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Federal Communications Commission

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Dear Sirs,

I have spent the last 15 months extensively researching the current medical literature on the biological or “non-thermal” effects of microwave radio frequency transmissions. I was motivated to do this by increasing concerns regarding the health effects of these exposures in my patients and in my community.

The FCC has not chosen to implement any safety standards regarding non-thermal effects of microwave RF exposure. But the existing literature demonstrates that there is significant cause for concern regarding the growing impacts of these exposures on the public. Research documenting their adverse biologic and health effects is robust now. The implications of this research cannot be discounted, and must not be ignored.

There is clear evidence that microwave RF exposures can cause both acute adverse non-thermal effects (including electrohypersensitivity syndrome in a portion of the population) and chronic health effect (including an increase in various forms of cancer, and reduction in human sperm counts). As evidence of this research, I am submitting a review of this subject recently prepared for the Eugene Planning Commission (in commentary on a proposed cell phone tower siting), and another document reviewing the current literature on the effects of cell phone use on the risk of brain tumors.

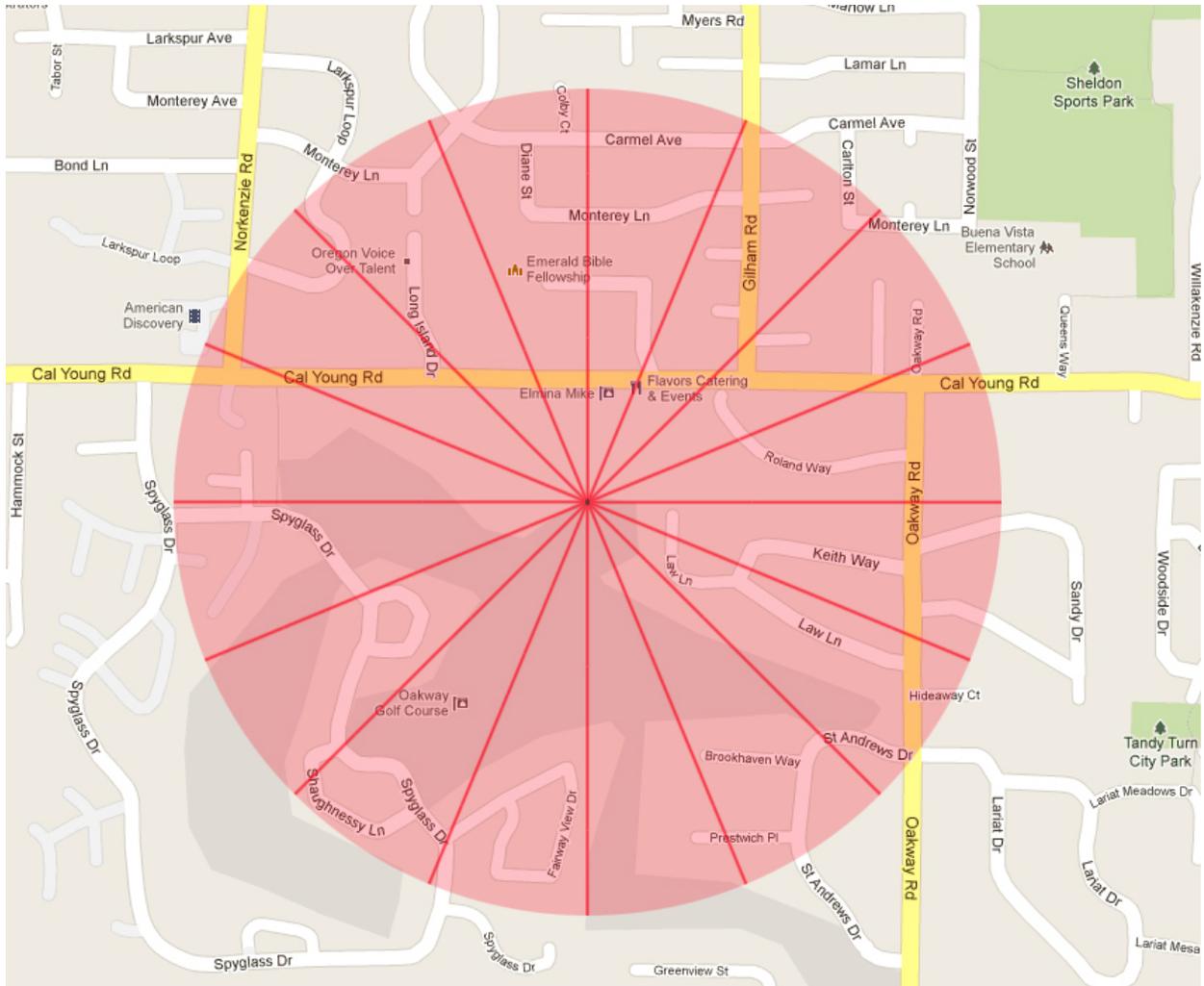
The FCC should request that the EPA impanel a Working Group composed of health experts who have no conflicts of interest with industry to review the scientific literature on EMR. The Group should recommend biologically-based EMR standards that ensure adequate protection for the general public and occupational health based upon the precautionary principle. Finally, the FCC should adopt the standards, testing procedures, and appropriate precautionary warning language recommended by the Working Group.

It would be indefensible at this time for the FCC to take any actions that may increase exposure of the population to EMR from cell phones, base stations, Wi-Fi, Smart Meters and other RF- or ELF-emitting devices. The current levels of exposure need to be reduced rather than increased further. The FCC must especially protect vulnerable groups in the population including children and teenagers, pregnant women, men of reproductive age, individuals with compromised immune systems, seniors, and workers.

Sincerely yours,

Paul Dart MD FCA

PUBLIC HEALTH IMPLICATIONS OF THE PROPOSED CELL PHONE TRANSMISSION TOWER AT OAKWAY GOLF COURSE



Submitted to the Eugene Planning Commission

by

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PREFACE

We are physicians who have been in private practice in Eugene for decades. Collectively, we have had multiple patients with severe electrohypersensitivity problems in our practices over the years. When EWEB proposed installing a “mesh” smart meter network in Eugene, we became concerned. We knew that a major increase in radio transmission in Eugene residential neighborhoods could make them unlivable for some of our patients.

And it was unclear to us whether the people making decisions about these matters had any clear understanding of the health implications of chronic exposure to microwave radio transmissions.

The FCC regulations on Radio Frequency (RF) exposures are only designed to protect against the thermal effects of extremely high exposure levels. And representatives of the telecommunications industry state that no clear scientific evidence exists regarding adverse “non-thermal” or biological effects of RF exposure.

In actuality, a great deal of evidence about such effects is documented in the scientific literature. But how accessible is this information to decision-makers on a planning commission (for example)? How are policy makers supposed to figure out what is going on? They generally don’t have the time or expertise to digest the scientific literature in detail. Industry sources state that everything is fine, nothing to worry about. Polemics on the internet cry out that the sky is falling. The original articles are difficult to access without academic library privileges, and difficult to understand without a strong scientific background. Giant and exhaustive reviews of the subject, like the Bioinitiative Report (1497 pages), are overwhelming and difficult to evaluate.

Last year we organized a group of physicians and professionals with scientific and engineering expertise to review this subject. We’ve spent the last 14 months collecting and reviewing hundreds of scientific articles regarding the biological effects of RF. We’ve tried to identify the most important primary research articles and research reviews, and read through these articles in detail. And we’ve attempted to create a coherent and well-referenced summary of the main health risks of RF exposure and the key scientific evidence for these risks--risks that we can assure you are quite real, and quite significant. This document is the result of our efforts. It is organized into four sections.

The first section examines the scientific research which examines the acute “non-thermal” reactions which can be provoked by excessive RF exposures, including insomnia, headaches, tinnitus, dizziness, memory disturbances, and other symptoms.

These adverse symptoms in their most severe form are called electrohypersensitivity syndrome (EHS), a problem which was first described by Russian researchers in the 1950’s as “microwave sickness”. Current research in Europe and the United States suggests that EHS may affect 2-3% of the population at the current time.

The second section reviews the function of melatonin, reviews the research on suppression of melatonin by “light at night” and by nocturnal RF exposures, and discusses the acute and chronic consequences of melatonin suppression.

PREFACE

The third section discusses the scientific evidence measuring the long term effects of prolonged RF exposure, which produces oxidative stress that can lead to DNA damage and increased levels of cancer and infertility.

We've tried to produce a document that presents information clearly, and covers things in enough academic detail to have some substance, so that the reader can get a view of both the trees and the forest.

In addition to our written testimony, we are also submitting a document titled "*Report on Cell Tower Radiation Submitted To Secretary, DOT, Delhi, Prepared By Prof. Girish Kumar*". Dr. Kumar takes a somewhat broader approach to discussing this subject, but his report is very well organized and up to date. This testimony by Dr. Kumar was a major factor in the decision made last year by the Government of India to reduce the maximum public exposure level of RF radiation to one tenth of its previous value, forcing a major reconfiguration of the telcom infrastructure in that country.

The evidence detailed here shows that placing cell phone towers in residential areas will have significant short and long term consequences. We hope that this scientific evidence is useful to the Planning Commission. At the very least, it should help you reach a clearer understanding of the actual implications of any decisions you make on this matter.

Thank you for your attention,

Paul Dart, M.D. F.C.A.

Kathleen Cordes, M.D.

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ELECTROHYPERSENSITIVITY

"MICROWAVE SICKNESS"

Acute symptoms provoked by microwave radiation were first described by Russian medical researchers in the 1950's. They described a constellation of symptoms including headache, ocular dysfunction, fatigue, dizziness, sleep disorders, dermatographism, cardiovascular abnormalities, depression, irritability, and memory impairment. (Liakouris, 1998)

In the years between 1953 and 1978 the Russian government harrassed the U.S. Embassy in Moscow by targeting it with radiation from a microwave transmitter. Concern about health effects led to a detailed study by A.M. Lilienfeld, an epidemiologist at Johns Hopkins University. (Lilienfeld AM, 1979)

The abnormalities found in this study were an embarrassment to the U.S. government, since the levels of exposure experienced by embassy staff were in the order of 2 to 28 microwatts/cm², a level dramatically below the described U.S. safety standards for microwave exposure. The conclusions of the study were altered to soft-pedal any abnormal findings. (Goldsmith, 1995b) (Cherry, 2000)

But outside epidemiologic analysis of the Lilienfeld report's published data showed that exposed embassy staff experienced a statistically significant excess of several problems, including depression, irritability, difficulty in concentrating, memory loss, ear problems, skin problems, vascular problems, and other health problems. Symptom incidence increased significantly with accrued years of exposure. (Goldsmith, 1995a) (Cherry, 2000)

THE EMERGENCE OF "ELECTROHYPERSENSITIVITY" AS A DIAGNOSIS

In recent years the buildout of cellular communication networks has created a markedly increased exposure of the public to RF transmissions. Each new generation of cell phone technology has occupied a higher frequency on the microwave scale, with potentially increasing impact on body physiology. (Cherry, 2002) As this has occurred, mounting evidence has pointed to the fact that a percentage of the population experiences adverse reactions associated with these exposures. The term "electrohypersensitivity" (EHS) has been used to describe a constellation of symptoms, including headache, sleep disturbance, difficulty in concentration, memory disturbance, fatigue, depression, irritability, dizziness, malaise, tinnitus, burning and flushed skin, digestive disturbance, tremor, and cardiac irregularities. Sleep disturbance, headache, nervous distress, fatigue, and concentration difficulties are the most commonly described symptoms. (Roosli et al., 2004)

These symptoms are identical to the symptoms of "microwave sickness" described by Russian physicians in the 1950's.

SYMPTOMS PROVOKED BY TRANSMISSION TOWERS

In 2002, Santini reported significant increases in such symptoms in individuals living closer than 300 meters to cell towers. (Santini et al., 2002) (Santini R, 2003)

In Poland, Bortkiewicz found similar increases in symptoms among residents near cell towers. Symptoms showed equal association to proximity of the tower, regardless of whether or not the subject suspected such a causal association.

