DA 16-676
Office of Engineering and Technology
Technological Advisory Council (TAC)
Noise Floor Technical Inquiry
ET Docket No. 16-191

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Dear Sir or Madam,

Thank you for opening a docket on Incidental and Unintentional Radiators, as well as Unlicensed Intentional Radiators, Industrial, Scientific, and Medical (ISM) Radiators, and Licensed Radiators. Regulation of these devices needs to be tightened substantially. Regulation was originally designed to prevent equipment from interfering with other equipment. We now know that the human body is extremely sensitive to that same interference. **Since the human body cannot be "hardened" to prevent "noise" (a source of radiofrequency (RF) exposure) from affecting it, regulations need to be tightened substantially to make technology safe.** Currently, polluting technology is causing serious health problems. Cars are one area that is becoming particularly problematic. For safety reasons, regulations governing intentional, unintentional, and incidental radiators in cars need much tighter regulatory control.

Earlier in 2016, **the U.S. National Toxicology Program (NTP) released results showing that exposure to non-thermal levels of RF radiation causes cancer and DNA breakage.** Furthermore, **a replicated European toxicology study showed that RF radiation promotes cancer growth**. I have attached a comprehensive discussion of the NTP results from http://ehtrust.org/science/facts-national-toxicology-program-cellphone-rat-cancer-study/. This alone provides an important basis for tightening regulations on *Intentional*, *Unintentional*, and *Incidental* RF levels in cars.

The Department of Interior stated **"the electromagnetic radiation standards used by the Federal Communications Commission (FCC) continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today."** in a comment on the serious danger that installation of microwave communication towers for FirstNet poses to migratory birds. http://www.ntia.doc.gov/files/ntia/us_doi_comments.pdf

U.S. Occupational Safety and Health Administration (OSHA) website acknowledges, "There are no specific standards for radiofrequency and microwave radiation issues." https://www.osha.gov/SLTC/radiofrequencyradiation/index.html

The Centers for Disease Control had precautionary statements posted on its website which were changed after attention was drawn to them (probably due to industry pressure). The original statements were "Along with many organizations worldwide, we recommend caution in cell phone use. More research is needed before we know for sure if using cell phones causes cancer."; "Scientific studies are ongoing. Someday cellphones may be found to cause health problems we are not aware of at this time."; and "Children who use cell phones – and continue to use them as they get older – are likely to be around RF for many years. If RF does cause health problems, kids who use cell phones may have a higher chance of developing these problems in the future." (http://www.prlog.org/12359483-cdc-issues-precautionary-health-warnings-about-

cell-phone-radiation.html) These statements have been replaced with statements expressing more uncertainty and calling for more research, in other words typical industry stall statements, very distinct from statements of safety (http://www.prlog.org/12362077-cdc-retracts-its-precautionary-health-warning-about-cell-phone-radiation.html).

At least 98 experts are calling for the FCC to modernize their outdated thermally-based RF limits because the limits do not protect from most biological effects and only apply to very short-term exposures for a large male (http://www.prlog.org/12245111-everything-you-wanted-to-know-about-cell-phone-radiation.html). Most of the population is now continuously exposed and most do not fit the description of a large male.

According to **The International Commission on Non-Ionizing Radiation Protection (ICNIRP),** "*Different groups in a population may have differences in their ability to tolerate a particular NIR (non-ionizing radiation) exposure. For example, children, the elderly, and some chronically ill people might have a lower tolerance for one or more forms of NIR exposure than the rest of the population. Under such circumstances, it may be useful or necessary to develop separate guideline levels for different groups within the general population, but it may be more effective to adjust the guidelines for the general population to include such groups. Some guidelines may still not provide adequate protection for certain sensitive individuals nor for normal individuals exposed concomitantly to other agents, which may exacerbate the effect of the NIR exposure, an example being individuals with photosensitivity.*" from ICNIRP STATEMENT, GENERAL APPROACH TO PROTECTION AGAINST NON-IONIZING RADIATION PROTECTION, (HEALTH PHYSICS 82(4):540-548; 2002) https://www.icnirp.org/documents/philosophy.pdf

In 2015, 220 scientists from 42 countries with over 2,000 peer-reviewed journal articles to their collective credit in the field of biological impacts from RF/EMF appealed to the U.N. and the WHO for greater precautions with regard to exposures from wireless technologies. This is the latest in many such alerts to the health effects of RF/EMF exposure https://www.emfscientist.org/.

Radiofrequency radiation, which includes the radiation emitted by wireless devices, as well as *Incidental* and *Unintentional* radiators, was classified by IARC as a class 2B possible human carcinogen, similar to lead, DDT, and chloroform, in 2011.[1] There are an increasing number of experts stepping forward to say that that classification should be changed to either 2A "probable" carcinogen[2] or even class 1 - carcinogen.[3] Even if the classification is not changed, exposure to a class 2B carcinogen should be minimized in vehicles, especially in light of the aforementioned NTP carcinogenicity findings.

There are numerous studies showing that radiation from wireless technology seriously harms a variety of animal species and also plants, impairing reproduction, growth, and navigation.[4,5,6]

The Soviet Union performed large amounts of research and found biological effects at levels far below our "safety" guidelines, hence their much lower safety limits.[7] Our current safety regulations are not designed to protect people from the non-thermal hazards posed by transmitting meters or other devices. The FCC "safety" standards are solely designed to protect a 6 ft 185 lb man from tissue heating during a short (6 minute) exposure. They are not designed to protect even a 6 ft man from biological effects during a continuous exposure.[8] They are not designed to protect women, children, and smaller men even during short-term exposures. Since the general population is continuously exposed, these "safety" standards are meaningless for the population as a whole.[9]

A number of studies show that electromagnetic radiation, including radiofrequency radiation, alters heart rate variability, blood pressure (including inducing hypertension with microwave exposure) and increases risk of arrhythmia related heart disease and heart attack.[7,10,11,12,13]

Recent replicated double blind studies show that a cordless phone base station operating at WiFi frequencies can cause cardiac arrhythmias in susceptible individuals.[11,12,13] This short video discusses the cardiac effect that wireless can have- http://www.youtube.com/watch?v=_EI9fZX4jww. View this video http://www.youtube.com/watch?v=sv1E9IXUd6M to see further discussion, including the fact that regular screening for cardiac susceptibility prior to exposure, and at least yearly thereafter, would be recommended according to RF exposure protocols. The very serious consequences of cardiac arrhythmia or arrest while operating a vehicle should impel the FCC to tighten RF limits on all classes of RF emitters in vehicles.

Obviously, wireless technology does not belong in cars - if it can induce arrhythmia, it can also cause cardiac arrest, a fact Frey proved in frogs years ago.[14] **Cardiac arrest is undesirable at any time but when a person is operating a large potentially lethal object, it is particularly so.** Cardiac arrest has also been related to other RF exposures [15] so RF exposures from *Unintentional* and *Incidental* emitters should also be minimized.

Wireless technology was NOT safety tested prior to release. Safety is only "proven" by continued industry insistence that the only way wireless technology can have any biological effect is through thermal or tissue heating effects. This is totally untrue. Disconnect by Devra Davis, an epidemiologist, discusses the coverup and research supporting non-thermal biological effects at great length. She also discusses research done years ago demonstrating the ability of pulsed microwave radiation to stop the heart. Cellular Telephone Russian Roulette (http://microondes.files.wordpress.com/2010/03/robert_c_kane_cellular_telephone_russian_roulette.pdf), written by Robert C. Kane, a former Motorola engineer, discusses the fact that numerous studies show that significant biological effects occur at such low levels that useful wireless technology is by definition unsafe wireless technology. He further discusses the problem of microscopic, but biologically harmful hot spots which occur at levels far below those normally considered to cause thermal harm.

There is extensive documentation in the literature of alterations of Ca^{2+} homeostasis.[10] This is likely to be responsible at least in part for the profound effects that radiofrequency radiation has on the heart and neurological function. Ca^{2+} regulates gap junction opening. Gap junctions are key in many intercellular communications. "*Microwave electromagnetic fields act by activating voltage-gated calcium channels: why the current international safety standards do not predict biological hazard*" has concrete suggestions for how to quickly enact a first revision of the FCC RF safety limits to protect against many of the biological effects of exposure to RF. [16] RF can have serious psychological effects, including anxiety, irritability, and depression. Links are also made to psychosis and other psychological disorders. [17] With all the problems with road rage etc., the last thing this country needs is for drivers or passengers to be exposed to any more RF in their vehicle than absolutely necessary. There is plenty of evidence to justify a meaningful initial revision of FCC vehicle safety codes to minimize RF exposure from all sources within vehicles while further study is done to determine the shape of future revisions.

Exposure to radiofrequency radiation also interferes with the action of enzymes, signaling pathways, and makes the immune system simultaneously hyperactive and less effective.[10,18] Immune impairment results in part from the disruptive effect of radiofrequency radiation on calcium ion homeostasis. In addition to radiofrequency radiation-induced immune impairment increasing risk of various types of infection, it is likely to increase the risk of getting cancer from the DNA breakages radiofrequency radiation is well-documented to induce. [19] Now also substantiated by the NTP results. While radiofrequency radiation is non-ionizing, the metabolic changes it can cause result in oxidative damage to DNA and subsequent breakage. Direct interactions between radiofrequency radiation and DNA can have similar results, as well as causing changes in gene transcription, through changes in electron flows induced by the radiation.[19]

Neurological function can be seriously impaired by radiofrequency radiation. Cholinesterase enzyme activity is impaired by exposure to radiofrequency radiation in a manner similar to impairment caused by organophosphate pesticides, often rendering a person with radiofrequency sickness particularly sensitive to small amounts of chemicals.[20] Radiofrequency radiation can lower the pain threshold, slow reaction times, cause fatigue, muscle weakness, headaches, difficulty concentrating, short-term memory problems and even memory loss.[7,18,19,21] These may be caused by disruption of Ca^{2+}, disruption of various enzyme pathways, induction of the stress response and associated effects, increased permiability of the blood-brain barrier, or various other effects of over-exposure to radiofrequency radiation.[7,10,20]

Radiofrequency radiation significantly decreases melatonin levels, causing poor quality sleep, and also decreases the ability of existing melatonin to fight cancer.[10]

All these biological effects are good reasons to REMOVE sources of exposure to RF from vehicles. A review of old Soviet literature discusses the fact that reflexes, including conditioned reflexes, are slower in individuals exposed to RF. They go on to state "It is possible to observe degeneration of the neurons in the cerebral cortex and the basal ganglia, the pons, the medulla oblongata, and in some cases even the cerebellum, as well as histological and chemical changes in the vicinity of nerve fibers." Obviously, it is not a good idea to have an environmental toxin that can impair reflexes and damage nerves inside vehicles whose safe operation relies on those very reflexes and good neurological and brain function.[7]

Many more people are adversely affected by RF radiation than realize it. Radiation from wireless devices may exacerbate the effects of a distraction such as conversation and impair reflexes and slow brain processing even at the lower levels phones emit when not connected. This may occur in part due to RF lowering dopamine levels, [22] as well as the other effects mentioned above.

"A Comparison of the Cell Phone Driver and the Drunk Driver" shows delays in reaction times that may relate to the RF emissions from the phone.[23] Unfortunately, driving studies have not been designed to examine whether it is the RF emissions of the phones that are causing the problem. In "Examining the Impact of Cell Phone Conversations on Driving Using Meta-Analytic Techniques," the authors state "There was a similar pattern of results for passenger and remote (cell phone) conversations."[24] However, it is not clear whether both driver and passenger had their cellphones on and emitting at the time of the conversation, which would obviously be a confounder. Measuring Cognitive Distraction in the Automobile,[25] a recent report on distracted driving also provides data additional technology in cars may not be safe. Unfortunately, the potential effect of the RF exposure itself whether from transmitters, electronics, or the vehicle electrical system was not factored into the experimental design. An article with the great title "*A Problem of the Brain, Not the Hands: Group Urges Phone Ban for Drivers*" (http://www.nytimes.com/2009/01/13/health/13well.html?_r=1&) probably has it right - although perhaps not for the right reason. Radiation from cellphones does indeed interfere with brain function, thus it may matter little whether the driver is conversing on a phone they hold, hands-free, or, indeed, with a passenger, as long as phones are on in the car or the area is high in wireless radiation. Ambient microwave radiation levels have gotten quite high in many metropolitan areas.

There are long-term public health implications of wireless radiation exposure. Detrimental biological effects, distinct from tissue heating effects, have been extensively documented in studies at a range of different frequencies and at levels below the current United States safety standard.[10,26,27] Many other nations already have more rigorous safety standards than does the US. Microwave and radiofrequency radiation are now being associated with attention deficit disorder, autism, sleep disorders, multiple sclerosis, Alzheimer's disease and epilepsy, as well as asthma, diabetes, malignant melanoma, breast cancer, and other illnesses that have become increasingly more common. Please see www.bioinitiative.org to read a 2012 review of the peer-reviewed science on the long-term risks of exposure to transmitted microwave and radio frequency

radiation. Studies finding no health effects are predominantly industry funded.[28] A report by Hallberg and Johansson[29] published recently in Pathophysiology asks the provocative question about whether the recent (1997 and later) increase in exposure to microwave frequencies may be responsible for the recent decline in public health in Sweden. The data seem to say that public exposure to microwave frequencies is a likely culprit.

Independent reviews such as "Criticism of the Health Assessment in the ICNIRP Guidelines for Radiofrequency and Microwave Radiation (100 kHz - 300GHz)" (www.electricalpollution.com/documents/Cherry2000EMR_ICNIRP_critique_09-02.pdf), first completed on behalf of Ministry of Health/ Ministry for the Environment of New Zealand, and the BioInitiative Report, written by highly qualified independent scientists (www.bioinitiative.org), conclude that there are biological effects at levels well below existing safety limits. Both reviews find existing RF limits to be completely inadequate.

In light of the very serious threat that RF poses to public health, limiting exposure to RF in vehicles from all sources makes sense. This would have the added benefit of providing persons with radiofrequency sickness a safe method of travel and allowing them to fully exercise their civil rights.

Radiofrequency sickness is a functional impairment caused by overexposure to radiofrequencies, which includes the pulsed modulated microwave frequencies used in wireless communication, as well as *Incidental* and *Unintentional* radiators.[7,10,20,21] Once one has radiofrequency sickness, exposure to radiofrequencies causes functional impairments which can range from frustrating to life-threatening. EHS or electrohypersensitivity, which often encompasses radiofrequency sickness, affected 3% of the population twelve years ago, according to the California State Department of Health. More recent independent studies show the numbers may be higher now. A recent Amicus Brief discusses recognition, prevalence, etc.[30]

The proliferation of wireless technology is increasing the number of people with radiofrequency sickness and also restricting the daily activities of people with radiofrequency sickness. Past rules changes have made it more difficult for people with radiofrequency sickness to get vehicles that do not give them symptoms - one example is the requirement for wireless tire pressure gauges. While the radiation levels emitted are below the FCC guidelines, that is irrelevant in terms of biological symptoms and safety, as previously discussed. A rules change that results in minimizing RF levels in vehicles would benefit everyone, improving public health, but it would particularly benefit the growing segment of the population experiencing RF sickness.

The FCC has extra responsibility under the American's with Disabilities Act (ADA) to make personal vehicles safe for persons with radiofrequency sickness since private vehicles are often the only way people with radiofrequency sickness can travel due to the rampant proliferation of wireless technology.

Symptoms that occur with RF radiation exposure vary depending on the particular frequencies involved, their amplitude, and the duration of exposure and the size, height, and build of the exposed person. Headache, brain-fog, short-term memory loss, scattered thinking, irritability, nerve pain, muscle weakness, heart palpitations, and appetite loss are common. Longer stays in polluted environments intensify and worsen the symptoms.[7]

It is important that the FCC Office of Engineering and Technology promulgate rules related to vehicle engineering to minimize RF exposure from all sources within vehicles so that vehicles are not causing radiofrequency sickness in previously well individuals and such that there are well-engineered vehicles that are safe for people with radiofrequency sickness.

Radiation from wireless devices is not the only source of exposure to RF in cars. High frequency signals on wiring also occur in cars and cause radiofrequency sickness. Milham and Morgan found a dose-response

relationship between high frequencies present on building wiring and cancer.[31] Removing high frequencies on building wiring has improved MS symptoms, blood sugar levels, asthma, sleep quality, teacher health, headaches, ADD, and numerous other health problems.[32,33,34] 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.[35] Another technical paper 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.[36] The induced currents disturb normal intercellular communications. This causes harmful short-term and long-term effects. The effects seem to be the same whether the system is AC or DC since the most biologically active component is the "noise" from poorly engineered devices. (Please see www.electricalpollution.com for more information.)

Electrical engineering and biological sciences are largely separate disciplines. Biologists, molecular biologists, and doctors have been largely unaware of the high frequency pollution of electrical systems (AC and DC). The assumption, until recently, by biologists was that AC and DC systems were "clean". This is not so and has not been so for many many years. This has been well known by electrical engineers, but they have been taught that from a biological standpoint it is insignificant, after all the pollution, even in extreme cases, usually does not amount to much more than a couple of volts and in many cases is measured in millivolts. However, the assumption of safety is proving not to be true.[31,32,33,34,35,36] This shows the importance of establishing vehicle standards that reflect the biological reality, especially since any biological impairment caused by poor engineering could cost lives. If proper standards are established, and the above mentioned references offer a good basis for establishing initial standards, safe un-polluted cars can be engineered. This would benefit everyone in the long run and decrease the isolation of people with radiofrequency sickness.

Cars used to be lower RF environments. They now have wireless tire pressure gauges, bluetooth, wifi, cellphones, large stereo or even video systems in close proximity to drivers. Unfiltered and unshielded spark plugs, ignition switches, alternators, fuel pumps, and a variety of other DC motors also contribute RF that is conducted around the car on wires and returned on the frame, often leading to recognized RF interference problems * and unrecognized RF health problems. These problems have worsened as cars have had more and more electronics and wiring installed. RF used to be limited to *Incidental* and *Unintentional* sources and in basic models with mostly mechanical features, the exposures were tolerable. More electrical wiring which conducts the "noise" into close proximity to occupants causes RF health effects due to increased exposure through capacitive coupling and radiation from wiring. Furthermore, RF health effects result from cumulative exposure, so the more there is overall, the less tolerance there is for the contribution of any one source. **In addition to requiring minimization of *Incidental* and *Unintentional* RF exposure through good engineering, the FCC should require all current be conducted on wires.** The frame should only be used as a ground, not a return.

Our family's experience with RF-induced functional impairment, supported by the literature and many other first-hand reports, strongly suggests that the proliferation of wireless technology and electrically polluting electrical technology is a serious public health threat that is likely to be behind many of the rapidly increasing public health problems such as multiple sclerosis, fibromyalgia, chronic fatigue syndrome, diabetes, asthma, allergies, migraines, ADD/ADHD, sleep disorders, etc. Please publicly acknowledge the inadequacy of the current thermally based FCC guidelines and re-evaluate vehicle standards to require safe clean electrical systems and eliminate transmitters from within the vehicle. Filtering of electrical systems can be quite simple and inexpensive and should be undertaken in all vehicles by the manufacturers. A further step toward safety would be to include a shielded compartment for the storage of cellphones and tablets so that even those who do not know how to turn them completely off will be safer drivers. Manufacturer installed wireless technologies should be banned within the vehicle to minimize driver impairment. In fact,

great attention should be paid to whether electronics installed within vehicles contribute to impaired driving and unsafe passenger conditions. Certain types of installations, such as screens on the backs of headrests, may need to be banned.

In short, automated vehicles utilizing wireless signals (V2V), other wireless technologies installed in the vehicles, and polluting electrical technology are unsafe and access-limiting. Please protect the health and rights of the citizens of this great country - enact biologically-protective RF limits for all sources of RF within vehicles.

The Stetzerizer "dirty" electricity meter was evaluated in Kazakhstan and health standards were set such that no more than 50 G/S units of dirty electricity should be allowed on building wiring to protect health (www.electricalpollution.com/documents/Sanitary_Norms.pdf) and attached. Standards in cars may need to be even tighter due to proximity and the serious risk driver cognitive impairment or cardiac effects pose to the public. Frequencies above the range of the Stetzerizer meter should also have much tighter standards. Their effect is related to capacitive coupling and energy. New standards should extend the full frequency range of existing and future intentional and unintentional transmitter output and be tight enough to protect human health.

Thank you.

Sincerely,

Catherine Kleiber

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http://ehtrust.org/science/facts-national-toxicology-program-cellphone-rat-cancer-study/

Frequently Asked Questions About The U.S. National Toxicology Program Radiofrequency Rodent Carcinogenicity Research Study

The U.S. National Toxicology Program Radiofrequency Carcinogenicity Research Study

On May 27th, 2016, the U.S. National Toxicology Program, of the U.S. National Institutes of Health, released a report with partial results of their large study on the carcinogenicity of radiofrequency radiation (RFR, also known as microwave radiation) in male and female rats and mice.

The world's largest, most well-designed study of its type, at a cost of $25 million, found increased occurrence of rare brain tumors called gliomas in male rats and increases in nerve tumors called Schwannoma of the heart, thymus and mediastinum in both male *and* female rats exposed to RFR. The released results are "partial" because more rat results and all of the mouse study results will be forthcoming, by 2017.

Study Design And Results

How Were The Animals Exposed?

Animals were exposed daily during gestation and for two years after their birth to two commonly used types of RFR—Global System for Mobile (GSM) and Code Division Multiple Access (CDMA). For each type of RFR there were three exposure groups: 1.5 W/kg, 3W/kg, and 6 W/kg.

The rodents were housed in specially designed underground chambers for uniform RFR exposure.

RFR exposures were 10-minutes on, 10-minutes off for 18 hours a day, resulting in a total exposure of 9 hours daily.

Exposure intensity was at low *nonthermal or non-heating levels*. Heating from microwaves is the only adverse effect recognized by US regulators, who rely on standards set almost two decades ago. The NTP study set exposures at low levels determined *not* to heat the body in order to test if biological effects occur at non-thermal levels.

What Cancers And Tumors Were Found?

Increased incidence of gliomas, a rare and aggressive, highly malignant brain cancer, as well as schwannomas (a rare tumor of the nerve sheath) of the heart were found in both sexes but reached statistical significance only in males. Overall, there were more brain abnormalities and tumors in exposed male rats than in exposed female rats. In humans, gliomas are also more common in men than in women.

In addition to the gliomas, there were significantly more rare, pre-cancerous changes in the glial cells of the brain in both sexes, while not a single one of the unexposed control animals developed these same abnormal brain cells. Male rats exposed to all levels of CDMA developed exceptional numbers of damaged, pre-cancerous brain cells (glial hyperplasia). Both male and female rats, exposed to all levels of microwave radiation, developed increased incidence of rare malignant tumors of Schwann cells (nerve sheaths) of the heart. Females exposed to all levels of CDMA also developed precancerous hyperplastic Schwann cells, while none of the unexposed controls developed this rare abnormality.

