Igor Belyaev, Amy Dean, Horst Eger, Gerhard Hubmann, Reinhold Jandrisovits, Olle Johansson, Markus Kern, Michael Kundi, Piero Lercher, Wilhelm Mosgöller, Hanns Moshammer, Kurt Müller, Gerd Oberfeld*, Peter Ohnsorge, Peter Pelzmann, Claus Scheingraber and Roby Thill

EUROPAEM EMF Guideline 2015 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses

DOI 10.1515/reveh-2015-0033
Received October 1, 2015; accepted October 13, 2015

Abstract: Chronic diseases and illnesses associated with unspecific symptoms are on the rise. In addition to chronic stress in social and work environments, physical and chemical exposures at home, at work, and during leisure activities are causal or contributing environmental stressors that deserve attention by the general practitioner as well as by all other members of the health care community. It seems certainly necessary now to take "new exposures" like electromagnetic field (EMF) into account. Physicians are increasingly confronted with health problems from unidentified causes. Studies, empirical observations, and patient reports clearly indicate interactions between EMF exposure and health problems. Individual susceptibility and environmental factors are frequently neglected. New wireless technologies and applications have been introduced without any certainty about their health effects, raising new challenges for medicine and society. For instance, the issue of so-called non-thermal effects and potential long-term effects of low-dose exposure were scarcely investigated prior to the introduction of these technologies. Common EMF sources include Wi-Fi access points, routers and clients, cordless and mobile phones including their base stations, Bluetooth devices, ELF magnetic fields from net currents, ELF electric fields from electric lamps and wiring close to the bed and office desk. On the one hand, there is strong evidence that long-term-exposure to certain EMF exposures is a risk factor for diseases such as certain cancers, Alzheimer's disease and male infertility. On the other hand, the emerging electromagnetic hypersensitivity (EHS) is more and more recognized by health authorities, disability administrators and case workers, politicians, as well as courts of law. We recommend treating EHS clinically as part of the group of chronic multisystem illnesses (CMI) leading to a functional impairment (EHS), but still recognizing that

European Academy for Environmental Medicine (EUROPAEM) – EMF working group:
***Corresponding author: Gerd Oberfeld,** Department of Public Health, Government of Land Salzburg, Austria, E-mail: gerd.oberfeld@salzburg.gv.at
Igor Belyaev: Cancer Research Institute, Slovak Academy of Science, Bratislava, Slovak Republic; and Prokhorov General Physics Institute, Russian Academy of Science, Moscow, Russia
Amy Dean: American Academy of Environmental Medicine, Wichita, Kansas, USA
Horst Eger: Association of Statutory Health Insurance Physicians of Bavaria, Medical Quality Circle "Electromagnetic Fields in Medicine – Diagnostic, Therapy, Environment", Naila, Germany
Gerhard Hubmann: Center for Holistic Medicine "MEDICUS", Vienna, Austria; and Wiener Internationale Akademie für Ganzheitsmedizin (GAMED), Vienna, Austria
Reinhold Jandrisovits: Medical Association Burgenland, Environmental Medicine Department, Eisenstadt, Austria
Olle Johansson: The Experimental Dermatology Unit, Department of Neuroscience, Karolinska Institute, Stockholm, Sweden
Markus Kern: Medical Quality Circle "Electromagnetic Fields in Medicine – Diagnosis, Treatment and Environment", Kempten, Germany; and Kompetenzinitiative zum Schutz von Mensch, Umwelt u. Demokratie e.V, Kempten, Germany
Michael Kundi and Hanns Moshammer: Institute of Environmental Health, Medical University Vienna, Vienna, Austria
Piero Lercher: Medical Association Vienna, Environmental Medicine Department, Vienna, Austria
Wilhelm Mosgöller: Institute of Cancer Research Medical University Vienna, Vienna, Austria
Kurt Müller: European Academy for Environmental Medicine, Kempten, Germany
Peter Ohnsorge: European Academy for Environmental Medicine, Würzburg, Germany
Peter Pelzmann: Department of electronics and computer science engineering, HTL Danube City, Vienna, Austria
Claus Scheingraber: Working Group Electro-Biology (AEB), Munich, Germany; and Association for Environmental- and Human-Toxicology (DGUHT), Würzburg, Germany
Roby Thill: Association for Environmental Medicine (ALMEN) Beaufort, Luxembourg

the underlying cause remains the environment. In the beginning, EHS symptoms often occur only occasionally, but over time they may increase in frequency and severity. Common EHS symptoms include headaches, concentration difficulties, sleeping problems, depression, lack of energy, fatigue and flu-like symptoms. A comprehensive medical history, which should include all symptoms and their occurrences in spatial and temporal terms and in the context of EMF exposures, is the key to the diagnosis. The EMF exposure can be assessed by asking for typical sources like Wi-Fi access points, routers and clients, cordless and mobile phones and measurements at home and at work. It is very important to take the individual susceptibility into account. The primary method of treatment should mainly focus on the prevention or reduction of EMF exposure, that is, reducing or eliminating all sources of EMF at home and in the workplace. The reduction of EMF exposure should also be extended to public spaces such as schools, hospitals, public transport, and libraries to enable persons with EHS an unhindered use (accessibility measure). If a detrimental EMF exposure is reduced sufficiently, the body has a chance to recover and EHS symptoms will be reduced or even disappear. Many examples have shown that such measures can prove effective. Also the survival rate of children with leukemia depends on ELF magnetic field exposure at home. To increase the effectiveness of the treatment, the broad range of other environmental factors that contribute to the total body burden should also be addressed. Anything that supports a balanced homeostasis will increase a person's resilience against disease and thus against the adverse effects of EMF exposure. There is increasing evidence that EMF exposure has a major impact on the oxidative and nitrosative regulation capacity in affected individuals. This concept also may explain why the level of susceptibility to EMF can change and why the number of symptoms reported in the context of EMF exposures is so large. Based on our current understanding, a treatment approach that minimizes the adverse effects of peroxynitrite – as has been increasingly used in the treatment of multisystem disorders – works best. This EMF Guideline gives an overview of the current knowledge regarding EMF-related health risks and provides concepts for the diagnosis and treatment and accessibility measures of EHS to improve and restore individual health outcomes as well as for the development of strategies for prevention.