(Bortkiewicz et al., 2004) (Bortkiewicz et al., 2012)

In two studies, Abelin and Altpeter found evidence of disruption of sleep cycle and melatonin physiology by RF transmission during the operation and subsequent shut-down of the short wave radio transmitter in Schwarzenburg, Switzerland. (Abelin et al., 2005) (Altpeter et al., 2006)

Research at the military radar installation in Akrotiri, Cyprus, showed that residents of exposed villages had markedly increased incidence of migraine, headache, dizziness, and depression, and significant increases in asthma, heart problems, and other respiratory problems. (Preece et al., 2007)

In a study done in urban and rural sites in Austria, Hutter found a clearly significant correlation between exposed signal power density and headaches and concentration difficulties--despite the fact that maximum measured power densities were only 4.1 mW/m^2 ($= 0.41 \text{ } \mu\text{W/cm}^2$ -- well below established "safe" limits). (Hutter et al., 2006)

In Egypt, research of inhabitants near the first cell phone tower in Menoufiya found a significant increase in headaches, memory changes, dizziness, tremors, depressive symptoms, and sleep disturbance, with lower performance on tests of attention and short-term auditory memory. (Abdel-Rassoul et al., 2007)

Studies in Murcia, Spain yielded similar findings, and based on measured exposures the authors suggested that safe levels of indoor exposure should not exceed $1 \text{ } \mu\text{W/m}^2$ ($0.0001 \text{ } \mu\text{W/cm}^2$) (Navarro et al., 2003) (Oberfeld et al., 2004)

In a study of residents of Selbitz, Bavaria, researchers found statistically significant increases in multiple health symptoms that demonstrated a dose-response relationship with cell phone tower transmissions. Individuals living within 400 meters of the cell phone tower had significantly more symptoms than those living > 400 meters from the tower. And individuals living within 200 meters of the tower had significantly higher symptoms than those living between 200 and 400 meters from the tower. (Eger and Jahn, 2010)

Two recent reviews provide a detailed overview of research in this area. (Khurana et al., 2010) (Levitt and Lai, 2010)

SYMPTOMS PROVOKED BY CELL PHONE USE

Multiple studies of cell phone users in the last decade found evidence of a similar pattern of symptoms to be provoked in some users. (Chia et al., 2000) (Oftedal et al., 2000) (Santini R, 2002) (Wilen et al., 2003) (Salama and Abou El Naga, 2004) (Al-Khlaiwi and Meo, 2004) (Balikci et al., 2005) (Balik et al., 2005) (Szyjkowska et al., 2005) (Meo and Al-Drees, 2005) (Soderqvist et al., 2008) (Landgrebe et al., 2009) (Hutter et al., 2010)

PHYSIOLOGY OF ELECTROHYPERSENSITIVITY

A variety of research models have demonstrated that RF exposure does not have a uniform effect on people. In many studies, a cohort of individuals has been identified that has a more sensitive response to RF in one way or another.

Reduced heart rate variability

In one study, patients with symptoms consistent with EHS were found to have decreased circadian changes in heart rate variability. (Lyskov et al., 2001) Similar changes in HRV were found in another study where subjects self-identified as having

EHS symptoms from exposure to video display terminals, TV screens, fluorescent lights, or other electrical equipment. (Sandstrom et al., 2003) An occupational study of RF plastic sealer workers also found alterations in heart rate compared to normal controls.

Fatigue and reduced melatonin

In the more recent Schwarzenberg study, the effect of RF exposure on producing morning fatigue and reduced melatonin secretion was significantly greater in the subjects whose general quality of sleep was below the median. (Altpeter et al., 2006)

EEG changes

Alterations in EEG have been found in animals and in people with exposure to both magnetic fields and cell phone transmission frequencies. (Marino et al., 2003) (Marino et al., 2004)

Nanou et al found the EEG response to be gender dependent after exposure both to 900 MHz and 1800 MHz signals. (Nanou et al., 2005) (Nanou et al., 2009)

Bachman found EEG changes with 450 MHz microwave exposure in 25-30% of healthy volunteers (Bachmann et al., 2005) (Bachmann et al., 2006). In another study, EEG changes were 5 times as common in depressive subjects as in healthy controls. (Bachmann et al., 2007)

Landgrebe found decreased intracortical excitability in EEG after transcranial magnetic stimulation in self-identified EHS patients, as compared with normal controls. (Landgrebe et al., 2007)

Schmidt found alteration in sleep EEG after exposure to a 900 MHz RF signal modulated at two different frequencies, and noted a marked individual variation in sensitivity to this effect. (Schmid et al., 2011)

Loughran found alterations in non-REM EEG after cell phone RF exposure. These alterations were consistently stronger in one subset of his study group, over multiple tests. (Loughran et al., 2012)

Altered Immune Function

Exposure to both GSM and UMTS cellular transmissions at non-thermal exposure levels have been shown to alter DNA repair mechanisms in lymphocytes. (Markova et al., 2005) (Belyaev et al., 2009) Multiple additional studies have demonstrated non-thermal biological effects of RF radiation on immune cell function, as reviewed here. (Johansson, 2007) (Johansson, 2009b)

One of the most intriguing findings is Johansson's research showing that patients with electrosensitivity have higher levels of mast cells in their skin, and that these mast cells migrate closer to the skin surface. (Johansson, 2006) Mast cells are responsible for the itching, burning, and skin flushing that occurs after sunburn exposure. The presence of higher levels of mast cells in EHS patients provides an explanation for the symptoms of flushed, itching, and burning skin on the face and other areas that is described by these patients, who appear to be reacting to RF exposure like others might react to excessive sun exposure. Since mast cells are distributed throughout the body, the presence of mastocytosis in EHS patients may relate to some other symptoms as well.

Hormonal Changes

Chronic exposures to electromagnetic field effects have also been shown to cause

alterations in secretion of multiple hormones. A study published in 2007 showed that physiotherapists working with various electromagnetic treatment modalities had significantly elevated secretion levels of the stress hormones cortisol, adrenaline, and noradrenaline. (Vangelova et al., 2007)

Another study measured urinary secretion of the stress hormones adrenaline and noradrenaline, along with levels of dopamine and phenylethylamine, prior to and over the 1 1/2 years following the installation of a GSM cell phone tower in Rimbach, Bavaria. Levels of adrenaline and noradrenaline showed a significant increase over the first six months after exposure, and never returned to baseline levels. Responses showed a proportional relationship to residential exposure levels, and were clearly present at levels as low as 60 to 100 microwatts/m² (= 0.006 to 0.010 μ W/cm²). This suggested a chronic stress effect of the GSM microwave signal on the population. (Buchner K, 2011)

Chronic adrenal stress will in time lead to decompensation and symptoms of adrenal fatigue in a certain percentage of the population.

A recently published study evaluated human hormone profiles over six years of exposure to the microwave RF emissions of GSM cell phones or cell phone towers. Findings included highly significant decreases in ACTH, cortisol, both T4 and T3 thyroid hormones. In male subjects, serum testosterone levels gradually decreased with increased time of exposure. In females, alterations in serum prolactin and progesterone levels gradually increased over increased time of exposure. (Eskander et al., 2012)

Current Research

One of us had the opportunity this spring to visit the practice of Dr. Dominique Belpomme, Professor of Oncology at Paris Descartes University, who is conducting research on electrohypersensitivity with the Association for Research and Treatments Against Cancer (ARTAC) in Paris. The ARTAC group has been following several hundred patients with EHS over the last four years, and has documented that these patients have clear and consistent changes in oxidative metabolism, and also in blood flow to the limbic system (as measured by doppler studies). Dr. Belpomme considers these changes in the limbic system to directly correlate with many of the cognitive changes (memory problems, difficulty with concentration, etc.) that are experienced by these patients. The ARTAC group expects to publish a series of papers on their findings during the next year. (Dart, 2012)

PROVOCATION STUDIES

Over the last ten years, many attempts have been made to evaluate the nature of electrohypersensitivity through provocation studies. The limitations of these studies have been discussed in detail in some recent papers. (Loughran et al., 2012) (Regel and Achermann, 2011)

Problems of methodology that have compromised many provocation studies include:

- Many studies have been performed single-blind rather than double-blind.
- Many studies divide the study group and normal controls based on the individual's self-identification as having (or not having) electrohypersensitivity. Since it is certainly possible for people to have reactions to EMF without being aware of this connection, and since the entire population is exposed to EMF at this point in time, it is difficult to be sure that the "control" group is indeed

composed of “non-reactors”. This will tend to weaken the power of any study set up in this fashion.

- Many studies evaluate whether or not the subject can discern when the RF signal is present and when it is absent. Absence of the ability to make this judgement is taken as evidence that electrohypersensitivity does not exist. This is an extremely illogical assumption. A person can develop a headache during or after an RF exposure without knowing when the signal is “on” or “off”, just as they can develop bacterial gastroenteritis without knowing what food was contaminated with the bacteria. Having symptoms from RF and being a reliable RF meter are not the same thing.
- Unspecified or inadequate control of background levels of RF/EMF is also a problem with some “negative” studies. For example, one recent study (Kim et al., 2008) was performed with background RF levels in the study area of 0.5, 0.7, and 0.8 V/m from three different mobile phone service providers. This adds up to a reported 2.0 V/m of background RF, equivalent to several thousand microwatts/m², which is well above threshold levels reported to cause symptoms in many sensitive individuals.
- Many studies assume that all patients who complain of EHS will react to any constant RF signal, and that they will react to it every time. Yet some studies have demonstrated that patients vary in which frequencies they respond to, and that patients can react more strongly to the starting and stopping of a signal than they do to the presence of a steady signal.
- Furthermore, the assumption is often made that EHS symptoms will start when a signal is turned on, and stop when it turns off. These assumptions are problematic, since many patients with EHS report having symptoms that continue for a significant time (hours, in many cases) after a triggering exposure. Few studies discuss whether or not an adequate “washout time” was provided for before starting the study, or between provocation challenges. The absence of such washout times seriously weakens the power of these studies.

In order to do a reliable RF provocation study with EHS exposure, it is necessary to isolate the subjects from background RF levels, and to maintain them in this isolation for long enough that they stop reacting to any prior exposures which they have received, before attempting to provoke a new reaction.

Some studies that are designed to address all these methodologic issues have found clear evidence of electrosensitivity. For example, a study done in 1991 that was performed in an isolated EMF environment tested EHS patients with a variety of different frequencies of RF stimulus, to determine their individual reactivity spectrum. 100 patients who identified themselves as having electrohypersensitivity were tested single blind with a variety of RF frequencies. 25 of these 100 patients showed an increase in symptoms of 20% over baseline, with no more than one placebo response.

These 25 patients were retested in a double blind setting with 25 healthy controls. 16 of the 25 patients (64%) reacted to the positive challenges, which were performed at a variety of frequencies.

These 16 patients reacted to 53% of the 336 active challenges, and 7.5% of the 60 blanks. No patient reacted to all tested frequencies. The 25 healthy controls had no reactions to challenges or to blanks.

Finally, these 16 patients were again tested in a double blind setting, each patient challenged with the single frequency to which they were most sensitive. In this phase of the study, the patients reacted 100% of the time to the active transmissions (with both reported symptoms and autonomic changes on iriscorder) and did not report reactions to the sham transmissions. (Rea et al., 1991)

It must be reiterated that having an adverse reaction to a provoking RF signal and having the ability to determine when the signal is “on” and when it is “off” are two completely different things. A recent double blind study demonstrated that a patient can have consistent provocation of symptoms from a signal without having any clear awareness of when the signal is actually present. (McCarty et al., 2011)

These provocation studies involve short term exposures to the RF signal (typically an hour or less). Since a great deal of the physiology research shows a more powerful effect with chronic exposures, these short-term studies are probably not the most effective way to assess the clinical significance of reactions to RF.

