Health Effects of Electromagnetic Fields (EMF): A Snapshot of the Literature Regarding Cellphones

By

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Clinical Services – Worker and Employer Services

About this report

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About the Evidence-Based Practice Group

The Evidence-Based Practice Group was established to address the many medical and policy issues that WorkSafeBC officers deal with on a regular basis. Members apply established techniques of critical appraisal and evidence-based review of topics solicited from both WorkSafeBC staff and other interested parties such as surgeons, medical specialists, and rehabilitation providers.

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Table of contents

Background

Electromagnetic fields with insufficient quantum energy to cause ionization in living matter are termed non-ionizing radiation. This group includes static and power frequency fields, radiofrequencies (RF), microwaves, infra-red and visible radiation.[1]

Mobile phones are a network of two elements, which transmit radio waves: the base station and the hand set (phone). The radiation from radio waves (radiofrequency), which also include mobile phones, is non-ionizing and sits at the lower end of the electromagnetic spectrum (9 kHz and 300 GHz). The first generation of mobile telephones operated at 450 MHz or 800/900 MHz and today's mobile phones operate at 1900 and 2200 MHz.[2] There are very low frequency (VLF) and extremely low frequency (ELF) waves further down the spectrum (e.g. radiation from computers at15-30 kHz or 50-90 kHz, and power-EMF at 50 or 60 Hz).[3] Microwaves, with frequencies of several billion Hz, are higher up in the spectrum compared to radio waves, and also have a thermal (heating) effect on body tissues.[4] However, these frequency ranges may vary depending on the device technologies and government policies employing additional wireless communication spectrums. For example, a recent report by the World Health Organization (WHO) refers to mobile phones as "low-powered radiofrequency transmitters, operating at frequencies between 450 and 2700 MHz".[5] The International Commission on Non-Ionizing Radiation Protection (ICNIRP) and Institute of Electrical and Electronics Engineers (IEEE) are two international organizations which have developed exposure guidelines for workers and for the general public.[5] Unlike ionizing radiation (which is believed to act cumulatively), RF exposure is not considered a cumulative hazard and measured with standard thresholds. Unless the RF exposure is above the threshold value, it is not considered harmful. In the US, the American National Standards Institute (ANSI)[6] and in Canada, Health Canada's Safety Code 6[7] set the RF threshold limits (both occupational and for the public). The presentation document by Bradley (2009), which includes Health Canada's Safety Code 6 RF threshold values in comparison to ANSI/IEEE and ICNIRP values, concludes that "There is no convincing scientific evidence to support speculated health effects from RF exposure at levels below the limits."[8] In Europe, the ICNIRP Guidelines were incorporated in a European Council Recommendation, in 1999;[9] this was also endorsed in the UK, replacing the 1993 guidelines of the National Radiological Protection Board (NRPB). Cell phones became available in the 1980s

and were in widespread use by the 1990s. As of May 2010, the WHO estimates there were 4.6 billion cell phone users.[5]

The same WHO document states that there are no established adverse health effects related with cell-phone use from short-term studies. Studies assessing the relationship between "exposure to radiofrequency and brain electrical activity, cognitive function, sleep, heart rate and blood pressure" have not suggested any consistent evidence at levels below those that cause tissue heating. Also, no causal relationship between exposure to electromagnetic fields and symptoms of electromagnetic hypersensitivity (EHS) were found. Studies which assess the long-term effects of cell phone use usually focused on brain tumours as the outcome of interest. These are population-based case-control studies or prospective cohort studies; some of which are ongoing. The completed ones have not supported a causal relationship between radiofrequency exposure and adverse health effects. However, these studies were not able to completely rule out an association due to their own limitations. Also, the oldest data available on cell-phone use goes back only 15 years, which may still not capture all possible long-term effects.[5]

With ever-increasing use of wireless telecommunication devices, including cell-phones, the public interest and worry regarding the health risks introduced by EMF also increases. Governments, international agencies, and scientific communities are supporting a wide range of studies on the topic, including larger scale epidemiologic studies with longer study periods. The currently available literature and the guidelines mostly focus on the potential carcinogenic effects of EMFs; studies focusing on Electrical Hypersensitivity and other health outcomes are fewer. We will highlight findings from recent studies (mostly, from review papers) and guidelines, as well as from available grey literature reports.

Method and Literature

The literature on the health effects of electromagnetic exposures focuses on the brain and development of other neurological tumors. Consistent with the presented claim case, we searched for an association between electromagnetic exposures and

a) multiple chemical sensitivity syndrome
b) infection of facial skin, and
c) electromagnetic field sensitivity syndrome

We did a rapid PubMed search combining the keywords *cellular phone, cellular telephone, cell telephone, cell phone, mobile phone, and mobile telephone,* then searched for any associations with the three health conditions listed above.

a) A search for *multiple chemical sensitivity syndrome* in combination with the cell phone keywords did not find any relevant articles.
b) A broad search using the keyword *dermatitis* in combination with the cell phone keywords found 28 citations. Limiting articles to those written in English, in the last 10 years, and focused on human subjects, this number was refined to 23, with only 2 of the citations being review articles. We collected the full text of these articles.

