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Electromagnetic hypersensitivity – an increasing challenge to the medical profession

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Abstract

Background: In 1970, a report from the former Soviet Union described the “microwave syndrome” among military personnel, working with radio and radar equipment, who showed symptoms that included fatigue, dizziness, headaches, problems with concentration and memory, and sleep disturbances. Similar symptoms were found in the 1980s among Swedes working in front of cathode ray tube monitors, with symptoms such as flushing, burning, and tingling of the skin, especially on the face, but also headaches, dizziness, tiredness, and photosensitivity. The same symptoms are reported in Finns, with electromagnetic hypersensitivity (EHS) being attributed to exposure to electromagnetic fields (EMF). Of special concern is involuntary exposure to radiofrequency (RF)-EMF from different sources. Most people are unaware of this type of exposure, which has no smell, color, or visibility. There is an increasing concern that wireless use of laptops and iPads in Swedish schools, where some have even abandoned textbooks, will exacerbate the exposure to EMF.

Methods: We have surveyed the literature on different aspects of EHS and potential adverse health effects of RF-EMF. This is exemplified by case reports from two students and one teacher who developed symptoms of EHS in schools using Wi-Fi.

Results: In population-based surveys, the prevalence of EHS has ranged from 1.5% in Sweden to 13.3% in Taiwan. Provocation studies on EMF have yielded different results, ranging from where people with EHS cannot discriminate between an active RF signal and placebo, to objectively observed changes following exposure in reactions of the pupil, changes in heart rhythm, damage to erythrocytes, and disturbed glucose metabolism in the brain. The two students and the teacher from the case reports showed

similar symptoms, while in school environments, as those mentioned above.

Discussion: Austria is the only country with a written suggestion to guidelines on the diagnosis and treatment of EMF-related health problems. Apart from this, EHS is not recognized as a specific diagnosis in the rest of the world, and no established treatment exists.

Conclusion: It seems necessary to give an International Classification of Diseases to EHS to get it accepted as EMF-related health problems. The increasing exposure to RF-EMF in schools is of great concern and needs better attention. Longer-term health effects are unknown. Parents, teachers, and school boards have the responsibility to protect children from unnecessary exposure.

Keywords: medical diagnosis; prevention; radiofrequency electromagnetic fields (RF-EMF); school children; Wi-Fi.

Background

In recent decades, human beings and other species have been increasingly exposed to radiofrequency electromagnetic fields (RF-EMF) (1, 2). Exposure is involuntary from, e.g. base stations and wireless fidelity (Wi-Fi) routers used for wireless internet communication, but also voluntary through personal use of such devices as mobile phones, cordless phones and wireless connected laptops, iPads, etc. At homes and in offices, we now see a new development with wireless “talk” between different appliances causing increased passive exposure to RF-EMF.

Many people are concerned about the potential adverse health effects of RF-EMF. Of special concern is exposure from sources that the individual cannot control, close out, or even reduce. However, most people are unaware of this type of exposure, which has no smell, color, or visibility. Cordless phones may be placed close to the bed, whereby the sleeper is unnecessarily exposed to RF-EMF from its base station. Many take their smart phones everywhere and put them on the bedside table or even under the pillow at night. Laptops and iPads are frequently used in schools, at work, and in the home. Schools in Sweden usually have wireless networks reaching every

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room in the building. This makes it easy and convenient to teach and keep in contact everywhere. In some schools, almost all education is conducted through a personal computer given to each student. The same type of development is going on in offices and other workplaces. Free Wi-Fi is also available to everyone in some city centers in Sweden.

Electric light can be switched on all day during dark winter months, and in our homes, we are dependent on electricity and electric appliances for cooking, cleaning, and washing clothes and dishes. Technical development has accelerated rapidly during the last century. It has made life easier and more convenient.

However, there are people who experience side-effects from electrical and wireless equipment. They can experience symptoms that include headaches, nausea, dizziness, skin problems (itching, pricking, and heating), heart arrhythmias, concentration and memory difficulties, sleep problems, aches in muscles and joints, etc. (3). They present different symptoms depending on the frequency of the EMF. It can also vary widely which symptoms a person gets depending on his or her individual sensitivity and weaknesses. The intensity of the symptoms can vary from weak to strong within seconds and last from minutes to several days. The symptoms can make everyday life very disabling and difficult to manage.