PREVALENCE OF EHS

Research in Stockholm County, Sweden in 1997 found that 1.5% of the population reported being hypersensitive to electrical or magnetic fields. (Hillert et al., 2002)

In California in 1998, Levallois et al found that 3.2% of the adult population reported being sensitive to sources of EMF. (Levallois et al., 2002)

In Switzerland in 2004, researchers studying a representative sample of the Swiss population found that 5% of the population had symptoms attributable to EHS, with sleep disorders and headaches being the most common reported symptoms. (Schreier et al., 2006)

In Austria in 2004, 2% of the population was estimated to have electrohypersensitivity. In a survey performed in Austria in 2008, 29.3% of respondents reported having some sort of adverse response to electromagnetic pollution. Of this cohort, 2.1% reported intense disturbance, and 3.5% had experienced enough difficulty that they had consulted a physician about the problem. (Schrottner and Leitgeb, 2008)

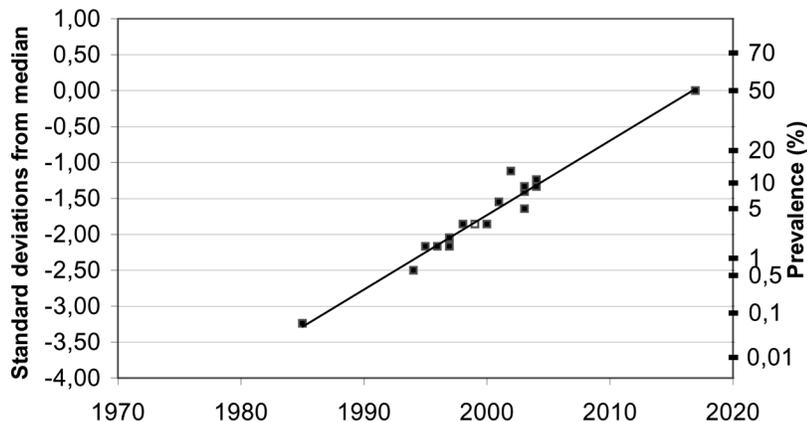


Figure 1: Increasing prevalence of EHS

In much of the world, exposure to microwave radio signals has continued to significantly increase since the early 1990's. Reported electrosensitivity also appears to be increasing over time. In 2006, Halberg and Oberfeld reviewed research on this subject from 1985 forward, and estimated that if the trend in increased prevalence

continues, fifty percent of the population could be reporting adverse effects from EMF by the year 2017 (Figure 1). (Hallberg and Oberfeld, 2006)

GOVERNMENTAL RESPONSE

The various forms of research described above have provided strong support for the fact that RF/EMF exposures can produce symptoms in human beings and that there is a percentage of the population that is more sensitive to this effect. Continued research is suggesting that this is not a static situation--that the prevalence of electrohypersensitivity is a growing over time.

By the middle of the last decade, various government agencies were attempting to define the scope of the problem. (Irvine, 2005) Research

The roll-out of mobile phone technology occurred earlier in scandinavia than in other places in the world, and governmental recognition of EHS as a health problem occurred earlier there than in other places. By the year 2000, EHS was recognized as a disability by the Swedish government. (Ministers, 2000)

In Stockholm, individuals with EHS can receive municipal support to reduce the presence of and penetration of EMF/RF into their homes. The construction of a village with houses specifically designed to mitigate this problem is being considered. Patients with EHS have the legal right to receive mitigations in their workplace, and some hospitals have build low EMF hospital rooms for use by such patients. (Johansson, 2006)

Various government reports or reviews on the question of electrohypersensitivity have been commissioned in the last few years. (Aringer et al., 1997) (Irvine, 2005) And legislation to address the problem has been proposed in some countries. (Snoy, 2011) (Parliamentary Assembly, 2011) Many libraries and schools in europe have banned wifi due to concerns about health effects on employees and on the public.

REGULATORY RESPONSE

Regulations on exposure limits vary dramatically from country to country. In general, exposure limits have been mandated at a lower level in Russia and eastern Europe, where research on the health effects of RF exposure has been performed for a longer period of time. (Repacholi et al., 2012)

The regulatory standards established by the FCC and the World Health Organization are based on defining safe levels against the thermal effects of RF (i.e. damage from being cooked by high levels of microwave exposure). The FCC has not established exposure standards for potential non-thermal or biological effects of microwave exposure. (Hankin, 2002)

For example, the FCC has established Limits for Maximum Permissible Exposure (MPE). For the general population, the permissible level of exposure at 900 MHz is 600 $\mu\text{W}/\text{cm}^2$, and at 1800 MHz is 1000 $\mu\text{W}/\text{cm}^2$. (FCC, 1999) These exposure levels were last updated in 1996, and are considered to be protective against thermal effects of microwave radiation. However, current scientific research shows that these permissible levles of exposure are hundreds of times higher than the threshold levels for adverse "non-thermal" biological effects.

For the past ten years, the WHO has consistently equivocated on the issue of recognizing non-thermal biological effects from microwave RF exposure, despite the

mounting research evidence of health problems and health risks produced by current levels of public exposure.

The following table shows exposure standards for various countries in 2001. (Firstenberg, 2001)

Country	($\mu\text{W}/\text{cm}^2$)
New South Wales, Australia	0.001
Salzburg, Austria (for pulsed transmissions)	0.1
Russia	2–10
Bulgaria	2–10
Hungary	2–10
Switzerland	2–10
China	7–10
Italy	10
Auckland, New Zealand	50
Australia	200
New Zealand	200–1000
Japan	200–1000
Germany	200–1000
United States	200–1000
Canada	200–1000
United Kingdom	1000–10,000

Figure 2: RF exposure limits (2001)

PHYSICIAN AND RESEARCHER RESPONSE

In response to this inaction on the part of government and international regulatory bodies over the past decade, a variety of groups of physicians and researchers in the field of RF/EMF health effects have called for regulatory action to address the documented biological consequences of the increasing exposure of the public to RF transmissions.

In 2000, the Salzburg Resolution suggested a total high frequency radiation limit of $100 \text{ mW}/\text{m}^2$ ($10 \mu\text{W}/\text{cm}^2$), and a total emission level of pulse modulated exposure (such as GSM) of $1 \text{ mW}/\text{m}^2$ ($0.1 \mu\text{W}/\text{cm}^2$). (Altpeter et al., 2000)

In 2002 a group of German physicians described a growing problem with adverse clinical effects from RF/EMF, and called for stricter safety limits on RF transmissions, restrictions on cell phone use by children and adolescents, and a ban on cellular and cordless phone use in preschools, schools, hospitals, nursing homes, event halls, public buildings, and vehicles. (2002)

Multiple similar appeals have been made by research groups and medical associations over the past ten years. (Association, 2004) (Leitgeb et al., 2005) (Association, 2012) (Dean A, 2012) (Johansson, 2011) (Johansson, 2009a) (Fragopoulou et al., 2010) (Israel et al., 2011)

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RADIOFREQUENCY EFFECTS ON MELATONIN

THE FUNCTION OF MELATONIN

Many physiologic functions in the human body are entrained in a circadian rhythm, fluctuating through the day/night cycle. The hormone melatonin, secreted by the pineal gland, is a key agent in coordinating these physiologic responses throughout the body. (Zawilska et al., 2009)

The entrainment of melatonin secretion with the day/night cycle is maintained by the suprachiasmatic nucleus in the hypothalamus, which receives input on the presence of light from the retina via the retinohypothalamic tract. In the presence of ambient light, melatonin secretion is suppressed. In the absence of ambient light, melatonin secretion increases. So melatonin secretion is high during the night-time hours, peaking shortly after midnight. Higher melatonin levels are part of what makes us feel “sleepy” at night. Exposure to light during the night-time hours will lead to a rapid suppression of melatonin secretion by the pineal gland, and this can cause disruption of sleep and derangement of the circadian rhythm.

Since the length of the day varies seasonally, melatonin also provides our physiology with information and influence produced by the different seasons of the year. This seasonal influence was obviously more profound prior to the widespread introduction of artificial electric lighting.

The circadian rhythm of high nocturnal melatonin levels supports the natural function of sleep, and disruption of this rhythm by bright light at night, night shift work, or travel to different time zones can produce sleep disturbances.

Melatonin is one of the most potent anti-oxidant molecules in the human body, and acts to reduce reactive oxidative processes in the body. Melatonin can quench the damaging free radical activity produced by inflammation. The presence of elevated melatonin at night is therefore a key factor in the healing and rejuvenating functions that we associate with “a good night’s sleep”.

Many body processes (serum cortisol levels, body temperature, patterns of digestive function, etc.) have a circadian rhythm that is coordinated by the timing signal of melatonin secretion. Melatonin has a protective effect on the health of the gastrointestinal tract. Melatonin is also protective against the growth of cancer cells, and disruption of the circadian melatonin cycle has been shown to lead to increased tumor growth in a variety of cancer types. (Reiter et al., 2011)

Research has clearly demonstrated that melatonin inhibits the proliferation, invasiveness, and metastasis of human breast cancer cells. Women who have lower levels of nocturnal melatonin are at greater risk for developing breast cancer. (Schernhammer et al., 2008) (Schernhammer and Hankinson, 2009) Breast cancer is more common in industrialized societies, and geographically the incidence of breast cancer is strongly associated with higher levels of “light-at-night”. (Kloog et al., 2008) (Kloog et al., 2010)

Current research suggests that disruption of nocturnal melatonin signals by “light at night” can promote both the development and the growth of breast cancer. (Hill et al., 2011) (Stevens, 2009) Primarily for this reason, in 2007 the International Agency for Research on Cancer declared night shift work to be a probable carcinogen. Subsequent epidemiologic research continues to support this finding. (Bonde et al.,

2012)

Recent research has also suggested similar associations between “light at night” and the incidence of prostate cancer. (Kloog et al., 2009)

ELECTROMAGNETIC AND RADIOFREQUENCY EXPOSURES CAN LOWER MELATONIN SECRETION

Research has demonstrated that shortwave radio transmissions can alter melatonin secretion and cause sleep disturbance. (Cherry, 2002) Significant levels of sleep disturbance have been demonstrated at exposure levels as low as 0.1 nanowatts/cm². Improvements in both sleep quality and melatonin secretion levels occur with silencing of the transmission source. (Abelin et al., 2005) (Altpeter et al., 2006)

Multiple studies in a variety of settings have demonstrated an effect of EMF/RF on melatonin physiology. (Davinipour and Sobel, 2007) (Davanipour and Sobel, 2009)

Recent studies in animals have demonstrated suppression of melatonin by prolonged pulsed microwave RF exposures (2 hours a day for 45 to 60 days). (Kumar et al., 2011) (Kesari et al., 2011) (Kesari et al., 2012)

And multiple epidemiologic studies have shown an association between residential RF exposure from microwave transmission towers and increased breast cancer risk. (Cherry, 2005) (Eger et al., 2004) (Wolf and Wolf, 2004) (Oberfeld, 2008) (Khurana et al., 2010) (Levitt and Lai, 2010) (Yakymenko et al., 2011)

RAISING THE LEVEL OF RADIOFREQUENCY TRANSMISSION IN RESIDENTIAL NEIGHBORHOODS CARRIES SIGNIFICANT RISKS

Unlike visible light, microwave radio transmissions penetrate walls and human bodies. They are not easily blocked out by window blinds or eye shades. If melatonin secretion can be disrupted by RF in a portion of the population, then a significant increase in nocturnal RF transmission levels in a residential neighborhood would be expected to produce an increase in sleep problems and, over the long run, an increase in the incidence of breast and prostate cancer. The first evidence of such an effect would be a significant increase in complaints of sleep disruption. It might require several years of exposure for the increase in cancer incidence to reveal itself.

If we use complaints of sleep disruption as a marker for this effect, we can suspect that the recent installation of MESH-networking smart meters in California and in other municipalities around the world has pushed many residential areas across a threshold, producing chronodysruption in a significantly increased portion of the population. The early evidence that this is occurring is the dramatic increase in complaints of sleep difficulties to physicians, to public utility commissions, and in posting on the internet which has occurred following these smart meter roll-outs.

