-52 48 64 00
Fax 468-30 39 04
Fax (KI) 468-31 11 01

Karolinska Institutet
Department of Neuroscience
Experimental Dermatology Unit

4) EMR exposures should be reduced now rather than waiting for proof of harm before acting. It is not in the public interest to wait.

5) There is a need for mandatory pre-market assessments of emissions and risks before deployment of new wireless technologies. There should be convincing evidence that products do not cause health harm before marketing.

6) The use of telephone lines (land-lines) or fiber optic cables for SmartGrid type energy conservation infrastructure is recommended. Utilities should choose options that do not create new, community-wide exposures from wireless components of SmartGrid-type projects. Future health risks from prolonged or repetitive wireless exposures of SmartGrid-type systems may be avoided by using fiber-optic cable. Energy conservation is endorsed but not at the risk of exposing millions of families in their homes to a new, involuntary source of wireless radiofrequency radiation, the effect of which on their health not yet known.

Many smart meters are close to beds, kitchens, playrooms, and similar locations. These wireless systems are never off, and the exposure is not voluntary. The smart meters are being forced on citizens everywhere. Based on this, the inauguration of smart meters with grudging and involuntary exposure of millions to billions of human beings to pulsed microwave radiation should immediately be prohibited until 'the red flag' can be hauled down once and for all.

The recent determination of the World Health Organization (WHO) to include radiofrequent radiation on the 2B list of carcinogens also applies to devices such as smart meters. Already September 4, 2008, the European Parliament voted 522 to 16 to recommend tighter safety standards for cell phones (Europ. Parl. resolution on the mid-term review of the European Environment and Health Action Plan 2004-2010). In light of the growing body of scientific evidence implicating cell phone use with brain tumors, the Parliament said, "The limits on exposure to electromagnetic fields [EMFs] which have been set for the general public are obsolete." The European Parliament "was greatly concerned at the Bioinitiative international report concerning EMFs, which summarises over 1500 studies on that topic and which points in its conclusions to the health risks posed by emissions from mobile-telephony devices such as mobile telephones, UMTS, WiFi, WiMax and Bluetooth, and also DECT landline telephones, and now it is again – and more firmly and seriously - repeated in the form of WHO's recent cancer classification.

With my very best regards,
Yourssincerely,

Olle Johansson, Assoc. Prof.,
The Experimental Dermatology Unit,
Department of Neuroscience,
Karolinska Institute,
171 77 Stockholm, Sweden
&
Professor,

Mailing address
Experimental Dermatology Unit
Department of Neuroscience
Karolinska Institutet
171 77 Stockholm
Sweden

Visiting address
Retziuslaboratoriet
Retzius väg 8
Solna

Telephone
Direct 468-52 48 70 58
Switchboard 468-52 48 64 00
Fax 468-30 39 04
Fax (KI) 468-31 11 01

Karolinska Institutet
Department of Neuroscience
Experimental Dermatology Unit

The Royal Institute of Technology,
100 44 Stockholm, Sweden

Mailing address
Experimental Dermatology Unit
Department of Neuroscience
Karolinska Institutet
171 77 Stockholm
Sweden

Visiting address
Retziuslaboratoriet
Retzius väg 8
Solna

Telephone
Direct 468-52 48 70 58
Switchboard 468-52 48 64 00
Fax 468-30 39 04
Fax (KI) 468-31 11 01