Historical aspects

As early as in the 1970, a report from the former Soviet Union described the “microwave syndrome”. The Soviet military recognized early on the possible side-effects from radar and radio radiation. The microwave syndrome was seen in up to a quarter of the military personnel working with radio and radar equipment, even though the EMF were below today’s reference value. They showed symptoms such as fatigue, dizziness, headaches, problems with concentration and memory, sleep disturbances, and being hot tempered. The treatment suggested was a change of assignments and to keep away from EMF. Rest, physical exercise, and nutritious food were offered (4). The symptoms described are the same as those found 40 years later in Finnish people with electromagnetic hypersensitivity (EHS) (3).

In the 1980s, symptoms from cathode ray tube (CRT) computer screens appeared among office workers, most of whom were women. They showed symptoms that included flushing, burning, and tingling in the skin, especially on the face. When it worsened, they could develop eczema and swollen faces, with dilated blood vessels and vesicles, which was usually diagnosed as Rosacea. Björn Lagerholm, a Swedish dermatologist, histologically found

a similarity between skin biopsies from these women and those from heavily UV-radiated skin. He compared it with elastosis solaris, seen in elderly people after long sun-bathing or working out in the sun. The term “screen dermatitis” was suggested. If the affected office workers went on working in front of CRT screens, they could develop more symptoms – headaches, dizziness, tiredness, and light and noise sensitivity. Both at work and at home, they could become sensitive to fluorescent light, the stove, TV, and other electric devices (5).

The Swedish Confederation of Professional Employees, Tjänstemännens Centralorganisation (TCO), succeeded in making their recommendation of 0.2 μT the limit for the extremely low frequency (ELF) magnetic fields from the CRT screens internationally accepted. It might not only have been the high magnetic fields from earlier screens but also chemicals like brominated flame retardants in the materials in the screen and the computer that caused these reactions. When the devices were heated, new chemicals were vaporized in the electronics (5). Polybrominated diphenylether, a flame retardant used in electronics, was later found significantly elevated in a group of patients with EHS compared to a healthy control group (6).

Reference values

The reference values for RF-EMF were recommended in 1998 by the International Commission on Non-Ionizing Radiation Protection to 2–10 W/m^2 for frequencies between 10 MHz and 300 GHz. Up to 400 MHz, the recommendation is 2 W/m^2 . The formula: $\text{frequency}/2 \times 10^8$ is used for frequencies between 400 and 2000 MHz. Above 2000 MHz up to 300 GHz, the recommended reference value is 10 W/m^2 (7). These reference values protect against injuries caused by a heating effect over 1°C after an exposure of 30 min, and with a safety factor of 50 for general public. Injuries caused by other biological mechanisms than heating or from chronic effects of EMF exposure are not believed to exist. Sweden and many other countries apply these reference values. Other countries, like Russia, Poland, Italy, and India have chosen lower reference values down to 0.1 W/m^2 . Some of the researchers behind the BioInitiative Report in 2012 suggest 3 $\mu\text{W}/\text{m}^2$ as a reference value, because research work on biological effects has shown some influence of RF-EMF down to 30 $\mu\text{W}/\text{m}^2$ (8).

Measurements of outdoor exposure in Sweden in 2013 showed a median power density for RF fields between 30 MHz and 3 GHz to be 16 $\mu\text{W}/\text{m}^2$ in rural areas, 270 $\mu\text{W}/\text{m}^2$ in urban areas, and 2400 $\mu\text{W}/\text{m}^2$ in city areas (9).

Wi-Fi in schools

Over the last few years, while all public schools and most private schools in Sweden have installed wireless access to the Internet (Wi-Fi), there have been reports in newspapers of teachers and children experiencing symptoms of EHS (10, 11). In classes with one laptop per student, exposure to EMF can be especially high. Symptoms often include tiredness, headaches, dizziness, and difficulties with concentration and memory. Some recover at home, whereas others have problems sleeping at night. Palpitation of the heart is another reported symptom.

A debate has started in Sweden as to whether students should be allowed to use their mobile phones during school time. It is usually not exposure to EMF from the phone that is the issue of this debate, but rather the time, energy, and attention it takes away from school work.

Methods

Following a short literature review of different aspects on EHS, we will discuss the increasing use of Wi-Fi in schools. This is of special concern regarding EHS and other potential health effects. Two students and one teacher from the Nordic countries with health problems exacerbated by such a school environment are presented as case reports.