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RADIOFREQUENCY EXPOSURE INCREASES OXIDATIVE STRESS AND DAMAGES DNA

Over the past 20 years, a great deal of research evidence has accrued which demonstrates that EMF and RF can alter cellular physiology.

INDUCTION OF STRESS PROTEINS

When cells are stressed in a way that damages DNA in cells, an early response of the cellular physiology is to increase the production of proteins involved in the repair of these structures. These repair proteins are called stress proteins or "heat shock" proteins (since early research models used heat to stress the cells). Increased production of these proteins are direct evidence of physiologic stress and damage to cell DNA, as they represent the effort of the cell to protect against and repair that damage.

The physiologic stressors that trigger this response stimulate specific regions on the cell's chromosome. These regions initiate the transcription of the stress response genes that encode for these repair proteins.

In the late 1990's research demonstrated that EMF exposures can produce these stress proteins. (Lin et al., 1997) (DiCarlo et al., 1998)

Further research demonstrated that EMF/RF stimulation promotes gene transcription at different promotion sites than those triggered by heat stress (Lin et al., 1998) (Lin et al., 1999), and that this promotion by EMF/RF can occur at power levels that are not high enough to produce thermal changes in the cells. (DiCarlo et al., 1999) (Weisbrot et al., 2003) (Blank and Goodman, 2004) (Blank, 2007)

Subsequent research has shown that at DNA transcription sites activated by low level EMF and RF exposure, higher levels of exposure can lead to single or double strand breakage of the DNA chain. (Blank and Goodman, 2009)

Current research confirms production of the stress protein response by microwave signals in the 900 MHz and 1800 MHz bands. (Cao et al., 2011) (Jiang et al., 2012) (Calabro et al., 2012)

DNA DAMAGE

Many research studies performed in the last decade have demonstrated that radiofrequency radiation at non-thermal levels can produce fragmentation of DNA.

In 2003, Ivancsits reported that intermittent low frequency EMF could cause single and double strand breaks in DNA at magnetic flux densities as low as 35 microtesla, well below levels producing thermal effects. Effects were time and dose dependent. (Ivancsits et al., 2003)

This work was confirmed in 2004 in a study showing that 24 to 48 hour exposures to a 0.01 mT 60 hz magnetic field could produce single and double strand DNA cleavage, apoptosis, and necrosis of brain cells in rats. These effects could be blocked with antioxidants, suggesting that free radicals played a role in the damage process. (Lai and Singh, 2004)

Subsequent research demonstrated that these effects also could be produced by non-thermal effects of radiofrequency microwave exposures--at power levels that were below the levels producing thermal effects--and that this non-thermal damage could be prevented by administration of anti-oxidant free radical scavengers. (Adlkofer, 2006)

The results of in vitro studies on DNA damage from EMF/RF are variable, since different cell types have different sensitivities to these effects. (Schwarz et al., 2008) Several detailed reviews of these studies have been published in the last five years. These reviews document multiple studies showing production of DNA damage at low power densities, with more prolonged exposure times producing more significant effects. (Lai, 2007) (Ruediger, 2009) (Phillips et al., 2009) (Levitt and Lai, 2010)

Current research continues to validate these findings. For example, Cam and Syhand found an increase in the production of single strand DNA breaks in hair root cells following 15 to 30 minutes of mobile phone use. (Cam and Seyhan, 2012)

Kesari et. al. exposed Wistar rats to 2.45 GHz frequency at 0.34 mW/cm² power density (340 μW/cm², whole body SAR ~ 0.11 W/Kg), 2 hours a day for 35 days, and demonstrated increased double strand DNA breakage ($p \leq 0.0002$) in brain tissue. This was accompanied by decreased activity levels of glutathione peroxidase ($p < 0.005$) and superoxide dismutase ($p < 0.006$), and increased catalase activity ($p < 0.006$) suggesting that the microwave exposure produced severe oxidative stress. (Kesari et al., 2010a)

Kumar et. al. exposed Wistar rats to 50 GHz continuous source microwave transmission, 2 hours a day for 45 days, with a power density of 0.86 μW/cm² (calculated SAR 8.0×10^{-4} W/kg). Other rats were exposed to 10 GHz, 2 hours a day for 45 days, power density 0.214 mW/cm² (214 μW/cm², SAR 0.014 W/kg). Both forms of exposure produced significantly altered levels of reactive oxygen species, antioxidant enzyme activity, and blood cell micronuclei formation, demonstrating the production of oxidative stress with genotoxic effects. (Kumar et al., 2010)

RF EXPOSURE PRODUCES OXIDATIVE STRESS

It is a truism among apologists for the telecommunications industry that microwave radiofrequency transmissions cannot possibly cause cancer, because the energy of a photon of this wavelength is not powerful enough to directly break an ionic bond the way an xray can, and therefor could not possibly cause mutations in DNA. Such an argument sounds like good physics, but it isn't good biology. Ionizing radiation is only one way to cause the mutations in DNA that can produce cancer.

Chronic inflammation can cause cancer. Cigarette smoke can cause cancer. Toxins and autoimmune disease can cause cancer. One common pathway shared by these causes is that they produce an inflammatory response in the body that increases the activity of free radicals (reactive oxygen species). These free radicals produce oxidative damage in the tissues.

This oxidative activity is the tool that our bodies use to destroy foreign bacteria, which can be completely broken up--DNA and all--and digested by our immune system. Free radicals are an important defensive weapon for our bodies, but an excess of oxidative activity can lead to damage of our own tissues. Such excesses have been associated with many chronic problems including autoimmune disease, heart disease, and some forms of cancer. Every week another article is published suggesting that taking anti-oxidants may be protective against some of these problems.

The mechanisms through which EMF/RF increase oxidative stress in living tissues have not been clearly elucidated, although some ideas have been proposed. (Liboff, 2010) (Georgiou, 2010)

But in the last decade, the scientific research clearly established that EMF and RF exposure cause an increase in reactive oxygen species in living tissues, leading to

oxidant damage of DNA. (Shiroff, 2008)

Studies cited above document that microwave RF exposures at very low power densities produce oxidant stress accompanied by DNA damage. (Kesari et al., 2010a) (Kumar et al., 2010)

Other recently published studies also show that RF exposure can increase oxidant stress and tissue damage in brain tissue (Maaroufi et al., 2011) (Avci et al., 2012), liver tissue (Guler et al., 2012), white blood cells (Lu et al., 2012), and human salivary glands (Hamzany et al., 2012).

SUPPRESSION OF MELATONIN SECRETION COMPOUNDS THE PROBLEM.

The problems caused by increased oxidative stress from EMF/RF are compounded by the fact that EMF/RF can also suppress melatonin secretion by the pineal gland, since melatonin is one of the most potent antioxidant molecules produced in the body.

In recently published study, Kesari et. al. exposed Wistar rats to 2.45 GHz microwave radio transmission, 2 hours a day for 45 days, at a power density of 0.21 mW/cm² (240 μW/cm², whole body SAR ~ 0.14 W/kg). Pineal melatonin was significantly decreased in the exposed group. (Kesari et al., 2012)

Multiple studies have documented that exposure to microwave RF can reduce melatonin levels in animals and in people. (see Section 1).

CONSEQUENCES OF OXIDATIVE DAMAGE TO DNA

EVIDENCE FOR CANCER

When DNA is damaged, the body attempts to repair it. Errors in DNA coding sequence produced during the repair process can produce mutations. And it is hypothesized that such mutations in DNA are a major cause of cancer.

So if radio frequency (RF) and microwave (MF) exposure increase oxidative damage to DNA, we would expect to see evidence that chronic RF exposure increased the rate of some forms of cancer. A significant body of epidemiologic research in a variety of exposure settings suggests that this is indeed the case.

Electronics technicians

In the 1980's, Milham published evidence of increased leukemia in electrical workers (Milham, 1985b)

Another study of workers in the electronics industry found an increased risk of brain tumor associated with exposure to microwave radio transmission, with a highly significant increase in risk in those with more than 20 years of exposure. (Thomas et al., 1987)

A case/control study of brain cancer deaths in Maryland found a three-fold greater brain cancer incidence in electrical or electronic engineers and technicians, compared to the reference population. (Lin et al., 1985)

A study of leukemia rates in different occupational groups in the U.S. Navy showed increased leukemia risk in electrician's mates. (Garland et al., 1990)

A study performed for the U.S. military published data comparing a cohort of 20,000 Korean War veterans with higher occupational exposure levels to RF/MW exposure to 208,000 Korean war veterans with minimal occupational exposure during their service years. Mortality statistics were reviewed for the interval between 1950 and 1974. (Robinette et al., 1980) This data shows that the group with the highest rated

occupational exposure level (aviation electronic technicians) had a significantly higher total death rate during the study period, and a higher death rate from disease, from malignancy, and from lymphatic and hematopoietic malignancies. (Goldsmith, 1997a)

A study of Polish career military personnel from 1971-1985 showed double the risk of cancer in personnel with occupational exposure to RF/MW transmission, as compared other personnel. The exposed cohort had higher morbidity rates for GI cancers (Observed versus Expected Ratio = 3.19-3.24), brain tumors (OER = 1.91), and hematopoietic malignancy (OER = 6.31), including chronic myelocytic leukemia (OER = 13.9), acute myeloblastic leukemia (OER = 8.62), and non-Hodgkin lymphoma (OER = 5.82). (Szmigielski, 1996)

Radio Operators

Increased rates of acute myeloid leukemia and of other lymphatic malignancies have been found in large population-based studies of amateur radio operators (Milham, 1985a) (Milham, 1988a) (Milham, 1988b).

Another study of female radio and telegraph operators in Norway found an increased incidence of breast cancer in this group as compared to the standardized incidence rate in the female population of that country. (Tynes et al., 1996)

Police radar operators

Two studies have shown increased rates of testicular cancer (Davis and Mostofi, 1993), and of testicular cancer and melanoma (Finkelstein, 1998) in police officers with occupational exposure to hand-held radar.

Airline pilots

Airline pilots have significant occupational exposure to RF/MF (radio frequency and microwave frequency) transmissions.

A study of U.S. Air Force personnel showed an increased risk of brain tumors associated with increasing rank, and associated with estimated exposures to both microwave radio and low frequency radio transmissions. No increased risk associated with exposure to ionizing radiation was found in this study population. (Grayson, 1996)

A study of commercial airline pilots in Iceland found an increased risk of malignant melanoma. (Rafnsson et al., 2000) Another study with Danish pilots showed increased risk of total cancer, melanoma, other skin cancers, and acute myeloid leukemia in commercial airline cockpit crews. (Gundestrup and Storm, 1999) Neither of these studies specifically controlled for RF/MF exposures as compared to other exposures (cosmic rays, tropical sun on the beach, etc.) incurred by flying personnel.

However, an extensive study of German commercial airlines crews (including 6,017 cockpit and 20,757 cabin crew members) showed an increased brain cancer risk for cockpit crew and an increased all-cancer risk for cockpit crew with more than 30 years employment compared to those with under 10 years of employment. Notably, these increased risk were not found in cabin crew members, who share equal exposure to cosmic rays and tropical beaches, but are farther from the radios. (Zeeb et al., 2010)

U.S. Embassy Moscow 1953--1976

From the 1950's to the mid-1970's the U.S. Embassy in Moscow was exposed to a constant low intensity radar signal, as a form of harassment by the Russian government. The exposure level on the outside of the west facade of the building was measured at 5 microwatts/cm², and was present for 9 hours a day. Since the wall and windows

attenuated the signal, inside exposure levels were likely to be in the range of 0.02 to 0.1 $\mu\text{W}/\text{cm}^2$.

