

Technology and Health

Submitted to:

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TECHNOLOGY AND HEALTH

Introduction

You cannot see it, taste it, or feel it, but everyday we are swimming in an increasingly turbulent sea of electromagnetic radiation (EMR) produced by power lines, electrical appliances and novel technologies that are a part of our modern world. From the digital alarm clock and the microwave oven to the mobile phone and Wi-Fi receiver, exposure to these invisible energy fields is growing daily and with it, our lifetime risk of serious health consequences.

Electromagnetic radiation can be classified into two types, ionizing and non-ionizing, based on its ability to strip electrons from atoms and break molecular bonds. Gamma rays, X-rays, and other high-frequency ultraviolet radiations are ionizing and their harmful effects in biological systems are well documented. Non-ionizing radiation is found at the low end of the electromagnetic spectrum and is unable to break chemical bonds or ionize atoms. Low frequency electromagnetic fields produced by electricity, microwave ovens, radio, television, radar, mobile phones and Wi-Fi transmitters are examples of man-made sources of non-ionizing radiation. Their energies are expressed as excitations in the vibrational, kinetic energies of atoms and molecules, which give rise to thermal heating.¹

A persistent view in the engineering sciences has been that low frequency EMR is incapable of inducing adverse biological effects other than thermal heating. This view has now been challenged as a plethora of recent scientific studies has exposed a broad range of potentially harmful effects. The findings of a groundbreaking report, conducted by an international working group of scientists, researchers and public health policy professionals, and released in August 2007, reveals health risks to humans and wildlife resulting from the global rollout of wireless technologies. The report documents serious scientific concern about present limits regulating how much EMF exposure is allowable from power lines, cell phones, and other sources. The scientific evidence tells us that our safety standards are grossly inadequate and that urgent public action must be taken to protect ourselves and avert a possible epidemic of brain tumors and other health risks associated with these technologies.²

What are Electromagnetic Fields?

Electric fields are generated by an electric potential and magnetic fields are created by a flow of electric current. Together they comprise what is commonly known as electromagnetic radiation (EMF).

Electric fields exist whenever an electrical charge is present, even if no current is flowing. For example, a lamp plugged into a wall circuit will have an electric field surrounding it even though the lamp may be turned off. The higher the voltage, the stronger is the electric field of an appliance. The strength of an electric field diminishes rapidly as you move away from the source. Common building materials can effectively diminish the strength of an electric field.

In contrast, a magnetic field is created only when an appliance is turned on and exists together with the electric field. The larger the current or amperage, the stronger is the magnetic field. Like an electric field, magnetic field strength diminishes rapidly as you move away from the source; however, unlike an electric field the only other way of diminishing the strength of a magnetic field is to enclose the appliance in a metal box that serves to redirect the magnetic field internally (such as is found in microwave ovens).

Until recently, thermal heating was believed to be the principal biological effect of EMF radiation and exposure limits were developed to ensure such appliances were designed to operate within prescribed limits of safety. While each country sets its own standard for exposure to EMFs, the majority of these standards draw on the guidelines set by the International Commission on Non-Ionizing Radiation Protection (ICNRP). Alarming, recent investigations have uncovered the possibility of harmful non-thermal effects at exposure levels far below these thresholds. While much remains to be uncovered, “What is clear is that the existing public safety standards limiting these radiation levels in nearly every country of the world look to be thousands of times too lenient.”²

Electromagnetic Fields in the Home

The home environment is subject to a variety of EMF sources, ranging from Extremely Low Frequency sources to Radiofrequency sources, depending on wiring configurations and the number of modern electronic devices employed.

The electromagnetic fields created by power lines and household appliances, such as toasters, lights and electric heaters, are examples of Extremely Low Frequency (ELF) fields with frequencies up to 300 cycles per second or 300 Hertz (Hz). Other technologies, such as computer screens, security alarms and anti-theft devices, create Intermediate Frequency (IF)

fields ranging from 300 Hz to 10 million Hz (MHz). Depending on their strength and proximity, ELF and IF fields can induce currents in the human body that produce a range of biological effects. Radiofrequency (RF) fields are higher energy fields from 10 MHz to 300 billion Hz (GHz). Radio, television, radar, microwave ovens, Wi-Fi transmitters and cellular telephones are examples of RF field generators.¹ At these high frequencies the EMF radiation produced is capable of molecular excitation and rapid thermal heating. With billions of cell phones in use today, researchers are now uncovering the harmful biological consequences of their use when in close proximity to the body.