A search for citations using the keywords *electromagnetic sensitivity, electromagnetic sensitivity syndrome, electromagnetic hypersensitivity, or electrical sensitivity* combined with the cell phone keywords resulted in 90 citations. Again, articles were then limited to those written in English, in the last 10 years, and focused on human subjects. The total number of citations was refined to 60, including 7 review articles. The abstracts of these 7 review articles were examined. Two were excluded from further review (one was not relevant and another was a duplicate from the search described in (b). We collected the full texts of the remaining 5 articles. In addition, other review articles were collected via hand search of the references of the retrieved articles.

Literature Review

Idiopathic Environmental Intolerance Attributed to Electromagnetic Fields (Formerly 'Electromagnetic Hypersensitivity'): An Updated Systematic Review of Provocation Studies [Rubin GJ, 2010][10]

The most recent (2010) review article on this topic was by Rubin GJ et al., and is an update of their 2005 systematic review of provocation studies. They collected data from an additional 15 experiments via literature search (total studies: 46). They searched whether exposure to electromagnetic fields was responsible for triggering symptoms in Idiopathic Environmental Intolerance (Idiopathic Environmental Intolerance Attributed to Electromagnetic Fields (IEI-EMF); previously

called Electromagnetic Hypersensitivity). They were not able to find any strong evidence to support their study hypothesis. Rubin et al. concluded that "…the best evidence currently available suggests that IEI-EMF should not be viewed as a bioelectromagnetic phenomenon.…when faced with someone who describes subjective symptoms that are apparently associated with exposure to an electrical device, it would be wise for clinicians and policy makers to begin with the assumption that an alternative explanation for these symptoms may be present, either in the form of a conventional organic or psychiatric disorder, or in terms of the more subtle psychological processes associated with the nocebo response. In the latter case, treatment based on cognitive behaviour therapy may be helpful for some patients."

Electromagnetic fields (EMF): Do they play a role in children's environmental health (CEH)? [Otto M, 2007][11]

In a 2007 article by Otto and Muhlendahl, the authors present an overview of possible adverse effects of exposure to electric, magnetic and electromagnetic fields (EMF) and review the literature on various frequency levels of EMFs, a topic of much discussion in the last two decades. They also discuss the question of whether children are more vulnerable to such exposure, and examined the position of the International Agency for Research on Cancer (IARC) in 2001, which regards low-frequency EMFs as being "possibly carcinogenic to humans", based on the results of epidemiological research concerning childhood leukemia. Otto and Muhlendahl call high-frequency EMF, used in mobile/wireless technologies (mobile telephone according to the GSM and UMTS standard, cordless DECT phones, wireless local area networks (WLAN), Bluetooth) and also in radio and televisions, "practically omnipresent". At high intensities, the generation of heat is the principal effect. The authors state that current guidelines, limits, and regulations prevent heat generation by these devices. They also point out that in certain circumstances mobile phone calls may lead to local exposures close to limit values. The authors underline that presently there is no data suggesting that children and adolescents are especially vulnerable to high-frequency EMF.

Electrohypersensitivity: State-of-the-Art of a Functional Impairment [Johansson O, 2006][12]

In this narrative review article from Sweden on electrohypersensitivity (EHS), the author describes several survey studies from Sweden, as well as his own studies on the cellular and neuronal systems of the skin of people with EHS. His studies included age- and sex-matched controls with no subjective or clinical symptoms or dermatological history. People with EHS are defined as presenting with "subjective and objective skin- and mucosa-related symptoms, such as itch, smarting, pain, heat sensation, redness, papules, pustules, etc., after exposure to visual display terminals (VDTs), mobile phones, DECT telephones, as well as other electromagnetic devices." The author offers his data for utilization by other researchers. He also concludes that preliminary data shows that there are various disturbances in the skin of electrohypersensitive persons.

Cell phone allergic contact dermatitis: Case report and review [Rajpara A, 2010][13]

Rajpara and Feldman reported on a case of allergic contact dermatitis to cell phone metal and normatively presented other similar cases from the literature. Their case was a 28-year-old woman with an isolated itchy, dry patch on her right cheek. They also found a patch of dermatitis on her right jaw, where the metallic menu button on her cell phone contacted her skin. The authors point out two metals specifically which are emerging as associated with several reports of contact dermatitis: nickel sulfate and hexavalent chromium. "Covering the cell phone with a plastic film, using a wireless ear piece, or switching to a different cell phone that does not contain metal on surfaces that contact the skin" are the suggested treatments.