Results

There are different names for the medical condition called the microwave syndrome, which some now call EHS (3, 12). Other names are idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) (13) and electromagnetic field intolerance syndrome. As the different names point out, opinions are divided on whether the symptoms are caused by EMF (14, 15) or if there is anxiety about new technology that could be the cause of the symptoms (16). In population-based surveys, the prevalence of EHS has ranged from 1.5% in Sweden (17), 3.2% in California (18), 5% in Switzerland (19), up to 13.3% in Taiwan (20).

Provocation studies

Provocation studies with exposure to EMF have produced divergent results. Some studies have shown how people with EHS cannot discriminate between an active microwave

signal and a placebo signal, or do not get more symptoms from active exposure compared to sham exposure (21–23). Other studies on healthy or EHS people have shown objectively observed changes in the reactions of the pupil (14), changes in heart rhythm (15, 24, 25), damage to erythrocytes (26), and disturbed glucose metabolism in the brain (27) following exposure to EMF. Several studies indicate some influence on electrical activity in the brain seen in electroencephalograms after exposure to RF-EMF during both sleep and active memory tests (28, 29). An increased activity in the sympathetic nervous system and hyperreactivity to sensor stimulation has been found in patients with EHS (30).

Some reviews on provocation studies on EHS and IEI-EMF conclude that it is difficult, under blind conditions, to show that exposure to EMF can trigger the symptoms described by people with EHS or support the existence of a biophysical hypersensitivity to EMF (31, 32). Another review points to the sparse literature on this condition and discusses the controversy surrounding the legitimacy of the EHS diagnosis (33).

Provocation studies where the subject is supposed to tell whether an EMF is on, or has to report subjective symptoms can be difficult to conduct and have many sources of error. For people with EHS, the background environment of EMF can have a considerable influence on the test results. The best situation would be a test room with very low EMF both from ELF and RF.

Rea et al. did a provocation study in an environmentally controlled area with porcelain-on-steel walls to minimize airborne chemical pollution and external EMF, which might interfere with the testing procedure (14). Their provocation study had an alternating magnetic field with 21 active challenges frequencies from 0.1 Hz to 5 MHz and tested 100 subjects with self-reported EHS. Sixteen subjects reacted to active challenges but not to blanks.

The subjects' health and well-being on the test day may also influence the results. If the journey from home to the test room is long, it may find the EHS subject in a worse condition and more hypersensitive to EMF. This can make them react even to the lower power of EMF.

In the study by Rubin et al. on self-reported EHS, subjects were exposed to a pulsing 900 MHz global system for mobile communication (GSM) signal from a mobile phone as an active signal, which produced a targeted specific absorption rate of 1.4 W/kg (21). The sham signal, a continuous wave, was supposed to have a minimal leakage of <2 mW/kg. This low, but not negligible, signal may account for some of the positive reactions from the sham exposure. Of the EMF-sensitive participants, 60% believed that a signal was present during exposure to GSM, whereas 63% reported an active signal on the sham exposure.

Another difficulty with provocation studies is that EHS subjects may be sensitive to many different frequencies, but not all. Some react mostly to ELF-EMF and some mostly to RF-EMF (14). Furthermore, the symptoms can be very different between two subjects with EHS depending on their sensitivity and other illnesses, where some mainly get dermatological symptoms whereas others get heart effects (3). The time from exposure to appearance of symptoms may also differ from seconds to days (15, 26).

Case reports

Case 1

A previously healthy boy aged 15. Starting at the age of 5, he frequently played computer games, which often made him angry. He disliked the mobile phone he got when he was 7 and therefore seldom used it. In the fall of 2013, he started eighth grade, and his class moved to a building with mold problems. He started to have headaches, get very tired, and had difficulties concentrating at school. It seemed that he was in his own world and had trouble hearing what other people said. He became increasingly sensitive to light and sounds, experienced itching around his mouth and nose, and had palpitations of his heart with increasing rhythm, for which acute medical care was sought. In the hospital, he had tachycardia with a heart rhythm of above 200 beats per minute, which was treated with intravenous drug injections and only returned to normal after about 2 h. He started to sleep very badly, and became sad and depressed.

Except from offering allergy and psychiatric medicines, the doctors seemed helpless. In the spring of 2014, a friend recommended that the parents seek help from an alternative medicine therapist. The therapist made some muscle tests and found the boy's muscles very tense. After turning off the main power switch in the house, the boy's muscles and body relaxed. The therapist suggested he could be hypersensitive to EMF.