It should be noted that this partial report focused only on these brain and heart tumors, and that additional results from the rats study will be released by 2017.

How Strong Are These Results?

"Game-changer" is increasingly being used to describe these results. For decades people believed that microwave radiation at low (non-heating) levels is safe and cannot cause harm. The NTP results clearly show that this assumption is false. Microwave radiation can cause harmful effects even at low non-heating- levels.

Although the results show "low" increases in tumors, these tumors are quite lethal. Moreover, even a small increase can have a great impact. As the NTP report stated, *"Given the extremely large number of people who use wireless communication devices, even a very small increase in the incidence of disease resulting from exposure to the RFR generated by those devices could have broad implications for public health."*

Significantly more gliomas were seen in males exposed to CDMA (95% confidence level). Positive trends for a greater number of tumors at higher doses were observed for both gliomas and schwannomas o

f the heart in males. Both the trends and the replication make these very strong results.

Why Is This Study Considered A "Landmark" Study?

These results are very significant for three reasons:

1. In case-controlled studies, humans develop the same types of tumors from cell phone exposures. Epidemiological studies in humans show increased risks for gliomas and schwannomas after long-term use of cell phones – these are the same types of tumors that were found in the exposed rats.

1. The results show adverse biological effects at non-thermal levels meaning that current international regulations (based on avoiding heating) do not adequately protect public health.

The NTP study was designed to test if the basis for government safety standards is accurate. Current safety standards are based on the premise that only RFR levels that cause heating are harmful. The study was carefully designed to ensure that the body temperature of the exposed rats did not increase significantly. *Yet an effect was shown at non-thermal levels.* The NTP study provides well-documented, scientific evidence that current international regulations are based on a faulty assumption.

1. The results add significant weight to the scientific evidence that radio frequency radiation is carcinogenic.
    - In 2011, the International Agency for Research on Cancer of the World Health Organization (IARC/WHO) classified radio frequency radiation as a Class 2B "possible carcinogen." One of the reasons for the classification "possible" was because human epidemiological studies showed increased brain tumors after long term exposures, however, *more evidence* was needed from animal studies showing carcinogenicity and a mechanism of action. The recent NTP results provide new, well-designed research evidence in animal models that links RFR to cancer. As the NTP stated, "These findings appear to support the International Agency for Research on Cancer (IARC) conclusions regarding the possible carcinogenic potential of RFR."

Is It True That The Ntp Study Found Dna Damage In The Exposed Animals?

Yes – the NTP study found statistically significant evidence of DNA damage. The preliminary data with comet assay showed a statistically significant trend in RF-induced DNA damage in both rat and mice brain tissues. These findings were shared by the National Toxicology Program during the BIOEM 2016 Annual Meeting.

Associate Director of NTP John Bucher described some of the DNA findings in a Science Magazine interview stating that, "In a small side experiment of the NTP study, DNA from the tissues of 80 mice and rats that had

spent 90 days in the reverberation rooms were examined for breaks in the DNA strands. There was more DNA damage in some of the rodents that received the highest radiation levels."

Genotoxicity findings will be published in the forthcoming paper from the NTP rodent study entitled "Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure" (as noted on page 3 of the released NTP Report).

Is This Study Well Designed?

This $ 25 Million Study is, in fact, the world's largest and most comprehensive rodent study of radiofrequency electromagnetic fields. The design of this study was presented at an annual meeting of the Bioelectromagnetics Society prior to the start of these studies.

According to Ron Melnick PhD, *"the overwhelming opinion expressed by the meeting participants was that this would be the largest and most comprehensive study in animals exposed to cell phone radiation, and that the results from this study would trump all other animal carcinogenicity studies of this agent."*

Seven thousand rodents were used for the entire study, which used a three-phased study design: (1) Pilot studies to establish field strengths that did not excessively raise body temperatures; (2) Subchronic toxicology studies in which the rodents were exposed to various low-level field strengths for up to two months; and (3) Chronic toxicology and carcinogenicity studies in which the rodents were exposed prenatally and for the majority of their lifetime (up to 24 months). The chronic exposure study employed seven groups of 90 rats: a sham control group that was not exposed to the radiation, and three groups for each of two common types of cell phone signal.

Why Was This Study Initiated?

The US Food and Drug Administration (FDA) nominated this study because, "There is currently insufficient scientific basis for concluding either that wireless communication technologies are safe or that they pose a risk to millions of users. A significant research effort, including well-planned animal experiments, is needed to provide the basis to assess the risk to human health of wireless communications devices." Read the FDA Nomination here.

The National Toxicology Program Testified to US Congress that, "The FDA nomination was based on the following concerns:

- There is widespread human exposure;
- Current exposure guidelines are based on protection from acute injury from thermal effects;
- Little is known about the potential for health effects of long-term exposure; and
- Sufficient data from human studies to definitively answer these questions may not be available for many years."

The recommendation for the NTP study was made in 1999 with a contract signed in 2005. It is years behind schedule as results were due to be published in 2014. See the slide presentation that the NTP gave in 2013 here describing the experiments initial results. See slides from 2009 NTP presentation describing the experiment setup.

What Was The Objective Of The Study?

According to Ron Melnick who lead the study design, the researchers wanted to test the hypothesis that *cell phone radiation could not cause adverse health effects at levels that did not cause heating.* The study was designed to provide data to characterize dose-response for any detected toxic and/or carcinogenic effects of cell phone radiofrequency radiation (RFR) in Sprague-Dawley rats and B6C3F1 mice exposed unconstrained in reverberation chambers.

At the time the study was initiated, slightly more more than 100 million Americans used wireless communication devices, yet guidelines for cell phone radiation were (and still are) are based largely on protection from acute injury from thermal effects. The researchers were aware of several ongoing animal studies, but felt they might not

provide an adequate challenge to the null hypothesis, so the NTP set out to design the world's largest animal study on radiofrequency radiation to date.

Some Clarifications In Response To Concerns Raised In The Media

Does The Fact That Increased Numbers Of Tumors Were Statistically Significant In The Male Rats, But Not In The Female Rats, Mean The Findings Of Carcinogenicity Can Be Dismissed?

No. In *previous* NTP toxicology studies male rats were *more than ten times more likely* to develop malignant gliomas (brain tumors) than females. For malignant schwannoma of the heart, males were *more than twice as likely* to develop this type of cancer than the females. (These statistics called "historical control incidence" are documented in the NTP report at the bottom of the tables starting at page 9.)

Microwave News quoted Ron Melnick's comments on the sex differences:

"It is not surprising that the exposed males had more tumors than the females given what we have seen in the historical controls. But we can go one step further, the fact that we saw any of these tumors in the exposed females but none in the concurrent controls adds support to the conclusion that cell phone radiation leads to cancer among rats."

These gender-specific results are not uncommon in animal carcinogenicity research studies. As the American Cancer Society explains in their statement about the NTP results, "It's important to note that these sorts of gender differences often appear in carcinogenic studies, so the fact they show up here should not detract from the importance of the findings."

Analyses of NTP bioassays show that "male rats are more sensitive to chemical carcinogens compared to female rats." The fact that male rats are more likely to show carcinogenesis in NTP studies is well documented in "Gender differences in chemical carcinogenesis in National Toxicology Program 2-year bioassays".

It is also important to note that in human studies, gender differences in cancer incidence and mortality is a regular finding.

Notably, in the NTP study, increased incidence of rare malignant tumors of Schwann cells (nerve sheaths) in the heart was found in both male *and* female rats, as were precancerous hyperplastic Schwann cells. The findings in the female rats were not statistically significant, but these tumors are known to occur more rarely in females.

The NTP findings cannot be dismissed because of the gender differences.

Were The Results Peer Reviewed?

The findings have undergone extensive reviews. The biological tissue analyses were reviewed by multiple pathologists and statisticians who were unaware of the test agent being evaluated, and looked solely at the obtained slides. The report has addressed several expert reviews with responses that are appended to the online document.

The National Toxicology Program states in the abstract, "The findings in this report were reviewed by expert peer reviewers selected by the NTP and National Institutes of Health (NIH). These reviews and responses to comments are included as appendices to this report, and revisions to the current document have incorporated and addressed these comments."

Results have not yet been published in a journal but were released early by the NTP because of their importance for public health.

Is The Statistical Power Strong?

Typically, in this type of testing the NTP uses 50 animals per group. For this study they used 90 animals per group, as such, so it may be considered a large study relative to other similar animal studies. The expected background rate of the two tumors that have been found (glioma and Schwannoma of the heart) is also extremely low.

The chances of finding a true effect–or power of a study– depend on two principal things: (1) the size of the sample studied and (1) the size of the expected occurrence of the endpoints under study. With smaller numbers of animals, the chances of finding an effect—called the statistical power—would have been lower. Studies that are underpowered do not have enough data to present a full and clear picture. Had more animals been studied, there might have been further positive associations, possibly resulting in statistical significance in the female rats as well. The NTP finding of positive results in *multiple* tumor types means that these study results are even more important.

As Associate Director of the U.S. National Toxicology Program John Bucher stated in the May 27, 2016 NTP Press conference, "The power to detect these tumors is probably in the range of between 10% and 20%, which also actually makes it more interesting that we have found statistically significant findings."

Contrary to some claims about this study, false positives are not a significant concern. The reason that clinical trials (such as those Dr. Lauer conducts) use large numbers of people is to increase their chances of finding a true effect. The smaller the sample, the greater the chance of NOT finding an effect *when one is actually there*–also called a false negative.

Control Group Animals Did Not Develop Either Schwannomas In The Heart Or Gliomas. The Control Group Animals Also Did Not Live As Long As Those That Were Exposed. Does This Call Into Question The Validity Of The Study?

NTP scientists carefully considered this question. Control group lifespans were within historical ranges, and a statistical procedure was used so as not to over-estimate risks. In fact, it is not surprising to see that the stresses of RFR exposure might contribute to increased lifetime while also contributing to serious health damage. For example, calorie-restricted animals live longer on average. It is important to note that other statistically significant effects from exposure were seen early on, as the pups exposed *in utero* had lower body weights at birth and remained at a lower weight throughout their lifetimes.

The mortality rates are not as important a fact as it seems when the data is analyzed. First, there was no statistical difference in survival between control male rats and those exposed to CDMA at 6 W/kg (the group with the highest rate of gliomas and heart schwannomas); at week 94, survival of rats in these two groups were the same. Second, no glial cell hyperplasias (potential precancerous lesions) or heart schwannomas were observed in any control rat, even though glial cell hyperplasia was detected in a CDMA-exposed rat as early at week 58 and heart schwannomas were detected as early as week 70 in exposed rats. If the control rats were going to develop tumors, these precancerous lesions and tumors *would have already been present*. Yet not a single control had any evidence of an effect.

It is notable that a US Air Force study from the 80's which also found increased cancer also showed chronic RF exposure increased life span in rodents. The median survival time was 688 days for exposed animals and 663 days for the sham-exposed.

In This Study, The Exposed Group Developed Tumors At Rates Comparable To Historic Rates Of Tumors In Rats In Other Such Studies. How Is This Finding Considered Statistically Significant?

Most importantly, in every study, *the preferred control group is the present one*, as every detail of feed, housing, etc. is truly identical. If all groups of rats are treated the same in the same experiment and only the exposed group has a statistically significant effect, then an effect has been shown.

A crude analysis comparing all controls—historic and present—with all exposed animals in the present study still shows a consistently increased probability of developing cancer.

This chart shows the percentage of exposed rats that got tumors as compared with the percentage of the same tumor in all current and historical control rats. *In every case there were more tumors in the exposed group than in the control group.*

Probability of cancer compared with all controls, in rats in NTP wireless radiation study

>>	Ratio of % exposed cases / % cases in all controls including historic
Glioma	
Male	1.19
Female	3.50*
Schwannoma	
Male	3.08
Female	2.19

*gliomas are extremely rare in these female rats; there were more gliomas in males, both in unexposed and exposed animals, so the ratio is lower.

The Rats Were Exposed For Nine Hours Per Day For Two Years, Over The Whole Body, With Some At Levels Higher Than Cell Phones. How Is This Study Relevant To People?

The study is relevant to humans because it tests the scientific basis for current cellular communication safety regulations, which are intended to protect humans from adverse health effects.

In case-control studies that compare persons with brain cancer to matched controls without the disease, increased gliomas have been seen with less than 1,000 hours of cell phone exposure. Animal studies typically last two years, or the lifetime of the rodent. The animals are specially bred in an attempt to induce tumors in an animal with a short lifetime. The overall exposure of the rats is set to approximate that of humans.

Government safety regulations for microwave radiation are based on the assumption that *"as it does not heat you, it will not hurt you."* To test the "no-heating" cut-off for harm, animals were exposed up to almost the maximum dose they could tolerate with no increase in body temperature. The animals in this experiment never had an increase in body temperature over one degree Celsius. This study shows that adverse biological effects occur at non-thermal (non-heating) levels.

Dr. Moskowitz calculated the overall risk for the male rats in the group exposed to the lowest intensity of cell phone radiation (i.e., 1.5 watts/kilogram or W/kg). He found 12 of 180 (or 1 in 15) male rats in the exposed group developed cancer or a precancerous lesion. He concluded that, "This latter finding has policy implications as the FCC's current cell phone regulations allow cell phones to emit up to 1.6 W/kg at the head or near the body (partial body SAR)."Read his review here.

Why Was Keeping The Rats From Overheating So Important?

Exposure to high levels of RFR energy, particularly at microwave frequencies, can rapidly heat biological tissue. This is known as a *thermal effect*. Thermal effects can cause harm by disrupting biological processes, and damaging tissue. Government safety regulations require mobile phones and wireless devices to operate at power levels well below the threshold for known thermal effects.

The study was carefully designed to ensure that the exposed rats did not have an increase in temperature beyond one degree, so the tumor development reflects a "non-thermal" mechanism of action. If adverse non-thermal effects are confirmed, then cell phone and wireless device emissions regulations will need to be re-evaluated *because they would not be protecting humans from non-thermal effects*. This is precisely why this NTP study is so significant.

Why Were Effects For Cdma-Modulated Rfr Exposures Different From Gsm?

Code Division Multiple Access (CDMA) and Global System for Mobile (GSM) are two *different* communication technologies. CDMA is the primary type of technology used for cell phones in the United States with providers including Verizon, Sprint, and US Cellular. GSM is the primary type of technology used for cell phones in the rest of the world. In the United States, T-Mobile and AT&T use GSM. Europe adopted GSM technology in the 1980s, and users will not find access to CDMA networks in any European countries.

It is unclear why the more modern modulation (CDMA) proved to be more harmful, and there is no way to determine this from the NTP study. However, it makes sense that the body, at a cellular level, might have a different reaction to a different types of exposures and waveforms, *even if the power level is the same.*

Swedish cancer researchers have reported differences in gliomas associated with different modulations, with the more recent technologies appearing to have more of a biological effect. Modulations are evolving to transmit more data faster at a given frequency, and this results in higher peak to average power ratios. In the lab, it is notable that experiments using real-life devices are much more likely to find significant effects.

This is an important finding, that hopefully will spur researchers to explore in future studies how different radio frequency radiation technology impacts the body. Until recently, regulators considered the power density of the radiation (linked to heating) important for human health and the issue of modulation was assumed to be less significant. *However, the reality is that cellular communication signals are very complex and all signal characteristics, such as modulation, waveform, and power density, must be considered.*

This is a topic of great concern as we prepare to move to newer technologies, driverless cars, and more and more wireless in schools with young children.

The Study Is Not Applicable To Modern Cell Phones And Wireless Devices. Cell Phones Are Now Using Even Newer Technology That Uses Even Lower Power.

In fact, the newer technology may have more adverse effects. These newer devices involve technology with greater variations in pulsed signaling the information content of signals that are being used. The pulse of the signals may well prove to be more important biologically than their power. The biological effects of the NTP study that produced an increase in cancer occurred *without heat.*

In addition, the NTP animals were exposed solely to *one frequency* throughout their lifetimes. This scenario does not even compare to the real life exposures we are exposed to. People are now exposed to *multiple* exposures

from multiple devices in our everyday environment. Each device itself often has multiple antennas. The combined effect of such microwave radiation exposures is a matter of serious concern in light of these findings of increased cancer in the NTP animals which were exposed to just *one frequency* at non-thermal levels.

Cell Phones Have Been Around For Decades And If They Caused Cancer Brain, Then Cancer Rates Would Be Rising. Instead Research Shows Brain Cancer Rates To Be Steady For The Last Few Decades. These Results Must Then Be Wrong.

Brain tumours are now the leading cancer in American adolescents, and *the incidence of the most aggressive gliomas (a category of brain tumors) are rising in young US adults* according to the American Brain Tumor Association's largest, most comprehensive analysis of these age groups to date. This study shows increased yearly incidence of the following brain tumors: anaplastic astrocytoma, tumors of the meninges, tumors of the sellar region and unclassified tumors. Glioblastomas, the type of brain cancer found to be linked to cell phone radiation in the NTP study and in human studies, are increasing in those age 15-39 in the United States.

These increases are *not* evident in population based research studies when the incidence of *all* brain cancers "overall" are considered. As Microwave News points out in a detailed analysis of this rise of glioblastomas, "The higher incidence of glioblastomas is being masked by the lower rates of the other types of brain cancer."

International registries have *also* indicated an increase. Zada et al, 2012 shows an increase in brain tumors in three major cancer registries in the United States. An Australian study showed an overall significant increase in primary malignant brain tumors from 2000 to 2008, particularly since 2004 (Dobes 2011).

Brain cancers are slow growing and can take decades to develop after a toxic exposure. For example, studies of smokers found no increase in risk just ten years after most have begun to smoke. While cell phones have been around for decades, the majority of cellphone users have only become heavy users recently, so it is not likely that a large *overall* increase in incidence rates will have appeared yet. Research shows increased prevalence in the most aggressive malignant forms of brain cancer in younger people; however, since brain tumors are predominantly a disease of aging, and there are not increases in all *other* tumor types, the level of brain tumors "overall" is not rising.

More importantly, population based studies are not the best way to assess the cell phone cancer link. Instead, research looking at high-risk groups using case-control designs are more suited to showing cancer risk from cell phones. All independant research using a case control design that looked at long term (ten years plus) users have showed increases in brain cancer.

Read Dr. Davis, Dr. Miller and Lloyd Morgan's response in Oxford University Press: Why there can be no increase in all brain cancers tied with cell phone use where they state:

"The link between the carcinogenic effects of tobacco and cancer did not come about from studying population trends, *but by special study of high-risk groups using case-control designs of selected cases and comparing their histories with those of persons who were otherwise similar but did not smoke, and cohort studies of groups with identified smoking histories followed for up to 40 years*, as in the American Cancer Society and British Doctors studies. The fact that population-based trends in Australia do not yet show an increase in brain cancer does not mean it will not be detectable in the future—perhaps soon."

While glioblastoma is a very rare cancer, it is an often fatal one.

Putting The National Toxicology Program Study In Context

Have Any Other Animal Studies Shown A Link To Cancer?

Yes. With the results of the NTP, there are now *three* important animal studies within the past six years showing increased development of cancers after RF-EMF exposure. A German study published in 2015 replicated 2010 research which showed carcinogen-induced tumor rates were significantly higher in the lung and liver of animals exposed to RF -EMF along with a known carcinogen.

Furthermore, there are many examples of research over the last few decades which have indicated that radiofrequency radiation is carcinogenic and can damage DNA.

A 5 year, $5 Million U.S. Air Force study conducted in the early 1980's and later published in Bioelectromagnetics (Chou et al., 1992) also found that significantly higher numbers of male rats exposed to low-intensity microwave radiation developed cancer in comparison to those not exposed. The Chou study exposed experimental animals to 2450 MHz, which is similar to the frequencies used for WiFi, whereas the NTP study exposed rodents to 900 MHz and 1800 MHz microwave radiation. However in the Air Force Study, the rats' average exposure was about 4-10 times *lower* than in the NTP study. Read more about this study in Dr. Moskowitz analysis.

It is notable that in this study the researchers state, "Only male rats were used to minimize statistical variation, i.e., to avoid the hormonal variations characteristic of female rats. Use of female rats would have required a substantial increase in the number of animals."

In the 1990's, Henry Lai and V.J. Singh demonstrated that low levels of microwave radiation (2.45GHz) well below that of cell phone radiation levels could increase the frequency of single-strand DNA breaks in the brain cells of live rats. The in-vitro studies of the $15 Million dollar REFLEX project *lead by Franz Adlkofer* also indicated a genotoxic effect of RF-EMFs at levels below proposed radiation safety levels. In an June 2016 interview, Professor Adlkofer commented that the NTP and Reflex study complement each other, and "intensify in their significance."

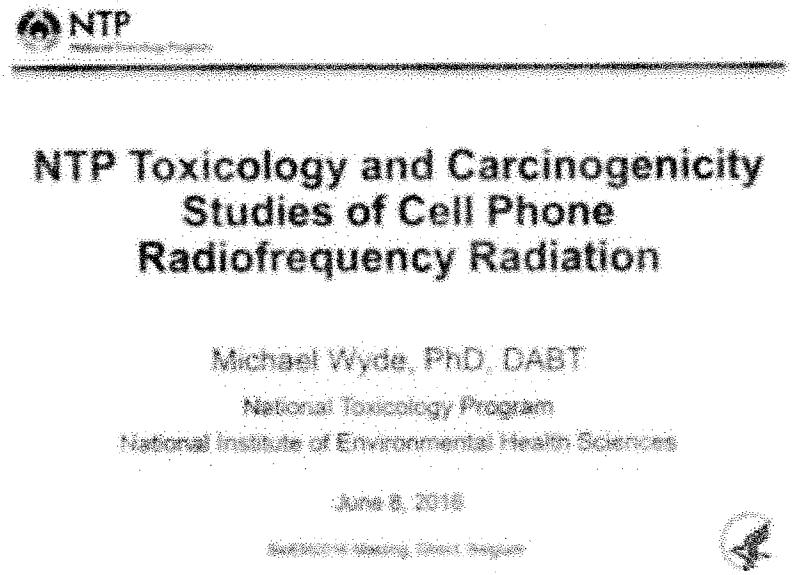
In the late 90's, the $25 Million Wireless Technology Research (WTR) project (funded by the Wireless Industry) researchers found genetic damage inside cells exposed to RF radiation in two separate studies, an increased risk of a non-malignant tumor called acoustic neuroma, and an increased risk of neuroepithelial cancer (both rare brain tumors). The WTR epidemiologist George Carlo, later wrote the book Cell Phones, Invisible Hazards in the Wireless Age documenting the suppression of these research results by the Wireless Industry. The research studies listed above are just a few examples of the past research demonstrating the link between radiofrequency and radiation cancer.

How Could Radiofrequency Radiation Cause Cancer?