Electromagnetic hypersensitivity (EHS) and subjective health complaints associated with electromagnetic fields of mobile phone communication—a literature review published between 2000 and 2004 [Seitz H, 2005][14]

The authors reviewed literature from 2000 to 2004 systematically for electromagnetic hypersensitivity (EHS) and subjective, unspecific health symptoms in relation to electromagnetic field (EMF) exposure during mobile phone communication. The measures/symptoms studied included: perception of electromagnetic fields, electromagnetic hypersensitivity, sleep quality, dizziness, headache, skin problems, problems in concentration and memory loss, and nervousness. After assessment of study design and quality, they included 13 studies in

their review. One provocation study was a self-reported EHS study, with the perception of field status being no better than as expected by chance. Five randomized cross-over studies did not deliver the expected higher quality exposure assessment – for some the exposure period was short or the sample size was small – and their findings were conflicting. Since the studies were cross-sectional, no causal inferences were possible between exposure and outcomes.

GUIDELINES / REPORTS

International Commission on Non-Ionizing Radiation Protection (ICNIRP)

The International Commission on Non-Ionizing Radiation Protection (ICNIRP), an independent scientific organization recognized by the WHO, has published guidelines on limits for human exposure to electromagnetic fields (i.e. guidelines on radiofrequency, static magnetic fields, LF range)[15] The basic restrictions first published in 1998, Guidelines on radiofrequency, Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz), were reconfirmed in 2009 for the 100 kHz–300 GHz range (which includes the frequency range for mobile phones). The document was titled: ICNIRP Statement on the "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)".[16] These 'basic restrictions' from the 1998 guidelines were restrictions on exposure to time-varying electric, magnetic, and electromagnetic fields that were based directly on established health effects and were "depending upon the frequency of the field, the physical quantities used to specify these restrictions are current density (J), specific energy absorption rate (SAR), and power density (S). Only power density in air, outside the body, can be readily measured in exposed individuals."[17]

ICNIRP chose not to make immediate revisions to its guidance and set new exposure limits for higher frequency EMFs, as they believed that the scientific research since 1998 has not provided further evidence on established health effects. In spite of some inconsistent, contradicting studies (mostly with small sample sizes and lacking rigorous methodologies), INTERPHONE, a multi-country study undertaken by the International Agency for Research on Cancer (IARC) scientists, has not revealed any elevation in the risk of cancers in the head within a 10-year period of first use.

INTERPHONE Study Report, 2010

Although the INTERPHONE Study specifically investigated "whether RF exposure from mobile telephones is associated with cancer risk" and did not assess any other adverse health outcomes (including EHS) it will be included in this review since, to date, it is the largest epidemiological study that focused on effects of mobile phone use. It consisted of a set of studies which were initiated in 2000. These studies used the same study protocol, were conducted in 13 countries, and were under the leadership of the WHO International Agency for Research on Cancer (IARC). The primary study method was a computer-assisted interview, but in some countries additional research material (blood or buccal cells, etc.) was also collected. More than 6000 people with cancer were compared with more than 7000 controls. The tumours of the brain, acoustic nerve and parotid gland were studied. In 2010, the first combined study results on brain tumours (glioma and meningioma) emerged. One major message from the Interphone Study Group was the lack of elevated risk for glioma or meningioma in relation to ≥10 years after first phone use. However, the authors noted that "Biases and errors limit the strength of the conclusions that can be drawn from these analyses and prevent a causal interpretation". One major point, which made the results of this study questionable, was the change in the pattern of cell phone use in the last decade (compared to the cell phone use patterns in the early years).

Although the INTERPHONE Study was not able to provide definitive answers for the long-term cancerogenic effects of RF exposures from cell phones, it remains one of the strongest epidemiological studies in this area.[18-20]

Mobile Telecommunications Health Research Programme (MTHRP) 2007 Report

The 2007 report by the Mobile Telecommunications Health Research Programme (MTHRP), UK summarizes findings from studies on cancers of the brain and nervous system, brain function, electrical hypersensitivity, biological mechanisms, base stations, risk communication, mobile phones and driving, in relation to exposure to mobile phone or base station signals. The report states that no associations between 'less than 10 year mobile telephone use' and brain or other nervous system cancers were found and long-term effects are not clear and research studies are continuing.[21] The report also provided a section on findings from a number of studies on

Electrical Hypersensitivity (EHS) that were conducted by other researchers with support from the MTHRP group. One example of these studies is from Fox et al., where a questionnaire was developed and validated for identifying individuals reporting symptoms consistent with electrical hypersensitivity (EHS) syndrome. The researchers implemented the survey via mail in Southeast England. The study estimated the prevalence of EHS to be between 1% and 4%; with twice as much prevalence within the female population.[22] Acknowledging the existence of these reported symptoms, the MTHRP report underlines: "this does not mean that the symptoms are necessarily caused by exposure to magnetic fields". The authors suggest the 'provocation' study method as a suitable method for studying this relationship (in a double blind fashion), where both sensitive individuals and non-sensitive controls are exposed to an electromagnetic source and later be subject to a sham exposure. The report cites two previous studies (Hansson Mild et. al. 2004, and Rubin et. al. 2005) which did not find an association between electromagnetic signals and reported symptoms; additional references to other studies were also provided (Hietanen 2002, Oftedal et al. 2007, Rubin et al. 2007, Regel et al. 2006). Other researchers hypothesized that symptoms reported by EHS sufferers (headache, disorientation, nausea) may be related with inner ear function/changes in hearing or equilibrium and conducted studies in an effort to detect potential linkage (Bamiou et al. 2007). No significant radiofrequency-dependent effects were found. Overall, the MTHRP supported studies found no convincing association between EHS and mobile phone use (or base station signals). However, MTHRP recognizes that emergency service TETRA radios and TETRA base services need further investigation.