Extremely Low Frequency Fields

Proximity to high voltage power lines, electrical wiring and household appliances accounts for the background level of ELF fields found in the home environment. Studies show that homes not located near high voltage overhead lines generally have background EMFs below 0.2 micro Tesla (μT), well within presently established exposure limits for the general public. However, directly beneath high voltage power lines the field strength can be quite high. In 2001, researchers noted a doubling in the incidence of childhood leukemia for EMF fields greater than 0.4 μT .³ This finding was later corroborated when scientists found a 70% increase in childhood leukemia rates for those living within 200 meters of a high voltage overhead power line.⁴ Later work conducted by Bristol University researchers suggests that the increased incidence may be caused by the ability of high voltage power lines to attract aerosol pollutants. In a 2007 report, released by a stakeholder advisory group to the UK department of Health, the link between proximity to high voltage power lines and childhood leukemia was found to be strong enough to issue recommendations to lay power lines underground and prevent construction of new buildings within 60 meters of existing lines.⁵

In the home, the field strength of appliances decreases rapidly as you move away from the appliance. At a distance of 30 centimeters, it is 100 times lower than the guideline exposure limit.¹ Televisions and computers both produce electromagnetic fields that are well below currently acceptable limits at normal operator distances. Newer computer screens with liquid crystal displays do not give rise to significant EMFs. As well, portable phones, because they are employed very close to their base stations, do not require large field strength and, consequently, do not give rise to large RF fields.

The prevailing consensus of opinion appears to be that low frequency EMF associated with normal household living does not constitute a short-term or a long-term health hazard.^{1, 6} Two major reviews carried out by the US Institute of Environment and Health Sciences (1999) and the UK National Radiological Protection Board (2001) conclude that the

scientific evidence suggesting that ELF exposures pose any significant health risk is weak. A WHO Fact Sheet, published in June, 2007, contends that there are no substantive health issues related to ELF fields at levels generally encountered by the public.⁷ However, concern is now being expressed that these opinions are based on outdated exposure limits designed to minimize the chance of thermal effects. The question arises as to whether these limits are sufficiently conservative to protect against possible non-thermal effects.

Several recent studies support the existence of non-thermal adverse biological effects from ELF fields.⁸⁻¹⁸ Although exposure from common electrical appliances has been less thoroughly investigated, several studies have revealed an association with childhood cancer.¹⁷ A 2005 review of the epidemiological evidence on EMF exposure reports a consistent pattern of increased risk for childhood leukemia associated with ELF fields.¹¹ Cancer was first associated with exposure to electromagnetic fields in 1979 when investigators reported that children dying from cancer resided in homes believed to be exposed to higher ELF frequencies than those of healthy children.¹⁹ These findings have been corroborated in recent studies.¹⁸ Other research has implicated ELF exposure to a host of adverse effects, ranging from adult melanoma²⁰ to neurodegenerative disease^{21, 22} and miscarriage.²³⁻²⁵

The results of epidemiological research with respect to childhood leukemia prompted the International Agency for Research on Cancer in 2001 to classify these fields as “possibly carcinogenic to humans.”¹⁶ Similarly, in a 2002 report, the California Department of Health concluded that ELF fields from power lines, wiring and household appliances were, in fact, responsible for an observed increase in childhood leukemia, adult brain cancer, amyotrophic lateral sclerosis (ALS) and miscarriages.²⁶ In a research paper documenting the effects of man-made electromagnetic fields on the stimulation of allergic and inflammatory responses, Olle Johansson, Associate Professor at the Karolinska Institute, Stockholm, concludes that “the existing public safety limits are inadequate to protect public health and that new public safety limits, as well as limits on the deployment of untested technologies, are warranted.”¹⁴

Protecting Yourself from ELF Radiation

Consider the following suggestions as a means of reducing your exposure to ELF fields around the home:

- Purchase an inexpensive Gauss meter to identify areas of high ELF exposure. Once you know where the hot spots are, you can simply avoid them when the appliance is turned on;
- Unplug appliances that are not being used to eliminate the magnetic field that is there as long as the appliance is plugged in;

- Adjust your seating arrangements to favor areas where the ELF flux is lower;
- Move your bed if it is situated above or beside a high ELF generator, such as an electrical heating unit;
- As much as you can, remove electronic appliances from your bedroom;
- If you heat electrically, consider switching to gas, solar or geothermal sources to eliminate a major source of ELF flux;
- Reduce your exposure to blow-driers that can generate high intensity ELF flux and are operated close to the head.