The State Department contracted an epidemiologic analysis potential health effects on exposed personnel and their dependents, which was performed by A.M. Lilienfeld M.D., and epidemiologist at John's Hopkins University. This report was published including all of the tabulated raw data. (Lilienfeld AM, 1979)

The report as finally released stated as a conclusion that personnel "suffered no ill effects" from the microwave exposure. However, the published conclusions differed from the original conclusions written by Dr. Lilienfeld, and evidence suggests that the final conclusions were "white-washed". (Goldsmith, 1997b) One can presume that this might have been done to avoid embarrassment of the federal government, since any harm, if produced, would have been produced at levels of exposure orders of magnitude less than those exposure levels permitted by United States FCC guidelines.

A hematologic study performed on employees at the Moscow embassy was submitted to the U.S. government in October, 1976. This study showed significant abnormalities in hematologic parameters in this group, in comparison with studies of foreign service workers in the United States. (Goldsmith, 1997a)

The published data from the Lilienfeld study of Moscow embassy workers and their dependents has subsequently been analyzed by other epidemiologists and found to show a statistically significant increase in total adult and childhood cancers, in breast cancer, and in childhood leukemia. (Goldsmith, 1995) (Cherry, 2002a)

Residential exposure to Radio/TV Transmission towers

By the late 1990's, a significant body of epidemiologic literature had accumulated that demonstrated an association between exposure to radar and RF radiation and the occurrence of certain types of cancer.

Evidence for association between radio transmission tower exposures and adult and/or childhood leukemia has been reported in studies from Hawaii (Maskarinec et al., 1994) and Australia (Hocking et al., 1996).

A study from England shows an increased risk of adult leukemia in those residing within two kilometers of the transmission tower, and decreased risk of leukemia, skin cancer, and bladder cancer with increased distance of residence from the tower. (Dolk et al., 1997b) A follow-up study involving multiple other sites in England also showed a statistically significant decline in risk of adult leukemia with increasing distance of residence from transmission sites. (Dolk et al., 1997a) (Hocking et al., 1998)

A study in Rome evaluated the incidence of adult and childhood leukemia as a function of residential proximity to the Vatican Radio transmission tower. Pediatric leukemia cases were more common than expected at less than 6 kilometers from the tower, and significantly elevated in adult men living within 2 km of the tower. Adult male leukemia mortality and childhood leukemia rates showed a significant decrease with increasing distance between tower and residence. (Michelozzi et al., 2002)

A study of cancer incidence in proximity to the Sutro radio/TV tower in San Francisco also showed a strong correlation of exposure and incidence of several types of childhood cancer. (Cherry, 2002b) This study was notable for its rigor in analyzing the actual exposure levels around the tower in relation to the data set. Power density/exposure levels around UHF and VHF broadcasting antennae are not distributed in a simple and symmetrical regression ("with the square of the distance"). Transmission exposure levels form a series of peaks and valleys around these antennae, and the

antennae can be arranged to focus more power in one direction than another, aiming a stronger signal at the target audience in a population center. Studies that fail to take this distribution into account and assume that exposure is in direct ratio to distance will mix higher and lower exposure groups together, diluting the power of the study and underestimating true risk in relation to exposure.

In another paper, Dr. Cherry analyzes this issue in detail, and uses his more rigorous approach to review and refine the analysis of data from many of the earlier studies on health effects of radio/TV broadcast towers. His analysis strengthens the evidence for increased cancer risk from these exposures. (Cherry, 2002a)

A large population case/control study in south Korea looked at 1928 leukemia patients and 956 brain cancer patients under 15 years of age who were diagnosed between 1993 and 1999 at 14 large hospitals in Korea. These cases were matched with 3082 age matched patients who received respiratory disease diagnoses (primarily asthma) at the same hospitals during the study period. Case and control exposure levels were calculated for 31 transmitters in South Korea that had a transmission power greater than 20 kW, using a mathematical model that was correlated with field testing. Children residing within 2 kilometers of a transmission tower had a significantly increased risk of leukemia as compared to children with residence greater than 20 km from the tower (OR 2.15, 95% CI = 1.00 to 4.67). (Ha et al., 2007)

Residential Exposure to Cell Phone Tower (Base Station) Transmissions

With the dramatic roll-out of commercial cell phone service in the 1990's, large segments of the population became exposed to significantly higher levels of microwave RF exposure due to the installation of cell phone towers in urban areas. Several recent papers have reviewed the significant evidence for ill effects from these urban exposures. (Khurana et al., 2010) (Yakymenko et al., 2011) (Kumar, 2010)

Netanyu, Israel

Wolf and Wolf studied rates of cancer incidence during the second year of operation of a 1500 watt 850 MHz cell phone tower in Netanya, Israel. The study group was composed of 622 individuals who had lived in area A, within 350 meters of the tower, for the previous 3-7 years. A control group of 1,222 individuals living in an outlying area B was also studied.

During the study year, 8 cases of cancer occurred in the study group, and 2 cases occurred in the control group. The cancer rate for the entire town was 31 cases per 10,000. Relative cancer rates for females was 10.5 for the study group, 0.6 for the control group, and 1.0 for the town as a whole ($P < 0.0001$).

Signal power densities of the tower's transmissions in the homes of the cancer cases ranged from 0.3-0.5 $\mu\text{w}/\text{cm}^2$.

In the year following the close of the study, another 8 new cases of cancer occurred in area A, and another 2 cases occurred in area B. (Wolf and Wolf, 2004)

Naila, Germany

A cell phone transmission tower was placed in the town of Naila, Germany, in 1993. Eger, Hagen, et. al. reviewed the medical health records from 1994-2004 for around 1000 residents of the municipality (roughly 90% of the population). All included patients had been living at the same address during the entire 10 years of observation.

Over the course of the entire study period, patients living in an inner area within

400 meter of the transmission tower had 2.27 times the relative risk of cancer incidence, compared to patients living more than 400 meters from the tower ($p < 0.05$). Cancer patients in the inner residential area also developed cancer an average of 8.5 years earlier in life than did cancer patients residing in the more distant area.

For the years 1999 to 2004 (after 5 years of tower operation) the relative risk of cancer incidence in residents less than 400 meters from the tower increased to 3.29 ($p < 0.01$). Relative risk of breast cancer was 3.4 in the inner area, where average age of diagnosis was 50.8 years, compared to 69.9 years in the outer area. (Eger et al., 2004)

Hausmannstätten and Vasoldsberg, Austria

Oberfeld performed a case/control study of cancer patients in the municipalities of Hausmannstätten and Vasoldsberg, Austria. All subjects had resided within 1,200 meters of an analogue cell phone tower that operated between 1984 and 1997 in the municipalities.

Residential outdoor exposure levels were measured, and three different case/control groups were assessed, for case exposure levels outside the residence of 10-100 $\mu\text{W}/\text{m}^2$ ($= 0.001\text{-}0.01 \mu\text{W}/\text{cm}^2$), 100-1000 $\mu\text{W}/\text{m}^2$ ($= 0.01\text{-}0.1 \mu\text{W}/\text{cm}^2$), and greater than 1000 $\mu\text{W}/\text{m}^2$ ($> 0.1 \mu\text{W}/\text{cm}^2$), respectively. The reference exposure level for the control group was less than 10 $\mu\text{W}/\text{m}^2$ ($= 0.001 \mu\text{W}/\text{cm}^2$).

Cancer risk for all cancers was significantly elevated for all three elevated exposure categories, and was 5 to 8 times higher in the $>1000 \mu\text{W}/\text{m}^2$ ($> 0.1 \mu\text{W}/\text{cm}^2$) category ($p = 0.001$). In this highest risk group, breast cancer risk was 23 times higher ($p = 0.0007$) and brain tumor risk was 121 times higher ($p = 0.001$). (Oberfeld, 2008)

Belo Horizonte, Brazil

Dode et al. studied deaths from cancer in the city of Belo Horizonte in southern Brazil from 1996 to 2006. This city of over 2 million inhabitants was rated by the United Nations in 2007 as having the best quality of life in Latin America. The researchers used the database of deaths by neoplasm of the City Health Department, the database of cell phone base station sites from the Brazilian Telecommunications Agency, and a database of the city census and demographics. Exposure duration was calculated from the date of installation of the first antenna to which the individual had been exposed, and residential distance from that exposure was calculated in 100 meter increments.

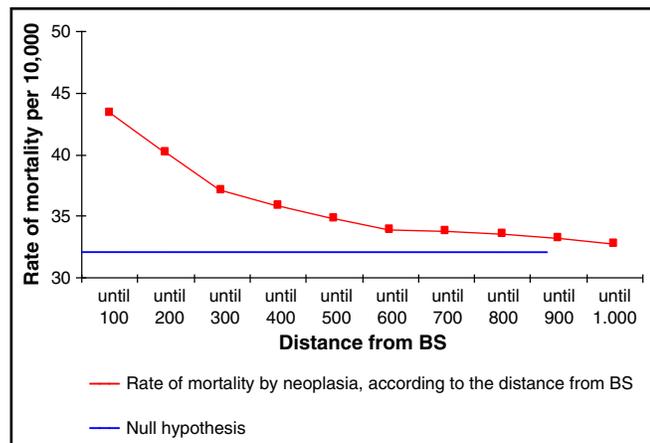


Figure 1: Cancer death rate as function of residential proximity to cell phone transmission towers in meters (Dode et al., 2011, *Sci Total Environ*, 409, 3649-65)

The highest concentration of base stations was in the south central part of the city. In 2008, environmental monitoring of microwave radiation was performed at 400 sites, measuring frequency bands between 800 MHz and 1800 MHz. Signal intensity averaged 7.32 V/m (~ 14.2 $\mu\text{W}/\text{cm}^2$), with a range from 0.4 to 12.4 V/m (~ 0.04 to 40.7 $\mu\text{W}/\text{cm}^2$). These intensity levels are well below the ICNIRP guidelines for microwave radiation exposure, which are based on protection against thermal effects.

Analysis of the data showed that cancer mortality rates were higher near the cell phone transmission towers. Within the range of 100 meters of a tower, the mortality rate was 43.42 persons per 10,000 (compared to a rate of 32.12 per 10,000 for the city as a whole), with a relative risk of 1.35.

The mortality rate reduced in proportion to residential distance from cell phone tower. Relative risk of cancer mortality was clearly elevated at residential distances of 500 meters or less from a cell transmission tower (base station, or BS) as illustrated in Figure 1. (Dode et al., 2011)

Taiwan

Li et. al. performed a case/control study of 2606 children age 15 or less who were diagnosed with a neoplasm in Taiwan between 2003 and 2007. Each case was matched with 30 controls. Residential exposure of cases and controls was calculated based on the annual power density in watt-years per kilometer squared for each of the 367 townships in Taiwan, averaged out for the 5 year period prior to diagnosis in the township where the subject resided at time of diagnosis.

This study is notable for the large number of cases and controls, which should increase the power of the study. On the other hand, if elevated microwave exposure is associated with cancer risk, assuming that power density of cell phone tower transmissions is constant throughout each township would serve to minimize the effects of higher exposure levels closer to the towers, minimizing the distinction between higher and lower cohorts, and diluting the power of the study.

Case/control analyses were performed for "all cancer types", for leukemia, and for brain neoplasm. Odds ratio for cases of "all cancer types" with calculated exposure greater than median exposure value of controls were significantly elevated at 1.13 (95% CI = 1.01 to 1.28). Odds ratio for cases of leukemia with calculated exposure greater than median exposure value of controls were elevated at 1.23 (95% CI = 0.99 to 1.52). Odds ratio for cases of brain neoplasm with calculated exposure greater than median exposure value of controls were slightly elevated at 1.14 (95% CI = 0.83 to 1.55). (Li et al., 2012)

EVIDENCE FOR IMPAIRMENT OF FERTILITY

Toxic exposures that damage DNA can cause cancer. They can also cause damage to the production of healthy eggs and sperm, leading to infertility. If microwave RF exposure causes oxidative damage to DNA, this should lead to measurable alterations in function of reproductive function and fertility. Current research is beginning to prove the presence of this effect.

