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May 20th, 2008

Dear Ms. Hamilton,

Re: FortisBC ~ Certificate of Public Convenience and Necessity for the Okanagan Transmission Reinforcement Project ("OTR Project') ~ Project No. 3698488

Please accept these attachments into subject hearing as **Evidence # 18** for future reference in subject hearing.

Fielding a current idea: exploring the public health impact of electromagnetic radiation – Stephen J Genuis

I cite here:
Sickness is often the consequence of an interaction between a causative agent and a susceptible host, and adverse EMR appears to be one such causative agent. With increasing evidence linking significant EMF exposure to adverse health sequelae, and with the increasing intensity of electronic pollution resulting from wireless technology and dirty electricity, it may be prudent to consider erring on the side of caution.

Yours truly,

Colin Harlingten

Public Health (▮▮▮▮) ▮, ▮▮▮–▮▮▮

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Review Article

Fielding a current idea: exploring the public health impact of electromagnetic radiation

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KEYWORDS
Dirty electricity;
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Electromagnetic radiation;
Ground current;
Human exposure assessment;
Non-ionizing radiation

Summary Several publications in the scientific literature have raised concern about the individual and public health impact of adverse non-ionizing radiation (a-NIR) from electromagnetic field (EMF) exposure emanating from certain power, electrical and wireless devices commonly found in the home, workplace, school and community. Despite the many challenges in establishing irrefutable scientific proof of harm and the various gaps in elucidating the precise mechanisms of harm, epidemiological analyses continue to suggest considerable potential for injury and affliction as a result of a-NIR exposure. As environmental health has not been emphasized in medical education, some clinicians are not fully aware of possible EMF-related health problems and, as a result, manifestations of a-NIR may remain misdiagnosed and ineffectually managed. It is important for physicians and public health officials to be aware of the fundamental science and clinical implications of EMF exposure. A review of the scientific literature relating to the link between electromagnetic radiation and human health, several public health recommendations, and four case histories are presented for consideration.

'A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it.' Max Planck (Nobel Prize Winner—Physics).

It was only a few decades ago when individuals queued up in shoe shops and malls to view their metatarsals under fluoroscopy machines; with expert reassurance that such a novelty was perfectly safe, the increased cancer rates in participants came as a surprise. While there is recognition of the potential cellular and tissue damage associated with exposure to ionizing radiation from X-rays, electromagnetic radiation (EMR) emanating from power lines, mobile phones, common electrical devices and some types of machinery has also begun to attract recent attention as a potential health hazard. Conflicting

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information is found in the medical literature; while some reports dismiss the alleged risk associated with EMR, various international bodies including the World Health Organization[1] and the International Agency for Research on Cancer[2] (IARC) have called for intense investigation of the impact of non-ionizing radiation (NIR) on human health in response to mounting research suggesting a link between adverse EMR and various afflictions including reproductive dysfunction, cancer and central nervous system (CNS) disorders.

Overview of electromagnetic spectrum and NIR

Radiation refers to a type of energy that is given off or 'radiates' away from the source of that energy. There are different forms of energy, each with distinct physical properties that can be measured and expressed in terms of frequency and wavelengths. Some waves have a high frequency, some medium and some low. The electromagnetic spectrum is a name used to describe a group of distinct energy forms that emanate from various sources; the energies released are referred to as types of EMR (Fig. 1). Exhibiting high frequencies are gamma rays, X-rays and ultraviolet light; lower frequencies of the spectrum include microwaves and radio waves. Light wave emission, which occurs at medium frequencies, provides for normal vision and the light we perceive; infra-red energy allows for the perception of heat.

Most energy forms such as X-rays, ultraviolet energy and radio waves are invisible and imperceptible to the human. Without specialized instrumentation, most frequencies cannot be detected and, as a result, people generally do not appreciate their exposure to energy fields in these ranges. Despite the lack of perception, exposure to high-frequency energy including X-rays is termed 'ionizing radiation' and is potentially damaging to human cells. By altering the atomic composition of cell structures, by breaking chemical bonds and by inducing free radical formation, sufficient exposure to ionizing radiation may inflict DNA damage or mutation, thus increasing the risk of malignancy or cell death.