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) 2009 Report on "Health Effects of Exposure to EMF"

This is an extensive report by the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) of the European Commission's Directorate-General for Health & Consumers, published in 2009. While this report consists of information from studies on various levels of the EMF spectrum, a notable part of it is on radiofrequency (RF) field studies. The report combines relevant and critically evaluated scientific information on the topic from the physical, engineering, medical and biological sciences, including their own review from 2007 and another report called BioInitiative Report.

It is worth mentioning that the BioInitiative Report clearly supports the position that there is evidence proving the carcinogenic nature of EMF exposure. After an in-depth review of the recent scientific evidence the SCENIHR concludes that based on the independent lines of evidence from epidemiological, animal and in vitro studies, "exposure to RF fields is unlikely to lead to an increase in cancer in humans." They continue by stating "… further studies are required to identify whether considerably longer-term (well beyond ten years) human exposure to such phones might pose some cancer risk." The SCENIHR report specifically touches upon non-carcinogenic outcomes, including subjective symptoms. They indicate that even if an association between RF exposure and single symptoms was shown in some new studies, overall the results were inconsistent. The SCENIHR report states their previously published findings, which concluded that "scientific studies have failed to provide support for an effect of RF fields on self-reported symptoms", still holds. They mention the "nocebo effect (an adverse non-specific effect that is caused by expectation or belief that something is harmful)", that was referred to in some studies, as a possible factor which may have played a role in symptom formation. The studies did not reveal any evidence that the individuals, attributing symptoms to RF exposure, were able to detect RF fields. They detected some evidence with regards to RF fields influencing human EEG patterns and sleep. But, the health relevance was uncertain and will require further investigation. Reviews of studies on the functions/aspects of the nervous system (e.g. "cognitive functions, sensory functions, structural stability, and cellular responses") revealed either no or inconsistent effects.[23]

WHO Fact Sheet on Electromagnetic hypersensitivity (EHS) (No 296), 2005

This WHO fact sheet on Electromagnetic hypersensitivity (EHS) was based on information collected from the WHO workshop on electromagnetic hypersensitivity, which took place in Prague, Czech Republic, October 25 -27, 2004.[24] It defines EHS as "…a variety of non-specific symptoms that differ from individual to individual. The symptoms are certainly real and can vary widely in their severity. Whatever its cause, EHS can be a disabling problem for the affected individual. EHS has no clear diagnostic criteria and there is no scientific basis to link EHS symptoms to EMF exposure. Further, EHS is not a medical diagnosis, nor is it clear that it represents a single medical problem." The fact sheet gave a definition of Idiopathic Environmental Intolerance (IEI), described as a condition which "incorporates a

number of disorders sharing similar non-specific medically unexplained symptoms that adversely affect people", including multiple chemical sensitivities (MCS). However they stick with the term EHS in the document, as per its common use. The fact sheet touches upon the wide range of prevalence of EHS reported in different studies (from occupational medical centres the prevalence of EHS was estimated to be "a few individuals per million"; whereas a survey of self-help groups yielded much higher estimates). In general, about 10% of reported cases of EHS were considered severe. The geographical variability in prevalence of EHS and the reported symptoms were also mentioned (e.g. higher incidence of EHS in Sweden, Germany, and Denmark, than in the United Kingdom, Austria, and France). Video display units (VDU)-related symptoms were more prevalent in Scandinavian countries, and were more often related to dermatologic problems than other parts of Europe. Of note, the fact sheet states that symptoms which were attributed to EMF exposure as reported by EHS individuals, were also common in the general population. Studies indicated that EHS individuals were not able to detect EMF exposure "any more accurately than non-EHS individuals" and controlled, double-blind studies had shown that EMF exposure and symptoms were not correlated. Some had suggested that the symptoms experienced by EHS individuals might be related to other environmental factors (e.g. "flicker" from fluorescent lights, glare and other visual problems with VDUs, poor ergonomic design of computer workstations, poor indoor air quality, stress in the workplace or in living environment). It was also suggested that there could be instances where "these symptoms may be due to pre-existing psychiatric conditions as well as stress reactions as a result of worrying about EMF health effects, rather than the EMF exposure itself."[25]

Possible health implications of subjective symptoms and electromagnetic fields
A report prepared by a European group of experts for the European Commission, DG V, 1997

This report on 'electromagnetic hypersensitivity' was prepared by the National Institute for Working Life, Sweden's Center for Research and Development on Labour Market, Working Life and Work Environment. The term 'Electromagnetic hypersensitivity' refers to a phenomenon "where individuals experience adverse health effects while using or being in the vicinity of electric, magnetic or electromagnetic field sources and devices (EMF devices)." This term "does not – by itself – presuppose or indicate any causes of these adverse reactions."