Laboratory studies in insects

In 2004, Panagopoulos et. al. demonstrated that exposure to a modulated GSM 900 MHz cell phone signal for 6 continuous minutes daily for two days decreased the fertility of both male and female fruit flies (*Drosophila melanogaster*). Exposure power density was ~ 0.436 milliwatts/cm² (= 436 $\mu\text{W}/\text{cm}^2$). (Panagopoulos et al., 2004)

In a later study, Panagopoulos et. al. exposed *Drosophila* fruit flies to a cell phone transmitting GSM 900 MHz at 0.40 mW/cm^2 ($= 400 \text{ }\mu\text{W/cm}^2$ -- Group 1) or GSM 900 MHz at 0.29 mW/cm^2 ($= 290 \text{ }\mu\text{W/cm}^2$ -- Group 2), or DCS 1800 MHz at 0.29 mW/cm^2 ($= 290 \text{ }\mu\text{W/cm}^2$ -- Group 3). Transmission exposures were 6 consecutive minutes per day for six days. The exposure induced fragmented DNA during oogenesis. Cell death scores in the ovaries of female flies were 63% in Group 1, 45% in Group 2, and 39% in Group 3, as compared to 7.8% in the sham and control groups. (Panagopoulos et al., 2007)

Subsequent research exposed *Drosophila* fruit flies to GSM 900 MHz or DCS 1800 MHz signals for signal durations of 1 to 21 minutes a day for five consecutive days, at a power density of $10 \text{ }\mu\text{W/cm}^2$. Impairment of fertility increased linearly with duration of exposure (see figure 2). Even at 1 minute of exposure a day, fertility was significantly decreased in exposed versus sham exposure specimens ($p < 0.00001$). (Panagopoulos and Margaritis, 2010)

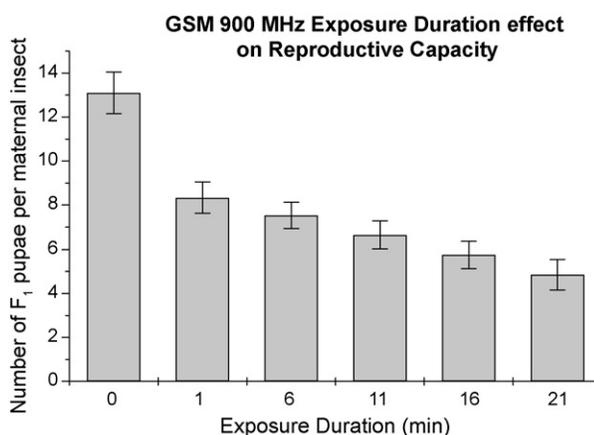


Figure 2: Decreased fertility at exposure level of $10 \text{ }\mu\text{W/cm}^2$ {Panagopoulos and Margaritis, 2010, *Mutat Res*, 699, 17-22}

In another study using a GSM 900 MHz cell phone signal at 0.35 mW/cm^2 ($= 350 \text{ }\mu\text{W/cm}^2$), six minutes of daily exposure was divided into one, two, or three minute segments, spaced 10 minutes apart. This was compared with one 6 minute constant exposure and with two 3 minute exposures spaced 6 hours apart. DNA damage and cell death in the intermittent exposures sequenced 10 minutes apart was essentially the same as with the constant 6 minute exposure ($p > 0.92$), and markedly higher than in the sham group ($p < 10^{-8}$). The group with divided exposures 6 hours apart had less cell death than the more frequently exposed group, but still showed significantly higher infertility than the control group ($p < 0.002$). (Chavdoula et al., 2010)

In yet another study, the Panagopoulos group evaluated influence of GSM 900 MHz and 1800 MHz cell phone transmissions on *Drosophila* fertility using exposures of 6 minutes per day for 6 days, at exposure distances varying from 0 to 100 cm. They were able to demonstrate an adverse effect on fertility for all exposures at all power densities greater than or equal to $1 \text{ }\mu\text{W/cm}^2$. (Panagopoulos et al., 2010)

Recently Panagopoulos published another study demonstrating that exposure to a GSM 900 MHz modulated cell phone transmissions at $\sim 0.35 \text{ mW/cm}^2$ ($= 350 \text{ }\mu\text{W/cm}^2$) for 6 minutes during ovarian development can seriously retard ovarian maturation and reduce final size of ovaries in *Drosophila* fruit flies. (Panagopoulos, 2012)

Laboratory studies in animals

Magras and Xenos placed caged mice at various locations in an antenna park in Thessaloniki, Greece, at locations with RF power densities ranging from 168 nW/cm^2 ($= 0.168 \text{ }\mu\text{W/cm}^2$) to 1053 nW/cm^2 ($= 1.053 \text{ }\mu\text{W/cm}^2$). The mice lived in these locations for six months, during which time they were mated repeatedly. Numbers of newborns per litter decreased progressively, and ended with complete infertility by the fifth mating cycle. This infertility was not reversible with removal to an unexposed laboratory environment. (Magras and Xenos, 1997)

Meo et. al. exposed Wistar rats to cell phone transmissions for either 30 or 60 minutes a day for 3 months, and then measured serum testosterone levels. Testosterone levels decreased with increased duration of exposure, and the difference in testosterone level between subjects and controls was statistically significant in the 60 minutes per day group ($p < 0.02$) (Meo et al., 2010)

Otitolaju et. al. evaluated sperm head morphology in laboratory mice that were exposed to cell tower transmissions at two locations with mean RF exposure levels of $489 \pm 43 \text{ mV/m}$ ($\sim 0.6 \text{ }\mu\text{W/cm}^2$) and $625 \pm 25 \text{ mV/m}$ ($\sim 0.10 \text{ }\mu\text{W/cm}^2$). A control group was held in a laboratory with RF exposure levels of $59 \pm 17 \text{ mV/m}$ ($\sim 0.001 \text{ }\mu\text{W/cm}^2$). After six months of exposure, exposed rats showed mean sperm head abnormalities of 40% and 46%, versus 2% in control animals. (Otitolaju et al., 2010)

Kesari and Behari exposed male Wistar rats to 50 GHz continuous microwave radiation at a power density of $0.86 \text{ }\mu\text{W/cm}^2$ (calculated SAR $8 \times 10^{-4} \text{ W/kg}$), 2 hours a day for 45 days. Sperm cells showed significant reductions of glutathione peroxidase and superoxide dismutase activity ($p \leq 0.05$) and increased catalase activity ($p < 0.02$), consistent with a significant increase in oxidative stress. Histone kinase activity was also increased ($p < 0.016$), and significantly increased apoptosis (programmed cell death) and alteration in phases of sperm development were also present. (Kesari and Behari, 2010)

In a similar study, Kesari et. al. confirmed a significant increase in cell death through apoptosis, reduced sperm count, and reduced protein kinase C activity in male Wistar rats exposed to cell phone transmissions 2 hours daily for 35 days. Exposure power densities ranged from $0.1 - 2.0 \text{ mW/cm}^2$ ($= 100 - 2000 \text{ }\mu\text{W/cm}^2$, calculated SAR 0.9 W/kg). (Kesari et al., 2010b)

In 2011 and 2012 Kumar and Kesari published four additional papers documenting the adverse effects of 10 GHz microwave exposure (2 hours daily for 45 days at power density of 0.21 mW/cm^2 ($= 210 \text{ }\mu\text{W/cm}^2$, SAR 0.014 W/kg) on fertility in male Wistar mice. These studies document significant levels of pathological change including increases in reactive oxygen species, increased apoptosis (cell death) in sperm cells and altered sperm cell cycle (Kumar et al., 2011), increased free radical formation, decreased activity of glutathione peroxidase and superoxide dismutase, increased activity of catalase and malondialdehyde, decreased histone kinase (Kesari et al., 2011), reduced testosterone levels, shrinkage of seminiferous tubules and testicular size, distortion of sperm structure, decreased number and weight of progeny (Kesari and Behari, 2012), formation of micronuclei bodies in lymphocytes, DNA strand breakage, altered levels of histone kinase, altered percentage of spermatogenic phases, and (again) reduced testosterone levels and shrinkage of seminiferous tubules. (Kumar et al., 2012)

In 2012, Atasoy et. al. published a study of rats exposed to a WiFi router (802.11.g, 2.437 GHz) for 20 weeks, 24 hours a day. Histological and

immunohistochemical examinations of the rats' testes showed evidence of DNA damage compared to controls ($p < 0.05$) and decreased activity levels of antioxidants (catalase and glutathione peroxidase, $p < 0.05$). (Atasoy et al., 2012)

Other animal studies

Experimental laboratory evidence clearly demonstrates that microwave RF radiation can adversely effect reproduction in insects and animals. Some evidence to support this is also available from studies of animals exposed to RF in their natural environment.

Balmori studied a white stork population that was nesting near a cluster of cell phone towers in in Valladolid, Spain. Power densities at ground level ranged from $10 \mu\text{W}/\text{cm}^2$ at 50 meters from the towers to $1 \mu\text{W}/\text{cm}^2$ at 100 meters distance and a tenths of a $\mu\text{W}/\text{cm}^2$ at 150 to 200 meters distance. Total breeding productivity was significantly reduced at nests closer than 200 meters, compared to nests farther than 300 meters from the towers. (Balmori, 2005)

Balmori performed bird counts at 30 locations during 40 visits to Valladolid, Spain, over the interval between October 2002 and May 2006, and measured mean electric field strength at each counting site. Bird population density declined significantly over the observation period ($p = 0.0037$), and population density was significantly lower in areas with higher electric field strength ($p = 0.0001$). (Balmori and Hallberg, 2007)

Balmori also studied reproductive success of common frogs (*Rana temporaria*) at a breeding site 140 meters from a cluster of cell phone towers. Electric field intensities measured at 1.8 to 3.5 V/m (~ 0.9 to $3.2 \mu\text{W}/\text{cm}^2$). Some eggs were in enclosures that were permeable to microwave radiation, and others were shielded in grounded Faraday cages. Exposed eggs showed asynchronous growth with varying tadpole size and a 90% mortality rate, while shielded eggs developed synchronously with a 4.2% mortality rate. (Balmori, 2010a)

Much more work needs to be done on in vivo studies of the effects of microwave cellular transmissions on animals and plants. Two reviews of the existing research have been published. (Balmori, 2009) (Balmori, 2010b)

Human studies

Human sperm counts have been declining for decades. In 1992 Carlsen et. al. published a meta-review of 61 studies published between 1938 and 1991, with 14,947 subjects. They found a decreased in mean sperm count from 113 million/ml to 66 million/ml ($p < 0.0001$) between 1940 and 1990, with a decrease in seminal volume from 3.40 ml to 2.75 ml ($p = 0.027$). Additionally, the percentage of men with sperm counts < 20 million/ml increased over this time period, while the percentage of men with sperm counts > 100 million/ml decreased. The incidence of testicular cancer increased between two and fourfold during this interval. (Carlsen et al., 1992)

Carlsen's analysis produced controversy initially. But subsequent analysis has shown that their results were essentially correct. Analytic approaches to their data set that refined the analysis to adjust for bias of various kinds have continued to support the validity of their conclusions. (Swan and Elkin, 1999)

In another meta-analysis, Swan et. al. looked at 54 of the most robust studies in the Carlsen data set, and at 47 additional studies, covering studies from 28 countries over a total time interval from 1934 to 1996. They found a rate of decrease in sperm

counts of 0.80 million/ml per year in North America and 3.13 million/ml per year in Europe/Australia. (Swan et al., 2000)

And more recent studies have shown that this downward trend in sperm counts is continuing. Jorgensen et. al. found decreasing levels in sperm concentration, total sperm count, and percentage of morphologically normal sperm in Finnish men born in 1979-81 versus 1982-83 vs 1987. (Jorgensen et al., 2011) Sperm counts in New Zealand sperm donors decreased 50% between 1987 and 2007, an average of 2.5% per year. (Shine et al., 2008)

In the early 1990's, it was hypothesized that this decrease in sperm counts and increase in testicular pathology might be due to exposure of male embryos to exogenous estrogens (DES, pesticide residues, plasticizers like Bis-phenol A, etc.) early in development. (Sharpe and Skakkebaek, 1993) (Carlsen et al., 1995) (Irvine, 1997)

In 1994, Abell et. al. described higher sperm counts in members of a Danish organic farmer's association, as compared with Danish men who had occupational exposures to xenoestrogens. (Abell et al., 1994) Jensen et. al. found a 43.1% higher sperm concentration ($p = 0.033$) in 55 members of Danish organic foods associations who ate at least 25% organic foods, as compared with 141 normal controls. (Jensen et al., 1996)

Multiple studies in animal models have shown that in utero exposures to estrogenic chemicals can alter testicular health and function. Regional variations in sperm count and testicular cancer rates suggest the possibility of environmental influences. A recent paper by Nordkap et. al. reviews current perspectives on this subject. (Nordkap et al., 2012)

On the other hand, estrogenic xenobiotic chemicals have been present in the food chain since the 1950's. Adverse clinical effects of these exposures have been discussed since the early 1960's. (Randolph, 1962) Unless the human body burden of these chemicals has continued to significantly increase over the last 50 years, we would expect the influence of this effect on sperm counts to plateau.