At home, the family turned off their Wi-Fi, electric devices, and lights. The boy got a lot better, especially during the summer of 2014 when he was outside and often at the seaside. Presently (2015), during his last year in primary school, he has increasingly been missing school and gets help to study at home. He develops symptoms soon after entering the school building, even in a small building without mold. The parents have not had any success in making the school authorities turn off the Wi-Fi. Mobile phones are supposed to be switched off when he is in class, but few teachers enforce this. Outdoors and at

home, he feels better and can now use the cabled computer for a while. He is concerned about his future and whether there is any school he can go to next year.

Case 2

A boy aged 15. Before starting school and during his first school years, the boy was healthy. In his first school, where he went from grades 1 to 7, he started to get headaches, especially when his friends brought their smart phones to school. Later, he also started to be more tired and had problems with memory, concentration, and sleep. In grade 9, in August 2014, all classes moved into a newly built school building with Wi-Fi already installed. Here, his symptoms got a lot worse. During this school year he has often been very tired when he returned home. Sometimes he slept from five in the afternoon to seven in the morning the next day, complaining that he slept badly. He also complains of severe headaches, poor memory, dizziness, and problems with his balance. He began to have stomach problems. He recovers during weekends, but still has symptoms. He lives near a base station and has neighbors using Wi-Fi. The school board and the local government refuse to turn off the Wi-Fi in the boy's classroom, but other students are supposed to turn off their smart phones during school hours.

In his earlier school, where he went from grades 1 to 7, measurements of RF-EMF were made in March 2012. With the RF-Analysator Gigahertz Solutions HF 59B, Isotrop antenna UBB27_G3, and frequency filter FFGE with the range of 27 MHz–3.3 GHz, measurements showed values from 41 to 10,000 $\mu\text{W}/\text{m}^2$. Most of the measured RF-EMF came from UMTS (3G). Wi-Fi was not installed in this school in 2012. In October 2011, measurements were made in the school yard and showed a maximum of 6200 $\mu\text{W}/\text{m}^2$ (average 470) increasing to 10,800 $\mu\text{W}/\text{m}^2$ (average 1300) in February 2015 (www.EMF-consult.no). In the area around this school, the number of mobile base stations increased between 2011 and 2015 from 12 to 22.

The school board at the school the boy is attending since 2014 has refused to do any measurements because the exposure of RF-EMF is thought to be well under the country's reference value of 10 W/m^2 for RF-EMF >2000 MHz.

Case 3

A previously healthy female teacher aged 47. Wi-Fi was installed in her school in the spring of 2011, and all students in grades 7–9 got their own laptop in the fall. All the

teachers were encouraged to use the computers in every lesson. The school did not buy any textbooks for any of the classes starting that year. The fall semester started with downloading several programs to each student's laptop for the different school subjects. After 3 weeks, the teacher started to feel heart palpitations, with both a very fast and uneven rhythm, when working in school. This disappeared when she went on a 2-week planned education trip to another country. Back at home, the palpitations returned after a week's work and got steadily worse. She consulted the hospital as an emergency patient, but her heart calmed down on her way to the clinic, and she had a normal rhythm at medical examination. She was on sick leave at home for a week, recovered, and felt well again. Back at work she started to get palpitations within 3 days and felt dizzy as though she was about to faint. She was now sure about the association between her palpitations and her work with Wi-Fi and all the laptops being used during the school day. This time she also became hypersensitive to ELF-EMF at home, from the television monitor, the induction stove, and the corded computer.

During the first 2 years, the school authorities did not recognize her EHS or make arrangements for it, but she finally got help with the support of her labor union. Now, 4 years later (June 2015), she remains sensitive to Wi-Fi and wireless equipment, but tolerates regular electricity and electronic devices. She still works as a teacher, but in another school in a classroom without Wi-Fi and has all her school meetings there. The students can use their laptops and smart phones in her classroom, but they have to be off-line in flight mode. She can use her own mobile phone, but does so sparingly. She feels well and has no heart problems as long as she avoids excessive use and exposure to wireless devices.