Keywords: accessability measures; alternating; Alzheimer's; cancer; chronic multisystem illnesses (CMI); diagnosis; electric; electromagnetic field (EMF); electromagnetic hypersensitivity (EHS); functional impairment; infertility; leukemia; magnetic; medical guideline; nitrosative stress; nonionizing; oxidative stress; peroxynitrite; prevention; radiation; static; therapy; treatment.

Current state of the scientific and political debate from a medical perspective

Introduction

The Environmental Burden of Disease Project assessed the influence of nine environmental stressors (benzene, dioxins including furans and dioxin-like PCBs, secondhand smoke, formaldehyde, lead, noise, ozone, particulate matter and radon) on the health of the population of six countries (Belgium, Finland, France, Germany, Italy, and the Netherlands). Those nine environmental stressors caused 3%–7% of the annual burden of disease in the six European countries (1).

The Bundespsychotherapeutenkammer (BPtK) study in Germany showed that mental disorders had increased further and especially burnout as a reason of inability to work escalated seven-fold from 2004 to 2011 (2). In Germany, 42% of early retirements in 2012 were caused by mental disorders, depression being the leading diagnosis (3). In Germany, psychotropic drugs are at third place for the prescriptions of all drugs (4).

The consumption of methylphenidate (Ritalin, Medikinet, Concerta), a psychotropic drug prescribed as a treatment for attention deficit hyperactivity disorder (ADHD) especially for young children and adolescents, has increased alarmingly since the early 1990s. According to statistics of the German Federal Institute for Drugs and Medical Devices (Bundesinstitut für Arzneimittel und Medizinprodukte), prescriptions have increased even more dramatically since 2000 and reached a climax in 2012. In 2013, only a slight decline in the number of prescriptions was observed (5). Interestingly the rapid increase in the use of methylphenidate coincides with the enormous expansion of mobile telecommunication and other related technologies, posing an open research question.

In Germany, work disability cases and absence days due to mental health disorders more than doubled from 1994 to 2011 (6). In OECD countries, a huge variability in the prescription of antidepressants has occurred and generally an increasing trend has been observed. Socioeconomic status and therapeutic standards cannot fully explain these observations (7). Functional disturbances like chronic inflammation and changes of neurotransmitter functions caused by environmental influences are not investigated.

A steady increase in the prevalence of allergic/asthmatic diseases globally has occurred, with about 30%–40% of the world population now being affected by one or more allergic/asthmatic conditions (8).

It is suspected that environmental conditions such as the increasing exposure of the population to electromagnetic fields (EMFs) like radio-frequency radiation (RF), emanating from e.g. cordless phones (DECT), mobile phone base stations and cell phones (GSM, GPRS, UMTS, LTE) – especially smartphones, data cards for laptop and notebook computers, wireless LAN (Wi-Fi), wireless and powerline communication-based smart meters, but also exposure to extremely low frequency (ELF) electric and magnetic fields including "dirty electricity", emanating from disturbances on the electric wiring, power lines, electric devices, and other equipment, do play a causal role for EMF-related health effects (9–12). For the society and the medical community, all of this raises new challenges.

Chronic diseases and illnesses associated with unspecific symptoms are on the rise. In addition to chronic stress in social and work environments, physical and chemical exposures at home, at work, and during leisure activities are causal or contributing environmental stressors that deserve attention by the general practitioner as well as by all other members of the health care community. It seems certainly necessary now to take "new exposures" like EMF into account.

Worldwide statements of organizations regarding EMF

The recommendations of the World Health Organization (WHO) regarding extremely low frequency (ELF) electric and magnetic fields and radio-frequency radiation, compiled by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (13, 14), are based on inductions of currents in the body and thermal effects (SAR values). These recommendations were adopted by the EU in its Council Recommendation of 1999 without taking into account long-term nonthermal effects. However, it should be stressed that at an international EMF conference in London (2008), Professor Paolo Vecchia, head of ICNIRP, said about the exposure guidelines "What they are not": "They are not mandatory prescriptions for safety", "They are not the 'last word' on the issue", and "They are not defensive walls for industry or others" (15).

Even for short-term effects, the application of specific absorption rate (SAR) estimates seems to be not appropriate (16).

In contrast to the WHO headquarter in Geneva, the International Agency for Research on Cancer (IARC) , a WHO-affiliated specialized agency in Lyon, classified extremely low frequency magnetic fields as possibly carcinogenic to humans (Group 2B) in 2002 (17) and radiofrequency radiation in 2011 (18).