A 2016 review paper reported that in 93 of 100 studies RFR produced a cellular stress response which can lead to DNA damage and cancer. In 2001, Catholic University physics professor Theodore A. Litovitz briefed US Congressional members on how chronic exposure to non-thermal levels of electromagnetic radiation can diminish DNA repair and the body's immune response. His conclusion, "because stress proteins are involved in the progression of a number of diseases, *heavy daily cell-phone usage* could lead to great incidence of disorders such as Alzheimer's and cancer" has been reiterated by two leading EMF/RF researchers, Frank Barnes and Ben Greenebaum in a 2016 article published in *IEEE Power Electronics Magazine*. Barnes and Greenebaum stated, "We present the possible theoretical mechanisms and experimental data that show long-term exposures to relatively weak static, low-frequency, and RF magnetic fields can change radical concentrations. As a consequence, a long-term exposure to fields below the guideline levels may affect biological systems and modify cell growth rates, while an organism's built-in mechanisms may compensate for these changes."
Notably, in 2002, Leszczynski and colleagues published the results of an experiment using a human cell line and *just like in the NTP rat study*, the researchers ensured that the exposures were non thermal. They found that after merely one hour of exposure to a 900 MHz GSM signal at an average SAR of 2 W/kg , a specific type of cellular stress response was activated. They hypothesized that this effect links the radiation to cancer because "These events, when occurring repeatedly over a long period of time, might become a health hazard because of the

possible accumulation of brain tissue damage. This suggests that the presently allowed radiation emission levels for the mobile phones, although low, might be sufficient to induce biological effects."

Why Was This Study Released *Before* It Was Published In A Journal?



According to page 4 of the NTP Report, these findings were released after extensive reviews because:

"Given the extremely large number of people who use wireless communication devices, even a very small increase in the incidence of disease resulting from exposure to RFR resulting from those devices could have broad implications for public health."

"Lastly, the tumors in the brain and heart observed at low incidence in male rats exposed to GSM- 2 and CDMA-modulated cell phone RFR in this study are of a type similar to tumors observed in some epidemiology studies of cell phone use. These findings appear to support the International Agency for Research on Cancer (IARC) conclusions regarding the possible carcinogenic potential of RFR."

The NTP has now created a new webpage on cell phones and posted a link to the FDA's recommendations on how to reduce cell phone radiation exposure.

Click Here for NTP PowerPoint Slide Presentation

How Are Humans Exposed To Radiofrequency Radiation?

The International Agency for Research on Cancer (IARC) of the World Health Organization classified the range of radio frequency from 30 kHz to 300 GHz as a "Possible Human Carcinogen." The classification is for radio frequency from any source, be it a cell phone, laptop, Wi-Fi, baby monitor, cell tower, tablet or electric utility meter.

Dr. Robert Bann, the World Health Organization International Agency for Research on Cancer Secretary stated in a 2011 lecture and in his writing found here.

"It should be noted that the working group in the overall evaluation decided to make a generic evaluation of radio frequency fields and did not want to limit it to mobile telephone use and all other exposures .. that was based on the diversity of the exposures in the animal cancer studies where different types of radiation with different frequencies across the radio frequency part of the emf spectrum were noted and the radiation from the

environmental sources.(i.e Wi-Fi, Cell Towers etc) and from the mobile telephones is basically and physically speaking the same type of agent."

Considering we now use cell phones all day and even sleep with them at night, cell phones probably expose humans to radio frequency more than any other single device. Indoor exposures are primarily from wireless computer networks, home cordless phones and the myriad of wireless devices we purchase and bring into our home. In addition, homes, offices and buildings now have various built-in wireless equipment and apparatus such as thermostats, security networks, sound systems, appliances and utility meters called "Smartmeters".

Outdoor exposures are primarily from base stations (cell towers) and building mounted cellular antennas in addition to the cell phone you may carry in your pocket as you walk down the street.

The Bottom Line

Wireless radiation from phones, tablets, routers, baby monitors, and a growing number of applications has never been tested for safety, because it was assumed to have no effect except heating. That assumption is no longer valid. While details relating to the increased cancer will continue to be evaluated, this study clearly shows that wireless radiation produces biological impacts in animals. The weight of evidence has significantly increased now that the the NTP study findings are placed in the context of the epidemiological, animal and in vitro studies done to date.

Rates of cancers specifically associated with cell phones are increasing; especially the most aggressive forms. In February 2016, the CBTRUS (Central Brain Tumor Registry of the US) reported that brain tumors are now the leading type of cancer in adolescents, surpassing leukemia and lymphoma.

It is imperative that there be experimental testing, now, of newer technologies *before* they enter the marketplace. Data on wireless exposures must be collected in a systematic way to understand real life exposures, and to enable correlation with health. Without such testing and monitoring, we are engaging in a massive experiment with no controls and without the public's knowledge or consent.

Based on this new information, regulatory and health agencies should make strong recommendations for consumers to take precautionary measures, to choose non-wireless devices whenever possible, and to avoid close contact with their cell phones and Wi-Fi devices. Since children and pregnant women are more vulnerable to radiation exposures, health authorities must especially educate families and communities about how to reduce children's exposures. Schools, offices and homes can be equipped with non-wireless internet connections to significantly reduce indoor exposures. Technology companies must design and provide safer communication devices so that the public can reduce exposure.

Most importantly, international regulations on cell phones and radiofrequency radiation exposures need to be immediately updated. The NTP study provides strong evidence that the current limits — based on thermal effects only — *do not adequately protect us*. New regulations must protect against these non-thermal biological effects.

NATIONAL TOXICOLOGY PROGRAM (NTP) INFORMATION

Report of Partial findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats (Whole Body Exposure)

NTP Press Conference Audio is online to listen to here.

NTP Press Release: Media Telebriefing: NTP Cell Phone Radiofrequency Radiation Study: Partial Release of Findings

New NTP Webpage on Cell Phones

NEWS MEDIA COVERAGE

Wall Street Street Journal: Cell Phone Study Fans Cancer Worries

Consumer Reports: Does Cell Phone Use Cause Brain Cancer? What the New Study Means For You

Science Magazine: Questions abound after study links tumors to cellphone radiation

Mother Jones: Game-Changing" Study Links Cellphone Radiation to Cancer

PBS: How Might Cell Phone Signals Cause Cancer May 30, 2016

Scientific American: How Might Cell Phones Cause Cancer in Rats

Scientific American: Major Cell Phone Radiation Study Reignites Cancer Questions: Exposure to radiofrequency radiation linked to tumor formation in rats

Science Magazine: Questions abound after study links tumors to cellphone radiation

ADDITIONAL RESOURCES ON THE NTP STUDY RESULTS

Environmental Health Trust: Everything You Wanted to Know About the National Toxicology Program Rodent Study on Cell Phone Radiation

Microwave News Cell Phone Radiation Boosts Cancer Rates in Animals

Joel Moskowitz, PhD. Summary and preliminary analysis EMR Safety; May 27, 2016

- National Toxicology Program Finds Cell Phone Radiation Causes Cancer
- Spin Versus Fact on the NTP Study by Dr. Moskowitz. Download the Factsheet

Dr. Gautam Khurana, NeuroSurgeon, Comments: Breaking News – Cell Phones and Brain Tumors – Leaked Insight from the U.S. National Toxicology Program?

Interview with Prof. Adlkofer the NTP study of the US government: Translate the page.

American Cancer Society Press Release: ACS Responds to New Study Linking Cell Phone Radiation to Cancer

CONFIRMED:
The order of the Head State Sanitary Physician of the Republic of Kazakhstan
« 28 » November 2003 г. № 69

Permissible levels of high-frequency electromagnetic pollutions' voltage in a wires of industrial frequency alternating current

Sanitary-epidemiologic norms

1 General provisions

1. Sanitary-and-epidemiologic norms «Permissible levels of high-frequency electromagnetic pollutions' voltage in a wires of industrial frequency alternating current» (further - norms) define levels electromagnetic pollutions in electric wires of power supply of an industrial electric equipment, office techniques, electrical household appliances in a range 1 kiloHertz – 400 kiloHertz (further – kHz).

2. The present norms are directed on improvement and optimization of a sanitary-epidemiologic situation and prevention of environmental contamination by electromagnetic radiation, and also management of corresponding risk, in addition to existing norms.

3. Heads of the organizations and physical persons which activity is connected to operation of the industrial organizations using the equipment and devices, being sources of electromagnetic radiation, provide maintenance of requirements of the present norms.

4. In the present norms the following terms and definitions are used:

1) electromagnetic pollution – parasitic (casual) frequencies in a network of an alternating current of industrial frequency of 50 Hertz (further – Hz) which source is not determined;

2) electromagnetic pollutions – one of kinds of electromagnetic pollution in a range of frequencies 1 kHz – 400 kHz, arising in networks of an alternating current of industrial frequency.

2 Permissible level of electromagnetic pollutions' voltage

5. The permissible level of a high-frequency electromagnetic pollutions' voltage in a range of frequencies 1-400 kHz in a wires of an alternating current of industrial frequency of 50 Hz should not exceed 0,05 volts (further – V) 50 millivolts (further – mV).

3 Choice of points of the control

6. Control points get out in the socket of wires of an alternating current of industrial frequency (50 Hz), taking place near to a plug (socket) of a cable of the connected equipment. The number of control points depends on number of workplaces. In each control point one measurement is carried out.

4 Recommended devices for the control

7. For the control high-frequency electromagnetic pollutions in a range of frequencies (1-400) kHz in a wires of an alternating current of industrial frequency of 50 Hz are recommended to be used millivoltmeter, having corresponding characteristics and registered in the State Register of Republic of Kazakhstan.

5 Requirements to carrying out of measurement

8. The device is plugged into socket of an alternating current in a control point.

9. Tap switch of ranges necessary to put in position of 1-2 V.

10. If indications are not fixed or are small, tap switch put in position 100-999 mV or in position 1,1-99,9 mV, depending on a registered level of a voltage.

Results are registered and compared to the norms specified in item 5 of the present norms.

Cardiac Effects of Natural and Artificial EMR:

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16th December 2002

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Cardiac Effects of Natural and Artificial EMR:

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Abstract:

The heart is a muscular organ whose regular coordinated contraction, called a heart beat, is regulated by an electrical pulse that initiates a cascade of calcium ions that carry the message into all the heart cells to initiate the contraction of the heart beat. Therefore it is biologically plausible that natural and artificial electromagnetic fields will interfere with the heart activity. It has been shown that external ELF fields cause altered calcium-concentrations in neurons and heart cells. Altered blood pressure is associated with the Schumann Resonance signal, along with its modulation of human heart disease and mortality rates in a homeostatic manner. Electrical and electronic workers, radio/TV workers are shown to have increased risks of heart disease and mortality. We all live in electromagnetic fields which act to contribute to increase the rate of cardiac disease and death. A new high risk factor is the usage of a cellphone. Cellphones have been shown to interfere with electronic pacemakers. Therefore it is very reasonable that they will interfere with biological pacemakers, that is, our hearts. The use of a cellphone is associated with significant increase of blood pressure. This is a symptom of hypertension and shows that there is a cardiac risk factor. This risk factor is strongly confirmed in the context of the Schumann Resonance signal effects, electrical workers effects and altered cardiac functions in radio, TV and radar exposed workers.

Introduction:

A primary principle of Environmental Health is a necessity to understand how the natural system works before we can appreciate and understand how artificial signals and chemicals can alter the natural functions and cause human health effects. Muscular contraction and relaxation is regulated by the motor neuron system for skeletal muscles. Electrical signals come from the brain through a particular circuit, through the spine, to the motor neurons in the particular muscular system. This signal initiates a coordinated alteration of the calcium ion cell messengers which alters the contraction or relaxation of those muscles.

Heart muscle cells are very similar to the skeletal muscle cells, Alberts el al. (1994). Muscle contraction is initiated by a sudden rise in cytosolic calcium ions (Ca^{2+}). For the skeletal muscle force-generating molecular interaction takes place only when a signal passes to the skeletal muscle from its motor nerve. The signal from the nerve triggers an action potential in the muscle cell plasma membrane, and this electrical excitation spreads rapidly into a series of membranous folds, the transverse tubules that extend inward from the plasma membrane around each myofibril. A signal is then laid across a small gap to the sarcoplasmic reticulum, Figure 1.

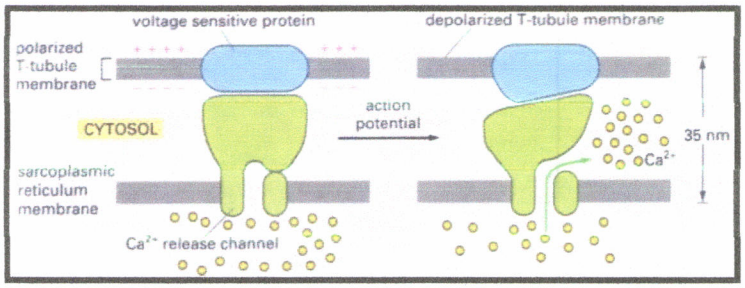

Figure 1: Schematic diagram showing how a calcium ion release channel in the sarcoplasmic reticulum membrane is thought to be opened by a voltage-sensitive transmembrane protein in the adjacent T-tubule membrane, Alberts et al. (1994).

When you see how electrical signals and ions have so many important roles in cells, controlling muscles and hearts, and many other bodily functions, through the electrical signals in the brain that are sent from the brain to the central nervous system and the motor neuron system, the opened understanding is that external electromagnetic fields can interfere with the body's systems. Certain organs such as the brain, the central nervous system and the heart, are very reliant on the electromagnetic signals and all the body's cells use many electromagnetic signals for their natural functions.

One of the earliest electromagnetic fields biological effects found and which is now well-established, is the calcium-ion efflux and influx of the cell membranes induced by extremely low-frequency (ELF) electromagnetic fields typically in the similar range of the brain EEG system frequencies. Another of the brain's most active frequencies is the alpha rhythm including 16 Hz. Dr Ross Adey's team showed that brain cells have been very strong in efflux and influx Ca^{2+} changes when exposed to 16 Hz fields and modulated RF/MW radiation Figure 2.

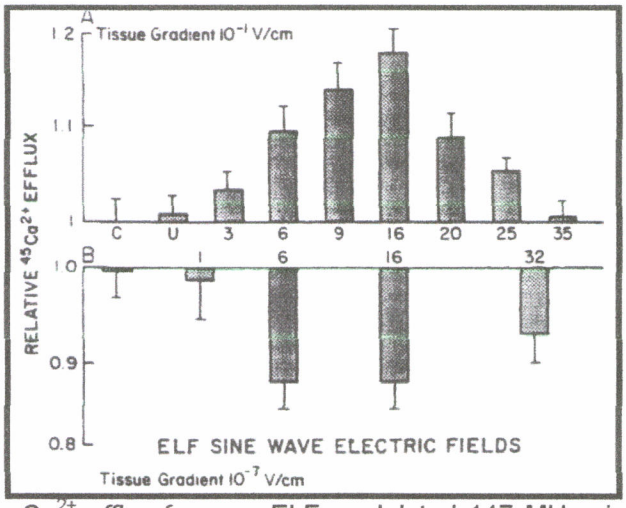

Figure 2: Relative Ca^{2+} efflux from an ELF modulated 147 MHz signal and (B) influx from the same external field strength (56V/m) but solely an ELF field, Adey (1988).

Figure 2 also indicated the strength of the induce fields in the tissue which for the RF field is 0.1V/m, a million times higher than the ELF field, 10^{-7}V/m. This I call the "EMR Spectrum Principle" because it is well-established that the higher the carrier frequency the higher the induced tissue electric gradient and induced tissue current strength. This means that biological and health effects of RF/MW exposures will be found to be much higher from much lower intensities than from ELF fields.

Dr Adey was basing his insights on a fascination with discovering how neurological tissue operated and how it was altered in extremely low level RF/MW and ELF fields. The current world leader in Ca^{2+} efflux research is Dr Carl Blackman of the U.S.E.P.A. Blackman has replicated and significantly extended the studies carried out by Dr Adey's group and other groups. Dr Blackman has produced over 20 peer-reviewed publications in this area, including several major reviews.

Blackman et al. (1989) identified multiple power density windows for Ca^{2+} efflux, using a 50 MHz carrier modulated at 16 Hz. Their results, using units of mW/cm^2, are summarized as follows:

No change	0.75	2.30	4.50	5.85	7.08		8.19	8.66	10.6	14.7
Enhanced efflux		1.75	3.85	5.57	6.82	7.65	7.77		8.82	

The intensity window data was considered as an example of non-linear dynamics because there appears to be no progressive decline in the magnitude of the effects at low exposure intensities. This data is consistent with a fractal process with a non-integer dimension which is approximately 1.4, Blackman et al. (1989).

The lowest published RF intensity that has been documented to produce significant Ca^{2+} efflux is 0.00015 W/kg from Schwartz et al. (1990). They used frog hearts, exposed for 30 mins, to a 16Hz modulated 240 MHz RF signal. This has an exposure intensity of about 0.4μW/cm^2.

Hearts use natural electric pulses to produce heart-beats. An electric pulse produces a cascade of calcium ions that cause the heart muscle to contract. The Electrocardiogram (ECG) is used to monitor heart activity and can detect heart disease through the altered electrical signals. Hence it is biologically plausible that electric signals, that are shown to interfere with artificial pacemakers, can also interfere with the natural heart-beat. This has been shown in several studies in relation to reduction of the heart rate variability (HRV). This is a known risk factor for heart disease.

Another important biophysics principal is the resonance interaction process. When an external frequency matches a natural internal frequency there is a very strong interaction from the process of resonance.

With the modern widespread use of mobile phones which expose the user's ear to much higher intensities of microwaves than radar repair workers usually receive, there is a real concern that the use of the phones and the close relation of cell site base stations near homes, cause possible or actual health effects. This review report has established that electromagnetic fields and radiation are plausibly changing non-thermal biological effects, and that resonant interactions are plausible because of the natural frequencies of the electromagnetic fields in the body. Therefore the evidence

is that natural global electromagnetic fields are associated with cardiac health effects. When the evidence of cardiac effects in electrical and electronic workers is considered, along with the evidence from radio frequency and microwave exposures for workers and military personnel, then it is found in epidemiological studies that they will also have elevated cardiac disease and mortality rates.

This review will include health effects found in physiotherapists whose work involved exposures to short waves and microwaves used for diathermy of patients.

Cardiac Associations with the Schumann Resonance Signal:

Cherry (2002) shows that the Schumann Resonance (SR) signal is the highly plausible biophysics mechanism, using the melatonin mechanism, for explaining how Solar and Geomagnetic Activity (S/GMA) causes serious human health effects in homeostatic relationship to the Schumann Resonance signal intensity including cancer, cardiac, reproductive and neurological diseases and mortality. The cardiac effects are summarized below.

S-GMA related Cardiac effects:

A 35-year old cardiologist, with a family history of hypertension and stroke, used an electronic blood pressure monitor to record his blood pressure every 15 minutes for 3 years. This revealed a significant periodicity of 27.7 days in systolic and diastolic blood pressure and heart rate, which was coherent with the GMA Kp-index, Watanabe et al. (1994).

An Italian study of 447 patients with hypertension also found very significant correlations between systolic and diastolic blood pressure and GMA indices over a 5-year period, Ghione et al. (1998). A multiple correlation with potential confounding factors, such as age and date, confirmed the significant correlation with GMA. Stratifying the days into quiet, disturbed and highly disturbed GMA days consistently showed significantly higher values in the highly disturbed days for all blood pressure parameters, except for systolic night-time pressure. The difference between quiet and highly disturbed GMA days was 6 to 8 mm for the 24 hour systolic and diastolic blood pressure. The GMA indices and the blood pressure measurements contain the 27-day period. The authors concluded that these results seem to reflect a real relation between geomagnetic disturbances and blood pressure.

The solar rotation cycle is just below 28 days and it produces the same frequency in the Schumann Resonance signal, Figure 3(a), with sub-harmonic period peaks at, 28, 14, 11, 9, 7 and 3.5 days. The daily admission of patients to the Christchurch, New Zealand hospital for arrhythmic cardiac symptoms has its frequency shown in Figure 3(b) with periods of 28, 14, 9, 7, 5.6, 4.6, 3.5, 2.8 and 1.8 days. This shows a very strong relationship between the Schumann Resonance signal and the loss of synchronization of their heart's rhythm modulated by the solar 27/28 day cycle.

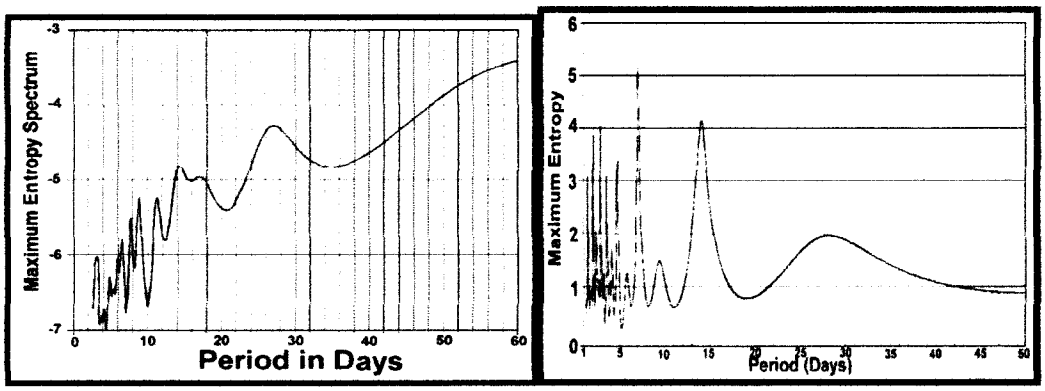

Figure 3: Maximum Entropy Spectrum of (a) The Schumann Resonance Intensity, 1997-99 (left) and (b) for the Cardiac Arrhythmia admissions to Christchurch Hospital, 1997-99 (right).

Because Melatonin is a natural highly potent antioxidant, reduced Melatonin enhances cell death. Geomagnetic activity is associated with reduced Melatonin in more than 6 published studies. Therefore it is plausible that reduced Melatonin, associated with solar and GMA, can be associated with increased rates of heart attacks. Geomagnetic Activity is also correlated with blood pressure changes in at least two independent studies. Hence a correlation with hypertension mortality was investigated and found, Table 1.

Table 1: Correlation parameters of cardiac mortality in Thailand and Sunspot Number, The gradient is the number of Cases per 100,000 people /100 sunspots, Cherry (2003).

Disease	Correlation Coefficient	t-value	p-value	Gradient
Hypertension (Male)	0.8497	6.2422	0.000012	0.7438
Hypertension (Female)	0.6653	3.4516	0.00329	0.5718

These correlations with Hypertension show some of the highest t-values and significance, confirming the sensitivity of the heart to altered electrical activity, the Schumann Resonance signal and reduced Melatonin.

Because the Schumann Resonance signal is extremely highly correlated with the sunspot number, Cherry (2002), I have produced graphs of the annual Hypertension mortality in Thailand with the annual sunspot number, Figure 4.

Two independent studies, Watanabe et al. (1994) and Ghione et al. (1998), show that human blood pressure is significantly correlated with GMA and a study shows that arrhythmic heart disease is correlated with acute variations in SR signal and another study produced here for the annual hypertension mortality is highly related to the SR signals and sunspot numbers.