Discussion

The two students and the teacher report similar symptoms as the military radio and radar workers in the former Soviet Union, the Swedish office workers who got symptoms in front of the CRT monitors, and the electromagnetic hypersensitive Finns (3–5). They experienced symptoms such as headaches, tiredness, dizziness, heart arrhythmias, problems with concentration and memory, sleep disturbances, hypersensitivity to light and sounds, and flushing, burning and tingling of the skin, etc. These people attribute their symptoms to different EMF, both from ELF-EMF from our household electricity and/or from RF-EMF from wireless devices.

There can be a combination effect between chemicals and allergens, such as mold, together with EMF, which may aggravate the EHS. The office workers in front of new CRT monitors and elevated levels of flame retardants in the blood of a group of EHS people point to this combination effect (5, 6). The boy from case 1 above exemplifies this with his symptoms exacerbating when his class moved into a building with mold problems.

The Austrian Medical Association has made suggestions as to guidelines for the diagnoses and treatment of EMF-related health problems and illnesses (34), but apart from this, EHS is not recognized by the rest of the world today as a specific diagnosis. There are no diagnostic criteria and no treatment has been officially accepted. Instead, persons with EHS are often offered cognitive therapy because some studies have shown a reduction in perceived hypersensitivity after its use (35, 36). Efforts to raise the question of a medical diagnosis for EHS have been made several times in the European Parliament and its committees, but every time these have been rejected.

Provocation studies under double-blind conditions, where EHS cases are supposed to tell whether they are exposed to EMF or report which symptoms they get, can be difficult to conduct as we have discussed above. Thus, it would be useful to do provocation studies with exposure to EMF and objectively observe and register changes in body reactions beyond voluntary control, such as heart rhythm and electric skin potentials (25), adverse effects on blood cells (26), and saliva (37). The discussed difficulties with provocation studies seem to be the same for assessing diagnostic criteria for EHS, because symptoms and sensitivity can differ considerably among EHS persons. This would require further research.

People with EHS report that they can be sensitive and get symptoms to RF-EMF down to a few $\mu\text{W}/\text{m}^2$. Residential areas with low RF-EMF exposure can be the best way of reducing the symptoms of EHS. Activist and non-governmental organizations in several countries are working on this, but because governments do not recognize EHS as a real medical illness and impairment, they usually do not give any support. Avoiding wireless devices and choosing cabled connections to the Internet are important. In the home and office, electricity, lights, and machines can be shielded from ELF-EMF with special equipment that can improve living and working conditions.

Both ELF- and RF-EMF have been evaluated by the International Agency for Research on Cancer (IARC) at the World Health Organization to be "possible" human carcinogens, Group 2B (38, 39), but these conclusions seem to have had little or no impact on regulating human exposure. Those people who are not actively seeking information,

especially children, are uninformed of the IARC evaluation, because, at least in Sweden, governmental agencies do not actively inform people about the problem. The situation in schools with increasing exposure to RF-EMF is of major concern and hard to understand and defend for medical reasons, not least because a wired solution gives equal or even better internet access. Longer-term health effects are unknown. Parents and school boards are responsible for protecting children who are at a vulnerable age to toxins and obliged by law to attend school.

Conclusions

The prevalence of EHS seems to be increasing today, and many people get symptoms when exposed to ELF- and/or RF-EMF. With the ever more extensive use of wireless technologies, nobody can avoid being exposed. It is important to work toward getting objective diagnostic criteria for EHS, and have it recognized and officially accepted as hypersensitivity, an illness caused by exposure to EMF. Thus, it is necessary to give an International Classification of Diseases to EHS. If and when EHS is accepted as a diagnosis by society and the medical profession, measures can be taken especially in consideration for this group of people with EHS regarding healthcare, accommodation, school, and work.

Measurements of exposure to EMF should be performed in classrooms and in school yards during a typical school week. The results must be evaluated in relation to current knowledge of biological effects from EMF exposure. This should lead to a precautionary approach using wired solution of the internet connection, but also reduction of other sources of EMF exposure. This approach should be similar as for control of exposure to other toxic agents such as asbestos and radon emissions. It is time to consider ELF-EMF and RF-EMF as environmental pollutants that need to be controlled.