In August 2007 and December 2012, the BioInitiative Working Group, an international group of experts, published comprehensive reports calling for preventive measures against EMF exposure based on the available scientific evidence (9, 10).

Since it is mostly neglected as a health hazard, the European Environment Agency compared the risks of non-ionizing radiation (EMF) to other environmental hazards such as asbestos, benzene and tobacco, urgently recommending to implement a precautionary approach regarding EMF (19). This position was confirmed and elaborated more deeply in further publications in 2011 and 2013 (20, 21).

In September 2008, a statement of the European Parliament called for a review of the EMF limits set out in the EU Council Recommendation of 1999, which was based on the ICNIRP guidelines, with reference to the BioInitiative Report (22). This was further strengthened in the European Parliament resolution of April 2009 (23).

In November, 2009, a scientific panel met in Seletun, Norway, for 3 days of intensive discussion on existing scientific evidence and public health implications of the unprecedented global exposures to artificial electromagnetic fields. Such electromagnetic field exposures (static to 300 GHz) result from the use of electric power and from wireless telecommunications technologies for voice and data transmission, energy, security, military and radar use in weather and transportation.

At the meeting, the Seletun Scientific Panel adopted a Consensus Agreement (24) that recommends preventative and precautionary actions that are warranted now, given the existing evidence for potential global health risks. It recognizes the duty of governments and their health agencies to educate and warn the public, to implement measures balanced in favor of the Precautionary Principle (25), to monitor compliance with directives promoting alternatives to wireless, and to fund research and policy development geared toward prevention of exposures and development of new public safety measures.

The Scientific Panel recognizes that the body of evidence on electromagnetic fields requires a new approach to protection of public health; the growth and development of the fetus, and of children; and argues for strong preventative actions. These conclusions are built upon prior scientific and public health reports documenting the following:

1) Low-intensity (non-thermal) bioeffects and adverse health effects are demonstrated at levels significantly below existing exposure standards.
2) ICNIRP and IEEE/FCC public safety limits are inadequate and obsolete with respect to prolonged, low-intensity exposures.
3) New, biologically-based public exposure standards are urgently needed to protect public health world-wide.
4) It is not in the public interest to wait.

The Panel also strongly recommends that persons with electromagnetic hypersensitivity symptoms (EHS) be classified as functionally impaired in all countries rather than with "idiopathic environmental disease" or similar indistinct categories. This terminology will encourage governments to make adjustments in the living environment to better address social and well-being needs of this subpopulation of highly sensitive members of society, and – as a consequence – protect everyone now as well as in the coming generations from toxic environmental exposures.

It is important to note that numeric limits recommended by the Seletun Scientific Panel, as well as by other bodies of society, do not yet take into account sensitive populations (EHS, immune-compromised, the fetus, developing children, the elderly, people on medications, etc.). Another safety margin is, thus, likely justified further below the numeric limits for EMF exposure recommended by the Panel.

In May 2011, the Parliamentary Assembly of the Council of Europe adopted the report "The potential dangers of electromagnetic fields and their effects on the environment" (26). The Assembly recommended many preventive measures for the member states of the Council of Europe with the aim to protect humans and the environment, especially from high-frequency electromagnetic fields such as: "Take all reasonable measures to reduce exposure to electromagnetic fields, especially to radiofrequencies from mobile phones, and particularly the exposure of children and young people who seem to be most at risk from head tumors" or "Pay particular attention to "electrosensitive" people who suffer from a syndrome of intolerance to electromagnetic fields and introduce special measures to protect them, including the creation of wave-free areas not covered by the wireless network."

Recognizing that patients are being adversely affected by EMF exposure, the American Academy of Environmental Medicine published recommendations regarding EMF exposure in July 2012. The AAEM called for physicians to consider electromagnetic exposure in diagnosis and treatment and recognize that EMF exposure "may be an underlying cause of the patient's disease process" (27).

Since 2014 the Belgium government has prohibited the advertising of cell phones for children under the age of seven and has required the specific absorption rate (SAR) of cell phones be listed. Furthermore, at the point of sale, well-marked warnings must be posted that instruct users to use headsets and to minimize their exposure (28).

In January 2015, the French parliament adopted a comprehensive law that protects the general public from excessive exposure to electromagnetic waves. Among other things, it was passed to ban Wi-Fi in nurseries for children under the age of three and to enable Wi-Fi at primary schools with children under the age of 11 only when used specifically for lessons. Public places offering Wi-Fi must clearly advertise this fact on a sign. At the point of sale of cell phones, the SAR value must be clearly shown. In the future, any cell phone advertisement must include recommendations on how users can reduce RF radiation exposure to the head such as the use of headsets. Data on local EMF exposure levels shall be made more easily accessible to the general public, among others, through country-wide transmitter maps. Also, the French government will have to submit a report on electromagnetic hypersensitivity to the parliament within a year (29).

In May 2015 almost 200 scientists directed an international appeal to United Nations (UN) and WHO and called for protection from nonionizing electromagnetic field exposure. In the appeal the scientifically proven effects on health and the hitherto inadequate international guidelines (ICNIRP) and their use by WHO had been addressed. In addition, various demands were made in nine points, such as that: "the public be fully informed about the potential health risks from electromagnetic energy and taught harm reduction strategies" and "that medical professionals be educated about the biological effects of electromagnetic energy and be provided training on treatment of patients with electromagnetic sensitivity" (30).