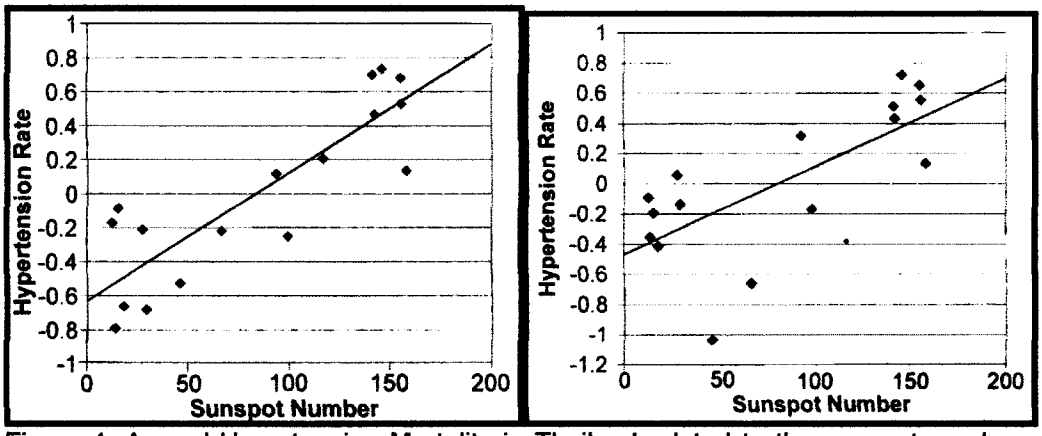

Figure 4: Annual Hypertension Mortality in Thailand related to the sunspot number as *an indicator of the annual Schumann Resonance signal strength*, Males (left) trend p=0.000012 and Females (right) trend p=0.0033.

Schumann Resonance-S/GMA melatonin reduction links:

Melatonin is a diurnal blood pressure regulator. S-GMA, through the Schumann Resonance signal, modulates human melatonin level, therefore these studies confirm that blood pressure change is a melatonin-related biological effect of S-GMA. Hence it is biologically plausible that extreme levels of S-GMA will cause a wide range of cardiac health effects and death.

Burch et al. (1999b) found that the strongest factor reducing melatonin in electrical workers, in addition to their occupational ELF and 3-phase exposures and cell phone usage, was the Geomagnetic Activity, in a dose-response manner, Figure 5. The Schumann Resonance signal, has a mean field strength of 0.1pW/cm^2 with a mean magnetic field strength about 1-3pT.

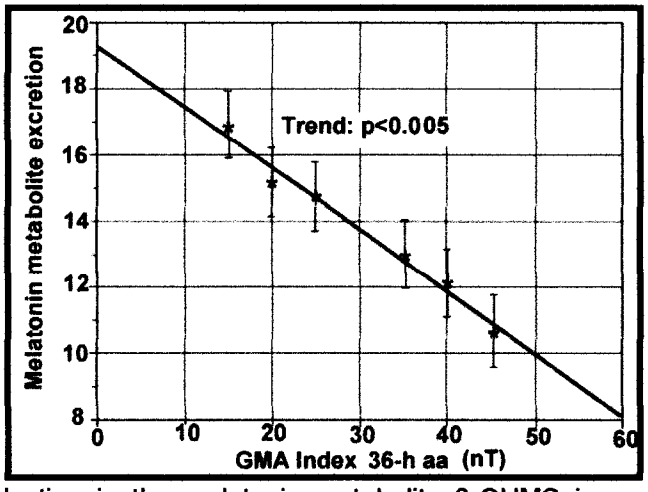

Figure 5: Reduction in the melatonin metabolite 6-OHMS in μg in urine from U.S. electric utility workers, as a function of the 36 hr global GMA aa-index, Burch et al. (1999).

Burch et al. (1999) showed a probable causal link between the Schumann Resonance signal and reduced melatonin, Cherry (2002). In addition there is Weydahl et al. (2001) and Rapoport et al. (1997, 1998, 2001). Bardasano et al. (1989) observed an extremely significant reduction ($p<0.001$) in synaptic ribbons of pinealocytes of rats during geomagnetic storms compared with quiet solar days. Thyroxine levels in a single limbic epileptic patient were highly correlated ($r = 0.66$) in a dose-response manner, with daily GMA, O'Connor and Persinger (1996). The strongest association ($r = 0.76$) was found between thyroxine levels and the Kp index during the previous night (2 am to 5 am). These analyses were carried out specifically to test the GMA Melatonin mechanism and they support it.

This is strong enough evidence to conclude that there is a causal link between reduced melatonin in people and animals and Solar/Geomagnetic Activity through the Schumann Resonance mechanism.

Reduced melatonin produces arrhythmic cardiac activity. The cardiac activity of rabbits was monitored during two GMA storms, Chibisov et al. (1995). At the initial and main phase of the storm the normal circadian structure of the cardiovascular parameter was lost. Desynchronization grew during the storm, leading to an abrupt drop of cardiac activity during the main phase of the storm. This was followed by the destruction and degradation of cardiomyocytes. The parameters of cardiac activity became significantly synchronized and the circadian rhythm restored during the storm's recovery period.

Human patients with ischemic heart disease (47-men and 33-women) were monitored for cardiac parameters daily over for 2-3 weeks, Gurfinkel et al. (1995). Changes in their microcirculations were related to GMA and to changes of atmospheric pressure. In the first day of a GMA storm pathological changes of capillary flow were detected in 71.5% of patients with acute myocardial infarction (men: 73.7%, women: 69.2%). They also observed perivascular edema, red blood aggregation, delay and slowing down of capillary flow. Similar changes were detected in 64.8% of patients with angina pectoris, (men: 73.3%, women: 56.3%). The reactions of these patients to GMA disturbances were over 2.5-times higher than the effects of atmospheric pressure changes.

GMA events are significantly correlated with increased blood coagulation and platelet aggregation, Pikin, Gurfinkel and Oraevskii (1998). Blood pressure, capillary flow, blood coagulation and aggregation changes are observed during GMA events, consistent with the effect expected with reduced melatonin in people with heart disease. Therefore, it is reasonably predicted that GMA will be associated with observable changes in cardiac disease and death when large human populations are studied.

Agadzhanian and Makarova (2001) studied changes in a number of respiration and circulation parameters during magnetic storms of varying intensities. The results were analyzed in 126 normal humans belonging to two age groups: 19-21 yr. old young men and women (29 of each) and 51-53 yr. old men ($n = 36$) and women ($n = 32$). Geomagnetic components D, H and Z were used. Systolic pressure, respiration volume, minute respiration volume and peak expiration rate were shown to be the most labile characteristics of the cardio-respiratory system responding by increases on magneto-disturbed days. The parameters under study exhibited sexual and age differences equally on quiescent and magneto-disturbed days. Adaptation to growing tension of the

magnetic field of Earth involves the neuroendocrine system and manifests itself by activation of the sympathetic nervous system entailing relative shifts in the cardio-respiratory parameters under study.

GMA Related Human Cardiac Disease and Death:

Early correlations between S-GMA and heart attacks were assumed by some authors to be spurious, inaccurate and inconsistent, Malin and Srivastava (1979, 1980) and Knox et al. (1979). Results found in India were not confirmed in populations in the U.S. These were seen as inconsistent. The lack of a plausible mechanism also made these results not credible to some researchers. The masking of the natural signals effects by artificial EMR exposures in developed countries is a plausible explanation of the results. In the 1990's many other studies identified relationships that are highly significant and consistent with the original results.

With clinical measurement being able to identify highly significant changes in blood pressure, blood flow, aggregation and coagulation during GMA events, these results are highly plausible. They are mediated by melatonin in the normal diurnal and seasonal cycles. Since melatonin is also significantly correlated with levels of GMA during solar storms this will also have cardiac effects. Reduced melatonin is associated with cardiac arrhythmia and heart rate variability in clinical studies cited above.

De Bruyne et al. (1999) studied older heart patients (>55 years) and compared their heart rate variability (HRV) with their increased risk of mortality from myocardial infarction. They found that both decreased and increased HRV were significant risk factors, with increased HRV being the greater risk factor. This shows a timing related homeostatic relationship and GMA events are related to desynchronization of cardiac rhythms. Measured HRV also demonstrates anomalies in myocardial infarction, sudden death, heart failure, autonomic neuropathy and hypertension, Kerut, McKinnie and Giles (1999).

The EEG pattern, pulse rate, blood pressure and rate of sensomotor reaction were measured in a group of people. The parameters significantly correlated these physiological variables with the Kp-index, Doronin et al. (1998). They noted that the oscillations in the Kp-index had identical periods in the monitored EEG Alpha-Rhythm. This confirms the whole-body changes that occur in conjunction with GMA alteration by changing the brain and heart patterns. This supports the Model that suggests that the brain wave pattern is changed, involving alteration of ELF brain signals, and this is transferred through melatonin receptors and the autonomic nervous system to the cardiovascular system.

Cardiac Effects of High GMA:

During periods of Active Sun and increased GMA the following statistically significant effects have been observed:

- Cardiac Arrhythmia in children, Markarov (1998).

- Novikova and Ryvkin (1977) observed a consistent and significant increase in heart attack incidence and death between active and quiet GMA conditions for 1961-66 at Sverdlovsk, USSR.

- GMA is highly correlated with daily myocardial infarction incidence rates during big GMA storms, Villoresi et. al. (1998).

- GMA activity is also correlated with sudden cardiovascular death, Sitar (1990), and Ischaemic Heart Disease mortality, Otto et al. (1982).

- Monthly solar activity was highly significantly correlated with monthly hospital admissions for cardiovascular disease, Stoupel and Shimshoni (1991). Solar activity is highly correlated with GMA and SR intensity.

- Stoupel et al. (1997) observed that during periods of low solar and geomagnetic activity, solar proton fluxes were correlated with cardiovascular deaths.

- Oraevskii et al. (1998a) found that 75 % of GMA storms caused an increased of the hospitalization of patients with myocardial infarction by 30 to 80%.

- Oraevskii et al. (1998b) report that MIR space orbital station staff experienced a significantly increased heart rate, reduced heart rate variability and decreased respiratory waves, corresponding with a specific adaptation of stress-reaction. At the same time hospital patients with ischemic heart disease had a similar reaction including deterioration of the physiological status, rheologic blood characteristics and heart rate disturbances, associated with GMA disturbances.

- Breus et al. (1998) report disturbance of cardiovascular activity among MIR astronauts during the main phase of solar storms compared to the recovery phase. Similar effects were observed in rabbits.

Cardiac Effects of Low GMA;

Periods of Quiet Sun activity are significantly associated with:

- Stoupel et al. (1990) found a highly significant correlation ($p=0.01$) for higher pregnancy induced hypertension for monthly periods of low GMA.

- Sudden death from cardiac arrhythmia, especially paroxymal atrial fibrillation, and stroke, Stoupel (1993) and Stoupel et al. (1995a). Stoupel, Martfel and Rotenberg (1994). Stoupel, Martfel and Rotenberg conclude that their results are consistent with previous studies showing increased heart electrical instability during periods of lowest geomagnetic activity.

- Ischaemic Heart Disease for ages >70 years. Stoupel et al. (1995b).

- Stoupel et al. (1999) found a very highly significant inverse correlation ($r= -0.64$, $p=0.0001$) *for a 72 month period between solar activity and stroke/ischemic heart*

disease death. They concluded that monthly ratio of deaths from stroke/ischemic heart disease is related to environmental physical activity.

Conclusions about Cardiac relationship to the Schumann Resonance Signal:

The cardiac studies are consistent with the Schumann Resonance Hypothesis and add considerable weight to the melatonin, homeostatic and arrhythmic factors in the Hypothesis, Cherry (2002). Blood pressure, blood coagulation, heart attack, cardiac arrhythmia and sudden cardiac death are highly correlated with GMA in a homeostatic (U shaped) manner. This data is consistent with the involvement of melatonin. Being directly supported by clinical cardiovascular monitored changes of blood pressure, capillary flow and blood aggregation, multiple studies have very highly significant correlations with solar activity and GMA. This gives robust evidence supporting a causal relationship between GMA and Ischemic and arrhythmic cardiovascular disease, heart attack and death. The highly significant correlation between S-GMA and the SR signal intensity gives robust support for the SR Hypothesis through a Melatonin Mechanism.

Given the causal link to Cardiac Health and Mortality effect to the Schumann Resonance signal with a mean intensity near 0.1pW/cm^2 and magnetic field strength of about 1-3pT, it is extremely plausible that electrical workers chronically exposed to ELF fields about a million times higher (1-3μT) electromagnetic fields will experience serious heart disease elevated rates. It is also extremely plausible that people living in vicinity to cell sites and high powered radio and TV towers, airport radars etc, with field strengths typically around 0.1 to 5μW/cm^2, 1 million to 50 million times higher than the SR signal, will experience significantly elevated cardiac health and mortality rates.

ELF Occupational Cardiac Studies:

Satre, Cook and Graham (1998) observed significantly reduced heart rate variability (HRV) in volunteers sleeping in 60Hz fields. Reduced HRV is known to be an indication of heart disease risk.

This is a powerful set of epidemiological evidence showing that EMR across the spectrum increases the incidence and mortality from arrhythmia related heart disease and from heart attack. For the total cumulative exposure the rate of rise per year for Arrhythmic Heart mortality was RR/μT-year = 1.08, 96%CI: 1.03-1.12 and for Acute Myocardial Infarction, RR/μT-year = 1.04, 95%CI: 1.03-1.06.The following graph shows the dose-response curve for Acute Myocardial Infarction (Heart Attack) in electric utility workers, Savitz et al. (1999), Figure 6.

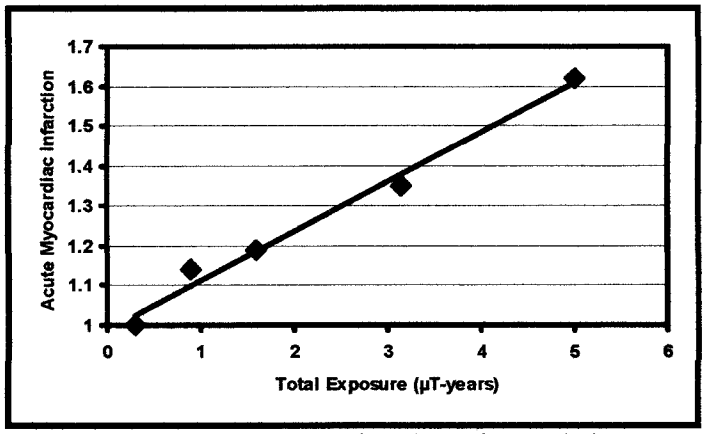

Figure 6: Acute Myocardial Infarction as a function of cumulative exposure to 60 Hz fields in U.S. electricity utility workers, Savitz et al. (1999), trend p<0.001.

Savitz et al. (1999) shows crude dose-responses for Cardiac Arrhythmia related heart disease, Figure 7, and a highly significant dose-response for Heart Attack, Figure 6, for exposed electrical occupations and for individual occupations of electrician, lineman and power plant operator.

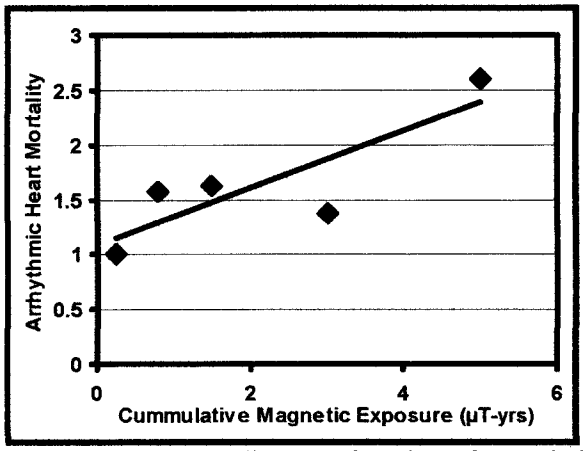

Figure 7: Arrhythmic heart disease mortality as a function of cumulative exposure to 60 Hz fields, with 5-year lag, in U.S. electricity utility workers, Savitz et al. (1999), trend p=0.07.

RF/MW Association with Heart Disease:

Extrinsic EMR signals interfere with hearts and cause heart disease and death. Bortkiewicz et al. (1995, 1996, 1997) and Szmigielski et al. (1998) found that RF exposure altered heart rate variability and blood pressure. Forman et al. (1982) present case studies of microwave exposed personnel with induced hypertension. Braune et al. (1998) showed that cell phone use significantly increased blood pressure.

The United States Embassy in Moscow was chronically exposed for over 10 years to a deliberately directed Soviet radar. The US State Department, after staff expressed concerns, got Professor Abraham Lillian of John Hopkins University to carry out a survey of staff health effects. Two reference groups were used. The general US public and comparison Eastern European Embassy staff and families. With years of tour service a number of illness rates rose significantly. In relation to the heart, the Vascular illness showed the strongest trends, Figure 7. The mean personal exposure was somewhat less than 0.1μW/cm^2.

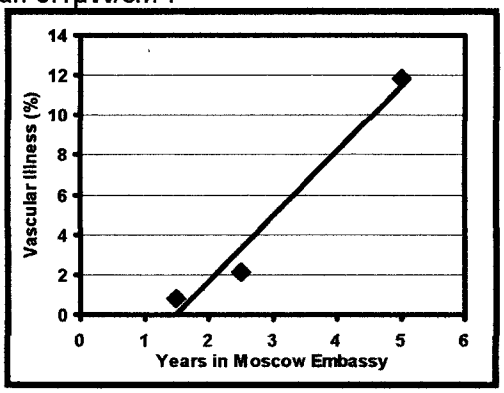

Figure 7: Vascular illness rate (%) in male staff at the United States Embassy in Moscow, for years of service while the Embassy was exposed to a very low intensity of a Soviet radar signal, Table 6.18, Lilienfeld et al. (1968). Trend p=0.004.

Seven young children of the embassy staff developed blood disorders during the first tour of duty. When compared with other US European Eastern Embassies the rate was over four times higher in the Moscow US Embassy, RR = 4.05.

The Korean War radar study, Robinette et al. (1980), assessed the relative greater radar pulse microwave exposure of U.S. Navy personnel in occupational groups of repairers versus users of the radar. Two higher exposed groups were AT and FT and a lower exposed group was ET. Comparing the cardiac mortality rate for "Diseases of the Circulatory System" in the FT+AT group compared with the ET group yields, RR = 1.27, 95%CI: 0.92-1.75, n=64. For hospital admissions, the diseases of blood forming organs yielded RR= 4.33, 95%CI: 1.53-12.3, p=0.001, and for the Circulatory system RR = 1.53, 95%CI: 1.07-2.18, p=0.007, and for Cardiovascular disease, RR = 2.03, 95%CI: 1.34-3.07, p<0.001.

These military occupational groups exposed to radar have elevated cardiac mortality and highly significantly elevated cardiac disease rates.

Hamburger, Logue and Silverman (1983) observed significant dose-responses for heart disease for male physiotherapists as a function of treatments per month with microwaves, OR = 2.51 (1.09-5.78), Trend p<0.05); shortwave, OR = 3.40 (1.56-7.39), trend p=0.005; and Combined Microwave and Shortwave, OR = 2.88 (1.21-6.70), trend p=0.025.

Dose-responses and consistent and significant elevation of disease rates and mortality gives evidence of a causal relationship. Therefore a causal relationship between

radiofrequency and microwaves exposure and cardiac illness in this assessment, is causally related. This is strongly confirmed by the natural electromagnetic radiation, SR signal 0.1pW/cm^2, causal link to cardiac illness and death rates. This strongly indicates that cellphone use is likely to be a major risk of Cardiac Disease because of the extremely high levels of microwave exposure from cell phone is produced for the phone users. The Moscow Embassy data also indicates that the passive cellphone exposure is very likely to enhances the risk factors are cardiac illness. This is confirmed by an Austrian study around cell sites presented at the Ischia Congress in October 2001. The study is being carried out by Prof Michael Kundi, of the University of Vienna, and shows a dose-response rate of cardiac diseases from cell site's exposures.

Cell Phone Radiation Cardiac Activity:

Cardiac pacemaker interference:

- Barbaro et al. (1996); showed interference, skipped three beats.
- Hofgartner et al. (1996); significant interference, $p<0.05$,
- Chen et al. (1996); extremely highly significant interference, $p=0.0003$,
- Naegeli et al. (1996); extremely highly significant interference, $p<0.0001$,
- Altamura et al. (1997); reversible interference,
- Schlegal et al. (1998); significantly induced electronic noise,
- Occhetta et al. (1999); various disturbances observed and;
- Trigano et al. (1999) warnings recommended

Blood Pressure increase:

- Braune et al. (1998), Cellphone usage significantly increases blood pressure.

Quite often the cellphone companies fund research to challenge the independent results studies showing adverse effects linked to exposure to cell phone radiation. However, the SR signal, over a billion times weaker than the cell phone signal exposes of the user, show a significant blood pressure alteration in people and causes cardiac disease and death. Therefore it is logical and scientifically reasonable that cell sites exposures and cell phone usage will alter the blood pressure and increase the rate of cardiac diseases and mortality.

Conclusions and Recommendations:

The brain and the heart are very sensitive electromagnetically controlled organs. They work together to maintain a regulated and activity responsive circulation system to provide fluid, energy and oxygen throughout the body. Both of these organs are synchronized by the natural Schumann resonance signal. When solar energy and Geomagnetic Activity alters the Schumann Resonance signal, then neurological and

cardiac functions in human populations are modulated. Because people are sensitive and reactive to this extremely subtle signal, it is not surprising that electrical workers and radar and radio exposed workers have significant and dose-response increases in cardiac disease and death rates. It is therefore strongly scientifically plausible, and confirmed by an Austrian study, that people living in the vicinity of cell sites experienced a dose-response of increase in cardiac illness. This shows that cell phone usage and passive cell phone exposure will not only interfere with electronic cardiac pacemakers but will also interfere with the natural cardiac pacemaker, the human heart. Therefore cellphone usage and the cellphone system is enhancing the cardiac illness and mortality rate in the community.

Santini et al. (2002) show that living in the vicinity of cell site exposure produces elevated neurological effects, many of which are shown in a dose-response manner. Another symptom also shown is a significantly calibrated as cardiovascular problems. A similar study in Austria, carried out by Professor Michael Kundi, found a significant dose- response relationship between cardiac disease and cell site exposure.

This provides strong support and motivation for promoting and using much safer cellular telephone technologies and sighting strategies, and accelerating the move to place radio and TV signals in fiber-optic cables to remove the genotoxic and cardiac damaging radiation and signals from the air in which people are living.

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Review/Original Article?