Electromagnetic hypersensitivity reactions varied with different individuals and throughout different geographies in Europe. The majority of cases presented mild, non-specific symptoms with no objective signs (unless there is another disease accompanying). Some individuals experience more severe symptoms affecting everyday life, including work. The diagnostic criteria for this phenomenon are lacking and it is not related to any long-term diseases. Similar to any risk perception, the perception of the risk posed by exposure to EMF-emitting devices varies, and is influenced by an individual's social background, country of origin and level of education. Perceptions vary amongst different stakeholders as well, such as between experts and the general public. The authors collected and reviewed the information brochures on EMFs distributed throughout different EU states. The leaflets/brochures were not homogenously distributed. Although each had sufficient information about EMFs they rarely contained information on EHS. For better informing those individuals with EHS complaints it was suggested that indoor and outdoor air quality must improve, and stress conditions should be prevented. Afflicted cases should be examined to detect any existing diseases. Treatment should be planned to reduce symptoms and functional handicap. The authors suggest that early intervention with the EHS cases reduces more severe sequelae. Prescribing change to any environmental factors or conditions (with regards to EMF exposure) should be considered, case-by-case. The authors recommended that currently available scientific information should be tailored for specific target groups, and individuals claiming adverse health effects from EHS should be handled early and on an individual basis.[26]

Health Effects from Radiofrequency Electromagnetic Fields, 2003
Report of an independent Advisory Group on Non-ionising Radiation (AGNIR), Health Protection Agency, UK

This extensive report prepared by AGNIR contains a specific section on Non-cancer Epidemiology and Clinical Research. Under the subtitle "symptoms when mobile phones are used", they reviewed studies and reported on common complaints. For example, pain, dysaesthesiae and warm sensation in the head were common. Also, warming of the ear and unspecified discomfort were also mentioned. While the biologic basis of "sensations of warmth in and around of the ear can be due to microwave irradiation from the antenna of the phone", a psychological basis was also felt to be possible. The Hietanen study (2002) used a blinded study method employing both real and sham exposures to

mobile phones. Fewer symptoms were reported during real RF exposure when compared to symptoms reported during sham RF exposure. At the end of this section the authors of the report concluded "the mechanism underlying symptoms and associated clinical abnormalities is uncertain, but in some cases, at least, could be psychological."[27]

Cell Phone Radiofrequency Radiation Studies, US 2009

The National Toxicology Program (NTP) of the US is presently conducting a set of animal studies. These studies were planned because of the apparent public concern over potential adverse health effects that may be linked to the widespread use of cell-phones in the community, in addition to the current lack of sufficient human subject data to be studied and insufficient scientific information on the long-term effects of exposure to RF. Rats and mice are being exposed to the frequencies of 900 and 1900MHz consistent with the current usage in the US. The studies are to be undertaken in three phases: 1) pilot studies, 2) subchronic toxicology studies (up to two months exposure to various non-thermal field strengths), and 3) chronic toxicology and carcinogenicity studies (24 months of exposure).[28]

OCCUPATIONAL EXPOSURE CONTEXT

National Institute for Occupational Safety and Health (NIOSH), 1998

The Center for Disease Control website includes a NIOSH fact sheet on EMFs in the workplace (power lines, electric wiring, and electric equipment and appliances), which usually operate at a frequency of around 60 Hz of electric power in North America.[29] The average daily EMF exposure for a worker with a clerical job with no computer use is 0.5 and one with computer use is 1.2 milligauss; the average is up to 5.4 for electricians and 8.2 for welders. This NIOSH document refers to some studies on EMF exposure and cancer relationship and states that "… data from all of these studies are too limited for scientists to draw conclusions. However, a national research effort is under way, and more study results are expected in a few years." The document also recommends that workers be informed about the workplace magnetic fields, increase the distance of the worker from the source, use of low-EMF designs, and less EMF exposure periods at work.[29]

European Physical Agents Directive, 2004

The European Parliament and Council of 29 April 2004 accepted a directive on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields). The directive incorporates the basic restrictions and reference levels advised by the ICNIRB in 1998 for occupational exposure, under 'exposure limit values' and 'action values'.

The Directive refers to the risk to the health and safety of workers due to short-term adverse effects on the human body. It suggests that the level of exposure to EMFs be reduced by "incorporating preventive measures into the design of workstations and by selecting work equipment, procedures and methods so as to give priority to reducing the risks at source." This was to be achieved by the employer by making "adjustments in the light of technical progress and scientific knowledge regarding risks related to exposure to electromagnetic fields, with a view to improving the safety and health protection of workers."