Finally, in 2015 Pall (12) published a comprehensive paper with the title "Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action".

EMF and cancer

Except for a few investigations in occupational settings, epidemiological research of EMF started in 1979 when Wertheimer and Leeper published their study about the relationship between the proximity to so-called power line poles with "service drop" wires and the occurrence of childhood cancer (specifically leukemia and brain tumors) (31). At the same time Robinette et al. studied mortality in a cohort of Korean War veterans having been trained on military radars in the early 1950s (32). Both studies found indications of increased risks and initiated a new era of studying health-relevant effects from exposure to EMFs.

In the following years, a large number of investigations about the relationship between childhood leukemia and extremely low frequency magnetic fields (ELF MF) have been published. However, the results seemed inconsistent until in 2000 two pooled analyses (33, 34) were conducted, providing little indication of inconsistency and demonstrating an increase of leukemia risk with increasing average exposure levels that was significant for levels above 0.3 or 0.4 µT relative to averages below 0.1 µT but without indication of a threshold. Based on these findings, the International Agency for Research on Cancer (IARC) classified ELF MF in 2002 as a Group 2B (possible) carcinogen (17). To this category belong e.g. lead, DDT, welding fumes, and carbon tetrachloride.

Since then additional epidemiological studies have been conducted that gave essentially the same results (35, 36). In a review on childhood leukemia and ELF MF, Kundi concluded that there is sufficient evidence from epidemiological studies of an increased risk for childhood leukemia from exposure to power-frequency MF that cannot be attributed to chance, bias, or confounding. Therefore, according to the rules of IARC, such exposures ought to be classified as a Group 1 (definite) carcinogen (10).

The prognosis of certain diseases can be influenced by EMF-reduction. For example, children who have leukemia and are in recovery have poorer survival rates if their ELF magnetic field exposure at home (or where they are recovering) is between 1 mG [0.1 µT] and 2 mG [0.2 µT] or above 2 mG [0.2 µT] in one study, over 3 mG [0.3 µT] in another study (9).

Epidemiological studies of radio-frequency fields before the general rise in exposure to mobile telecommunication networks was quite restricted and only a few studies had been conducted in the vicinity of radio transmitters, radar stations, other occupational exposures, a in radio amateurs. After the introduction of digital mobile telephony, the number of users of mobile phones increased dramatically and it was recommended in the 1990s to perform epidemiological studies with a focus on intracranial tumors. Since the first publication in 1999 by the Swedish group around Prof. Lennart Hardell (37), about 40 studies have been published. The majority of these studies investigated brain tumors, but also salivary gland tumors, uveal melanoma, nerve sheath tumors, testicular cancer, and lymphoma. Many of these studies are inconclusive because of too short exposure durations; however, two series of investigations, the international Interphone study conducted in 13 countries and the Swedish studies of the Hardell group, had a significant proportion of long-term mobile phone users and could in principle be used for risk assessment. In 2011, IARC classified radio-frequency electromagnetic fields (RF) as a Group 2B carcinogen based on evidence from epidemiological studies and animal experiments (18). Since then, additional studies have corroborated the assumption of a causal relationship between mobile phone use and cancer (38–40). Hardell and Carlberg (41) concluded that RF-EMF ought to be classified as a definitive human carcinogen (IARC Group 1). The evidence for a causal relationship between long-term mobile and cordless phone use and the risk for glioma has increased further in 2015 (42).

In Italy, the Supreme Court upheld a ruling in October 2012 for an 80% disability rating and permanent disability pension due to a tumor, which was causally connected with the occupation-related heavy use of cell and cordless phones (43).

EMF and neurodegeneration

Neurological effects are caused by changes in the nervous system, including direct damage (neurodegeneration) to nerve cells and their processes, the axons and dendrites, as well as their terminal common functional entities, the synapses with their receptors, ion channels and comodulators. Factors that act directly or indirectly on the nervous system causing morphological, chemical, and/or electrical changes in the nervous system can lead to neurological alterations. The final manifestation of these effects can be seen in neurocognitive changes, e.g. memory, learning and perception, as well as in primary sensory and motor incapacities.

The nervous system is an electrical organ based on a very complex chemistry. Thus, it should not be surprising that exposure to electromagnetic fields could lead to neurodegeneration and concomitant or consecutive neurological changes. Morphological, chemical, electrical, and behavioral changes have been reported in animals, cells and tissues after exposure to electromagnetic fields across a range of frequencies.

The consequences of physiological changes in the nervous system are very difficult to assess. We do not fully understand how the nervous system functions and reacts to external perturbations. The neuronal plasticity of the nervous system could compensate for external disturbances, at least to a certain degree. On the other hand, the consequence of neural perturbation is also situation-dependent. An EMF-induced severe change in brain performance, for instance, could lead to different consequences depending on whether a person is sitting in a sofa watching TV or driving a car. The latter could very well end dramatically, even fatally.

It should be noted that analyses of the recent neurological literature show that there are more publications showing effects than no effects. So the question is not if EMFs cause effects, but rather how serious they will be for a given person.

Neurological effects of radio-frequency radiation (RFR)

There are many studies on human subjects. Many of the published papers are on changes in brain electrical activities, the EEG, as well as impacts on sleep, after acute exposure to cell phone radiation.