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1. Microwave electromagnetic fields act by activating voltage-gated calcium channels: why the current international safety standards do not predict biological hazard

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Abstract. Microwave and other low frequency electromagnetic fields (EMFs) have been shown to act by activating voltage-gated calcium channels (VGCCs) with most biological effects being due to elevated intracellular calcium, consequent nitric oxide (NO) elevation and either peroxynitrite or NO signaling. This, the role of excessive intracellular calcium in microwave effects and some 20,000 papers on microwave biological effects show that the current international safety standards do not predict biological hazard. Such standards are based on the false assumption that the predominant effects of microwave and other low frequency EMF exposures are due to heating. A whole series of biological changes reportedly produced by microwave exposures can now be explained in terms of this new paradigm of EMF action via VGCC activation, including: oxidative stress; single and double stranded breaks in cellular DNA; therapeutic effects; blood-brain barrier breakdown; greatly depressed melatonin levels and sleep disruption; cancer; male and

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female infertility; immune dysfunction; neurological dysfunction; cardiac dysfunction including tachycardia, arrhythmia and sudden cardiac death. A two-phase program for greatly improving EMF safety standards is proposed.

There have been demonstrations by "activists" in many parts of the world against what they consider to be unsafe exposures to microwave frequency electromagnetic fields (EMFs). Such exposures have increased by large amounts in recent years. Such demonstrations have been met with assertions by government organizations and by industry that these exposures are well within international and national safety standards and therefore can be assumed to be safe. They are correct that these are well within safety standards. A central question being examined here is whether these standards are based on well documented science such that if they are, we should be assured of safety.

Current U.S. and International safety standards are based on the assumption that the only important thing that microwave and other low frequency EMFs can do biologically is to heat things (1-5), like heating things in a microwave oven. Based on that assumption, safety standards are based on heating (1-5) and the reasonable inference, *if that assumption is correct*, is that levels of exposures which only produce insignificant heating have no biological impact and therefore are "safe." In fact advocates for current standards argue that current safety standards are about 100 times more stringent than is needed (1), because even exposure levels 100 times higher than allowed by current safety standards produce only slight heating.

However, over 20,000 publications in the scientific literature have reported substantial biological effects of at exposures well within safety standards, such that none of these should be possible if current safety standards are scientifically based. These include some 4000 studies on therapeutic effects of microwave EMFs, effects that are well known to be non-thermal (6).

It should be noted that there is a reasonable basis for the heating assumption underlying current safety standards. The photons that make up microwave frequency and other low frequency fields are very low energy photons, without insufficient energy to individually change the chemistry of our bodies. That is they are different from ionizing radiation or even ultraviolet or visible radiation, where individual photons have sufficient energy to produce chemical changes. How, then can we understand the thousands of studies showing well-documented non-thermal biological effects of microwave frequency and other low frequency EMFs?

EMFs act via stimulation of voltage-gated calcium channels (VGCCs)

The author showed in a recent review (7), that in 2 dozen studies, EMF effects on cells and organisms could be blocked by calcium channel blockers, agents that block voltage-gated calcium channels (VGCCs; also known as voltage-operated, voltage-dependent or voltage-regulated calcium channels). In each of these two dozen studies, all of the measured effects were greatly lowered by the calcium channel blockers, suggesting that activation of these channels is responsible for most if not all of the EMF effects (7). In most but not all cases, it was L-type VGCCs that were primarily involved.

Activation of these channels is thought to produce most biological effects through increases in intracellular calcium levels.

In these studies, the EMFs studied were of various types, including extremely low frequency fields such as coming from the 50 or 60 cycle electrical wiring, microwave frequency EMFs, very short nanosecond pulses, and even static electric or magnetic fields. The findings for microwave EMFs create the most concerns, however, because our exposures have increased so quickly in recent years, and new technologies involving new exposures are becoming available at an ever increasing rate. The action of such microwave exposures via VGCC activation is also supported by a large number of studies, reviewed earlier (8,9), showing that elevated intracellular calcium levels were found following low level microwave EMF exposures, leading to changes in calcium signaling. This mode of action is also supported by two studies by Panagopoulos et al (10,11) who predicted that EMFs, including microwave EMFs can act by influencing the charged amino acid residues that control voltage-gated ion channels, to activate some of those channels. These were biophysical modeling studies and they not only support these VGCC findings, they also argue that the activation of these channels by microwave and other low frequency EMFs is biophysically plausible.

We are, therefore, in a situation where the old paradigm of such EMF action, where only heating effects were considered plausible and real (1-5), is replaced by a a new paradigm where VGCC activation by microwave and other EMFs is both plausible and real and provides an explanation for over 20,000 papers in the scientific literature that are inexplicable by the old paradigm.

That does not mean that there may not be other biological actions of EMFs, not involving VGCCs, through their actions on various charged

chemical groups including amino acid residues in proteins. Pilla reviewed two studies in which microwave EMFs increased calmodulin activation (6). Calmodulin is regulated by intracellular calcium such that its activation may act along with VGCC activation in two related pathways of action discussed below.

Two related pathways of action that can be activated by VGCC activation

VGCC activation is thought to act, to a great extent by increasing intracellular calcium levels. This is especially true for activation of the L-type VGCCs where the channels stay open relatively long periods of time. Whereas most other ion channels tend to stay open for only perhaps 1 or a few milliseconds, L-type VGCCs tend to stay open typically for a hundred milliseconds or more. Consequently their activation can easily produce a substantial impact on the levels of intracellular calcium.

While other effects of intracellular calcium are also likely to occur following VGCC activation, much of the effect of elevated intracellular calcium has been shown to be produced by calcium/calmodulin stimulation of the two calcium/calmodulin-dependent nitric oxide synthases, nNOS and eNOS (see Fig. 1, below), leading to large increases in nitric oxide (NO). NO can act along two pathways, as indicated in Fig. 1 below, to either stimulate NO signaling along the NO/cGMP, G kinase pathway which is

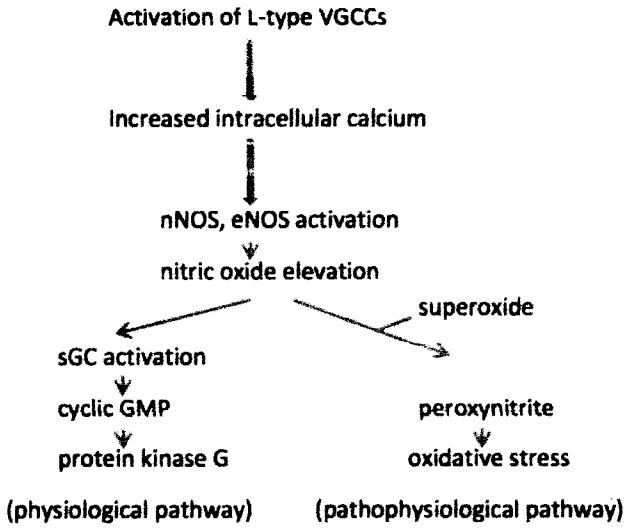

Figure 1. Possible pattern of action of VGCCs via nitric oxide (NO).

thought to be the main pathway of action of NO in producing normal physiological responses. This is thought to be the pathway involved in producing therapeutic effects of EMFs (6,7). In contrast, the pathway leading from NO to peroxynitrite and oxidative stress is thought to be the main pathway of action in pathophysiological responses to EMFs (7); it is the likely pathway of action of EMFs in producing single strand breaks in cellular DNA (7,15). So immediately we can see plausible mechanisms of action for some EMF effects, effects that were inexplicable by the old heating paradigm.

Other well-documented responses to microwave EMFs can also be produced via plausible mechanisms via VGCC activation

It can be seen from the previous section that three well-documented responses to microwave EMFs, namely therapeutic effects, single stranded breaks in cellular DNA and oxidative stress, can each be explained as being plausible consequences of VGCC activation by such EMFs. What about other such well-documented effects?

Double strand breaks in DNA, which are detected through the accumulation of micronuclei in cells after microwave and other EMF exposures, can be generated through the same mechanism as single stranded breaks.

Cancer is now well-established to be caused by weak microwave radiation exposures (reviewed in: 12-14). Adey many years ago showed that calcium effects were involved in cancer causation by such weak EMFs (9). It is known that cancer can be produced by a combination of single and double stranded breaks and other changes in DNA produced by peroxynitrite and its radical breakdown products. This NO/peroxynitrite pathway of action has been implicated in what is called inflammatory carcinogenesis (15-17) and provides, therefore a plausible mechanism of action for EMF/VGCC carcinogenesis.

Breakdown of the blood-brain barrier is another commonly reported response to microwave EMF exposure. Such breakdown occurs through peroxynitrite/oxidant product stimulation of the activation of matrix metalloproteinases (MMPs) (18-20), with the MMPs degrading the tight junctions between cells that are essential to maintain the blood-brain barrier (20,21). So again, we have a plausible mechanism leading from microwave EMF exposure to breakdown of the blood-brain barrier.

There are many studies showing that melatonin levels at night are greatly depressed in people exposed to microwave EMFs, with substantial sleep disruption as an apparent consequence. It has been shown that VGCCs and consequent intracellular calcium have effects on both the entrainment of the circadian rhythm which controls melatonin production as well as a more directly on melatonin production (22,23), providing simple explanations for this effect.

There has been much concern over the both male and female infertility in response to microwave EMF exposure. Such infertility may be caused by multiple effects of VGCC activation, including those produced through the peroxynitrite/oxidative stress pathway. Kesari et al (24) showed important roles of oxidative stress in cell-phone exposure caused male infertility. Double stranded breaks in the DNA of the gamete precursor cells, have been shown to have infertility roles (25). Such double stranded breaks in DNA produce a breakdown of the integrity of the genome and produces, therefore spontaneous early abortion and consequent infertility. However high levels of intracellular calcium can also induce apoptotic cell death through effects of elevated calcium in the mitochondria of those cells (26,27). In males, there may also be a breakdown of the blood-testis barrier via a mechanism identical to the breakdown of the blood-brain barrier, discussed above.

It can be seen from the above that 10 different well-documented microwave EMF effects can be easily explained as being a consequence of EMF VGCC activation: oxidative stress, elevated single and double strand breaks in DNA, therapeutic responses to such EMFs, breakdown of the blood-brain barrier, cancer, melatonin loss, sleep dysfunction, male infertility and female infertility.

This may be just the beginning

When one looks at what cell types carry functional VGCCs, there are many. Let's discuss a few of these where there has been substantial study. Most of the cells of the immune system carry VGCCs. O. Johansson (28) reviewed effects of microwave EMFs on the immune system and suggests that increases in allergies and inflammation may be produced by such EMFs.

VGCCs are found widely in the nervous system where almost every neurotransmitter is released in response to VGCC activation (29). There have been studies on the impact of cell phone or cordless phone use on various aspects of brain function but we are still in the very early stages in studying such effects. But given the widespread and important role of VGCCs in the central nervous system, one needs to carefully consider all

types of neuropsychiatric and neurodegenerative responses as to whether or not these may possibly be linked to microwave EMF exposure. There have been many studies showing various changes in neurological function and other brain changes following low level microwave EMF exposures (see for example, refs. 30-48).

Most of the hormones of the body are released under the control of mechanisms triggered by VGCC activation (29). What effects there may be of such possible linkage between EMFs and hormonal control is difficult to fathom. One hormone release system that has been studied in this context is the release of epinephrine/norepinephrine from the chromaffin cells of the adrenal gland. It has been shown in two studies that EMFs stimulate the release of these two hormones by chromaffin cells by a VGCC-dependent mechanism (7) as well as in many other EMF chromaffin cell studies where a VGCC role was not tested. These two hormones, when elevated produce major stress on the body, including psychological stress.

Another cell type where VGCCs have major roles are the pacemaker cells of the heart, endocrine system and central nervous system (29). These pacemaker cells have very high densities of VGCCs in them and may, therefore, be particularly susceptible to EMF activation. In the heart hyperactivity of the VGCCs produces tachycardia and arrhythmias, leading in some cases to sudden cardiac death (49,50). There are studies, in two cases going back to the 1960s (51,52), showing that isolated animal hearts exposed to microwave EMFs (again, well within current safety standards) developed tachycardia and arrhythmia and Havas has shown that some electromagnetic hypersensitive (EHS) individuals developed instantaneous tachycardia when unknowingly exposed to an activated cordless phone (53,54). We currently have an epidemic of tachycardia, arrhythmia and sudden cardiac death despite the fact that ischemic heart disease is decreasing. Could this be due to microwave EMF exposure? This is a possibility that cannot be ruled out at this point.

We are still in the early stages of studying many of these issues but safety standards should, of course, be genuinely tied to real safety, not simply to incomplete knowledge of extremely important potential and plausible hazards.

Are we going to jettison our false safety standards in favor of some that are at least somewhat biologically relevant?

Pulsed fields and different frequencies and intensities

It has been known for well over a quarter of a century that pulsed microwave fields are much more biologically active than are non-pulsed

fields. This is still another type of observation that is completely inconsistent with heating being the main effect. Pulsed fields are, of course, produced by any type of wireless communication device since it is the pattern of pulsations that conveys the information. However because different devices often use different types of pulsation patterns, we are left with the information that pulsations are important but we don't know how biologically active the different pulsation patterns are. So how can we rationally compare the dangers of one device vs another? The answer is we can't at this time because we don't have the required information.

Furthermore Barrie Trower, a retired military intelligence expert from the U.K. has stated that different wavelengths vary in their biological activities as well, but the specifics are all classified by multiple countries because of "national security." The problem of course is that this does not help the security of our bodies. However, this again says that we cannot compare different wireless communications devices with each other when they work on different wavelengths. Finally, it has been shown that there can be intensity "windows" where biological activity is greater than at intensities both higher and lower than the window intensity (55). This again argues against heating and also makes it impossible to currently predict biological activity without doing actual measurements of biological activity. While in general, lower intensities are safer than higher intensities, this "window" effect shows that there are some biologically important exceptions to this pattern.

Where do the threats come from and what can we do about them?

The threats come mainly but not solely from cordless communications devices, cell phones, cordless phones, cordless phone bases, Wi-Fi fields, Wi-Fi signaling from computers and tablets, cell phone and other microwave towers, radar units, microwave ovens, so called "smart meters" and all types of other cordless communications devices.

There are also concerns about extremely low frequency fields including 50/60 cycle fields coming from our wiring. In addition, essentially all such wiring nowadays, have various amounts of dirty electricity, which comes from high frequency transients in the electric wiring. These high frequency transients come from all types of digital devices. Digital power supplies, compact fluorescents and also digital inverter boxes used to convert photovoltaic energy from DC to AC and similar devices used in wind generated electricity may be particularly problematic. Dirty electricity can

move along the power lines and enter houses and other buildings from outside, so you have to deal with your own generation but also levels generated elsewhere in the vicinity. The biological effects of dirty electricity, as reported by Samuel Milham (56), Magda Havas and others are similar to those from microwave EMFs, so it seems likely that dirty electricity works, at least in part via VGCC activation, as well. I am not going to comment further on the dirty electricity problem here, although it is a substantial one.

The various types of devices listed in the first paragraph of this section, all put out pulsed fields with different patterns of pulsation from one device to another, making it impossible to currently predict biological effects of one device based on effects of another. Similarly since the different types of devices use different frequencies, they may differ from one another in biological impact in ways that cannot currently be predicted, given our current dearth of measurements of such effects by different devices. Accordingly, what is needed is a two-phase solution to this public health crisis:

1. Lowering exposures from current allowed levels, which use heating effects to compare different devices, by factors of 100 to 1000-fold. We know of, course, that this may be inadequate and that there may still be biological effects with many devices. But such lowering will produce a substantial improvement over current safety standards.
2. Use a series of biological response measures to compare biological responses to different devices to allow us to devise more biologically defensible safety standards in the future.

Lowering exposures by factors of 100 to 1000-fold

There are quite a number of things that can be easily done to improve the current situation. One can put shielding materials on the bottom of laptop computers and the back of tablets to lower exposures to our bodies. Wi-Fi fields are poorly designed with exposure levels of 1000 to 10,000 times that necessary for function when one is located near the Wi-Fi antenna. They can be redesigned to greatly lower such maximum exposures – the problem is that there has not been any focus on this issue. There are still problems using Wi-Fi in schools even if one does this, because a whole classroom of laptops communicating back to the Wi-Fi antenna still generates very high fields in a small space. My opinion is that it is better to go back to hard wiring computers in schools to completely avoid such unnecessary exposures.

Cell phones can be used with headsets or on speakerphone, both of which substantially lower exposures. Headsets should be given to anyone purchasing or otherwise receiving a cell phone, to encourage use. Cell phones can be carried in pouches shielded on one side, so by carrying the cell phone near the body with the shielded side towards the body, exposures can be greatly lowered.

Cordless (DECT) phones in the U.S. and many other countries are poorly designed, having bases which broadcast 24 hours per day. There are cordless phones available in Europe where the bases only broadcast when the phone is in use – this type of design should be standardized. Most cordless phones are designed so that they can be used circa 200 ft (60 m) away from the base. Most people do not need such long distance usage. By lowering the signal, cutting the distance to 20 ft (6 m), one can cut exposures from the phone 100-fold; redesigning antennae and other properties in such phones could, no doubt, produce further improvements. Changing the design of the phone antennae in either cordless phones or cell phones could lower exposures to the head when these are used without headsets or on speakerphone.

"Smart meters" should be abolished because they use short high-intensity pulses of microwave radiation. We know from the nanosecond pulse studies can be very damaging and act via VGCC activation, with activation continuing long after the pulse has ceased (7). It has been known for over 30 years that short microwave pulses can cause massive cellular damage (57). Until we have some biological measures of "smart meter" effects, it is foolhardy in my view to continue using them.

Cell phone and other microwave towers can be redesigned to lower maximum exposures near the tower. Austria has done such redesigns, lowering such exposures by 1000-fold and there is no reason that similar redesigns cannot be done elsewhere.

Microwave ovens also put out pulsed fields, pulsing with the alternating current that runs them. Exposures from microwave ovens can easily be lowered 100-fold or more through simple redesigning, including putting finer grounded metal mesh over windows.

We had, in the U.S., a huge shift in automobile safety from the 1950's and 60's to the 1980's when safety became a big marketing issue, so companies were competing based on safety, not just style and performance. We need a similar shift in the electronics industry. It can be done if the public knowledge is such that the public demands it, but probably not otherwise.

Biological testing

Hardell and Sage (58) argued for biologically based EMF safety standards before the VGCC central mechanism of action was realized. It is possible, of course, that EMF action may occur via other mechanisms, not just VGCC activation, but until such alternatives are identified, they cannot be easily assessed. Because we know that VGCC activation occurs and is very important biologically, this must be the current focus of biological testing. There are 10 types of VGCCs, including four types of L-type channels and also four other types of VGCCs (N-type, P/Q-type, R-type, T-type), with T-types having three forms. These 10 VGCCs differ from one another in their properties and may therefore differ from one another in how easily they become activated by various EMFs. These channels are also subject to multiple forms of biological regulation which may also produce still more heterogeneity in terms of biological responses to EMFs. In general then, cells differ from one another in whether they have VGCCs or not (most but not all do), the types of VGCCs found in specific cell types and the density of the different VGCCs in the plasma membrane and how these VGCCs are regulated in specific cells under specific conditions.

It is highly desirable to test EMF effects using diverse biological responses, to lower the probability of missing important responses to specific types of EMF exposures.

The proposal here is to use three types of biological response tests. Our discussion here is on these three general approaches, but does not provide detailed descriptions of each.

1. Cell culture tests: Should use cells known to be sensitive to EMFs. Probably the simplest way to measure responses is to use a nitric oxide electrode positioned in the gas phase over the cells in culture to measure increases in nitric oxide production, as shown earlier by Pilla (59).
2. Specific biological effects measured in experimental animals: Some effects that should be considered are:
   Tachycardia and other changes in heart beat in experimental animals
   Increased levels of epinephrine/norepinephrine in the blood
   Changes in neurological function, such as those reported during cell phone or cordless phone use
3. Whole animal studies can be done, by measuring whole body nitric oxide production. Nitric oxide is unstable in the body and it is typically measured through nitrate/nitrite in the blood.

We very much need to get started with such studies which are essential in order to approach genuine safety instead of the fictional safety we have now.

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Review

Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression

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ABSTRACT

Non-thermal microwave/lower frequency electromagnetic fields (EMFs) act via voltage-gated calcium channel (VGCC) activation. Calcium channel blockers block EMF effects and several types of additional evidence confirm this mechanism. Low intensity microwave EMFs have been proposed to produce neuropsychiatric effects, sometimes called microwave syndrome, and the focus of this review is whether these are indeed well documented and consistent with the known mechanism(s) of action of such EMFs. VGCCs occur in very high densities throughout the nervous system and have near universal roles in release of neurotransmitters and neuroendocrine hormones. Soviet and Western literature shows that much of the impact of non-thermal microwave exposures in experimental animals occurs in the brain and peripheral nervous system, such that nervous system histology and function show diverse and substantial changes. These may be generated through roles of VGCC activation, producing excessive neurotransmitter/neuroendocrine release as well as oxidative/nitrosative stress and other responses. Excessive VGCC activity has been shown from genetic polymorphism studies to have roles in producing neuropsychiatric changes in humans. Two U.S. government reports from the 1970s to 1980s provide evidence for many neuropsychiatric effects of non-thermal microwave EMFs, based on occupational exposure studies. 18 more recent epidemiological studies, provide substantial evidence that microwave EMFs from cell/mobile phone base stations, excessive cell/mobile phone usage and from wireless smart meters can each produce similar patterns of neuropsychiatric effects, with several of these studies showing clear dose–response relationships. Lesser evidence from 6 additional studies suggests that short wave, radio station, occupational and digital TV antenna exposures may produce similar neuropsychiatric effects. Among the more commonly reported changes are sleep disturbance/insomnia, headache, depression/depressive symptoms, fatigue/tiredness, dysesthesia, concentration/attention dysfunction, memory changes, dizziness, irritability, loss of appetite/body weight, restlessness/anxiety, nausea, skin burning/tingling/dermographism and EEG changes. In summary, then, the mechanism of action of microwave EMFs, the role of the VGCCs in the brain, the impact of non-thermal EMFs on the brain, *extensive epidemiological studies performed over the past 50 years, and five criteria testing for causality,* all collectively show that various non-thermal microwave EMF exposures produce diverse neuropsychiatric effects.

Contents

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Chemicals having roles:

Calcium(2+)
Nitric oxide (NO)
Oxido nitrite (peroxynitrite)

1. Introduction

Microwave syndrome (Hocking, 2001; Johnson Liakouris, 1998), a combination of various neuropsychiatric symptoms originally described in persons with occupational exposures to microwave frequency EMFs, has been disputed largely because of the lack of an apparent mechanism for generating these symptoms. It is reported to often include such symptoms as fatigue, headache, insomnia, dysesthesia (impaired sensation), irritability, lack of concentration and other symptoms (Hocking, 2001; Johnson Liakouris, 1998). Similar but more extensive combinations of symptoms have been reported following occupational exposures in two U.S. government reports from the 1970s/1980s (Naval Medical Research Institute Research Report, 1971; Raines, 1981) and following environmental exposures as described in two more recent reviews (Khurana et al., 2010; Levitt and Lai, 2010).