The directive further requires the employer to pay attention to the following during the risk assessment:

a) the level, frequency spectrum, duration and type of exposure;
b) the exposure limit values and action values referred to in Article 3 of this Directive;
c) any effects concerning the health and safety of workers at particular risk;
d) any indirect effects, such as:
    i. interference with medical electronic equipment and devices (including cardiac pacemakers and other implanted devices);
    ii. the projectile risk from ferromagnetic objects in static magnetic fields with a magnetic flux density greater than 3 mT;
    iii. initiation of electro-explosive devices (detonators);
    iv. fires and explosions resulting from ignition of flammable materials by sparks caused by induced fields, contact currents or spark discharges;
e) the existence of replacement equipment designed to reduce the levels of exposure to electromagnetic fields;
f) appropriate information obtained from health surveillance, including published information, as far as possible;
g) multiple sources of exposure;
h) simultaneous exposure to multiple frequency fields.

The directive also indicates: "In any event, where exposure above the limit values is detected, a medical examination shall be made available to the worker(s) concerned in accordance with national law and practice. If health damage resulting from such exposure is detected, a reassessment of the risks shall be carried out by the employer in accordance with Article 4."[30]

HPA NRPB documents: Volume 14, no 2, 2003
Health Effects from Radiofrequency Electromagnetic Fields: Report of an independent Advisory Group on Non-ionising Radiation

This was a synopsis document and the part on Occupational exposure, stated:
"Again there is a need for better studies rather than simply for more. In particular, the studies need to be of occupational groups for whom measurements show that there is genuinely a substantially raised

exposure to RF fields. If the studies are to be more informative than those so far, a key requirement will be for improved exposure measurement (or improved estimation of exposure) for individuals, or at least for occupational groups. It would be desirable, as far as practical, that the studies should measure the intensity and timing of RF field exposures, and also that they should include some assessment of major RF field exposures from sources other than the current occupation – i.e. domestically, from mobile phones, and from previous jobs. Ideally, exposure assessment needs to be anatomical site (organ)-specific, because some sources result in greatly differing doses to different parts of the body. It is a difficulty in these prescriptions, of course, that the appropriate exposure metric is unknown."[27]

French Agency for Environmental and Occupational health Safety (Afsset), 2009
Opinion of the French Agency for Environmental and Occupational Health Safety concerning the update of the expert appraisal relating to radiofrequencies

This opinion paper states that overall, "the level of evidence is not sufficient to accept, as is, that the detrimental effects to health have been conclusively established. For [the French Agency for Environmental and Occupational health Safety] Afsset, they constitute undeniable signals." Afsset recommends focusing on epidemiological studies, studies on reproduction and childhood development, and also studies that display biological effects. It recommends that particular attention should be paid to methodological aspects (especially regarding the characterization of the exposure of populations, starting with the exposure of children). It highlights the delay in the knowledge of health effects concerning frequency bands below 400MHz and those above 2GHz, which correspond to occupational exposures. In reducing the exposure to radiofrequencies, the priority goes to "mobile phones which are the main source of exposure for the public." They suggest that clear labeling of the Specific Absorption Rate (SAR) would favour the least radiation-emitting mobile phones. Afsset also recommends researching some points on the ground, where levels of radiofrequency waves are clearly higher than average and mapping them.[31]

Overall, Afsset's summary regarding Electromagnetic Hypersensitivity (EHS) is as follows: "the recent progress in terms of quantification of associated symptoms" and "the importance of introducing a support

protocol and of monitoring hypersensitive patients", should be considered. "Afsset recommends:

1. the development and assessment of a clinical diagnostic tool for electromagnetic hypersensitivity based on the work of Eltiti et al. (2007), Hillert et al. (2008) and Brandt et al. (2009);
2. the definition of the methods of overall care of hypersensitive subjects (treatment of other causes of functional symptoms, symptomatic treatment of residual functional complaints, care of identified psychological factors, etc.);
3. organising monitoring activities of patients and, if possible, centralising these activities;
4. developing information and training for health professionals;
5. developing research activities which have rigorous clinical and exposure methods (relationships between electromagnetic hypersensitivity and other functional syndromes; relationship between electromagnetic hypersensitivity and electrosensitivity; modification of the cerebral functional imaging, etc.)."[32]

Key Points

- Billions (4.6) of people use cell phones globally
- As of May 2010, no established adverse health effects related with cell phone use (except for increased road traffic accidents) are validated by rigorous science
- Studies to test the health effects of long-term cell phone radiofrequency exposure are ongoing
- The radiofrequency (RF) range in which cell phones operate is not unique to them; cordless phones, wireless computer networks, TVs, radios, radar and satellite communications operate in the same RF range (difficult to control for the effects from these other RF exposures when studying the effects of cell phone RFs)
- Not all appliances produce a single type of electromagnetic field. For example, welding machines produce electromagnetic energy in the UV, visible, infrared frequencies, and ELF ranges (difficult to control for effects from different EMF ranges during studies)
- Cell phones are widely used in personal daily life and are not telecommunication devices unique to workplaces (difficult to control for the effect of RF exposure from daily/personal usage when studying occupational exposure)
- Currently available studies on electrical hypersensitivity (EHS) and RF exposure from cell phones are contradicting
- The number of methodologically sound studies on EHS and cell phone RF exposure (association) are small
- The best available quality studies, included in the ICNIRP and IEEC Guidelines, have not found statistically significant evidence of an association between cell phone RF exposure and EHS
- With this rapid literature search, we did not come across a study that indicates a relationship between electrical hypersensitivity (EHS) and workplace cell phone use
- The WHO plans to conduct a formal health risk assessment of radiofrequency fields exposure by 2012. The International Agency for Research on Cancer (IARC) plans to study the carcinogenic potential of mobile phones in 2011, and in 2009 the UK-based Advisory Group on Non-Ionising Radiation (AGNIR) started a review of exposure to radiofrequency radiation and human health, which it states will take 2-3 years to complete