Bak et al. (44) reported effects on event-related potentials. Maganioti et al. (45) further reported that RFR affected the gender-specific components of event-related potentials [see also Hountala et al. (46)]. Croft et al. (47) reported changes of the alpha wave power in the EEG. The same authors (48) further reported that effects differed between various new cell phone transmission systems, which have different signaling characteristics. They observed effects after exposure to second generation (2G), but not third generation (3G) radiation, whereas Leung et al. (49) found similar EEG effects with both 2G and 3G types of radiation. Lustenberger et al. (50) found increased slow-wave activity in humans during exposure to pulse-modulated RF EMF toward the end of the sleep period. Vecchio and associates reported that cell phone RFR affected EEG and the spread of neural synchronization conveyed by interhemispherical functional coupling of EEG rhythms (51) and enhanced human cortical neural efficiency (52). An interesting finding is that RFR could interact with the activity of brain epileptic foci in epileptic patients (53, 54). However, no significant effect on EEG was reported by Perentos et al. (55) or Trunk et al. (56). And Kleinlogel et al. (57, 58) also reported no significant effects on resting EEG and event-related potentials in humans after exposure to cell phone RFR. Furthermore, Krause et al. (59) reported no significant effect of cell phone radiation on brain oscillatory activity, and Inomata-Terada et al. (60) concluded that cell phone radiation does not affect the electrical activity of the motor cortex.

There are studies on the interaction of cell phone radiation on EEG during sleep. Changes in sleep EEG have been reported by Hung et al. (61), Regel et al. (62), Lowden et al. (63), Schmid et al. (64, 65), and Loughran et al. (66), whereas no significant effect was reported by Fritzer et al. (67), Mohler et al. (68, 69) and Nakatani-Enomoto et al. (70). Loughran et al. (66) provided an interesting conclusion in their paper: "These results confirm previous findings of mobile phone-like emissions affecting the EEG during non-REM sleep". Importantly, this low-level effect was also shown to be sensitive to individual variability. Furthermore, this indicates that "previous negative results are not strong evidence for a lack of an effect…" Increase in REM sleep was reported by Pelletier et al. (71) in developing rats after chronic exposure. Mohammed et al. (72) reported a disturbance in REM sleep EEG in the rat after long term exposure (1 h/day for 1 month) to a 900-MHz modulated RFR. A Swiss Study revealed that, under pulse-modulated radiofrequency electromagnetic field exposure, sleep slow-wave activity is increased and – fitting to that – the sleep-dependent performance improvement is decreased (50).

Among the very many effects reported in the ever increasing number of scientific papers are also reduction in behavioral arousal, sleep latency alterations, effects on cognitive functions and EEG, on spatial working memory, on well-being, influences on overall behavioral problems in adolescents, alteration of thermal pain threshold and visual discrimination threshold, respectively, induced hyperactivity, hypoactivity and impaired memory, respectively, contextual emotional behavior deficit, olfactory and/or visual memory deficit, impact on food collection behavior (in ants), decreased motor activity, learning behavior deficit, induction of stress behavioral patterns, passive avoidance deficit, and reduced memory functions.

Almost all the animal studies reported effects, whereas more human studies reported no effects than effects. This may be caused by several possible factors: (a) Humans are less susceptible to the effects of RFR than are rodents and other species. (b) Non-thermal effects of RFR depend on a number of physical and biological parameters (73). The same exposure can induce effects in certain biological species while being ineffective in others. IARC also admits that some of the discrepancies between RFR studies could be due to differences in species [(18), p. 416]. (c) It may be more difficult to do human than animal experiments, since, in general, it is easier to control the variables and confounding factors in an animal experiment. (d) In the animal studies, the cumulative exposure duration was generally longer and studies were carried out after exposure, whereas in the human studies, the exposure was generally at one time and testing was done during exposure. This raises the question of whether the effects of RFR are cumulative. This consideration could have very important implications on real-life human exposure to EMF. However, it must be pointed out that neurophysiological and behavioral changes have been reported in both animals and humans after acute (one-time) exposure to RFR, and most of the EEG studies mentioned above are acute exposure experiments.

Neurological effects of extremely low frequency electromagnetic fields (ELF-EMF)

A number of authors have reported effects of ELF-EMF on various animal transmitter receptors in the brain such as NMDA receptors, dopamine and serotonin receptors, including the 5HT(2A) subtype of serotonin receptors. The latter is classically, particularly in the frontal cortex, believed to be related to the psychiatric syndromes of depression in humans. Kitaoka et al. (74) and Szemerszky et al. (75) did report depression-like behavior in both mice and rats, after chronic exposure to ELF magnetic fields. There are two reports on dopamine receptors. Shin et al. (76, 77) reported an increase in D-1 dopamine receptors and activity in the striatum of the rat after ELF magnetic field exposure. Dopamine in the striatum is, of course, involved in Parkinson's disease. Wang et al. (78) reported that ELF magnetic fields potentiated morphine-induced decrease in D-2 dopamine receptors. Both D-1 and D-2 dopamine receptors in the brain are involved in depression and drug addiction. Ravera et al. (79) reported changes in the enzyme acetylcholinesterase in cell membrane isolated from the cerebellum after ELF magnetic field exposure. Interestingly, these researchers also reported "frequency window" effects in their experiment. Window effects, i.e. effects are observed at a certain range(s) of EMF frequencies or intensities, were first reported by Ross Adey, Susan Bawin, and Carl Blackman in the 1980s. A study by Fournier et al. (80) reported an 'intensity window' effect of ELF magnetic field on neurodevelopment in the rat. The cholinergic systems in the brain play a major role in learning and memory functions.