Non-ionizing radiation

'Non-ionizing' radiation (NIR), generally referring to energy forms with lower frequencies, has been considered safe by many scientists and without adverse effects at common exposure levels. Recently, however, increasing evidence suggests that some frequencies of NIR may have potential to cause biological harm. Most of the research on the health effects of adverse NIR (a-NIR) has been done at: (1) extremely low-frequency (ELF) energy waves produced and emitted by power stations, power lines and some electrical equipment; and (2) radio and microwave frequencies given off by wireless communication technologies, cordless and cellular phones, and some electrical materials. Current study is also investigating the potential sequelae of intense exposure to a-NIR as a result of voltage originating from 'dirty electricity' and 'ground current'.

Just as clean water can become polluted when it travels through a contaminated environment, electricity becomes increasingly polluted when it comes into contact with assorted types of electronic equipment. Regular or 'clean' electricity enters buildings at a frequency of 50/60 Hz; power becomes 'dirty' or polluted when it develops scattered higher-frequency signals as a result of contact with equipment such as computers, plasma televisions and some appliances. NIR generated by dirty power may radiate to contaminate the adjacent environment and is alleged to be

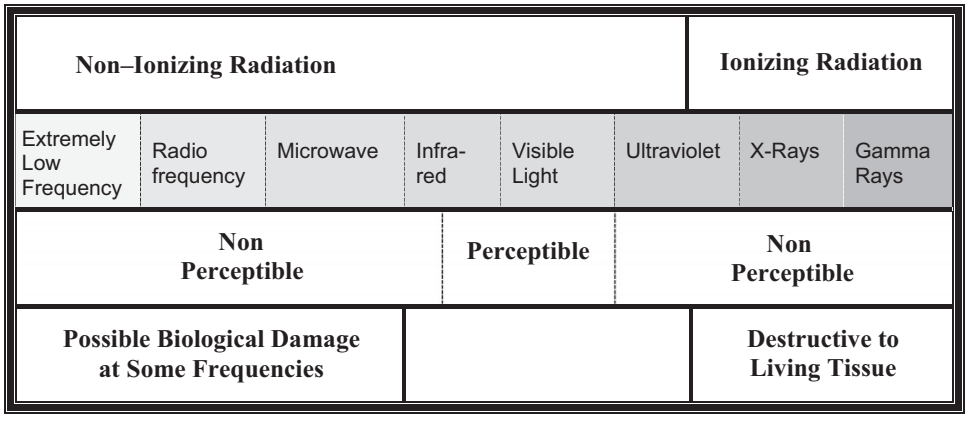

Figure 1 Electromagnetic spectrum—types of radiation.

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potentially harmful.[3] Ground current, sometimes referred to as 'stray current,' is electricity that is not confined to electrical wiring. Electrical current follows the path of least resistance and can flow through any and all available paths including earth, wires and various objects. Accordingly, electrical voltage can transmit through the ground and into building structures through such devices as metal pipes or rods in plumbing equipment, resulting in a-NIR scattering into the adjacent environment.[4–6] All forms of a-NIR, however, only inflict harm within their fields of influence.

A field is 'something' that exists in space around an object or device; the area over which the object exerts some form of physical influence. The inherent properties of the object or device produce the surrounding field. A magnet, for example, creates an invisible field that can attract or repel other objects within a certain distance. When power is generated, transmitted or used, electrical materials and devices produce fields around them called 'electric fields' and the combination of certain elements in various devices results in the production of both an electric and a magnetic component, called an 'electromagnetic field' (EMF). Another way of expressing this phenomenon is to consider that waves or rays of energy are released outward from some electrical materials, radio emitters and power devices, but the intensity of the field of exposure rapidly drops off with increasing distance from the source. Shielding against some energy frequencies, such as blocking X-rays with lead plates, is efficacious; it is difficult, however, to effectively shield against some energy wavelengths including ELF EMFs.