But sperm counts have not plateaued. They have continue to decrease throughout the developed world. A recent study of 26,609 french partners of totally infertile women seeking in vitro fertilization found a 32.2% decrease in sperm concentration between 1989 and 2005, with projected sperm counts for a 35 year old man dropping from 73.6 million/ml to 49.9 million/ml. (Rolland et al., 2012)

This continued trend should be a cause for significant alarm. The World Health Organization defines sperm counts above 20 million/ml as normal. But studies have shown that couples take longer to get pregnant at sperm counts below 40 to 55 million/ml. (Bonde et al., 1998) (Guzick et al., 2001) (Slama et al., 2002) In Israel, a recent study of sperm donors showed that over the last 10-15 years the average sperm count has dropped from 106 million/ml to 68 million/ml, an average decrease of 2.5 million/ml (0.8%) per year. 15 years ago, 66% of sperm donations were of acceptable quality; using the same criteria, at the current time only 18% of donations would be of acceptable quality. (Haimov-Kochman et al., 2012)

As discussed above, studies in insects and animals have demonstrated that microwave radio exposure at remarkably low power densities can have an adverse effect on male fertility. With the roll-out of cellular and wifi infrastructure, exposure to these radio frequencies has increased dramatically in the last 20 years. Would it be reasonable to ask if such exposures have played a role in the continued decrease in male

fertility that has occurred during this time period? The result of several recent studies suggests that the answer to this question is "Yes".

Erogul et. al. split sperm samples and exposed one part to signal from a 900 MHz cell phone. They found statistically significant decreases in motility of sperm in the exposed samples. (Erogul et al., 2006)

Fejes et. al. measured sperm quality a cohort of 371 subjects where confounding factors had been excluded, and found a significant decrease in sperm motility ($p < 0.01$) in individuals with talk time > 60 minutes/day versus talk time < 15 minutes/D 60 min/D. Decreased sperm motility also correlated with increased duration of cell phone ownership in months. (Fejes et al., 2005)

Agarwal et. al. studied semen quality in 361 subjects, divided into four groups based on daily cell phone usage (no use, < 2 hours/day, 2-4 h/D, > 4 h/D). They found that sperm count, motility, viability, and percent normal morphology all decreased with increased cell phone use. (Agarwal et al., 2008)

De Iuliis et. al. exposed human sperm to 1.8 GHz microwave radio transmissions. Statistically significant decreases in sperm motility and vitality were demonstrate at exposure levels as low as 1.0 W/kg ($p < 0.01$). This study also found an increase in reactive oxygen species, oxidative damage to DNA, and DNA fragmentation, that was not dependent on thermal effects. (De Iuliis et al., 2009)

Another recent study the effects of exposing motile sperm to 4 hours of WiFi transmission at a position 3 cm beneath a laptop computer, at power densities between 0.5 and 1.1 $\mu\text{W}/\text{cm}^2$. Temperature was maintained at a constant 25°C . Exposed specimens showed a statistically significant decrease in sperm progressive motility, and a significant increase in non-motile sperm and in sperm DNA fragmentation. (Avendano et al., 2011)

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CONCLUSIONS

ELECTROHYPERSENSITIVITY

- Since the 1950's, scientific research has confirmed that exposure to microwave radio (RF) transmissions can cause multiple symptoms, including headache, sleep disturbance, difficulty in concentration, memory disturbance, fatigue, depression, irritability, dizziness, malaise, tinnitus, burning and flushed skin, digestive disturbance, tremor, and cardiac irregularities, in a certain percentage of the population.
- Research has demonstrated that these exposures can cause multiple alterations in the physiology of some individuals, including altered production of stress hormones, thyroid hormones, and sex steroid hormones, alterations in neurologic function, and alterations in immune function.
- It is probable that 2 to 3% of the residents in the neighborhood around the proposed Oakway Golf Course already experience adverse effects from radio frequency (RF) exposures in their daily life in the city. Placing a cell phone tower at this site will expose these people to higher levels of RF exposure, 24 hours a day. They will get sicker. Some of these people are likely to be affected strongly enough that they won't be able to tolerate living in the area. Some EHS patients are extremely sensitive to low exposure levels. The radius of exposure within which such patients are adversely affected is likely to be significantly larger than the 500 meter radius illustrated in Figures 1 and 2.
- Adding another and larger level of RF exposure to the neighborhood is quite likely to produce acute symptoms (sleep disturbance, headache, nervous distress, fatigue, concentration difficulties) in some area residents who are not suffering from them at the current time. This affect could certainly be expected within the 500 meter radius circle illustrated in Figures 1.

MELATONIN SUPPRESSION

- Unlike visible light, microwave radio transmissions penetrate walls and human bodies. They are not easily blocked out by window blinds or eye shades.
- The new tower will mean a significant increase in nocturnal RF transmission levels in the residential neighborhood.
- If melatonin secretion can be disrupted by RF in a portion of the population, then this increase in exposure can be expected to produce significant levels of melatonin suppression in a percentage of the local residents.
- In the short term, this would lead to more cases of sleep disruption or insomnia.
- In the long term, this would increase the incidence of breast and prostate cancer in the local area.

CANCER

- Current research supports the assertion that placing a cell phone tower at the Oakway Golf Course site will place the residents within the 500 meter radius illustrated in Figures 1 at a four times greater risk of developing cancer of various types, with breast cancer being at the highest risk.
- This risk of increased cancer would apply to residents of the houses and apartments in the illustrated area, and possibly also to people working full time at the Golf Course and in area businesses and churches, and conceivably to children in day care centers or at the preschool at Emerald Bible Fellowship.

STIPULATIONS OF THE EUGENE METRO PLAN

The Eugene Springfield Metropolitan Area General Plan lists these policies on page 107:

- E.4 Public and private facilities shall be designed and located in a manner that preserves and enhances desirable features of local and neighborhood areas and promotes their sense of identity.
- E.5 Carefully develop sites that provide visual diversity to the urban area and optimize their visual and personal accessibility to residents.
- E.6 Local jurisdictions shall carefully evaluate their development regulations to ensure that they address environmental design considerations, such as, but not limited to, safety, crime prevention, aesthetics, and compatibility with existing and anticipated adjacent uses (particularly considering high and medium density development locating adjacent to low density residential).

RESPONSIBILITIES

The Planning Commission needs to seriously consider their options and their responsibilities to the public as put forth in the above policies.

Taking an action that will in all probability increase the incidence of sleep disturbance, headache, nervous distress, fatigue, concentration difficulties, cancer, and infertility cannot be considered as an enhancement of the desirability of a local residential neighborhood.

Increasing the level of microwave radio frequency exposure in this residential neighborhood is likely to deny accessibility of both neighborhood and home to local residents who already suffer from electrohypersensitivity, and will make the neighborhood a less safe place to live for all residents.

RECOMMENDATIONS

As physicians, we strongly recommend that you do not permit the placement of this cellular transmission tower in this residential neighborhood.

For all of us who are exposed to increasing levels of microwave radio transmission in our daily lives, it is important to have a place that is less exposed, where our physiology can rest and recover from the stress these signals produce. The appropriate place for this is in the bedroom of our homes, in our residential neighborhoods.

Putting more radio transmission in our residential neighborhoods interferes with this ability of our bodies to rest and repair themselves during the night. Instead, it adds an additional layer of constant physiologic stress to our bodies, that can and does produce significant adverse effects. This is a very bad idea.

As you read through the evidence that we have reviewed for you, you will have noted that much of the research we've reviewed was published in the last ten years. Yet the FCC regulations on microwave exposure date from 1996. They are more than a decade behind the science. The FCC regulations make no effort to address adverse "non-thermal" or biological effects of microwave radio exposure. It could be argued that the FCC has simply declined to take jurisdiction over this safety issue.

Yet the current science clearly shows that these adverse biologic effects are very real, and quite significant in their scope. And the research demonstrating this is getting

CONCLUSIONS

more robust every year. This science isn't going to go away. Just as it has become impossible for objective science to deny the occurrence of global warming, it is going to become continually more difficult to deny the adverse biological effects of chronic exposure to microwave radio transmissions. And as our overall levels of exposure to these transmissions rises, the effects are going to become more obvious, and more severe. The health of our communities is under significant and increasing risk.

At this time, the federal government is not protecting us against these risks. Unless we protect ourselves, no one will. And the most important places to protect are our homes, where we live and sleep at night.

We hope that you will take all this information to heart as you consider how to handle this problem.

Sincerely,

Paul Dart, M.D. F.C.A.

Kathleen Cordes, M.D.

Andrew Elliott, N.D.

CURRENT RESEARCH ON CELL PHONE USE AND BRAIN TUMOR RISK

Paul Dart, M.D. F.C.A.

INTRODUCTION

To be complete, any review of the health hazards of microwave radio exposures must include a discussion of the research on possible associations between cell phone usage and brain tumors.

This research is a hot topic politically. Cell phone use has permeated our society, and no one wants to think that use of a cell phone is going to increase their personal risk (or their child's personal risk) of acquiring a terrifying disease.

The roll-out of the cellular communications infrastructure has also created an extremely profitable industry. The telecommunications industry made \$3.1 trillion in gross profits in 2010. (Plunkett Research, 2012) This industry has a powerful incentive to downplay the health effects of EMF, and has funded a good deal of research that serves to further that aim. Some studies regarding cell phones and brain tumors have been funded in large part by the telecommunications industry. These industry-designed studies have generally concluded that the use of cell phones does not create a health hazard. And these negative reports have received wide coverage in the news media. However, the study designs funded by industry are more likely to use unblinded protocols and to underestimate risk, as compared to studies funded by public bodies. (Levis et al., 2012)

When powerful financial interests are at play, industry funding of favorable research studies is often used to influence the political and scientific playing field. We've seen this play out in pharmaceutical research, where several recent scandals have highlighted the distorting effects of corporate financing on research outcomes. In the past few decades the production of research providing favorable (to corporate interests) results has become something of a science in itself, with corporations essentially gaming the academic system, funding studies designed to produce favorable outcomes for their products, and hiding studies that do not support their interests. The peer review process of the scientific journals has not proved to be an adequate defence against this problem. (Smith, 2005)

In the research on cell phones and brain tumors, the situation is further confounded by the fact that cell phone usage has only become wide spread in the last 15 years or so. The first digital cell phone infrastructure was pioneered in Scandinavia, and the first research that raised concerns about cell phone cancer risks was produced in Sweden in the late 1990's. But environmental influences that promote cancer generally take years to do so.

Take the question of the potential risk of cell phone use by teenagers. Does this cell phone use increase the risk of brain tumors later in life? The mass market for cell phone use by teenagers really started after 1995, and extended use of cell phones to surf the web ballooned after the introduction of the iPhone in 2007. Looking for brain cancer today in 30 year olds who started using a cell phone in 1997 would be similar to looking for lung cancer today in 30 year olds who started smoking in 1997 (and who would be most likely to develop lung cancer in their 50's or 60's).