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References

1. Markov M, Grigoriev YG. Wi-Fi technology – an uncontrolled global experiment on the health of mankind. *Electromagn Biol Med* 2013;32:200–8.
2. Redmayne M. International policy and advisory response regarding children's exposure to radio frequency electromagnetic fields (RF-EMF). *Electromagn Biol Med*. DOI: 10.3109/15368378.2015.1038832.
3. Hagström M, Auranen J, Ekman R. Electromagnetic hypersensitive Finns: symptoms, perceived sources and treatments, a questionnaire study. *Pathophysiology* 2013;20:117–22.
4. Petrov IR, editor. Influence of microwave radiation on the organism of man and animals. Report from Academy of Medical Sciences of the USSR. Translated to English "Vliyaniye SVCh-Izlucheniya na Organizm Cheloveka I Zhivotnykh". *Meditsina Press, Leningrad, 1970*. Report from NASA TT F-708, Springfield, Virginia.
5. Nordström G. The invisible disease: the dangers of environmental illnesses caused by electromagnetic fields and chemical emissions. Alresford (UK): O Books, 2004.
6. Hardell L, Carlberg M, Söderqvist F, Hardell K, Björnfoth H, et al. Increased concentrations of certain persistent organic pollutants in subjects with self-reported electromagnetic hypersensitivity – a pilot study. *Electromagn Biol Med* 2008;27:197–203.
7. International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). *Health Phys* 1998;74:494–522.
8. BioInitiative Working Group. Bioinitiative 2012: a rationale for biologically-based public exposure standard for low-intensity electromagnetic radiation. Available at: <http://www.bioinitiative.org>. Accessed on August 12, 2015.
9. Estenberg J, Augustsson T. Extensive frequency selective measurements of radiofrequency fields in outdoor environments performed with a novel mobile monitoring system. *Bio Electro Magnetic Sci* 2014;35:227–30.
10. Mårtensson F. Utdraget kring elöverkänslighet. *Skolvärlden* 2012 Dec. 10: p. 6–7. In: Swedish. Available at: <http://www.skolvärlden.se/artiklar/utdraget-kring-eloverkanslighet>. Accessed on August 12, 2015.
11. Havas M. Independent view: Wi-Fi in schools: dumb and dangerous. *IndependentRI.com*, Independent Newspapers, Wakefield Jan 30, 2014. Available at: http://www.independentri.com/independents/north_east/opinion/letters/article_34f5e34a-ac83-5fed-bc3c-617d357a67e4.html. Accessed on Aug 12, 2015.
12. Hillert L, Hedman BK, Söderman E, Arnetz BB. Hypersensitivity to electricity: working definition and additional characterization of the syndrome. *J Psychosom Res* 1999;47:429–38.
13. Bogers RP, Bolte FJ, Houtveen JH, Lebert E, van Strien RT, et al. Design of an ecological momentary assessment study of exposure to radiofrequency electromagnetic fields and non-specific physical symptoms. *Br Med J Open* 2013;3:e002933.
14. Rea WJ, Pan Y, Yenyves EJ, Sujisawa I, Samadi N, et al. Electromagnetic field sensitivity. *J Bioelectricity* 1991;10:241–56.
15. McCarty DE, Carrubba S, Chesson AL, Frilot C, Gonzales-Toledo E, et al. Electromagnetic hypersensitivity: evidence for a novel neurological syndrome. *Int J Neurosci* 2011;121:670–6.
16. Boyd I, Rubin GJ, Wessely S. Taking refuge from modernity: 21st century hermits. *J R Soc Med* 2012;105:523–9.
17. Hillert L, Berglind N, Arnetz BB, Bellander T. Prevalence of self-reported hypersensitivity to electric or magnetic fields in a population-based questionnaire survey. *Scand J Work Environ Health* 2002;28:33–41.