Behavioral effects of ELF-EMF have been further substantiated in recent research. These include: changes in locomotor activity (76, 77, 81–86), learning and memory functions (80, 87–95), anxiety (81, 93, 96–98), depression-like behavior (74, 75), perception (99), cognitive dysfunction (100), emotional state (101), sleep onset (61), and comb building in hornets (102). As different behavioral effects have been observed in different exposure conditions, species of animals, and testing paradigms, they provide the strongest evidence that exposure to ELF-EMF can affect the nervous system.

The possible medical applications of ELF-EMF should also be given more attention. Several studies indicate that ELF-EMF (however, mostly at high exposure levels) could enhance recovery of functions after nervous system damage and have protective effects against development of neurodegenerative diseases. The majority of the studies used magnetic fields above 0.1 mT (1 gauss; the highest was 8 mT). The intensities are much higher than those in the public environment. Thus, caution should be taken in extrapolating the high-intensity cell and animal studies to long-term environmental human exposure situations.

In addition, however, there are studies at low or very low magnetic field exposure levels. Humans are sensitive to magnetic fields at levels <1 μT. A study by Ross et al. (99) showed "perception" alteration in human subjects exposed to a magnetic field at 10 nT (0.00001 mT), a study by Fournier et al. (80) showed an effect on brain development in the rat at 30 nT (0.00003 mT), and a study by Stevens (101) indicated changes in emotional states in humans exposed to 8–12 Hz magnetic fields at 5 μT (0.005 mT). These data do suggest magnetic fields at very low intensities could cause neurological effects in humans. In the 1990s, there was a series of more than 20 studies published by Reuven Sandyk, showing that pulsed magnetic fields at picotesla levels (1 pT=0.000000001 mT) could have therapeutic effects on Parkinson's disease and multiple sclerosis [see e.g. (103)]. However, Sandyk's findings have never been independently confirmed.

The above mentioned therapeutic applications of EMF elicit that different EMF-exposures have biological effects under certain conditions for short-term use.

Alzheimer's disease

Amyloid beta (Aβ) protein is generally considered the primary neurotoxic agent causally associated with Alzheimer's disease. Aβ is produced by both brain and peripheral cells and can pass through the blood brain barrier.

The BioInitiative review 2012 (10) summarized the evidence concerning Alzheimer's disease as follows:

1) There is longitudinal epidemiologic evidence that high peripheral blood levels of Aβ, particularly Aβ1-42, are a risk factor for Alzheimer's disease.
2) There is epidemiologic evidence that extremely low frequency (ELF, 50–60 Hz) magnetic field (MF) exposure upregulates peripheral blood levels of Aβ.

3) There is evidence that melatonin can inhibit the development of Alzheimer's disease and, thus, low melatonin levels may increase the risk of Alzheimer's disease.
4) There is strong epidemiologic evidence that significant (i.e. high), occupational ELF-MF exposure can lead to the downregulation of melatonin production. The precise components of the magnetic fields causing this downregulation are unknown. Other factors which may influence the relationship between ELF-MF exposure and melatonin production are unknown, but certain medications may play a role.
5) There is strong epidemiologic evidence that high occupational ELF MF exposure is a risk factor for Alzheimer's disease, based on case-control studies which used expert diagnoses and a restrictive classification of ELFMF exposure.
6) There are only single epidemiologic studies of Alzheimer's disease and radio-frequency electromagnetic field exposure, and only one epidemiology study of non-acute radio-frequency electromagnetic field exposure and melatonin. So, no final conclusions concerning health consequences due to RF exposure and Alzheimer's disease are currently possible.

Hallberg and Johansson (104) demonstrated that the mortality in Alzheimer's disease appears to be associated with mobile phone output power. Deeper studies in this complex area are still necessary.

There is epidemiological evidence that also residential exposure to ELF magnetic fields is associated with an increased risk for Alzheimer's disease (105, 106).

Earlier reviews of the association between exposure to ELF MF and neurodegenerative diseases came to different conclusions (107, 108). The discrepancy is mainly due to two aspects: the assessment of a possible publication bias and the selection and classification of exposed groups. Since most studies are about occupational exposure, it is mandatory to avoid misclassification. If care is taken to avoid such ambiguity, there is a clear meta-analytical relationship and an increased risk for Alzheimer's disease and amyotrophic lateral sclerosis (ALS). This association shows little heterogeneity across studies if the different methodologies are considered and publication bias has been detected for studies relying on mortality registries only (109).

EMF and infertility and reproduction

Infertility and reproduction disorders are on the rise. The BioInitiative review 2012 (10) summarized the evidence concerning infertility and reproduction as follows – with small adaptations by the authors:

Human sperm are damaged by cell phone radiation at very low intensities, in the low microwatt and nanowatt per cm^2 range ($0.00034–0.07\ \mu W/cm^2 = 3.4–700\ \mu W/m^2$). There is a veritable flood of new studies reporting sperm damage in humans and animals, leading to substantial concerns for fertility, reproduction, and health of the offspring (unrepaired de novo mutations in sperm). Exposure levels are similar to those resulting from wearing a cell phone on the belt or in a pants pocket, or from using a wireless laptop computer on the lap. Sperm lack the ability to repair DNA damage.