Nearly everyone in our society is exposed to some degree of EMF pollution, yet few are cognizant of the debate about health risks associated with a-NIR. As subatomic matter in human cells entails the movement of electrons, and various biological activities including brain function and cardiac conduction involve measurable electrical activity, it is not surprising that intense electrical fields can exert influence on the human electrical system. Although this evolving area of science provokes many unanswered questions, considerable research suggests that exposure to certain frequencies of EMR may affect physiological processes, with potential long-term sequelae.[7,8]

EMFs and human health

While medical studies correlating EMF with adverse health outcomes have sometimes yielded apparently contradictory results, recent research reported in respected medical journals has uncovered evidence about potential risk. Studies looking at reproductive dysfunction, cancer potential and CNS disorders appear to support previous suspicions that EMF exposure may present a health risk.

EMFs and reproductive dysfunction

Adverse pregnancy outcomes including miscarriage, stillbirth, preterm delivery, altered gender ratio and congenital anomalies have all been linked to maternal EMF exposure.[9–13] A large prospective study published in *Epidemiology*, for example, reported on peak EMF exposure in 1063 pregnant women around the San Francisco area. After participants wore a magnetic field detector, the researchers found that rates of pregnancy loss grew significantly with increasing levels of maximum magnetic field exposure in routine day-to-day life.[12]

Paternal EMF exposure has also been correlated with serious potential sequelae. The development of testicular abnormalities, atypical sperm, chromosomal aberrations and offspring congenital defects have all been linked to male EMF exposure.[14–18] Switchyard workers exposed to electrical current, for example, were compared with salesmen and clerks for evidence of chromosomal anomalies. With a significant increase in the number of chromosomal aberrations in switchyard workers,[18] and an increased tendency towards malformations among their children,[15] researchers have surmised that EMF exposure may be a factor in adverse outcome. Fathers employed in industries with higher than average EMF exposure have also been noted to have offspring with higher rates of brain and spinal cord tumours.[16,17]

EMFs and cancer

Numerous studies have investigated the allegation that intense exposure to some frequencies of EMR may be carcinogenic. For example, *International Journal of Cancer* recently published an important population-based case–control study on the link between childhood leukaemia and magnetic fields in Japan. By assessing magnetic field levels in children's bedrooms, the researchers confirmed that high EMF exposure was associated with a significantly higher risk of childhood leukaemia.[19] Furthermore, recent studies reported in major journals such as *The Lancet and International Journal of Oncology* discuss the apparent link between cordless and cellular phone use with conditions such as lymphoma,[20] malignant and

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benign brain tumours,[21–23] as well as other problems including alterations in blood pressure.[24]

An important case–control study reported in the *British Medical Journal* found a link between childhood leukaemia and prenatal proximity to high-voltage power lines.[25] Compared with children whose birth address exceeded 600 m from a high-voltage power line, those with birth addresses within 200 m had a relative risk of leukaemia of 1.69, and those between 200 and 600 m had a relative risk of 1.23.[25] In addition, extensive research by Johansson and others in Sweden recently confirmed that adverse EMR has the potential to induce various dermatological abnormalities[26] and is a determinant in the development of malignant melanoma,[27,28] an increasingly prevalent cancer that was uncommon until about 50 years ago. As a result of considerable EMF research undertaken in Sweden, it is interesting to note that Swedish authorities have officially acknowledged adverse EMR as a problem and have categorized electrohypersensitivity as a functional impairment.[26]

Although several reports suggest a possible link between certain types of EMF exposure and assorted malignancies,[29–37] including breast cancer[38–41] and childhood cancer,[42–45] some studies have reported differing results. A recent study published in *Cancer Causes Control*, for example, dismissed suspicions of an association between EMF exposure and female breast cancer,[46] and the UK Childhood Cancer Study published in 1999 failed to support a link between EMF exposure and childhood cancer.[47] After reviewing the available information in relation to cancer, however, the International Agency for Research on Cancer (IARC) has advised that EMF exposure should be classified as a possible carcinogen.[2]