Additional Studies

Additional studies were found through hand-searching of the references from the studies reviewed above. These are referenced below for your information and have not been reviewed or appraised by the Evidence-Based Practice Group.

Röösli M. Radiofrequency electromagnetic field exposure and non-specific symptoms of ill health: a systematic review. Environ Res. 2008 Jun;107(2):277-87.

Eltiti S, Wallace D, Ridgewell A, Zougkou K, Russo R, Sepulveda F, Mirshekar-Syahkal D, Rasor P, Deeble R, Fox E. Does short-term exposure to mobile phone base station signals increase symptoms in individuals who report sensitivity to electromagnetic fields? A double-blind randomized provocation study. Environ Health Perspect. 2007 Nov;115(11):1603-8.

Schröttner J, Leitgeb N. Sensitivity to electricity--temporal changes in Austria. BMC Public Health. 2008 Sep 12;8:310.

Nieto-Hernandez R, Rubin GJ, Cleare AJ, Weinman JA, Wessely S. Can evidence change belief? Reported mobile phone sensitivity following individual feedback of an inability to discriminate active from sham signals. J Psychosom Res. 2008 Nov;65(5):453-60.

Habash RW, Elwood JM, Krewski D, Lotz WG, McNamee JP, Prato FS. Recent advances in research on radiofrequency fields and health: 2004-2007. J Toxicol Environ Health B Crit Rev. 2009 Apr;12(4):250-88.

References

1. Health Protection Agency. Electromagnetic Fields. 2011 [cited 2011 March 18]; Available from: http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/ElectromagneticFields/.

2. ICNIRP. Exposure to high frequency electromagnetic fields, biological effects and health consequences (100 kHz-300 GHz). ICNIRP (International Commission on Non-Ionizing Radiation Protection); 2009.

3. National Institute of Environmental Health Sciences. EMF Electric and Magnetic Fields Associated with the Use of Electric Power; 2002.

4. National Institute of Environmental Health Sciences - National Institutes of Health. Electric & Magnetic Fields. 2010 [updated 2010 August 31; cited 2011 March 18]; Available from: http://www.niehs.nih.gov/health/topics/agents/emf/.

5. WHO. Electromagnetic fields and public health: mobile phones. Fact sheet N°193.; 2010 [updated 2010; cited 2011 March 18]; Available from: http://www.who.int/mediacentre/factsheets/fs193/en/.

6. Zeman G. Cellular Phone Safety. 2009 [updated 2009 December 18; cited 2011 March 18]; Available from: http://www.hps.org/hpspublications/articles/cellphonesafety.html.

7. Health Canada. Health Canada's Radiofrequency Energy Guidelines (Safety Code 6). 2009 [updated 2009 August 17; cited 2011 March 20]; Available from: http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/wireless_safe-securit_sansfil-eng.php.

8. Bradley R. Radiofrequency (RF) Exposure Standards. Health Canada; 2009 [updated 2009; cited 2011 March 20]; Available from: http://www.spectrum2020.ca/presentations/bradley.pdf.

9. EU Co. Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz): Council of the European Union 1999.

10. Rubin GJ, Nieto-Hernandez R, Wessely S. Idiopathic environmental intolerance attributed to electromagnetic fields (formerly 'electromagnetic hypersensitivity'): An updated systematic review of provocation studies. Bioelectromagnetics. 2010 Jan;31(1):1-11.

11. Otto M, von Muhlendahl KE. Electromagnetic fields (EMF): do they play a role in children's environmental health (CEH)? Int J Hyg Environ Health. 2007 Oct;210(5):635-44.

12. Johansson O. Electrohypersensitivity: state-of-the-art of a functional impairment. Electromagn Biol Med. 2006;25(4):245-58.

13. Rajpara A, Feldman SR. Cell phone allergic contact dermatitis: case report and review. Dermatol Online J. 2010;16(6):9.

14. Seitz H, Stinner D, Eikmann T, Herr C, Roosli M. Electromagnetic hypersensitivity (EHS) and subjective health complaints associated with electromagnetic fields of mobile phone communication--a literature review published between 2000 and 2004. Sci Total Environ. 2005 Oct 15;349(1-3):45-55.