Several international laboratories have replicated studies showing adverse effects on sperm quality, motility, and pathology in men who use cell phones and particularly those who wear a cell phone, PDA, or pager on their belt or in a pocket (110–115). Other studies conclude that the use of cell phones, exposure to cell phone radiation, or storage of a cell phone close to the testes of human males affect the sperm count, motility, viability, and structure (110, 116, 117). Animal studies have demonstrated oxidative and DNA damage, pathological changes in the testes of animals, decreased sperm mobility and viability, and other measures of deleterious damage to the male germ line (118–122).

There are fewer animal studies that have studied effects of cell phone radiation on female fertility parameters. Panagopoulos (123) report decreased ovarian development and size of ovaries, and premature cell death of ovarian follicles and nurse cells in *Drosophila melanogaster*. Gul et al. (124) report rats exposed to standby level RFR (phones on but not transmitting calls) caused decrease in the number of ovarian follicles in pups born to these exposed dams. Magras and Xenos (125) reported irreversible infertility in mice after five (5) generations of exposure to RFR at cell phone tower exposure levels of less than one microwatt per centimeter squared ($<1\ \mu W/cm^2 = <10\ mW/m^2$).

Electromagnetic hypersensitivity (EHS)

An increasing number of human beings are continuously exposed in their daily life to increasing levels of a combination of static, ELF and VLF electric and magnetic fields and RF electromagnetic fields. These exposures are of different signal patterns, intensities, and technical applications for varying periods of time. All these fields are summarized as EMF, colloquially referred to as "electrosmog".

In a questionnaire survey in Switzerland in 2001, which was addressed to persons attributing specific health problems to EMF exposure, of the 394 respondents 58% suffered from sleep problems or disorders, 41% from headaches, 19% from nervousness, 18% from fatigue and 16% from difficulties with concentration. The respondents attributed their symptoms, e.g. to mobile phone base stations (74%), cell phones (36%), cordless phones (29%), and high-voltage power lines (27%). Two thirds of the respondents had taken measures to reduce their symptoms, the most frequent one being to avoid exposure (126).

In a survey conducted 2009 in a Japanese EHS and multiple chemical sensitivity (MCS) self-help group (n=75), 45% of the respondents had EHS as a medical diagnosis, 49% considered themselves EHS. Every second responder had medically diagnosed MCS (49%) and self-diagnosed MCS had 27%. The main EHS-related symptoms were fatigue (85%), headache (81%), concentration problems (81%), sleeping disorders (76%) and dizziness (64%). The most frequent causes include: base stations (71%), other persons mobile phones (64%), PC (63%), power lines (60%), television (56%), own mobile phone (56%), public transportation (55%) , cordless phones (52%), air conditioner (49%) and car (49%). Suspected EMF source of EHS onset were: mobile phone base stations (37%), PC (20%), electric home appliances (15%), medical equipment (15%), mobile phones (8%), power lines (7%) and induction cookers (7 %) (127).

In 2001, 63 persons who attributed health problems to environmental exposure were counseled in an interdisciplinary environmental medicine pilot project in Basel. An interdisciplinary expert team assessed the individual symptoms by a medical psychological-psychiatric and environmental examination, including visits and environmental measurements at home. With respect to the 25 persons with EHS, the expert team attested that in one third of them, at least one symptom was plausibly related to electrosmog, although the EMF exposure was within the Swiss limits. They concluded that persons with EHS should be advised interdisciplinary, not only medically and psychologically but also environmentally (128, 129).

A representative telephone survey (n=2048; age >14 years) carried out in 2004 in Switzerland yielded a frequency of 5% (95% CI 4%–6%) for having symptoms attributed to electrosmog, so-called electromagnetic hypersensitivity. Remarkably, only 13% consulted their family doctor. Individuals with a past history of symptoms attributable to EMF gave "turned off the source" as the answer three times as often as the ones who still had symptoms (130).

In a Swiss questionnaire study of GPs in 2005, two-thirds of the doctors were consulted at least once a year because of symptoms attributed to EMF. Fifty-four percent of the doctors assessed a relation as possible. The doctors in this questionnaire asked for more general information about EMF and health and instructions on how to deal with persons with EHS (131).

In another questionnaire study, also mandated by the Swiss Federal Government and performed by the University of Bern in 2004, Swiss doctors working with complementary diagnostic and therapeutic tools reported that 71% of their consultations related to EMF. Remarkably, not only the patients, but even more so the doctors suspected a possible relation between illness and EMF. The reduction or elimination of environmental sources was the main therapeutic instrument in treating symptoms related to EMF (132).

A questionnaire study of Austrian doctors yielded similar results. In this study, the discrepancy between the physicians' opinions and established national and international health risk assessments was remarkable, considering that 96% of the physicians believed to some degree in or were totally convinced of a health-relevant role of environmental electromagnetic fields (133).

The question, whether EHS is causally associated with EMF exposure remains controversial. On the one hand, physicians judge a causal association between EMF exposures as plausible based on case reports, on the other hand, national and international health risk assessments mostly claim that there is no such causal association, because provocation studies under controlled blinded conditions mostly failed to show effects. However, all these studies used a very limited number of exposure conditions, the exposure duration and the examined effects were short, and the recruitment of the persons with EHS was not medically assessed.