18. Levallois P, Neutra R, Lee G, Hristova L. Study of self-reported hypersensitivity to electromagnetic fields in California. *Environ Health Perspect* 2002;110(Suppl 4):619–23.
19. Schreier N, Huss A, Rössli M. The prevalence of symptoms attributed to electromagnetic field exposure: a cross-sectional representative survey in Switzerland. *Soz Preventivmed* 2006;51:202–9.
20. Meg Tseng MC, Lin YP, Cheng TJ. Prevalence and psychiatric comorbidity of self-reported electromagnetic field sensitivity in Taiwan: a population-based study. *J Formos Med Assoc* 2011;110:634–41.
21. Rubin GJ, Hahn G, Everitt BS, Cleare AJ, Wessely S. Are some people sensitive to mobile phone signals? Within participants double blind randomised provocation study. *Br Med J* 2006;332:886–91.
22. Nieto-Hernandez R, Williams J, Cleare AJ, Landau S, Wessely S, et al. Can exposure to a terrestrial trunked radio (TETRA)-like signal cause symptoms? A randomized double-blind provocation study. *Occup Environ Med* 2011;68:339–44.
23. Wallace D, Eltiti S, Ridgewall A, Garner K, Russo R, et al. Do TETRA (airway) base station signals have a short impact on health and well-being? A randomized double-blind provocation study. *Environ Health Perspect* 2010;118:735–41.
24. Rezk AY, Abdulqawi K, Mustafa RM, Abo El-Azm TM, Al-Inany H. Fetal and neonatal responses following maternal exposure to mobile phones. *Saudi Med J* 2008;29:218–23.
25. Tuengler A, von Klitzing L. Hypothesis on how to measure electromagnetic hypersensitivity. *Electromagn Biol Med* 2013;32:281–90.
26. Öckerman PA. Free radicals in electromagnetic hypersensitivity. A simple and sensitive method for assay of damage to erythrocytes caused by free radicals. *Clin Pract Altern Med* 2000;1:81–7.
27. Volkow ND, Tomasi D, Wang GJ, Vaska P, Fowler JS, et al. Effects of cell phone radiofrequency signal exposure on brain glucose metabolism. *J Am Med Assoc* 2011;305:808–13.
28. Lowden A, Åkerstedt T, Ingre M, Wiholm C, Hillert L, et al. Sleep after mobile phone exposure in subjects with mobile phone-related symptoms. *Bioelectromagnetics* 2011;32:4–14.
29. Krause CM, Björnberg CH, Pesonen M, Hulten A, Liesivuori T, et al. Mobile phone effects on children's event-related oscillatory EEG during an auditory memory task. *Int J Radiat Biol* 2006;82:443–50.
30. Lyskov E, Sandström M, Hansson Mild K. Neurophysiological study of patients with perceived 'electrical hypersensitivity'. *Int J Psychophysiol* 2001;42:233–41.
31. Rubin GJ, Munshi JD, Wessely S. Electromagnetic hypersensitivity: a systematic review of provocation studies. *Psychosom Med* 2005;67:224–32.
32. Rubin GJ, Hillert L, Nieto-Hernandez R, van Rongen E, Oftedal G. Do people with idiopathic environmental intolerance attributed to electromagnetic fields display physiological effects when exposed to electromagnetic fields? A systematic review of provocation studies. *Bioelectromagnetics* 2011;32:593–609.
33. Genuis SJ, Lipp CT. Electromagnetic hypersensitivity: fact or fiction? *Sci Total Environ* 2012;414:103–12.
34. Austrian Medical Association. Guideline of Austrian Medical Association for the diagnoses and treatment of EMF-related health problems and illnesses (EMF syndrome). Consensus paper of the Austrian Medical Association's EMF working group 2012. Available at: <http://www.magdahavas.com/wordpress/wp-content/uploads/2012/06/Austrian-EMF-Guidelines-2012.pdf>. Accessed on August 12, 2015.
35. Hillert L, Kolmodin Hedman B, Dölling BF, Arnetz BB. Cognitive behavioural therapy for patients with electric sensitivity – a multidisciplinary approach in a controlled study. *Psychother Psychosom* 1998;67:302–10.
36. Rubin GJ, Munshi JD, Wessely S. A systematic review of treatments for electromagnetic hypersensitivity. *Psychother Psychosom* 2006;75:12–8.
37. Hamzany Y, Feinmesser R, Shpitzer T, Mizrahi A, Hilly O, et al. Is human saliva an indicator of the adverse health effects of using mobile phones? *Antioxid Redox Signal* 2013;18:622–7.
38. World Health Organization. International Agency for Research on Cancer. Non-ionizing radiation, part 1: static and extremely low-frequency (ELF) electric and magnetic fields. IARC Monographs Volume 80. Lyon: IARC Press, 2002. Available at: <http://monographs.iarc.fr/ENG/Monographs/vol80/mono80.pdf>. Accessed on August 12, 2015.
39. World Health Organization. International Agency for Research on Cancer. Non-ionizing radiation, part 2: radiofrequency electromagnetic fields. IARC Monographs Volume 102. Lyon: IARC Press, 2013. Available at: <http://monographs.iarc.fr/ENG/Monographs/vol102/mono102.pdf>. Accessed on August 12, 2015.

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