This means we cannot find great reassurance in "negative" cell phone cancer risk studies performed 8 or 10 years ago. And similarly, any "positive" findings of cell

phone cancer risk to date should produce real concern, since it is possible that they are identifying only the early cases of a larger problem.

Three major and ongoing research studies have been performed in the last 10 years. One is the INTERPHONE Study, which is funded in major part by the telecommunications industry. A second study which received much recent media attention is the “Danish Cohort” study. A third body of research has been produced by the Hardell group in Sweden, a research group with no financial support from the telecommunications industry.

THE INTERPHONE STUDY

The INTERPHONE Study is a large standard protocol study of brain and salivary gland tumor risk in relation to mobile telephone use, with branches of the study being performed in 13 countries, and combined together to increase the statistical power of the results. This study was funded in major part by the wireless communications industry.

The first major summary of this research was published in 2010. This “case-control” study looked at patients with brain tumors (2708 glioma cases, 2409 meningioma cases) and matched controls, and compared their estimated cell phone usage to determine if regular cell phone usage increased the odds of being a brain tumor patient. The authors concluded that “Overall, no increase in risk of either glioma or meningioma was observed in association with use of mobile phones.” (Group, 2010)

This reported result was then widely quoted by the press and government agencies like the World Health Organization (IARC, 2010) as demonstrating the lack of risk of wireless technology.

However, this study defined a member of the risk group as any subject who “*had an average of at least one call per week for a period of 6 months*”. This definition of “regular cell phone use” diluted the risk pool out with lower risk individuals to the point that no difference between risk and control groups was visible in the study.

Interestingly, the study did report its statistics stratified by total time of reported use, and the top decile (greater than 1640 hours use over a ten year interval, averaging out as greater than 3 hours a week) had an increased risk of certain tumors. Individuals who accrued that greater than 1650 hours of use over a 1-4 year interval (ranging from 8 to over 30 hours a week) had a markedly higher odds ratio of meningioma (OR 4.80) or glioma (OR 3.27).

In the discussion of their data showing increased risk within the higher usage group, the authors failed to consider the possibility that this data showed a real risk. Instead, they discounted this trend of increased risk in the heavier users, stating that various “biases and errors limit the strength of the conclusions we can draw from these analyses and prevent a causal interpretation.” And it is this “biases and error’s” comment that has been quoted by industry apologists in subsequent publications, rather than the study’s actual statistical findings of increased odds of brain tumor with cell phone talk time greater than 3 hours a week over a ten year period, or greater than 8 hours a week over a 1-4 year period.

The discrepancy between actual data and concluding discussion in this study was not highlighted by mass media coverage of this study. One must assume that reporters read the abstract rather than the complete article, and accepted the author’s

conclusions without question. Other researchers in the field were more critical in their assessments of the INTERPHONE project as compared to other published literature on the subject (Morgan, 2009), and pointed out that the INTERPHONE data really did document an increased risk, consistent with studies published by researchers in the field that were more independent from industry funding sources. (Hardell et al., 2011a) (Levis et al., 2011)

A more recent study from the INTERPHONE group found an increased risk for acoustic neuroma in individuals with > 1640 hours of talk time over up to 5 years of exposure (OR = 2.79, 95% CI = 1.51-5.16). For those subjects who routinely used their cell phone on the same side of the head where they had the acoustic neuroma, the odds ratio was 3.74 (95% CI 1.58-8.83). (Cardis and Schüz, 2011)

The most recent study from the INTERPHONE group showed increased odds ratio of glioma and meningioma with greater than 10 years of mobile phone use. The author's conclusions acknowledged this finding, but stated that "the uncertainty of these results requires that they be replicated before a causal interpretation can be made"--an interesting comment considering that this study result itself was essentially a replication of the actual findings of the earlier INTERPHONE study. (Cardis et al., 2011)

THE DANISH STUDY

A study from Denmark on the risk of mobile phones and brain tumors was published in the British Medical Journal in 2011. The conclusions of this study were that "there were no increased risks of tumors of the central nervous system, providing little evidence for a causal association". (Frei et al., 2011)

This study was widely quoted in the media and by government organizations as refuting the link between cell phones and brain tumors, with headlines like BBC News: "Mobile phone brain cancer link rejected." (Triggle, 2011)

In this case-control study, the risk group was composed of native Danes who had acquired a cell phone contract prior to 1995. However, any corporate users with a pre-1995 cell phone contract were excluded from the risk group (this was 32% of the original cohort). Also excluded were all 1995 subscribers who were less than 18 years old at the time they obtained their first subscription. The study did not determine how often members of the risk group used their phones, or make any determination as to exposure to portable phones in the home for risk or control group members.

The control group was composed of all Danes aged 30 or older and born after 1925 in Denmark. This of course means that the control group included the pre-1996 corporate subscribers (what we might call the "power users"), and also included the 85% of Danes who obtained a cell phone after 1995.

This contamination of the control group with large numbers of at-risk cell phone users made the conclusions of the study essentially meaningless. To the BMJ's credit, letters that pointed this out were printed in the same issue with the original article (but apparently not read by the members of the press). (Khurana, 2011) (Philips and Lamburn, 2011)

The net result of all this was that the public was falsely reassured by media reports of a peer-reviewed article in a prestigious medical journal, when the negative conclusions of that article were essentially meaningless. (Soderqvist et al., 2012)

THE HARDELL GROUP STUDIES

The first digital cell phone network (2G) was launched in Finland in 1991, and

the cell phone communication infrastructure expanded widely in Scandinavia during that decade. In the late 1990's case reports of brain tumors in cell phone users lead to the first of multiple studies produced by the Hardell research group in Sweden. In this case-control study of data collected between 1994 and 1996 from 233 living patients with biopsy-verified brain tumors, no clear distinction could be established between cell phone users and non-users in the patient population, but a trend was observed of increased odds of tumor presence in the temporal or occipital lobe on the same side of the head habitually used to listen to the cell phone. (Hardell et al., 1999)

In 2002 Hardell et al. published another and larger case-control study of 649 brain tumor cases diagnosed between January 1997 and June 2000. This study (and subsequent studies by the Hardell group) looked at exposure from both cellular phones and mobile (cordless) phones connected to land lines. Cumulative hours of cell phone use was calculated from questionnaires about phone usage habits. Increased risk of brain tumor was found for ipsilateral use (phone habitually on same side of head as brain tumor site) with both analogue and digital cellular phones and for cordless phones. Increased risk was also seen for increased duration of exposure. (Hardell et al., 2002)

Another expanded case-control study with 1617 brain tumor patients diagnosed between 1997 and 2000 was published later that year showed similar findings, with the highest calculated risk being for ipsilateral acoustic neuroma in analog cellular phone users (the older technology). (Hardell et al., 2002)

Hardell et al. analyzed this same data set of 1617 patients for incidence of vestibular schwannoma (VS), and found an increased odds ratio for VS associated with the use of analogue cell phones. They found that the incidence of VS in Sweden had significantly increased during the time period 1960-1998, with more of this increase occurring during from 1980-1998. All other brain tumors taken together had also showed a significant yearly increase between 1960 and 1998. (Hardell et al., 2003) (Hardell et al., 2003)

In 2006 and 2007, Hardell et al. published several more studies of brain tumor patients diagnosed between 1997 and 2003. Cell phones had been in wide use for a longer interval of time, and their data allowed evaluation of latency periods of > 10 years duration, and risk for subjects with first cell phone use at < 20 years of age. Cumulative lifetime use of > 2,000 hours showed elevated odds ratios for analog, digital, and cordless phones, and increased risk for malignant tumors with ipsilateral exposure. Risk of malignant tumors was more pronounced in individuals with first cell phone use at less than 20 years of age. (Hardell et al., 2006) (Hardell et al., 2006a) (Hardell et al., 2006b) (Mild et al., 2007)

Later in 2006, Hardell et al. published a pooled review of their data from all six of their previous case-control studies. (Hardell et al., 2006) And they have subsequently published three more papers updating and consolidating their earlier findings. (Hardell and Carlberg, 2009) (Hardell et al., 2010) (Hardell et al., 2011b)

CRITIQUES AND REVIEWS

In 2004 Kundi et al. published a review of 9 existing epidemiologic studies on the relationship between cell phone use and brain tumor risk, and found that all studies approaching reasonable latencies of exposure time showed an increased relative risk (range 1.3 to 4.6) of brain tumor in cell phone users, with highest overall risk for

acoustic neuroma (RR 3.5) and uveal melanoma (RR 4.2) (Kundi et al., 2004)

In 2007 Hardell et al. published a meta-analysis of two cohort studies and 15 case-control studies on the association between long-term use of cell phones and brain tumor. They found increased risk for acoustic neuroma and glioma with ≥ 10 years of exposure, with higher risk of tumor on the exposed side of the head. (Hardell et al., 2007a)

Hardell, Mild, and Kundi published exhaustive reviews of the existing literature on this subject in 2007 in the Bioinitiative Report. (Hardell et al., 2007b) (Kundi, 2007)

In 2008, Hardell et al. published two meta-analysis of the existing case-control studies in the literature including ten studies on glioma and nine studies on acoustic neuroma. They found “a consistent pattern of association between mobile phone use and ipsilateral glioma and acoustic neuroma using ≥ 10 -years latency period”. (Hardell et al., 2008)

In another metanalysis published in 2009, Hardell et al. again found “a consistent pattern of an increased risk for glioma and acoustic neuroma after >10 year mobile phone use . . . with highest risk found in the age group <20 years at time of first use of wireless phones.” (Hardell et al., 2009)

In a 2009 review, Ahlbom et al. stated that existing studies “do not demonstrate an increased risk within approximately 10 years of use for any tumor of the brain”. In a way, this statement is a somewhat back-handed acknowledgement of the fact that the published research to that date clearly does show increased risk with greater than 10 years of use. (Ahlbom et al., 2009)

In 2009 Khurana et al. published a metanalysis of the eleven existing long-term epidemiologic studies on cell phone use and brain tumor risk that met these criteria: Publication in a peer-reviewed journal; inclusion of subjects with greater than 10 years of cell phone use; analyzing “laterality” of cell phone usage in relation to brain tumor incidence. Their conclusion was that “using a cell phone for ≥ 10 years approximately doubles the risk of being diagnosed with a brain tumor on the same (“ipsilateral”) side of the head as that preferred for cell phone use”. (Khurana et al., 2009)

In 2011 the WHO/International Agency for Research on Cancer (IARC) classified radiofrequency electromagnetic fields as “possibly carcinogenic to humans (Group 2B), based on an increased risk for glioma, a malignant type of brain cancer, associated with wireless phone use”. (WHO, 2011) (Baan et al., 2011)

In 2012, Levis et al. published an analysis of published case-control studies, pooled-analyses, and meta-analyses on head tumor risk with mobile phone use. They found that “in studies funded by public bodies, blind protocols give positive results revealing cause-effect relationships between long-term latency or use of mobile phones (cellulars and cordless) and statistically significant increases of ipsilateral risk of brain gliomas and acoustic neuromas, with biological plausibility. In studies funded or co-funded by the cellphone companies non-blind protocols give overall negative results with systematic underestimation of risk; however, also in these studies a statistically significant increase in risk of ipsilateral brain gliomas, acoustic neuromas, and parotid gland tumours is quite common when only subjects with at least 10 years of latency or exposure to mobile phones (only cellulars) are considered.” (Levis et al., 2012)

CONCLUSIONS

The current epidemiological research shows that greater than 10 years of cell phone use incurs a significantly increased risk of ipsilateral brain tumor (glioma or meningioma). This risk is greater in individuals that start using cell phones as children.

This means that the RF exposure guidelines for cell phone use cannot be considered to be adequately protecting the public.

In light of these findings, current public policy that essentially ignores biological or “non-thermal” levels of RF exposure need to be reconsidered and revised, in order to significantly reduce the risk to the public health that is produced by these technologies.

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