EMFs and CNS dysfunction

The CNS appears to be a potential target organ system for adverse EMR. In addition to reports of specific EMF-related health problems, such as amyotrophic lateral sclerosis,[48] Alzheimer's disease,[49] insomnia,[50] headaches,[51] sexual dysfunction,[52] chronic fatigue,[50] learning and memory problems,[53–55] and assorted other maladies,[33,56] there is increasing evidence to suggest that neuropsychiatric problems may also result from EMR. Higher rates of depressive symptoms and suicide have been found to result from EMF exposure.[48,57–59]

In a recent epidemiological study, for example, researchers found that those living near power lines were more than twice as likely to report symptoms of depression compared with controls.[58] Preliminary evidence has also suggested a potential correlation between exposure to EMFs from dirty electricity with common medical conditions including attention-deficit disorder/attention-deficit hyperactivity disorder, asthma, diabetes and multiple sclerosis.[3,60] In review, many independent research projects have uncovered a link between adverse EMF exposure and a variety of afflictions in various organ systems, particularly the CNS.

Proposed mechanisms of EMF impact

Basic scientific study of the human body has demonstrated that most physiological functions in living organisms are electrochemical in nature. Living cells are made up of molecules and atoms, which in turn are made up of electrons, neutrons and protons. The intrinsic functioning of these atoms and molecules with homeostasis of cells, tissues and organs is entirely dependent on ordered chemical and electrical activity. Disturbance of intrinsic electrical or chemical processes within cell structures has the potential to disrupt cell functioning, leading to malfunction of organ systems and ultimately to clinical illness.

Extensive research has attempted to elucidate definitively the precise mechanisms whereby EMF exposure may disrupt normal physiology. For example, a wide-ranging research project entitled EMFRAPID (Electric and magnetic fields research and public information dissemination) was a 5-year US Federally organized effort co-ordinated by the National Institutes of Health to assess the effects of adverse EMR on biological systems.[61] The results of this and many other initiatives have revealed significant information.

Biological systems including the human organism intrinsically use some frequencies of EMR for cellular as well as hormonal function and regulation.[62] For example, imperceptible ultraviolet energy waves from sunlight are used in the production of human vitamin D,[63] an essential nutrient involved in myriad physiological functions. Just as external electrical signals can cause interference with radio and television signals resulting in static and distortion, exposure to adverse electrical frequencies can disrupt human metabolism and homeostasis by interfering with normal physiology of required energy frequencies.[62]

Cellular pathogenesis of adverse EMR

Although the cellular pathogenesis of damage from EMR is not completely understood, various

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hypotheses have been proposed based on preliminary evidence. It was previously thought that thermal alteration of cells and tissue heating may be the predominant mechanism of harm. More recently, however, increasing evidence has indicated the potential of EMR to induce cell stress[64] and to inflict specific damage on various intracellular components and mechanisms at non-thermal levels of EMF exposure.[62] For example, molecular vibrations from EMR may induce free radical formation and alter the conformation of protein molecules.[65] Adverse EMR has been found to affect DNA synthesis, to impair cell division and to potentially alter the electrical charge of ions and molecules within cells.[14,62] By affecting electrical charge, EMFs may also modify ionic structures of elements within cell membranes, potentially disturbing the influx and efflux of various elements including calcium ions.[66]

Just as certain chemical toxicants may induce expression of abnormal genes,[67] recent research is exploring potential epigenetic influences of EMR. By its impact on genetic expression,[68] adverse EMFs may serve as a trigger for the expression of pathological and disease-causing genes. Furthermore, direct damage to the DNA of human lymphocytes[69] and alteration of phagocytic activity in animal macrophages[70] has been confirmed recently, and may account for changes in immunological parameters and for immune system dysfunction attributed to EMR. With alteration of cell structures and impairment of cellular functions by these various mechanisms, it is not surprising that tissue disorders, organ dysfunction and clinical illness may ensue. Attenuation of insulin secretion characteristically found in diabetes, for example, can be induced or accentuated by exposure to adverse EMF through distortion of calcium influx in cells.[71]