The goal here is not just to review the epidemiology, however, but more importantly to consider the issue of possible physiological mechanism(s). Hennekens and Buring (1989), on p. 40 in their textbook Epidemiology in Medicine state "The belief in the existence of a cause and effect relationship is enhanced if there is a known or postulated biologic mechanism by which the exposure might reasonably alter risk of developing disease." It is of critical importance therefore to assess possible biological mechanism before considering the epidemiological evidence.

Accordingly, this paper considers the mechanism by which low intensity microwave EMFs impact the cells of our bodies, how that mechanism may be predicted to impact the nervous system, evidence for such impact from experimental animal studies, genetic polymorphism evidence for that mechanism acting in humans to produce neuropsychiatric effects and finally, the epidemiological evidence for such effects in human populations with repeated low level microwave EMF exposure. Consideration of each of these types of evidence influences the overall interpretation presented in this paper.

2. Microwave/lower frequency EMFs act to activate voltage-gated calcium channels

In 24 different studies reviewed earlier (Pall, 2013) and two additional studies (Li et al., 2014; Lisi et al., 2006), microwave and lower frequency low intensity EMF effects were blocked or greatly lowered by calcium channel blockers, agents thought to be specific for blocking voltage-gated calcium channels (VGCCs). In these 26 studies, a total of 5 distinct types of channel blockers were used, with each type having a distinct structure and binding to a distinct site, such that it is essentially certain that these must be acting by blocking VGCCs, which is their only known common property. In each of these 26 studies, each of the responses studied, were blocked or greatly lowered by calcium channel blockers, showing that VGCC activation has roles in producing a wide variety of EMF effects. There is a large literature on changes in calcium fluxes and in calcium signaling following microwave EMF exposure (partially reviewed in Walleczek, 1992; Adey, 1993); each of these, including calcium efflux changes, can be explained as being due to VGCC activation, again suggesting a widespread role of VGCC activation in producing biological responses to EMFs. Pilla (2012) showed that pulsed microwave field exposure, produced an almost *instantaneous increase in calcium/calmodulin-dependent nitric* oxide (NO) signaling, providing strong evidence that these fields can produce an almost instantaneous VGCC activation. It is likely, that these EMFs act directly on the voltage sensor of the VGCCs to produce VGCC activation (Pall, 2015) with the voltage sensor being exquisitely sensitive to these EMFs because of its physical properties and location in the plasma membrane.

EMFs have been proposed to act to produce a wide variety of responses in the cell, via downstream effects of VGCC activation (Pall, 2013, 2014, 2015), including elevated intracellular calcium [Ca2+]i, excessive calcium and nitric oxide signaling and also excessive peroxynitrite, free radicals and oxidative stress.

VGCC activation has been shown to have a universal or near-universal role in the release of neurotransmitters in the brain and *also in the release of hormones by neuroendocrine cells* (Berridge, 1998; Dunlap et al., 1995; Wheeler et al., 1994), with such release being produced by calcium signaling. There are high densities of diverse VGCCs occurring in neurons throughout the nervous system. Both the high VGCC density and their function in neurotransmitter and neuroendocrine release throughout the nervous system suggests that the nervous system is likely to be highly sensitive to low intensity EMFs.

3. Genetic polymorphism studies

Genetic polymorphism studies are powerful tools for looking at the roles of specific proteins in human populations. In Table 1, a series of genetic polymorphism studies have been performed that show that an allele producing increased expression of the gene encoding the channel of the main L-type VGCC in the brain, produces diverse neuropsychiatric effects. These studies clearly show that excess L-type VGCC activity can cause neuropsychiatric effects. They also predict, therefore, that increased VGCC activity produced by microwave EMFs may be able to also produce widespread neuropsychiatric effects.

4. Histological and functional changes in central nervous system (CNS) and peripheral nervous system (PNS) in animals exposed to microwave EMFs

The most extensive literature on histological and functional changes in animals is from the Soviet literature from the 1950s/1960s with additional Western literature from the same time period. Both Soviet and non-Soviet literature were reviewed in an English language Publication by Tolgskaya and Gordon (1973). This publication is, therefore, the main focus of this section. That publication was divided into thermal and non-thermal exposure studies, with the non-thermal studies which occupy the majority of the text (pp. 53–137) being of sole interest here.

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Table 1
Influence of genetic polymorphism of the CACNA1C in producing diverse neuropsychiatric effects.

Citation	Genetic polymorphism	Changes produced by allele of gene
Bhat et al. (2012)	Polymorphism producing Increased expression of CACNA1C L-type VGCC subunit	Review: The polymorphism Is associated with increased susceptibility to bipolar disorder, "depression, schizophrenia, autism spectrum disorders, as well as changes in brain function and structure *in control subjects who have no diagnosable psychiatric illness.*"
Bigos et al. (2010)	Polymorphism producing Increased expression of CACNA1C L-type VGCC subunit	Associated with increases in both bipolar disorder and schizophrenia
Krug et al. (2010)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Negatively influences language production on a semantic level
Krug et al. (2014)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Influences episodic memory and retrieval
Soutro de Souza et al. (2012)	Polymorphism producing increased expression of CACNA1C *L-type VGCC subunit*	Produces impaired facial emotion recognition
Tesh et al. (2013)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Produces increased activation of the amygdala during emotional processing
Thimm et al. (2011)	Polymorphism producing increased expression of CACNA1C L-type VGCC subunit	Associated with attention deficits including alerting, orienting and executive control of attention

These were all derived from the Tolgskaya and Gordon (1973) review and page numbers listed are page numbers from that document. All refer to changes produced by non-thermal exposures in the nervous system of experimental animals, with most being in rats.

This discussion scrolls down through Table 2.

The majority of the histological changes seen in these mostly rodent studies, are seen in the nervous system, despite its being less than 2% of the rodent cell mass. There are statements made that the nervous system, both central and peripheral, is the most highly sensitive tissue to these non-thermal microwave and lower frequency EMFs. Following the nervous system in sensitivity are *the myocardium and the testis; myocardial cells are known to have* very high densities of VGCCs with especially high densities in the pacemaker cells and the testis is known to have high densities specifically of the T-type VGCCs. Pulsed EMFs are more active in producing histological changes in the brain than are non-pulsed fields, in two studies reviewed; there is a much larger literature showing that in most cases pulsed fields are more biologically active (Pall, 2015; Pangopoulos et al., 2013; Belyaev, 2015).

A wide variety of brain and peripheral nervous system tissues show histological changes following non-thermal exposures. Among the important tissues impacted are the hypothalamus and pituitary gland, where both show similar patterns of changes in neuroendocrine activities. There Is an initial increase in neuroendocrine activity (this may be produced directly by VGCC stimulation of secretion), followed over time by "exhaustion" of neuroendocrine activity (this may be produced by tissue damage produced from long term intracellular calcium [Ca2+]i elevation).

There are widespread histological changes produced in neuronal and neuroendocrine tissues. These were repeatedly reported to be largely reversible on cessation of EMF exposure. They become, however, irreversible when exposure is extended in time. There are changes in EEG activity, which may be an easily measurable monitor of neurological damage.

In a summary statement, Tolgskaya and Gordon (1973) state, "This does not confirm the view, so widely held in the past among Soviet investigators and still maintained to a large extent even at the present time in the West, that the action of microwaves is entirely thermal."

While there were many studies of brain impact of non-thermal EMFs performed in the 1950s/60s that make the information content of Tolgskaya and Gordon (1973) quite high, there is also a substantial recent literature on brain effects of non-thermal microwave EMF exposures (see, for example: Ammari et al., 2008a,b; Bas et al., 2009; Brillaud et al., 2007; Carballo-Quintás et al., 2011; Eberhardt et al., 2008; Dasdag et al., 2009, 2012; Grafström et al., 2008; Kumlin et al., 2007; López-Martín et al., 2006; Mausset-Bonnefont et al., 2004; Odaci et al., 2008; Rağbetli et al., 2010; Salford et al., 2003; Sonmez et al., 2010).

5. Older epidemiological reviews and other related studies

Two U.S. Government reports each listed many apparent neuropsychiatric effects of microwave/radiofrequency EMFs and a third recognized the role of non-thermal effects on our bodies, but had only a little consideration of neuropsychiatric effects.

The earliest to these was a Naval Medical Research Institute (NMRI) Research Report (1971) which listed 40 apparent neuropsychiatric changes produced by non-thermal exposures including: 5 central/peripheral nervous system (NS) changes, 9 CNS effects, 4 autonomic system effects, 17 psychological disorders, 4 behavioral changes and 2 misc. effects. This NMRI report also provided a supplementary document listing over 2300 citations documenting these and other effects of microwave exposures in humans and in animals.

The Raines (1981) NASA report reviewed extensive literature based on occupational exposures to non-thermal microwave EMFs, with that literature coming from U.S., Western European and Eastern European studies. There are no obvious differences in the literature coming from these different regions. Based on multiple studies, Raines (1981) reports 19 neuropsychiatric effects to be associated with occupational microwave/radiofrequency EMFs.

The Bolen (1994) report put out by the Rome Laboratory of the U.S. Air Force, acknowledged the role of non-thermal effects of microwave EMFs on humans. This report states in the Conclusion section that "Experimental evidence has shown that exposure to low intensity radiation can have a profound effect on biological processes. The nonthermal effects of RF/MW radiation exposure are becoming important measures of biological interaction of EM fields." Clearly Bolen (1994) rejects the claim that only thermal effects occur. Bolen (1994) discusses a specific non-thermal neuropsychiatric effect, where anesthetized animals are awakened when the head is irradiated with microwave EMFs. This suggests a similar mechanism to that acting in humans where such EMFs produce insomnia (see below).

6. Specific epidemiological studies on neuropsychiatric effects of microwave EMFs

There are 26 different epidemiological studies described in Table 3. Although 4 of these only studied a single neuropsychiatric effect, 22 of these each provide substantial evidence for the pattern described in the earlier U.S. reports, that a wide range of

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Table 2
Histological and functional changes in brain function in animals following exposure to non-thermal microwave EMFs.

Observations including page numbers	Comment from Author
The majority of the histological changes seen following non-thermal exposures, occurred in the nervous system, despite its being only about 2% of the tissue mass in rodents; this suggests that the nervous system is highly sensitive to such exposures. Elsewhere (pp. 129, 136), it is suggested that the nervous system is the most sensitive tissue, followed by the heart and the testis, among all of the tissues of the body. The most severe histological changes produced by these non-thermal EMF exposures occur in the nervous system (pp. 136).	High CNS sensitivity to EMFs is predicted by the high density of VGCCs that occur in neurons throughout the nervous system, plus the VGCC role in neurotransmitter and neuroendocrine release.
Pulsed fields were more active than non-pulsed fields in producing histological changes (pp. 71, 97).	Pulsed fields have often been found to be more biologically active than are non-pulsed fields in many different studies from many countries (Pall, 2015; Panagopoulos et al., 2015; Belyaev, 2015).
Nervous system regions impacted by non-thermal microwave and lower frequency fields include: cortex, diencephalon including the hypothalamus and thalamus, hippocampus, autonomic ganglia, sensory fibers, pituitary gland including neurohypophysis.	
Neuroendocrine changes seem to undergo change over increased time of exposure. Neurosecretion in the hypothalamus and in the pituitary each go through a complex sequence over time, where EMF exposure initially produces increased hormone secretion but where over time, the neurosecretory cells become "exhausted", leading to lowered secretion and in some cases cell death (pp. 77–96).	Elevated [Ca2+]i stimulates hormone secretion. However when such elevated [Ca2+]i occurs over extended time periods it is highly damaging to the cell, leading in some cases to apoptosis; thus this time course of action should not be surprising.
Histological changes include boutons/argyrophilia, smaller neurons, vacuole formation in neuroendocrine cells, bead-like thickening along dendrites (pp. 66, 70, 71, 73, 97, 98, 100, 111, 115–117, 121–125). Spines near the ends of dendrites become deformed and *with still more sessions of irradiation, disappeared entirely (p. 70). Sensory neurons*, following exposures, developed changes characteristic of irritation, with "marked tortuosity of the nerve fibers." Many histological changes are seen in the hypothalamic cells (pp. 87–92) as their neuroendocrine function becomes impacted. Histological changes were found even with exposures that produced no apparent functional changes.	
Many histological and functional changes are reported to initially be reversible, following cessation of exposure, but progressively become irreversible with longer exposure. (pp. 64, 72, 74). Paralleling the development of irreversibility, it is found that "Repeated exposure leads to gradual increase in severity of observed changes." ... including "increasingly severe disturbance of conditioned reflex activity in the animals, changes in responses of animals particularly sensitive to acoustic stimulation. . .." (p. 104).	If this is also true in humans, then claims that there cannot be non-thermal effects, claims which act to prolong exposures, may be causing irreversible damage to many humans.
EEG changes (pp. 55, 60, 102), including seizure activity following sensory provocation.	Lai (1994) has an extensive review of EEG changes in animals following non-thermal microwave EMF exposures
Neurodegeneration is reported in a number of places in this review (pp. 72, 83, 117).	
Synaptic connections in regions of the brain are disrupted (pp. 65–74, 97, 113, 121, 136), and at the extreme, some neurons are completely asynaptic (p. 73).	Synaptic connections are known to be disrupted in autism; could this suggest that autism may be generated by EMF exposure? No doubt, we need much more evidence on this. One wonders whether almost 60 years ago, the Soviet literature may have already described a possible animal model for EHS. None is known to exist today, and because of that, EHS studies are severely constrained. Clearly one needs to be skeptical about this interpretation, but it is of great importance that this be further studied.
"after prolonged and repeated irradiation with low-intensity centimeter waves, with no elevation of the body temperature and when the animal's condition remained satisfactory, changes were nevertheless found in the sensory fibers of the skin and viscera in the form of irritation phenomena. These findings concur with the view in the literature that the receptor system as a whole and, in particular its preterminal portions are highly sensitive." p. 76. This description is similar to what is reported to occur in electromagnetic hypersensitivity (EHS). Other such studies are described and include cumulative changes over time, that may also explain changes reported in EHS (pp. 75, 99, 100, 104).	

neuropsychiatric effects are produced by exposure to various non-thermal microwave frequency EMFs. Perhaps the most important of these 26 is the Santini et al. (2003) study of people living near cell phone base stations.

There are three recent studies on the generation of headache during or shortly following long mobile phone calls (listed under Chu et al., 2011 in Table 3). The timing of development of these *headaches and the finding that they occur on the ipsilateral side of* the head, the side receiving much higher EMF exposure during the call, both argue strongly that these headaches are caused by the long mobile phone calls. Such causality was concluded earlier by Frey (1998) based on earlier studies and is now still more strongly documented.

7. Criteria for assessing causality in epidemiological studies

It is important to consider the different criteria that allow one to judge whether a cause and effect relationship is justified by the studies listed in Table 3 and the individual studies cited in Raines (1981). There are five such criteria that should be considered in making that judgment (see pp. 39–43 in Hennekens and Buring, 1989):

Strength of Association: Is there a strong correlation between exposure and the neuropsychiatric symptoms? There clearly is for several studies cited in Raines (1981). One example is the Dwyer and Leeper (1978) study (see Table 3) where there is a large increase in symptoms and where that increase is greater with *longer occupational exposure. Another example is the* Lerner (1980) study of 1300 microwave workers, where workers with relatively low exposure levels had an approximate doubling of neurological complaints and where those with substantially higher exposure levels had an approximate tripling of neurological complaints over controls. Sadcikova (1974) found that 7 of 8 neuropsychiatric symptoms studied, showed a statistically significant rise in prevalence with longer occupational exposure (see Table 3). Sadcikova (1974), also found that microwave workers had increases of 3 to over 10-fold in: feeling of heaviness in the head; tiredness; irritability; sleepiness; partial loss of memory; and skin sensitivity. There is also a strong association where important new exposures occur – this is clearly the case with all of the studies of people living near cell/mobile phone base

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Table 3
Neuropsychiatric symptoms apparently produced by exposure to various electromagnetic fields.

Citation	EMF exposure	Apparent neuropsychiatric symptoms
Abdel Rassoul et al. (2007)	Living near mobile phone base station	Significant increases in neuropsychiatric complaints included: headache, memory changes, dizziness, tremors, depressive symptoms, sleep disturbance; attributed to effects of EMFs on the human nervous system.
Al Khlaiwi and Meo (2004)	*Mobile phone use*	*Higher prevalence of fatigue, headache, dizziness, tension and sleep disturbance;* the authors conclude that mobile phone use is a risk factor for developing these symptoms.
Altpeter et al. (2000)	Short-wave broadcasting tower, ranging from 6.1 to 21.8 MHz	Sleep disruption shown to occur, correlated with exposures and apparent increase over time; short term suppression of melatonin shown, based on melatonin increases during a 3 day period when the tower was turned off.
Bortkiewicz et al. (2004)	Living near cell phone base station EMFs	Sleep disturbance, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite, headache, vertigo.
Bortkiewicz et al. (2012)	Living near mobile phone base stations	Dose response relationships for sleep disturbance, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite.
Chu et al. (2011), also Chia et al. (2008), Oftedal et al. (2000)	Mobile phone use	Headache during prolonged mobile phone use or within an hour following such use, with pain occurring on the ipsilateral side of the head; similar observations obtained in each of the 3 studies in column 1; see also Frey (1998).
Conrad (2013)	Smart meter EMF exposure	14 common new symptoms (both severe and moderate) among those exposed and symptomatic, 13 apparent neuropsychiatric: Insomnia, tinnitus, pressure in the head, concentration difficulty, headaches, memory problems, agitation, dizziness, fatigue, skin tingling/burning, involuntary muscle contractions, eye/vision problems, numbness; These ranged in prevalence from 63% to 19% of those experiencing symptoms, such that most symptomatic people experienced multiple symptoms.
Dasdag et al. (1992)	People working in MW broadcasting or at a television transmitter station	These groups suffered from headache, fatigue, irritability, stress, sleepiness, loss of appetite, loss of hearing.
Dwyer and Leeper (1978)	*People working in radiofrequency* EMFs	*Headache, eyestrain, dizziness, disturbed sleep, daytime sleepiness, moodiness,* mental depression, memory impairment, muscle and/or cardiac pain, breathing difficulties, increased perspiration, difficulty with sex life.
Eger and John (2010)	Living near mobile phone base station	Neuropsychiatric symptoms, with most showing dose–response relationships: depression; headache; cerebral symptoms; dizziness; disorders of optical and acoustic sensory systems; sleep disturbance; skin changes; with the exception of dizziness, all of these had $p < 0.001$.
Johnson Liakouris (1998)	Study of personnel in U.S. embassy in Moscow exposed to microwave EMFs	Statistically significant increases in neurological (peripheral nerves and ganglia), dermographism (skin responses), irritability, depression, loss of appetite, concentration difficulties, peripheral ganglia and nerve dysfunction.
Khan (2008)	Excessive mobile phone use	Complaints of headache, fatigue, impaired concentration, memory disturbance, sleeplessness, hearing problems.
Kolodynski and Kolodynska (1996)	Children living near a Radio Location Station, Latvia	Memory dysfunction, attention dysfunction, lowered motor function, slowed reaction time, lowered neuromuscular endurance.
Lamech (2014)	Exposure to wireless smart meter radiation in Victoria, Australia	The most frequent symptoms to develop after smart meter radiation exposure were insomnia, headache, tinnitus, fatigue, cognitive disturbances, dysesthesias (abnormal sensation), dizziness.
Navarro et al. (2003)	Living near cell phone base station	Statistically significant dose response relationships for fatigue, irritability, headache, nausea, loss of appetite, sleep disorder, depressive tendency, feeling of discomfort, difficulty of concentration, loss of memory, visual disorder & dizziness.
Oberfeld et al. (2004)	*Living near cell phone base station*	*Statistically significant dose–response relationships for headache, fatigue,* irritability, loss of appetite, visual disorder, nausea, sleeping disorders, dizziness, poor concentration, memory loss.
Otto et al. (1984)	Occupational exposure of 25 workers to either UHF television broadcasting (10) or to 1062 kHz medium wave broadcasting (15)	10 neuropsychiatric changes were assessed, all showing statistically significant changes compared with controls: Somatization*, obsessive compulsivity*, interpersonal sensitivity, depression, anxiety*, hostility*, phobic anxiety*, paranoid ideation, psychoticism*, sleeping disturbance. *$p < 0.001$.
Sadchikova (1974)	Occupational exposure to microwave radiation, including at <.07 mW/cm^2	Heaviness in head*, fatigue*, irritability*, sleepiness, memory loss*, cardiac pain*, dermographism (skin sensitivity)*, hyperhidrosis* * significant increase with time of exposure.
Salama and Abou El Naga (2004)	High cell (mobile) phone use	Most common effects were headache, ear ache, sense of fatigue, sleep disturbance, concentration difficulty, face burning sensation. The first three of these had very high statistical significance for correlation with extent of cell phone use.
Santini et al. (2003)	Living near cell phone base stations	Each of the following neuropsychiatric symptoms showed statistical significant dose–response relationships: nausea, loss of appetite, visual disturbance, irritability, depressive tendencies, lowered libido, headache, sleep disturbance, feeling of discomfort, fatigue.
Schuz et al. (2009)	Mobile phone use	Found a small, statistically significant increase in migraine and vertigo. Also found an apparent lowered occurrence of Alzheimer's, other dementia, Parkinson's and epilepsy – these latter were interpreted as being due to perhaps early symptoms of *the developing diseases lowering probability of acquiring a mobile phone.*
Söderqvist et al. (2008)	Use of mobile phone among adolescents	Increased mobile phone use was associated with increases in tiredness, stress, headache, anxiety, concentration difficulties and sleep disturbances.
Thomee et al. (2011)	High mobile phone use	High mobile phone use was associated with statistically significant rises in stress and sleep disturbance, with somewhat weaker association with depression.
Waldmann Selsam et al. (2009)	Digital TV signaling	Constant headaches, pressure in head, drowsiness, sleep problems, tightness in chest, shortness of breadth, depressive mood, total apathy, loss of empathy, burning skin, inner burning, leg weakness, pain in limbs, stabbing pain in various organs, *weight increase.*

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stations, listed in Table 3 and also with the two studies of people who become exposed to radiation from smart meters. The studies listed in Table 3 under Chu et al. (2011) (see also Chia et al., 2000; Oftedal et al., 2000) are of a special type. Here people making very long (over 1 h) cell/mobile phone calls develop headaches an hour or more following the initiation of the long call. So these occur within a specific time range following initiation of these long calls, such that headache would only occur very infrequently in that time frame by chance. So here again, there is a strong association. While there is no question that many of these studies show high strength of association, it is also clear that it is becoming progressively more difficult to do these studies. As exposures become almost universal in countries around the world, it is getting difficult if not impossible to find good negative controls. There may be a similar problem in doing animal studies, such that it may be necessary to raise animals in Faraday cages in order to avoid exposures that would otherwise occur as a consequence of our near ubiquitous EMFs.