Radiofrequency (Microwave) Fields

Microwave technology, with radiation ranging from 300 MHz to 300 GHz, was first developed by the German military during World War II. Soldiers who gathered around radar units to warm themselves were later found to develop illnesses, including cancer. Since this time, the background level of EMF from electrical sources has risen exponentially. The soaring popularity of wireless technologies such as cell phones and Wi-Fi networks promises to drive exposure levels to microwave fields even higher. Over 4 billion people worldwide now use mobile phones as the technology rapidly eliminates the use of traditional land-line phones. It is estimated that, in the United States, 85% of the population is now continually exposed to powerful cell phone radiation, created mere centimeters from their brains.

In the following section, the safety of two major domestic RF sources—microwave ovens and cellular phones—are discussed.

Microwave Ovens

Microwave ovens emit two types of electromagnetic fields: high frequency radio waves that create intense thermal heating, and the 60Hz magnetic fields common to other household appliances. Microwaves penetrate the food to excite the vibrational frequencies of the water molecules within. Reversing polarity billions of time per second, the increased kinetic energy of the water molecules is transferred to the food itself.

The design of microwave ovens redirects these magnetic fields internally. Effective shielding reduces microwave leakage to almost undetectable levels;¹ however, an improperly maintained oven can leak significant amounts of radiation. Old or faulty door seals have been found to be the main cause of microwave leakage. Studies conducted by the Ontario Ministry of Labour show that the level of radiation leakage found in early microwave models

has fallen precipitously from 1972 as designs have improved.²⁷ Consumer testing reveals that oven leakage levels in excess of allowable standards are rare. According to ARPANSA, the Australian Radiation Protection watchdog, the typical leakage from a properly maintained microwave oven, today, is far below current national safety limits.²⁸ While there are no confirmed studies proving causality between field exposure from microwave ovens and adverse effects, persons working around microwaves have reported headaches, eyestrain, general fatigue and sleep disturbances, suggesting that microwave fields interact with the central nervous system.²⁷

The oven door is the most dangerous place for potential leakage and, unfortunately, this is *exactly* where children like to stand to watch their popcorn pop. Accidental exposure to microwaves can quickly burn human tissue, cause cataracts and even temporary sterility. Microwave ovens have also been known to interfere with pacemakers. Even momentary exposure can lead to severe tissue necrosis and loss of the exposed extremity, as well as derangement of cardiovascular, gastrointestinal, endocrine, haematological and behavioural functions.^{29, 30} To avoid accidental exposure, it is best to maintain a safe distance of a meter or more. The magnetic field emitted from a microwave oven dissipates rapidly as you move away from the source.

People using microwaves often refer to “nuking” their food, a term that is incorrect and misleading; others believe that microwaves remain in the food. Microwave ovens are not radioactive sources and once the oven is turned off the microwaves cease to exist. They do not remain in the food.

While there has been controversy about the effects of microwaves on food quality and safety, including the generation of mutagenic compounds, a review of the literature found little support for this argument.^{27, 28, 31-33} The evidence suggests that microwaves do not change the nutritional content of foods or create carcinogens, as can occur in conventional cooking, presumably because the foods are not heated beyond the boiling point of water.³⁴ Several studies report that cooking with microwaves allows foods to maintain *more* of the nutrient content because the vitamins and minerals are not leached out as with conventional cooking.³⁵⁻³⁷ In fact, cooking of meats in a microwave (in particular, smoked and preserved meats, such as bacon) avoids the creation of carcinogenic heterocyclic amines (HCAs) and N-nitrosamines (NNAs) that is known to occur in conventional cooking.³⁸⁻⁴³

What *is* of real concern in microwave cooking is the migration of contaminants from the containers that are used to hold and cover the food while cooking. Several studies confirm that using plastics and plastic wraps that are not microwave “safe” can release contaminants into the food.⁴⁴⁻⁴⁹ Bisphenol A and other plasticizers commonly found in soft

plastics, such as baby bottles, can migrate into food during the heating cycle.⁵⁰ These powerful endocrine modulators have been associated with development problems. As well, the use of older, pre-1950s ceramic dinnerware has been shown to release significant levels of lead during the microwave process.⁵¹ Precautions should be taken to ensure all food destined for the microwave is contained or covered in materials (paper, most ceramics and glass) that will not degrade during the cooking process.