EMFs and melatonin metabolism

Some investigators have explored potential EMF disturbance of blood–brain barrier permeability with resulting increased susceptibility to CNS toxicants.[56] Particular attention, however, has recently been devoted to researching the impact of EMR on pineal gland physiology.[72] The pineal gland secretes the neuroendocrine hormone melatonin that is synthesized from the neurotransmitter serotonin. Melatonin is involved with regulation of myriad physiological processes including sleep patterns,[73] free radical metabolism,[74] blood pressure control,[75] nitric oxide physiology,[76] lipid metabolism,[62] immune system functioning,[77] and activity of sex hormones such as oestrogen.[78] The potential link between disordered melatonin physiology and the development of malignancy has emerged as a priority area of investigation,[79] particularly in breast and prostate cancer, melanoma, colon cancer, lung cancer and leukaemia.[72]

Adverse EMF exposure has the potential to impact directly on pineal gland function by interfering with melatonin production and metabolism.[80,81] As well as in cancer, reduced melatonin levels have been observed in assorted non-malignant conditions including coronary artery disease,[82] chronic pain[83] and various psychiatric conditions including Alzheimer's disease[84] and schizophrenia.[85] Although EMR exposure reduces melatonin production,[62,80,86] conclusive evidence of the direct clinical sequelae of specific EMR-related pineal dysfunction remains to be established.

Limitations and research challenges

Although preliminary evidence on disease pathogenesis such as melatonin dysregulation, epigenetic modification, DNA disruption and cell stress is important for continuing study, research designed to establish a definitive link between EMR and clinical health sequelae faces several obstacles. Within the scientific community, experimental studies such as randomized controlled trials where subjects are manipulated according to study protocol remain the gold standard to establish disease cause-and-effect, as well as efficacy of interventions. Such experimental study, however, is contraindicated in exposure research.

Limitations of exposure research

Just as it would be ludicrous to perform clinical trials on parachute efficacy by dividing skydivers into randomized groups with some using parachutes and some not,[87] it is not ethically possible to perform efficient randomized controlled trials with environmental issues by exposing some study participants to potentially dangerous exposures and comparing outcomes with an unexposed control group. As a result, more cumbersome and lengthy observational studies including epidemiological cohort studies and less definitive case-control research are employed to explore aetiology of harm. This presents difficulties, however, as epidemiological and case–control assessments of environmental exposure are sometimes plagued by confounders such as unfolding awareness of previously unrecognized exposures as well as multi-exposure interactions. For example, in complete contradiction to some other reports, a recent study

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funded by the telecommunications industry on cellular phone use in Denmark concluded there is no link with the development of brain tumours.[88] The comparison general population cohort in this study, however, included widespread users of cordless phones which have recently been implicated with potential EMF risk;[20–23] a determinant that was not fully realized at the outset of the epidemiological study and a confounder which potentially negates the reported outcomes. Numerous concerns relating to methodology and bias have also plagued this Danish study.[89]

Multiple concomitant exposures are another major confounder in some environmental research. Synergism and interaction of multiple exposures from various chemical, electrical or infectious sources may confound research outcomes. For example, some clinicians have observed that compromised patients with accumulated chemical toxicants may be more susceptible to EMR influence because of toxicant-induced loss of tolerance or 'spreading';[90] a phenomenon where individuals affected by one type of adverse environmental exposure become more sensitive to other exposures.[91,92] Other difficulties plague observational exposure research. With long lags between exposure and illness, for example, studies that have short follow-up periods do not provide opportunity for illness to manifest and conclusions may be erroneous. In addition, unique individual host sensitivity to exposure based on distinctive health status and genomic make-up presents a challenge when interpreting quantitative data. The result is that EMR studies have a high probability of significantly underestimating the risks of adverse health effects.[93]

In review, epidemiological study of adverse exposures does not generally establish indisputable evidence for or against a cause-and-effect hypothesis. In observational environmental research, a weight of evidence linking health sequelae to an exposure is produced and increased risks must be interpreted in context. Credible interpretation of findings is established when unbiased and qualified scientists examine the evidence with an open mind. A conclusion is then calculated based on the fundamental question: 'Is there another way of explaining the findings; is there another answer more likely than cause-and-effect?' When a conclusion is reached, the impact on public health is considered and protection strategies are amended as necessary. This imprecise approach, however, routinely renders the science of human exposure assessment and environmental medicine vulnerable to criticism and controversy; a vulnerability that has consistently been exploited by interest groups.