Biological credibility is extremely strong here, with three aspects of the biology predicting that these low intensity fields cause widespread neuropsychiatric effects. This was discussed above and is reconsidered in the following section.

Consistency within the different epidemiological studies and with other types of studies. The epidemiological studies listed in Table 3 and also those showing neuropsychiatric effects that were cited in Raines (1981) have been performed in many different countries with different cultures. They have been performed in multiple countries in Western Europe, Eastern Europe, the Middle East and in East Asia, as well as in the U.S. and Australia. They are, therefore, not limited to one or two cultural contexts. This is deemed, therefore, an important indicator of causality. We also have a surprising consistency of apparent neuropsychiatric effects of different fields, including various occupational exposures and exposures to cell/mobile phone base stations, exposure to the phones themselves, exposure to smart meter pulses, and other EMFs (see Table 3). Pulsation patterns, frequencies and exact intensities may produce various biological responses (Pall, 2015; Pangopoulos et al., 2013; Belyaev, 2015) so it is a bit surprising that we have as much consistency as we do have across different types of exposures. We also have consistency with the biology discussed in the previous section. Because elevated VGCC activity produced by genetic polymorphism (Table 1) produces diverse neuropsychiatric effects, it is not surprising that elevation of VGCC activity produced by microwave EMF exposure apparently also produces diverse neuropsychiatric effects. Similarly because non-thermal EMF exposures produce widespread changes in brain structure and function in animals (Tolgskaya and Gordon, 1973), it is not surprising that the neuropsychiatric symptoms, which are produced as a consequence of brain dysfunction are produced by such EMFs.

Time sequence: It is clear that the all of these effects follow exposure in the various studies that have been published. In some studies, it is also clear that longer occupational exposure times produce increased symptom prevalence. These include Dwyer and Leeper (1978) and Baranski and Edelwejn (1975). These observations all support a causal relationship between exposure to EMF and the development of neuropsychiatric symptoms.

Dose–response relationship: It is assumed, here, that biological effects have a positive correlation with the intensity of the apparent causal stressor. This is not necessarily true of EMF effects, because it has been shown that there are "window effects" where specific intensities have larger biological effects, than *do either lower or higher intensities* (Pall, 2015; Pangopoulos et al., 2013; Belyaev, 2015). Nevertheless, where different intensities were studied in these epidemiological studies, they do show the dose–response relationship assumed here including Altpeter et al. (2000), Dwyer and Leeper (1978), Eger and Jahn (2010), Lerner (1980), Navarro et al. (2003), Oberfeld et al. (2004), Salama and Abou El Naga (2004), Santini et al. (2003) and Thomée et al. (2011). Thus these data do fit well to the assumed dose–response relationship, found in most causal roles. The Altpeter et al. (2000) study showed a special type of evidence for causality: during a 3-day period when the broadcasting tower was turned off, the melatonin levels recovered to near-normal levels. The studies of headache occurrence on prolonged cell/mobile phone calls (typically well over one hour) listed under Chu et al. (2011) in Table 3 also suggest the assumed dose–response relationship (see also Chia et al., 2000; Oftedal et al., 2000 and earlier citations listed in Frey, 1998). Because such headaches only occur with prolonged cell/mobile phone calls, these studies also provide evidence for a dose–response relationship because low doses are ineffective. Furthermore these same studies provide evidence for such a dose–response relationship from another type of observation. Because the headaches occur predominantly on the ipsilateral side of the head which receives much higher EMF exposure intensity, rather than on the contralateral side of the head, which receives much lower intensities, this provides an additional type of evidence for the predicted dose–response relationship.

While the evidence is convincing that the various neuropsychiatric apparent consequences of microwave EMF exposure are in fact caused by such exposures, there may be somewhat more controversy about another EMF-neuropsychiatric linkage. Havas et al. (2010) have reported a similar list of neuropsychiatric symptoms in electromagnetic hypersensitivity (EHS) patients. They found that each of the following symptoms were common in EHS: poor short term memory; difficulty of concentration; eye problems; sleep disorder; feeling unwell; headache; dizziness; tinnitus; chronic fatigue; tremors; body pain; difficulty speaking; tingling sensation in feet or hands; difficulty writing; difficulty walking; migraine. The similarity of these symptoms to the most commonly found symptoms following non-thermal microwave EMF exposures (Table 3), suggests that EHS is a genuine sensitivity to EMFs. In the bottom row in Table 2, sensitivities were found in rodent studies following non-thermal exposure that suggest a possible animal model for the study of EHS. Each of these EHS-related issues needs to be followed up experimentally.

8. Discussion and conclusions

In the previous section, each of the five criteria for assessing whether an epidemiological association is causal, were considered. Those five are (Hennekens and Buring, 1989): (1) strength of association; (2) biological credibility; (3) consistency; (4) time sequence; (5) dose–response relationship. Each of these five provide strong support for causality such that the combination of all five provides compelling evidence for causality. Low-intensity microwave frequency EMFs do cause diverse neuropsychiatric symptoms. While each of these five is important here, the one that is most important is the criterion of biological credibility.

Three related sets of biological observations each predict that low-intensity microwave EMFs produce widespread neuropsychiatric effects:

1. Such EMFs act via activation of VGCCs, acting through the VGCC voltage sensor which is predicted to be exquisitely sensitive to these EMFs (Pall, 2015). VGCCs occur in high densities throughout the nervous system and have essential roles throughout the nervous system in releasing neurotransmitters and neuroendocrine hormones. These properties predict, therefore, that these low intensity non-thermal microwave EMFs cause widespread changes in the nervous system, causing, in turn, diverse neuropsychiatric effects.

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2. Elevated VGCC activity, produced by an allele of the CACNA1C gene which encodes the channel of the main L-type VGCC in the brain, produces various neuropsychiatric effects (Table 1). This predicts, that low intensity non-thermal microwave frequency EMFs which also produce elevated L-type and other VGCC activity, therefore produce widespread neuropsychiatric effects.
3. Studies reviewed in the Tolgskaya and Gordon, 1973 publication (Table 2) have shown that the cells of the mammalian nervous system show high sensitivity to various non-thermal microwave and lower frequency EMFs, being apparently more sensitive than any other organ in the body of rodents. These studies predict that the human nervous system is likely to be similarly sensitive to these EMFs, predicting, therefore, widespread neuropsychiatric effects in humans.

We not only have biological credibility but also more importantly, each of these distinct but interrelated biological considerations predicts that low-intensity, non-thermal microwave EMFs produce widespread neuropsychiatric effects. That common prediction is verified by extensive data summarized in citations provided by the Naval Medical Research Institute Research Report (June 1971), data provided by The Raines (1981) NASA report, and by 26 epidemiological studies summarized in Table 3.

The most commonly reported neuropsychiatric symptoms from these studies are summarized in Table 4.

A total of 22 different studies described in Table 3 were used for data for this table, but not 4 others that only assessed a single neuropsychiatric end point. The Altpeter study which only assessed sleep disturbance/melatonin depletion and the three studies listed under Chu et al. which only assessed headache occurrence following long cell phone calls, listed in Table 3 were not included. Because many of the studies only assessed from 3 to 7 specific symptoms, it is not surprising that the numbers of studies reporting a specific symptom fall far below 22. Where several symptom descriptions were included under one heading, such as dysesthesia, if a study had more than one of these symptom descriptions, it was only counted once.

All the symptoms listed in Table 4 should be considered established parts of microwave syndrome (Hocking, 2001; Johnson Liakouris, 1998). Even if the statistical significance in each study was of the lowest statistical significance ($p < .05$) one would expect only 1 positive study to occur at random out of the 22 studies included here. Because many individual symptoms were not surveyed in many individual studies, the expectation is substantially lower than that. Each of these, having shown positive results in 5 or more studies are highly unlikely, therefore, to have occurred by chance. Stong statistical significance is also seen for individual neuropsychiatric effects reported to have $p < 0.001$ in the Eger and Jahn (2010) and Oto et al. (1994) studies (see Table 3).

Table 4
Commonly reported neuropsychiatric symptoms following microwave EMF exposure.

Symptom(s)	Numbers of studies reporting
Sleep disturbance/insomnia	17
Headache	14
Fatigue/tiredness	11
Depression/depressive symptoms	10
Dysesthesia (vision/hearing/olfactory dysfunction)	10
Concentration/attention/cognitive dysfunction	10
Dizziness/vertigo	9
Memory changes	8
Restlessness/tension/anxiety/stress/agitation/feeling of discomfort	8
Irritability	7
Loss of appetite/body weight	6
Skin tingling/burning/inflammation/dermographism	6
Nausea	5

EEG changes may well be part of microwave syndrome, as well. While none of the studies described in Table 3 measured EEGs, six studies of human occupational exposure cited in the Raines (1981) showed EEG changes (Baranski and Edelwejn, 1975; Bise, 1978; Dumanskii and Shandala, 1974; Lerner, 1980; Sheppard and Eisenbud, 1977). Murbach et al. (2014) cited 10 human studies in support of their statement that "the most consistently reported effects (of mobile phone use) in various studies conducted by different laboratories are changes in the electroencephalogram (EEG) power spectrum." Three recent studies (Lustenberger et al., 2013; Schmid et al., 2012a,b) and several earlier studies cited in Wagner et al. (1998) have each shown EEG changes in sleeping humans exposed to non-thermal pulsed microwave fields. Two recent studies showed EEG changes in persons exposed to Wi-Fi fields (Maganioti et al., 2010; Papageorgiou et al., 2011). Lai (1997) described 8 animal studies showing changes in EEG patterns in animals exposed to non-thermal EMFs and three additional animal studies were described in Tolgskaya and Gordon (1973). With the exception of the 6 studies cited in the second sentence in this paragraph, all of these are direct experimental studies which are not, therefore, susceptible to the questions of causality that can be raised about epidemiological studies. It is the author's view that future studies should consider studying EEG changes as an objectively measurable assessment of brain physiology and that before and after increased exposure studies should be considered when a new EMF source is to be introduced into human populations. While such studies must be done carefully, given the complexity of EEGs, even very small numbers of individuals may produce highly statistically significant results in well designed studies analyzed with paired *t*-tests.

One of the citations from the previous paragraph, Bise (1978) reviewed earlier studies of low level microwave frequency exposures in humans and concluded that such EMFs produced the following neuropsychiatric effects: headache, fatigue, irritability, dizziness, loss of appetite, sleepiness, sweating, difficulty of concentration, memory loss, depression, emotional instability, dermographism, tremor, hallucinations and insomnia. The strong similarity of this list from 37 years ago and the list in Table 4 should be noted. The Bise (1978) list is based on occupational exposure studies whereas the current list in Table 4 is based primarily on EMF exposures from cell/mobile phone base stations, from heavy cell phone usage and from smart meters, *three types of exposures that did not exist in 1978*. The strong similarity between the Bise (1978) list and the current one 37 years later alone produces a compelling argument that the 11 neuropsychiatric effects found on both lists are caused by exposure to multiple types of low-intensity microwave EMFs.

The pattern of evidence is compelling in support of the earlier statement of Levitt and Lai (2010) that "the primary questions now involve specific exposure parameters, not the reality of complaints or attempts to attribute such complaints to psychosomatic causes, malingering or beliefs in paranormal phenomena."

We can barely imagine how the combinations of neuropsychiatric effects, including those in Table 4, will influence human behavior and social interactions, now that the majority of the human populations on earth are exposed to ever increasing intensities and diversity of microwave frequency EMFs. You may recall that three of the occupational exposure studies cited in (Raines, 1981 showed increasing prevalence of neuropsychiatric symptoms with years of exposure to consistent patterns of EMF exposure intensities (Dwyer and Leeper, 1978; Sadcikova, 1974;

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Baranski and Edelwejn, 1975). With ever increasing exposures in human populations, we have no idea what the consequences of these ever increasing exposures will be.

Conflict of interest

The author declares no conflict of interest.

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Magda Havas*

Radiation from wireless technology affects the blood, the heart, and the autonomic nervous system[1)]

Abstract: Exposure to electrosmog generated by electric, electronic, and wireless technology is accelerating to the point that a portion of the population is experiencing adverse reactions when they are exposed. The symptoms of electrohypersensitivity (EHS), best described as rapid aging syndrome, experienced by adults and children resemble symptoms experienced by radar operators in the 1940s to the 1960s and are well described in the literature. An increasingly common response includes clumping (rouleau formation) of the red blood cells, heart palpitations, pain or pressure in the chest accompanied by anxiety, and an upregulation of the sympathetic nervous system coincident with a downregulation of the parasympathetic nervous system typical of the "fight-or-flight" response. Provocation studies presented in this article demonstrate that the response to electrosmog is physiologic and not psychosomatic. Those who experience prolonged and severe EHS may develop psychologic problems as a consequence of their inability to work, their limited ability to travel in our highly technologic environment, and the social stigma that their symptoms are imagined rather than real.

Keywords: electrosmog; radio-frequency radiation; rouleau; tachycardia; WiFi; Wolff-Parkinson-White Syndrome.

[1)]Presented at the Corporate Interference with Science and Health: Fracking, Food, and Wireless, Scandinavia House, New York, NY, March 13 and 14, 2013.

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Introduction

Our exposure to devices using electricity and emitting extremely low-frequency and radio-frequency electromagnetic fields has been increasing ever since Edison invented the incandescent light bulb and Tesla and Marconi discovered that radio-frequency (RF) radiation can be transmitted without wires. Radio, television, computers, cell phones, and their accompanying cell phone antennas, cordless phones, wireless routers (WiFi), wireless baby monitors, wireless games, and smart meters are increasing our exposure to RF radiation and especially to microwave radiation (300 MHz–300 GHz).

As an example of the proliferation of this technology, access to WiFi was limited in 2002 but by 2012 access was virtually ubiquitous in the USA (Figure 1). We have city-wide WiFi in some communities, WiFi at work, at home, in school, universities, and hospitals, in restaurants and coffee shops, on public transit, at airports, and on an increasing number of airplanes. As a society, we seem to be insatiable for wireless technology and the connectivity it affords.

Although the downside to this technology, namely, the potentially harmful effects of nonionizing radiation, has received relatively little attention in North America and remains controversial, it is an area that deserves proper research funding based on the sheer number of users and people exposed worldwide to RF electromagnetic fields.

In this article, the relationship between electrosmog exposure and electrohypersensitivity (EHS), with a focus on the cardiovascular system, is presented, based on provocation studies and on reports of ill health among those living near cell phone base stations or exposed to WiFi in schools.

Electrohypersensitivity

Just as some people have multiple chemical sensitivity or react to pollen, mold, and certain types of food, a growing population is becoming "sensitive" to electromagnetic radiation.

Khurana et al. (1) reviewed ten epidemiologic studies, three dealing with cancer and seven with neurobehavioral effects, that examined the putative effects of mobile phone base stations. All of the neurobehavioral studies reported more symptoms with proximity to base stations, and only

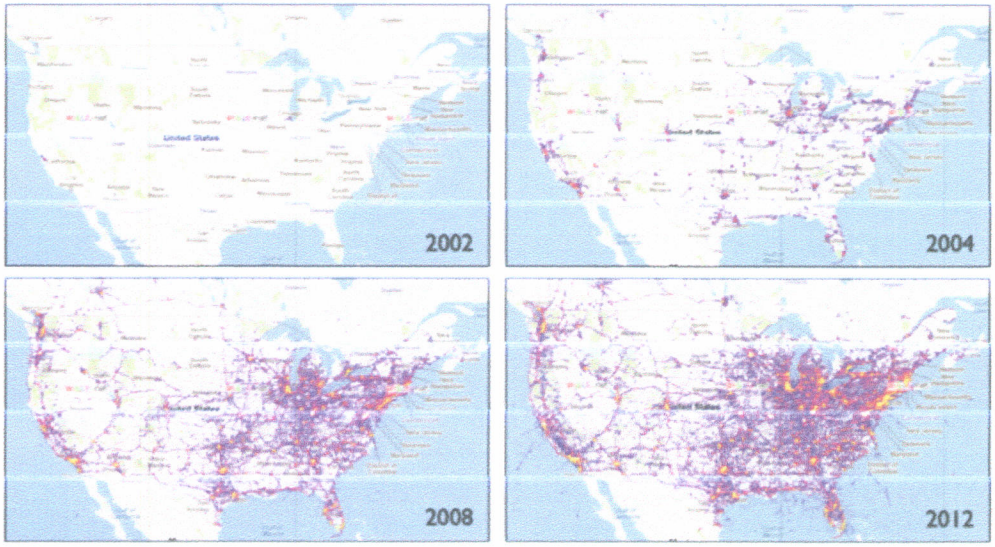

Figure 1 WiFi networks in the USA from 2002 to 2012 (source: wigle.net).

one attributed these health effects to stress rather than RF exposure.

The results from one of these studies are presented in Figure 2 (2). People who lived closest to the antennas experienced the following symptoms more often than those who lived further away: fatigue, sleep disturbance, headaches, feeling of discomfort, difficulty concentrating, depression, memory loss, visual disruptions, irritability, hearing disruptions, skin problems, cardiovascular problems, dizziness, loss of appetite, movement difficulties, and nausea. Many of these symptoms are more common as we age, thus I prefer to call this rapid aging syndrome (RAS). The difference between real aging and RAS experienced by those who are electrically hypersensitive is that when these people go into an electromagnetically clean environment, many of their symptoms diminish

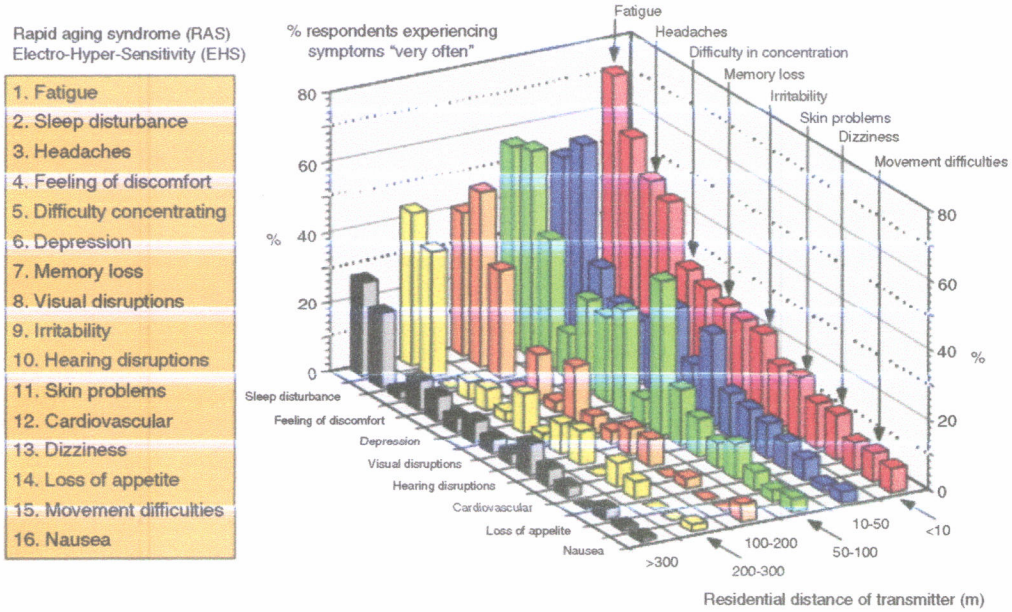

Figure 2 Symptoms experienced by people near cellular phone base stations [based on the work of Santini et al. (2)].

or disappear. Obviously, this does not happen with real aging.

Because cell towers are proliferating and difficult to avoid in both urban and rural communities and if the results of Santini et al. (2) represent what is happening to those who live near cell towers, then it is quite likely that we are going to experience (or are in the midst of experiencing) an emerging health crisis that is contributing to chronic ill health and is promoting the sale of pain medication, sleep medication, antidepressants and antianxiety medication, pills to moderate energy level and mood, and drugs for those with attention deficit hyperactivity disorder such as Ritalin® (metylfenidat).

In 2006, Hallberg and Oberfeld (3) documented the increasing prevalence of EHS. Figure 3 clearly shows that self-perceived EHS is on the rise. According to the authors, by 2017, 50% of the population is going to be complaining of this illness. Admittedly, this is a rough calculation but it demonstrates that symptoms of EHS are increasing.

It is difficult to estimate the percentage of the population that has EHS. I use a conservative estimate of 3% of the population for those who have severe symptoms, and this is based on the population in Sweden who have registered as being electrohypersensitive (4). Another 35% population may have mild to moderate symptoms of EHS when exposed to electrosmog (5). Based on these percentages, the cumulative number of people who may be adversely affected in Canada, the USA, and Europe is 25 million, for severe sensitivity (EHS), and another 300 million, for mild to moderate sensitivity (electrosensitivity). People in this latter group can function in an electrosmog environment but may develop headaches or have difficulty sleeping and are living a life compromised by increasingly poor health as a consequence of their exposure (Figure 2).

Historically, environmental contaminants have been presented as contentious issues due, in part, to the media's need for "balanced reporting" and, in part, to the economic consequences of altering our behavior as consumers. This was certainly the case with asbestos, dichloro-diphenyl-trichloroethane (DDT), lead, mercury, acid rain, and tobacco smoke and is currently the case with climate change and EHS.

EHS may be viewed as a contentious issue, yet a growing number of international experts, scientists, and medical doctors have been asking governments and international agencies for decades to lower existing guidelines for RF radiation because the current guidelines do not protect public health. Table 1 provides a list of some of these resolutions and appeals.

Some governments have heeded the warnings and have exposure guidelines that are a fraction of those recommended by the World Health Organization (WHO) and accepted by the USA, UK, and Canada.

The WHO held an international workshop on electrosensitivity in Prague in 2004 (6), and they defined EHS as follows:

> "... a phenomenon where individuals experience adverse health effects while using or being in the vicinity of devices emanating electric, magnetic, or electromagnetic fields (EMFs)."

> "Whatever its cause, EHS is a real and sometimes a debilitating problem for the affected persons.... Their exposures are generally several orders of magnitude under the limits in internationally accepted standards."

What role should the WHO and other leading health authorities play in helping these sensitive individual? Some would advocate, at the very least, lower exposure

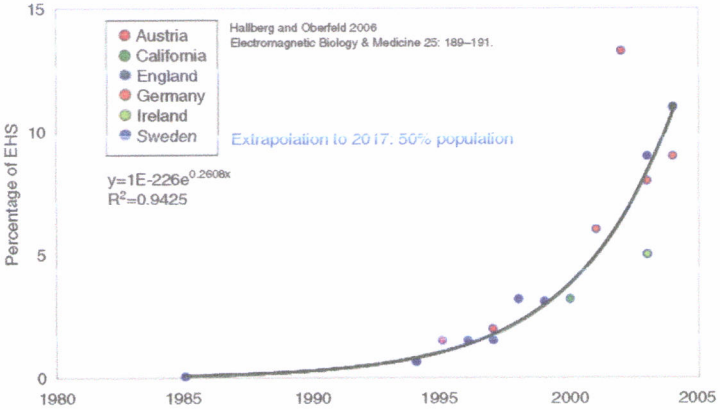

Figure 3 Estimated prevalence of self-proclaimed EHS in various countries [based on the work of Hallberg and Oberfeld (3)].