15. ICNIRP. Publications - EMF. ICNIRP (International Commission on Non-Ionizing Radiation)Protection; 2010 [updated 2010; cited 2011 March 20]; Available from: http://www.icnirp.de/PubEMF.htm

16. ICNIRP. ICNIRP Statement on the “Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)” 2009.

17. ICNIRP. Guidelines for Limiting Exposure to Time-varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz); 1998.

18. WHO-IARC. Interphone study reports on mobile phone use and brain cancer risk. 2010 [updated 2010; cited 2011 March 20]; Available from: http://www.iarc.fr/en/media-centre/pr/2010/pdfs/pr200_E.pdf.

19. WHO-IARC. The INTERPHONE Study. 2011 [cited 2011 March 20]; Available from: http://www.iarc.fr/en/research-groups/RAD/RCAd.html.

20. INTERPHONE Study Group. Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. Int J Epidemiol. 2010 Jun;39(3):675-94.

21. MTHRP. Report 2007: MTHRP (Mobile Telecommunications Health Research Programme) 2007.

22. Eltiti S, Wallace D, Zougkou K, Russo R, Joseph S, Rasor P, et al. Development and evaluation of the electromagnetic hypersensitivity questionnaire. Bioelectromagnetics. 2007 Feb;28(2):137-51.

23. SCENIHR. Health Effects of Exposure to EMF: SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks) 2009.

24. WHO. Workshop on electromagnetic hypersensitivity, Prague, Czech Republic. 2004 [updated 2004; cited 2011 March 20]; Available from: www.who.int/peh-emf/meetings/hypersensitivity_prague2004/en/index.html.

25. WHO. Fact Sheet on Electromagnetic hypersensitivity (EHS) (No 296). 2005 [updated 2005; cited 2011 March 20]; Available from: http://www.who.int/mediacentre/factsheets/fs296/en/index.html

26. Aringer L, Cunningham J, Gobba F, Leitgeb N, Miro L, Neubauer G, et al. Possible health implications of subjective symptoms and electromagnetic fields -- A report prepared by a European group of experts for the European Commission, DG V: National Institute for Working Life, Sweden; 1997.

27. National Radiological Protection Board. Health Effects from Radiofrequency Electromagnetic Fields: Report of an independent Advisory Group on Non-ionising Radiation. 2003 [updated 2009 October 21; cited 2011 March 20]; Available from: http://www.hpa.org.uk/Publications/Radiation/NPRBArchive/DocumentsOfTheNRPB/Absd1402/.

28. National Toxicology Program. Cell Phone Radiofrequency Radiation Studies. 2009 [updated 2009; cited 2011 March 20]; Available from: http://www.niehs.nih.gov/health/docs/cell-phone-fact-sheet.pdf.

29. National Institute for Occupational Safety and Health. NIOSH Fact Sheet: EMFs in the Workplace. [cited 2011 March 18]; Available from: http://www.cdc.gov/niosh/emf2.html.

30. Directive 2004/40/EC of the European Parliament and of the Council of 29 April 2004 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields). Official Journal of the European Union. 2004;L 184.

31. French Agency for Environmental and Occupational Health Safety. Radiofrequencies: Afsset recommends reducing exposure. 2009 [updated 2009; cited 2011 March 20]; Available from: http://www.afsse.fr/index.php?pageid=559&newsid=502&MDLCODE=news.

32. French Agency for Environmental and Occupational Health Safety. Opinion of the French Agency for Environmental and Occupational Health Safety concerning the update of the expert appraisal relating to radiofrequencies. 2009 [updated 2009; cited 2011 March 20]; Available from: http://www.afsset.fr/upload/bibliotheque/838965561866129504705299558421/09_10_ED_Radiofrequences_Avis_EV.pdf.

Appendix 1

WorkSafeBC Evidence-Based Practice Group levels of evidence (adapted from 1,2,3,4)

1	Evidence from at least 1 properly randomized controlled trial (RCT) or systematic review of RCTs.
2	Evidence from well-designed controlled trials without randomization or systematic reviews of observational studies.
3	Evidence from well-designed cohort or case-control analytic studies, preferably from more than 1 centre or research group.
4	Evidence from comparisons between times or places with or without the intervention. Dramatic results in uncontrolled experiments could also be included here.
5	Opinions of respected authorities, based on clinical experience, descriptive studies or reports of expert committees.

References

1. Canadian Task Force on the Periodic Health Examination: The periodic health examination. CMAJ. 1979;121:1193-1254.
2. Houston TP, Elster AB, Davis RM et al. The US Preventive Services Task Force Guide to Clinical Preventive Services, Second Edition. AMA Council on Scientific Affairs. American Journal of Preventive Medicine. May 1998;14(4):374-376.
3. Scottish Intercollegiate Guidelines Network (2001). SIGN 50: a guideline developers' handbook. SIGN. Edinburgh.
4. Canadian Task Force on Preventive Health Care. New grades for recommendations from the Canadian Task Force on Preventive Health Care. CMAJ. Aug 5, 2003;169(3):207-208.