Exposure research and vested interests

With incomplete understanding of pathogenetic mechanisms and intransigent disbelief by some vocal researchers, many scientists have been quick to dismiss any alleged health hazard related to EMF exposure. Medical history has confirmed, however, that controversy is customary when environmental issues involve sizeable economic and health implications. Havas, a pioneer in EMR research, noted that despite considerable evidence, 'asbestos, lead, acid rain, tobacco smoke, DDT, and PCBs were all contentious issues and were debated for decades in scientific publications and in the popular press before their health effects and the mechanisms responsible were understood'.[14] As with previous examples, there are strong political and economic reasons for wanting no adverse sequelae to EMF exposure.[94] Vested interests have been effective in delaying restrictive EMF legislation by injecting confusion and doubt into scientific debate, by focusing on uncertainties, and by deflecting attention from harm potential.[95,96]

Numerous examples have been discussed in the scientific literature where claims of environmental harm have been challenged by researchers who fail to disclose covert ties to industry.[96] The influence of economic interests on medical journals has also been discussed extensively in recent publications,[97,98] along with examples where some editors and journal staff have suppressed publication of scientific results that are adverse to the interests of industry.[96,99] In the area of adverse EMF exposure and cellular phones, for example, it has been suggested that independent study results have differed considerably from industry-funded study.[89] After reviewing the research on EMR extensively, the International Commission for Electromagnetic Safety concluded in 2006 that present sources of funding for EMF study are biasing the 'analysis and interpretation of research towards rejection of evidence of possible public health links'.[100] How does society at large respond to mixed messages and uncertainty from the scientific community?

With enormous potential to generate misinformation, publication of imprecise science has influenced academic and social thought profoundly.[96] In response to conflicting scientific allegations, legislators and the general public commonly feel uncomfortable and are unable to determine the legitimacy of scientific debate.[14] When doubt and confusion are introduced, the public are often quick to disregard data that appear disturbing or unwelcome. The typical outcome in the short term is 'paralysis by analysis'; by introduction of contrary information and

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recommendations for further study, restrictive legislation is effectively stalled for years or even decades. If the environmental exposure in question is eventually proven to be hazardous, as has often been the case historically, individual and public health is compromised in the interim.

Quo vadis

The study of environmental medicine and the relationship between human exposures and adverse health outcomes has not yet been incorporated into most medical education programmes.[101] At the same time, however, escalating news reports of concerns such as reproductive dysfunction in teachers working near power lines and neurological sequelae in people residing in close proximity to mobile phone masts have evoked public awareness of electromagnetic contamination as an emerging environmental health issue; as a result, primary care physicians are increasingly questioned about EMF-related health risks.[102] Accordingly, it behoves the medical community to consider a credible response to this up-and-coming issue.

Most would agree that the home, school, workplace and community need to be free from dangerous exposures, and that individuals need to be aware of the risk/benefit ratio of EMF exposures. Several recommendations have been suggested by environmental health groups and scientific organizations studying the EMF concern. It is the generally held scientific view that incomplete EMF knowledge beckons ongoing unbiased research, not dismissal of the issue.[103] The World Health Organization has recommended intensive research,[65] and various scientists have called for an international scientific commission to monitor this emerging hazard.[100] Further recommendations and ideas are presented for consideration.