Protecting yourself from RF microwave radiation

Here are some suggestions to use when cooking with a microwave:

- Do not use plastics to cover or contain your food, even if it is sold as microwave safe. There is strong evidence of the transfer of harmful contaminants in the plastics into your food while heating;
- Ensure your oven door engages securely and use a Gauss meter to test leakage from your oven from time to time;
- Avoid standing near the door of your microwave when in operation, particularly if you are pregnant;
- Avoid looking through the glass screen when the oven is in use;
- To help preserve nutrients, use techniques that promote the even distribution of heat and preventing “hot spots” from degrading certain food components;
- Use a food thermometer to ensure cooked foods have reached a safe temperature;
- It is possible to superheat fluids beyond the boiling point, causing violent action as soon as the liquid is removed. To avoid this, immerse a wooden splint into the fluid during the heating process;
- Thaw frozen food thoroughly before microwaving and ensure all food served is left standing or stirred well before serving;
- Use extreme caution if heating a baby’s bottle as uneven heating can cause severe burns. It’s best to heat a baby’s bottle in warm water — it’s even better to breast feed.

Mobile (cellular) Phones

The cell phone industry was born in the 1980s. Originally developed for the U.S. military, these devices were never originally tested for safety. In bringing mobile phones to market, the industry's argument of low-power exclusion—the belief that cell phone radiation does not cause thermal heating—allowed the industry to be largely exempted from regulatory oversight.⁵²

According to the Australian Radiation Protection and Nuclear Safety Agency, “there is no clear evidence in the existing literature that the use of mobile phones poses a long-term public health hazard (although the possibility of a small risk cannot be ruled out...)”⁵³ Likewise, the U.S. National Toxicology Program suggests that the scientific evidence has not conclusively linked cell phones with health problems but notes that current exposure guidelines are based on protection from acute injury due to thermal effects and concedes that evidence of adverse effects is now emerging.⁵⁴ The Agency is in the initial stages of conducting toxicology and carcinogenicity studies focusing on non-thermal effects. The Interphone Project, an International series of epidemiological studies conducted by 13 participating countries, has begun to release interim results. Some studies report an association with certain cancers of the head (acoustic neuroma and glioma) with prolonged cell phone use.⁵³

Almost 20 years after cellular communication was introduced to the global market, we are reaching the end of the latency period for cancers to appear, and the scientific evidence is quickly mounting that cell phone use *is* associated with the development of serious adverse health effects. Swedish researchers recently uncovered a startling and consistent decline in the general health of the population that coincided with the installation of cellular communication towers and the use of mobile phones throughout the country.^{55, 56} In other recent findings, scientists have identified brain tumors and other cancers,⁵⁷⁻⁶⁶ alterations in gene expression and genetic damage,⁶⁷⁻⁷⁸ adverse changes to the central nervous system,⁷⁹⁻⁸⁵ neurological abnormalities,^{84, 86-97} endocrine disruptions and induced stress responses,⁹⁸⁻¹⁰² and immunological disturbances.^{98, 103}

Regulatory agencies argue that mobile phone towers appear to add little to our total EMF exposure as the signal strength in places of public access is similar or lower than distant radio and TV transmitters.¹ Recent studies, however, have documented significant adverse health effects in populations living within the vicinity of such towers.^{104, 105}

Mobile phone users are exposed to intense levels of RF radiation that are significantly higher than those found in the general environment. This is principally because the devices are operated close to the head and deposit a large amount of energy directly into the brain. A

cellular phone is basically a radio that sends RF signals to a distant base station—as well as to your central nervous system. Cellular phones generate two types of signals: a near-field plume and a far-field plume. It is the near-field plume that is the cause for concern, as it is generated within 10 to 12 centimetres of the phone antenna. It easily penetrates the tissues of the brain and other organs, such as the hip bone, where 80% of the body's blood cells are manufactured.