Table 1 Appeals and resolutions from international groups of scientists and medical doctors.

Resolution/group	Country	Year	Link
Salzburg Resolution	Austria	2000	http://www.magdahavas.com/international-experts-perspective-on-the-health-effects-of-electromagnetic-fields-emf-and-electromagnetic-radiation-emr/
Catania Resolution	Italy	2002	www.emrpolicy.org/faq/catania.pdf
Freiburger Appeal	Germany	2002	http://www.magdahavas.com/international-experts-perspective-on-the-health-effects-of-electromagnetic-fields-emf-and-electromagnetic-radiation-emr/
World Health Organization	Czech Republic	2004	http://www.who.int/peh-emf/meetings/hypersensitivity_prague2004/en/
Irish Doctors' Environmental Association	Ireland	2005	www.ideaireland.org
Helsinki Appeal	Finland	2005	www.emrpolicy.org/headlines/helsinki_appeal_05.pdf
Benevento Resolution	Italy	2006	http://www.icems.eu/docs/BeneventoResolution_REVISED_march2008.pdf
BioInitiative Report	USA	2007 and 2012	www.bioinitiative.org
Venice Appeal	Italy	2008	http://www.icems.eu/resolution.htm
Porto Alegre	Brazil	2009	http://www.icems.eu/docs/resolutions/Porto_Alegre_Resolution.pdf
Seletun	Norway	2011	http://www.magdahavas.com/international-experts-perspective-on-the-health-effects-of-electromagnetic-fields-emf-and-electromagnetic-radiation-emr/
International Doctors Appeal	Germany	2012	http://www.icems.eu/resolution.htm

limits and possibly places where the radiation is not allowed, similar to smoke-free environments. Instead, the WHO recommended that this illness be referred to as "idiopathic illness", which basically means the cause is unknown. By refusing to acknowledge the cause, the WHO undermines the need for governing agencies to act.

In contrast to the WHO, the Austrian Medical Association (7) came out with guidelines to help doctors diagnose and treat those who experience EHS. In that document, they recognize that there is a rise in stress-related illness and that electrosmog may play a role. They even provide a temporary code (Z58.4, exposure to radiation) under the *International Classification of Diseases, 10th Edition* to be used for EMF syndrome, which is their term for EHS.

A group of psychologists considers EHS to be entirely a psychologic illness rather than a physiologic response to electrosmog (8, 9). A number of the articles reviewed by Rubin et al. are based on flawed assumptions about (1) who is truly experiencing EHS, (2) how people with EHS respond to exposure, (3) what frequencies and intensities they respond to, (3) how quickly they respond and recover following exposure, and (3) how the data should be analyzed. These flawed assumptions lead to flawed conclusions.

For example, not everyone who believes they have EHS actually have EHS. Thus, combing the results for the self-proclaimed "EHS group" is likely to dilute the results, producing no significant effect when analyzed statistically. The question that is being tested by this type of analysis is, "Do those who believe to be electrically sensitive all respond the same way to provocation testing?" and the answer is likely to be "no".

In the study by Rea et al. (10) of 100 people who believed they were electrically hypersensitive, only 16 responded consistently to real exposure and not to sham exposure. Had the results been statistically analyzed for the entire 100 subjects tested, they would have shown no effect of EMF exposure. Objective testing is required, and people should be assessed as individuals rather than members of a group for analysis. An analogous situation is if there were 16 people with diabetes among a group of 100 people who all thought they were diabetic. Statistical analysis of blood sugar measurements before and after consuming a standard meal for the entire group would likely miss the 16 people with diabetes.

The proper way to test for EHS is to monitor and assess individual responses to electrosmog exposure in a double-blind study, as was done by Rea et al. (10).

However, it is clear that those who experience EHS and are no longer able to live a "normal" life and who are not supported by their family, friends, and physicians also experience stress leading to psychologic problems including depression and anxiety disorders. Where I disagree with Rea et al. (10) about EHS is that I believe the physiologic response precedes the psychologic problem.

In this article, examples of the effects of electrosmog on the blood, heart, and autonomic nervous system (ANS) are provided, indicating that EHS is a physiologic response to electromagnetic pollution. The only legitimate use of the term "idiopathic" (i.e., disease or disorder that has no known cause) is in reference to the trigger that initiated the electromagnetic sensitivity. In some cases, with good medical investigation, this also can be surmised.

Electrosmog affects the blood

Healthy blood consists of erythrocytes (red blood cells), which are round and which float freely in the plasma. A live blood sample, consisting of a drop of blood from a finger prick, can be viewed under the microscope, as shown in Figure 4. Changes in the size, shape, and clumping of these erythrocytes can indicate impaired health.

Figure 4 shows live blood (blood without any chemicals added to it) in an electromagnetically clean environment (A) and the blood from the same person spoke on a cordless phone for 10 min (B) and after using a wired computer for 70 min (C). The erythrocytes are sticking together and resemble a stack of coins. This is known as rouleau formation and indicates unhealthy blood.

Usually rouleau is caused by an increased fibrinogen concentration or other changes in plasma proteins as in multiple myeloma or macroglobulinemia. An alternative explanation is that the rouleau may be due to a reduction in the electrical potential at the cell membrane, which would weaken the repellent forces between cells. A third possibility is that it is a microscopic artifact, which, in this case, is unlikely because the results are repeatable. Research on the mechanisms involved in the rouleau formation is needed.

With rouleau formation, the surface area of the red blood cells is significantly reduced, and the release of nutrients and the removal of waste products are compromised. Symptoms may include headaches, difficulty concentrating, dizziness, nausea, heart and blood pressure problems as well as cold, numbness, or tingling sensation in the extremities (hands and feet).

The good news is that live blood analysis may be a useful diagnostic for EHS. How quickly the blood clumps and how quickly it recovers following exposure may be a good indicator of the degree of sensitivity.

Electrosmog affects the heart and the autonomic nervous system

Some people who are electrically hypersensitive complain of pain or pressure in the chest area, heart palpitations,

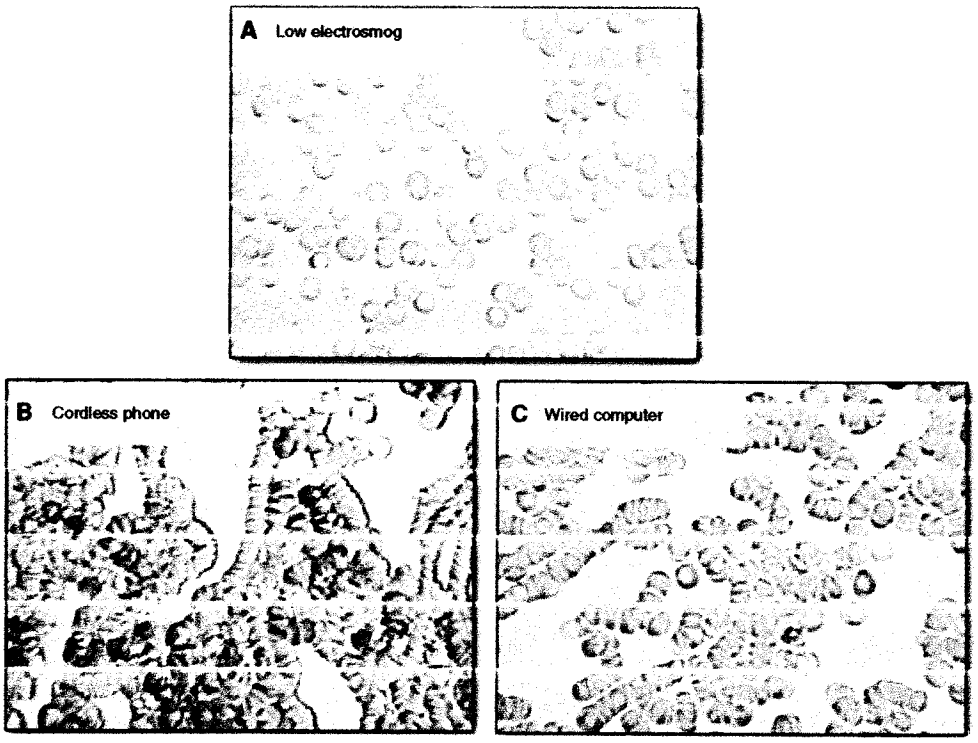

Figure 4 Live blood cells in a low-electrosmog environment (A), after using a cordless phone for 10 min (B), and after using a wired computer for 70 min (C).

and/or an irregular heartbeat, accompanied by feelings of anxiety that develop rapidly. The symptoms resemble a heart attack and thus contribute to even more anxiety.

To test the effect of electrosmog on the heart, Havas et al. (11) designed a simple experiment where subjects were exposed to electromagnetic radiation generated by the base of a cordless phone. This was a double-blind study with randomized real and sham exposure. A cordless phone base station was selected as the source of exposure because the base emits a constant beacon signal when it is plugged into an electrical outlet. The beacon signal in this case was a pulsed frequency of 2.4 GHz, the same frequency used in WiFi.

In the original study (11), 25 subjects from Colorado were tested, and although most subjects did not react adversely to the radiation from the cordless phone base station (see Figure 5, subject A), a few did react with either tachycardia (rapid heart rate) or arrhythmia (irregular heart rate) (Figure 5, subject B). The reaction was often immediate and coincided with exposure to the radiation. When the radiation ceased, the heart returned to normal.

Two examples of responsive subjects are provided. The heart rate of subject B increased from a resting heart rate of 68 beats per minute (bpm) to a rapid 122 bpm during exposure, decreased to 66 bpm as soon as the radiation was stopped, and increased to 129 bpm when it was resumed. This reaction occurred while the subject was resting in a supine position and was unaware of when he or she was or was not exposed.

During the exposure to radiation from the cordless phone base station, subject C (Figure 6) experienced a slight increase in heart rate (from 65 to 86 bpm), an irregular heartbeat, and changes in the response of the sympathetic and parasympathetic nervous system (SNS and PNS, respectively). This upregulation of the SNS and downregulation of the PNS is an example of the "fight-or-flight" response, indicating physiologic stress. During periods of this type of stress, the body redirects most of the blood and energy from the internal organs to the arms and legs to prepare the organism for fighting or fleeing a stressful situation. Intermittent exposure may not cause a problem but if the exposure is continuous and long-term, the immune system of the body will be compromised and the body will not be able to repair itself, resulting in symptoms that are commonly experienced by those who are electrically hypersensitive. This inability to heal is what then accelerates the symptoms of aging (i.e., RAS).

The level of radiation in this experiment was well below international guidelines. Subjects were exposed to 3 $\mu W/cm^2$, or 0.3% of the guidelines recommended by International Centre for Non-Ionizing Radiation Protection (ICNIRP), the Federal Communication Commission (in US) (FCC), and Health Canada for 2.4-GHz frequencies. According to these organizations, harmful biologic effects do not occur below these thermal guidelines. Both blood and heart results from these provocation experiments indicate otherwise, i.e., that biologic effects that can have serious health implications do occur at levels well below current thermal guidelines.

The cordless phone provocation study has since been repeated for a larger group of subjects and shows similar results (12).

Some suggested that the radiation from the cordless phone was interfering with the technology rather than the heart. If this were the case, then 100% of the subjects would have had similar results because the

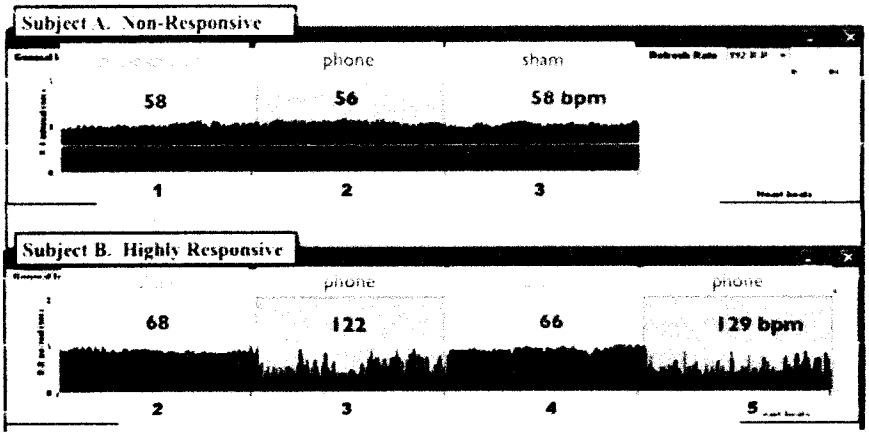

Figure 5 Rhythmograph of HRV during provocation with a digital 2.4-GHz cordless phone and sham exposure. The x-axis unit is time, with each stage lasting approximately 3 min. The y-axis is the R-R interval (in seconds).

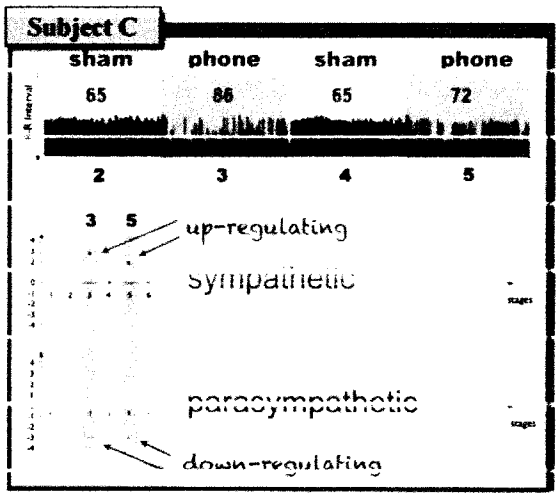

Figure 6 Rhythmograph of HRV and functioning of the SNS and PNS during provocation with digital 2.4-GHz cordless phone and sham exposure.

electromagnetic interference (EMI) would have been consistent rather than highly variable and individualistic. Additional testing of higher levels of radiation at the sensor did not affect the heart rate variability (HRV) of a subject who was nonresponsive to the original levels. Had it been EMI, then higher levels of exposure should have had a greater response, but this was not the case (12).

One subject (52-year-old man) told us that he normally experiences a delayed reaction to electrosmog exposure, and thus we monitored him for 30 min postexposure and observed the delayed response during a period of no exposure. The response included periods of short-term and intermittent irregularity in the R-R interval (HRV) as well as episodic downregulation of both the SNS and the PNS, which were both low to begin with (12). The normally low heart rate, 53–55 bpm, began to increase slightly (61 bpm) 25 min postexposure.

WiFi in schools affects student health

Students in schools with WiFi are complaining of headaches, difficulty concentrating, weakness, and heart palpitations, prompting their parents to take them to their family doctor and to their pediatric cardiologist to determine the nature of their problem.

In one Ontario school district, several students complained of heart problems. A 6-year-old girl had a "musical heart", and she experienced headaches and dizziness only at school. A 12-year-old boy had tachycardia (rapid heart rate). A 12-year-old girl experienced nausea, vomiting, no fever, insomnia, blurred vision, and tachycardia only at school. A 13-year-old boy had a pounding heart, insomnia, and headaches. His family moved to a different school district, and his symptoms disappeared.

In the same area, 4 students had sudden cardiac arrests (SCA) during exercise class within a 2-year period. Two of these students were resuscitated. The annual rate for SCA among young people in Canada is approximately 7 per year; hence, 4 in a small community is unusual.

According to Sinatra (13), a cardiologist, Wolff-Parkinson-White (WPW) syndrome, which is a disorder of the conduction system of the heart, is present in 1 out of 700 students. In a school district with 50,000 students, as many as 70 may have this generally undiagnosed condition. According to Sinatra (13), when students with WPW syndrome are exercising and are exposed to microwave radiation, the combined stress on the heart can lead to supraventricular tachycardia, thus creating the "perfect storm".

Fortunately, due to the Defibrillator Access Act, schools and other public buildings are installing defibrillators. What they should also be doing is trying to determine what is causing SCA and why students are complaining of headaches and heart palpitations at school. A key question that needs to be asked is, "What role does RF radiation from a school's WiFi system and from nearby cell phone base stations play in these symptoms?"

The effects of microwave radiation on the heart have been known for decades (14). In a 1969 symposium on the biological effects and health implications of microwave radiation, the authors clearly state that, "In the interest of occupational hygiene...researchers have recommended that cardiovascular abnormalities be used as screening criteria to exclude people from occupations involving radio-frequency exposures". Perhaps students need to be screened at school to ensure that they do not have an underlying heart condition that may be exacerbated with WiFi microwave exposure.

According to Drezner et al. (15), out-of-hospital SCA among young people is on the rise in the USA, although doctors do not know the reason. The increasing exposure to electrosmog may be to blame for at least part of this increase. More research is urgently needed in this area.

Children are much more sensitive to environmental toxins than are adults, and as such, there should be stricter guidelines for exposure. To date, at least nine countries have issued warnings that children should limit their use of cell phones. These countries include the UK (2000), Germany

(2007), France (2008), Russia (2008), India (2008), Belgium (2008), Finland (2009), the USA (2009), and Canada (2012). The same warning should be issued for children exposed to wireless games and WiFi routers, depending on the amount of time students are exposed to these emitters.

WiFi routers emit a beacon signal that is continuous as long as the device is activated. In other words, you do not have to be connected to the Internet to be exposed to the radiation generated by the wireless router. When information is either uploaded or download, the radiation levels increase both at the router and at the computer. The same is true for cordless phones and wireless baby monitors. Voice-activated baby monitors and cordless phones that radiate only when in use are available in Europe but are not currently available in North America.

Historic research on microwave illness resembles current research on electrohypersensitivity

The information provided in this article is not new. Reviews as far back as 1969 summarized the effects of microwave radiation and identified many of the same symptoms. Dodge (16) reviewed the Soviet and Eastern European literature and reported that microwave radiation affects the central nervous system, ANS (as shown here), neurohumoral systems, endocrine glands and functions, eye and ocular function, blood and hematopoietic system (as shown here), and miscellaneous organs.

Dodge (16) identified general subjective complaints resulting from exposure to electromagnetic radiation (Table 2) that are similar to the symptoms experienced by those who live near cell phone base stations (Figure 2). The major difference is that Dodge was reviewing symptoms for men who were occupationally exposed, whereas Santini et al. (2) was documenting symptoms for those who lived near cell phone antennas and were exposed to radiation in their own homes and as such were unable to avoid exposure.

Glaser (17) reviewed the literature on the biologic effects of microwave radiation and provided more than 2000 references in 1972. Although many of these studies were conducted at levels above existing guidelines, we are getting similar results at levels of microwave radiation that are well below these guidelines.

Most revealing are the "psychophysiologic disorders" based on human behavioral studies. These disorders include the following and are similar to those reported by Santini et al. (2): neurasthenia (general "bad" feeling), depression, impotence, anxiety, lack of concentration, hypochondria, dizziness, hallucinations, sleepiness, insomnia, increased irritability, decreased appetite, loss of memory, scalp sensations, increased fatigability, chest pain, and tremor of the hands.

Both Glaser and Dodge worked for the US Navy and had access to information that was later declassified. In one limited-edition (only 15 copies were produced) document, Pollack and Healer (18) recommended that the power density guideline in the USA be reduced from 10,000 $\mu W/cm^2$ to the same level used in the Soviet Union (10 $\mu W/cm^2$), but little attention was paid to this recommendation.

Table 2 Subjective symptoms associated with RF and microwave radiation.

General subjective complaints resulting from exposure to electromagnetic radiation (16)	Symptoms experienced "very often" by those who live within 300 m of a cell phone base station (2)
Similar symptoms	
Pain in head and eyes	Headaches and visual disruptions
Weakness, weariness, and dizziness	Dizziness and fatigue
Depression, antisocial tendencies, and general irritability	Depression and irritability
Impairment of memory and general mental function	Memory loss
Adenoma and inability to make decisions	Difficulty concentrating
Chest pain and heart palpitation	Cardiovascular
Dyspepsia, epigastric pain, and loss of appetite	Loss of appetite
Sensitivity of mechanical stimulation and dermagraphism	Skin problems
Different symptoms	
Lacrimation	Irritability
Hypochondria, sense of fear, and general tension	Nausea
Inhibition of sex life (male)	Movement difficulties
Scalp sensations and hair loss	Hearing disruption
Trembling of eyelids, tongue, and fingers	Sleep disturbance
Asthma	Feeling of discomfort
Brittle fingernails	

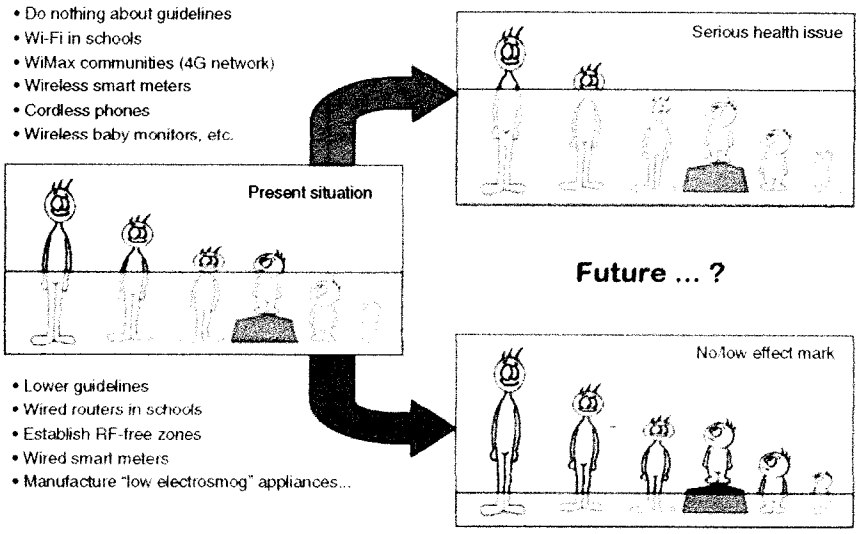

Figure 7 Two future health scenarios based on the steps we take or fail to take to reduce electrosmog exposure.

Years later, the power density guideline in the USA was reduced from 10,000 to 1000 $\mu W/cm^2$, although this was still based on thermal effects.

Where do we go from here?

If we do nothing about guidelines and allow WiFi to be installed in schools, if we allow WiMax to come into neighborhoods as part of the 4G network, if we allow wireless smart meters to be installed on homes, and if we fail to regulate the technology in a way that minimizes microwave exposure, then many more people are likely to become ill and some will die (Figure 7).

If we choose to minimize exposure by establishing biologically based guidelines rather than the current thermal guidelines, by encouraging wired Internet access in schools, universities, hospitals, workplaces, and homes, by installing wired smart meters, and by establishing RF-free zones for those who are highly sensitive, then we can reverse much of the damage that has been inflicted (Figure 7).

The choice is ours, and the real question is, "Do we have the foresight and courage to make the right decision or will we require a health tsunami before we act?"

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