Public health recommendations

- To ascertain effective public health policy, scientific integrity and reliability among researchers, medical publications, official guidelines and academic institutions must be established to ensure credible research and dissemination of results.[96,104]
- Easily accessible measurement methodologies for adverse EMR are required. As well as gauss meters to detect ELF/radiofrequency radiation, for example, microsurge meters purported to detect 'dirty' electricity have been introduced.[60] New technologies need to be evaluated expeditiously and incorporated if credible.
- Adverse biological impact has been described for exposure levels much below current EMR standards. Allowable levels should be amended to provide sound protection of public health.[62]
- Ongoing epidemiological research and monitoring of health effects on EMR-exposed populations should be undertaken and reported. An independent commission devoid of conflicts of interest should oversee such work.
- Regulations to minimize exposure to adverse EMR should be enforced by governments and power authorities.
- Potentially harmful radiofrequencies from telecommunications technology should be assessed and regulated by authorities. For example, in response to complaints from citizens in Brussels about sleep disruptions following the installation of mobile phone masts near their homes, Belgian authorities recently approved a bill to regulate such masts to minimize EMR exposure.[105]
- Emerging protective equipment should be assessed independently and implemented if useful. Graham–Stetzer filters, for example, allegedly diminish dirty electricity and potentially result in health benefits when installed properly.[3,60] Such reports should be scrutinized scientifically and results disseminated.
- While research is ongoing, a precautionary avoidance strategy should be considered.[100,106] Incorporation of protective air-tube headsets for cellular phone use, for example, and wireless-free zones in public buildings such as patient areas in hospitals and schools[100] might be favourable.
- Training of health professionals and public health officers about the EMF-health issue is an important step in addressing this challenge.
- Clinicians should consider implementation of precautionary avoidance with individual patients.[106] Chronically ill people exposed to EMR might benefit from avoidance of high EMF smog. Four cases employing a precautionary approach are presented for consideration.

Case reports involving EMF exposure

In each of the following cases, improvement was realized when EMF exposure was diminished. As with most environmental exposure case reports, however, it is impossible to prove conclusively that neither the source of affliction nor the benefit realized were related exclusively to environmental exposure and subsequent intervention.

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Without re-exposing patients and monitoring sequelae, improved outcomes may be suggestive but absolute proof of causation and benefit are unattainable.

Case history #1

A 66-year-old woman in generally good health complained of a 9-year history of debilitating daily headaches and intermittent dizziness. Neurological assessment was unremarkable and a computer tomography scan, magnetic resonance imaging and electroencephalogram were reported normal. At a chronic pain clinic, the patient received narcotic analgesics and a diagnosis of 'primary pain disorder'. Detailed aetiological history was unremarkable other than the patient used an electric toothbrush six times a day for meticulous care of failing dentition. Gauss meter assessment revealed inordinately high levels of EMFs (>200 mGauss) emanating from the toothbrush. Within 6 weeks of discontinuing the use of an electric toothbrush, the headaches subsided and, with assistance, she was able to quickly overcome her dependence on prescription analgesics.

Case history #2

A 33-year-old woman wishing to have a large family complained of six consecutive pregnancy losses. After two uncomplicated pregnancies with vaginal deliveries, the patient changed residence and subsequently experienced three first-trimester miscarriages. After assessments by a family physician, a gynaecologist, an infertility specialist and a specialty reproductive care unit, the patient subsequently sustained three second-trimester losses despite interventions including clomiphene, human chorionic gonadotrophin injections, progesterone supplementation and counselling. From history, no potential determinants appeared to have changed from the two completed gestations other than her employment as a seamstress for 6 h/day in the basement of her new residence; an environment with low ceilings and fluorescent lights. Using a gauss meter, the patient recorded high EMF levels (>140 mGauss) in the vicinity of her head when fluorescent lighting in her workspace was turned on and high EMF levels ($\sim$180 mGauss) adjacent to her sewing machine. Following advice to minimize EMR exposure by avoiding fluorescent lights and minimizing use of her sewing machine, the patient promptly conceived and carried the pregnancy to full term.

Case history #3

A 17-year-old boy experiencing a 3-year history of intrusive thoughts relating to religious themes believed he had committed unpardonable sins and was convinced the devil was imminently taking him to hell. As well as increasing depressive symptoms, the adolescent displayed escalating aggression towards his parents. The nominally religious parents took their son for religious counsel to no avail. Psychiatric diagnosis included a thought disorder. Psychotropic medication failed to control the symptoms but caused numerous side effects. Human exposure assessment uncovered extremely high gauss measurements (>200 mGauss) at the head of the teen's bed, as electrical entry to the house was immediately adjacent to the bedroom, right beside his bed. As well as changing rooms, all other sources of EMF exposure were minimized. Within 12 weeks, the intrusive thoughts abated considerably, the mood symptomatology declined, the medication was stopped, and the parents indicated that their son was now a friendly, motivated boy. One episode of symptom aggravation subsequently occurred immediately following 4 h of online work in a high school computer laboratory; symptoms subsided within 72 h of deliberate EMF avoidance. All adverse symptoms completely cleared within 6 months and wellness was maintained over the next 2 years and at the time of writing.