The advent of cellular communications has brought microwaves down from the sky to the street level, integrating these powerful EMF fields into our environment, something that is totally foreign to our bodies. It is postulated that the body responds to these energy fields as invading pathogens, setting in place a cascade of biochemical reactions that cause the release of damaging free radicals, alter the blood-brain barrier, kick start chronic inflammatory responses, and disrupt intercellular communications. The effects of other wireless communication devices, such as Wi-Fi are believed to be similar, as these devices also radiate microwave signals within the same radiofrequencies as cell phones.⁵²

After reviewing the evidence of the adverse health effects of wireless technology in June, 2008, the International Commission for Electromagnetic Safety issued the following statement.

*We are compelled to confirm the existence of non-thermal effects of electromagnetic fields on living matter, which seem to occur at every level of investigation from molecular to epidemiological ... we strongly advise limited use of cell phones and other similar devices by young children and teenagers, and we call upon governments to apply the Precautionary Principle as an interim measure while more biologically relevant standards are developed to protect against adverse health effects.*¹⁰⁶

On July 12, 2009 The BioInitiative Working Group, an International association of researchers investigating the effects of EMF, publically announced its research findings. The clear consensus of the group is that the existing public safety limits are *grossly* inadequate for both ELF and RF radiation. The group concludes that the body of evidence at hand suggests that adverse biological effects and health impacts *can* and *do* occur at exquisitely low exposure levels: levels that can be *thousands* of times below current public safety limits.

Citing their findings, the group states that there is little doubt that exposure to ELF causes childhood leukemia. As well, people who have used a cell phone for ten years or more have higher rates of malignant brain tumor and acoustic neuromas. It is worse if the cell phone has been used primarily on one side of the head. There is strong evidence that long-term exposure to ELF is a risk factor for Alzheimer's disease. Similarly, electromagnetic fields emitted by cell phones and cell phone use adversely affect electrical activity of the brain. According to their findings, the consequence of prolonged exposures to children,

whose nervous systems continue to develop until late adolescence, could have serious implications to adult health.

The working group also notes that ELF and RF exposures will damage DNA under exposure levels that are *lower* than existing safety limits. It cited evidence that ELF and RF can cause inflammatory reactions, allergy reactions, and can change normal immune function at exposure levels allowed by current public safety standards.

*The existing FCC and international limits do not do enough to protect people, especially children, from daily exposures to electromagnetic fields and radiofrequency radiation. The existing safety limits did not anticipate these new kinds of technologies affecting the health of people living with and using wireless devices on a daily basis. These effects are now widely reported to occur at exposure levels significantly below most current national and international limits.*¹⁰⁷

The researchers call for urgent action to educate decision-makers and the public about the harmful effects of exposure to RF radiation and to find alternatives that do not pose the same level of risk.¹⁰⁷

Protecting yourself from RF Cell Phone and Wi-Fi Radiation

Cell phone and other wireless technologies have become such a ubiquitous part of modern life, it is difficult to see how we can manage without them. However, as with all forms of EMF, the *further away* you are from the source the *lower* will be your level of exposure. With this in mind, consider these practical options to reduce your overall exposure to RF radiation:

- Remove cordless handsets and cell phones from around the home and replace them with wired (land-line) versions;
- If you *must* use a cellular phone, limit your use to only a few minutes a day;
- Strongly discourage children and teenagers from using cell phone devices, as their lifetime exposure from such devices will be high;
- Use a hands-free headset and keep the phone at least a half meter away from your head and other body parts (*please*, don't put it on your lap);
- Avoid wearing your cell phone on your hip;
- Avoid wireless headsets. Instead, use a tubular earpiece such as those used on stethoscopes;

- If you have a speakerphone mode on your cell phone, use it and place the cell phone away from your body;
- Supplement with melatonin and vitamins C and E, as several studies point to the efficacy of these nutrients in stemming the oxidative damage from cell phone use;
- If you use a Wi-Fi transmitter, remove it and replace it with CAT 5 wiring or coaxial cable;
- If you *must* use a Wi-Fi transmitter, place it in a location away from your desk or working area.

Conclusion

The current standard for exposure to the emissions of cell phones, cordless phones and other wireless technologies is *not* safe. In fact, **there may be no lower limit** at which exposures do not affect us. Consequently, it is unwise from a public health perspective to continue business-as-usual, deploying new technologies that increase ELF and RF exposures, particularly involuntary exposures. Changes must be made at the regulatory level to ensure public safety.

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