Case history #4

A 51-year-old man in generally good health complained of chronic difficulty with insomnia. Although he experienced no problem falling asleep, for the last 17 years he had routinely awoken at about 2:30 a.m after 4 h of slumber and was consistently unable to return to sleep. As a result of sleep deprivation, he experienced constant fatigue, often falling asleep at various intervals during the day. While on holiday in their mobile home, however, the patient enjoyed improved sleep, causing his physician to attribute the insomnia to job stress. Numerous therapies had been unsuccessful including counselling, relaxation techniques, benzodiazepine medication, acupuncture and various nutritional supplements. Microsurge meter assessment in the patient's bedroom revealed power surges reaching 1600 GS units (safe levels reported as <30 GS units). Filtration of dirty electricity reduced levels to under 30 GS units, and the patient noticed a dramatic and consistent improvement in sleep patterns within 1 week.

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Concluding thoughts

Despite differing perspectives on the severity of impact, there is compelling research to suggest that EMR has the potential to have an adverse effect on cells and tissues. Commenting on research by himself and co-workers,[107] Trosko recently summed up the prevailing sentiment: 'until now, the weight of the theoretical and experimental evidence has suggested that [low-frequency EMFs] did not have the ability to interact with genetic material to damage it', but recent studies show that '…there is a biological effect of the energy imparted by extremely-low-frequency EMF on living systems'. Definitive conclusions on the extent of resultant harm, however, remain difficult to establish comprehensively as controlled trials with exposure of cohorts to potentially toxic influences are unethical. Furthermore, the allegation that industry-funded studies tend to produce industry-desired outcomes further complicates the ability to establish veracity on this issue.

It is thus difficult to winnow fact from fiction among the many claims relating to the impact of EMR on people as well as on the environment. While some authors have discussed adverse effects of EMR on plants and trees,[8,108] and much research suggests health disorders and behavioural abnormalities in animals exposed to adverse EMFs,[109–111] the intensity of impact on human health remains the subject of much debate. With a multiplicity of views and potentially competing priorities including comfort, convenience, financial interest, health and technological necessity, a consensus on the risk/benefit ratio of EMF exposure may be challenging to achieve in the near future. However, with a great percentage of people in the early 21st Century bathing in EMF smog resulting from living, working and playing in close proximity to electrical appliances, wireless networks, cellular phone masts, power lines, TV and radio towers, fluorescent lighting and dirty power, as well as from ubiquitous use of cordless and cellular phones, automobile seat warmers, electric toothbrushes, electric shavers, hair dryers etc., a response from the medical and public health community is indicated.

The moral and political question arises regarding whether public health policy should be based on 'proof of safety' or 'proof of harm'. In relation to environmental health issues, an 'innocent until guilty' approach has generally been adopted whereby public health initiatives commence only after 'proof of harm' is established conclusively.[112] Medical history has repeatedly demonstrated that despite strong suspicions and preliminary evidence, various toxic agents and devices routinely remain in use for years prior to the availability of definitive evidence of harm; precautionary avoidance is generally not implemented. As a result, schools and residences continue to be erected in immediate proximity to power lines emitting immense EMR, pregnant women continue unawares to be exposed to EMR in various occupations, teens spend inordinate amounts of time attached to cellular phones, and mobile phone masts continue to be placed in communities close to residences, schools, preschools, hospitals and workplaces.

Sickness is often the consequence of an interaction between a causative agent and a susceptible host, and adverse EMR appears to be one such causative agent. With increasing evidence linking significant EMF exposure to adverse health sequelae, and with the increasing intensity of electronic pollution resulting from wireless technology and dirty electricity, it may be prudent to consider erring on the side of caution. Considering the potential long-term danger, physicians and public health officials should alert individual patients and the public to this issue and provide ongoing information on precautions to diminish potential risk associated with EMF exposure.

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