The WHO, for example, does not consider EHS as a diagnosis and recommends to medical doctors that the treatment of affected individuals should focus on the health symptoms and the clinical picture, and not on a person's perceived need for reducing or eliminating EMF in the workplace or home (134).

The evaluation report about electromagnetic hypersensitivity mandated by the Swiss federal government assessed the evidence of a causal relationship between EMF exposure and biological and health effects. It took into account not only experimental, observational studies and meta-analyses, but also individual experiments and case reports. For the evaluation of the scientific evidence, the GRADE criteria were applied. Individual case reports were considered to be of great importance because it is likely that, at the same exposure level, not all people react the same as rare cases may be misunderstood by otherwise statistically reliable scientific methods of investigation, and since habituation and sensitization processes of a person's reaction can change during the time of exposure. The significance of case reports with regard to scientific evidence based on the strict GRADE criteria used in this evaluation, however, was considered to be limited, mainly because of the distortion due to methodological flaws. It was noted in the report that individual case experiments with repeated testing of an EHS person under double-blind conditions and controlled exposure would be more revealing than experimental studies with larger groups. Ideally, a test of the person concerned should be carried out in their familiar surroundings (e.g. at home) with a reliable and accurate measurement of exposure. With positive test results, a re-evaluation would be required also from a scientific perspective (135).

The paper "Electromagnetic hypersensitivity: fact or fiction" by Genius and Lipp (136) offers an instructive review of studies of the last decades concerning EHS, including historical milestones, reviews, pathogenesis, biochemical markers, therapeutic management, as well as the debate about the legitimacy of EHS.

In Sweden, EHS is an officially fully recognized functional impairment (i.e. it is not regarded as a disease). Survey studies show that somewhere between 230,000 and 290,000 Swedish men and women out of a population of 9,000,000 – report a variety of symptoms when being in contact with EMF sources. With reference to UN Resolution 48/96, Annex, of 20 December 1993, the Swedish government grants support to individuals with EHS. Employees with EHS have a right to support from their employers so as to enable them to work despite this impairment. Some hospitals in Sweden provide rooms with low-EMF exposure (137).

In Sweden, impairments are viewed from the point of the environment. No human being is in itself impaired; there are instead shortcomings in the environment that cause the impairment (as with the lack of ramps for the person in a wheelchair or rooms requiring low-EMF remediation for the person with EHS). Furthermore, this environment-related perspective of the impairment EHS means that – even though we do not have a complete scientific explanation, and, in contrast, to what many individuals involved in the EMF discourse at present think – any person with EHS shall always be met in a respectful way and with all necessary support required to eliminate the impairment. This implies that the person with EHS shall have the opportunity to live and work in a low-EMF environment (138).

In Sweden, the City of Stockholm offers low-EMF housing on its outskirts to electrosensitive individuals. In France, the first low-EMF zone has been established at Drôme in July 2009 (139). In Austria, the construction of a multi-family house has been planned for 2015, which was designed by a team of architects, building biology professionals, and environmental medicine health care professionals to provide a sustainable healthy living environment. Both the outdoor and indoor environments were explicitly chosen and designed to meet low-EMF requirements (140). The implementation of low-EMF zones for electrosensitive individuals is pursued in numerous countries. The realization of such projects greatly depends on the understanding, knowledge, and tolerance of the members of the chosen community.

In a human provocation study, Johansson (141), using a controlled, double-blind pilot setup, found one EHS person that correctly identified the presence of a mobile phone nine times out of nine provocations ($p<0.002$), both in the "acute" phase as well as in the "chronic" phase ($p<0.001$).

In facial skin samples of electrohypersensitive persons, the most common finding has been a profound increase of mast cells (142). From this and other studies, it is clear that the number of mast cells in the upper dermis is increased in the EHS group. A different pattern of mast cell distribution also occurred in the EHS group. Finally, in the EHS group, the cytoplasmic granules were more densely distributed and more strongly stained than in the control group, and the size of the infiltrating mast cells was generally found to be larger in the EHS group as well. It should be noted that increases of similar nature later on were demonstrated in an experimental situation, employing normal healthy volunteers in front of cathode ray tube (CRT) monitors, including ordinary household television sets (143).

In one of the early papers, Johansson et al. (144) made a sensational finding when they exposed two electrically sensitive individuals to a TV monitor situated at a distance of 40–50 cm away from them. The scientists used an open-field provocation in front of an ordinary TV set with persons regarding themselves as suffering from skin problems due to work at video display terminals. Employing fluorescence microscopy-based immunohistochemistry, in combination with a wide range of antisera directed towards cellular and neurochemical markers, they were able to show a high to very high number of somatostatin-immunoreactive dendritic cells as well as histamine-positive mast cells in skin biopsies from the anterior neck taken before the start of the provocation. At the end of the provocation, however the number of mast cells was unchanged and the somatostatin-positive cells had seemingly disappeared. The reason for this latter finding could be discussed in terms of loss of immunoreactivity, increase of breakdown, etc. The high number of mast cells present may explain the clinical symptoms of itch, pain, edema, and erythema.

Against this background, it is interesting to see that the early Swedish findings from the 1980s and 1990s are supported by the latest work of Belpomme and Irigaray (145). Since 2009, Belpomme and Irigaray prospectively investigated clinically and biologically 1200 consecutive EHS and/or MCS-self reported cases in an attempt to establish objective diagnosis criteria and to elucidate the pathophysiological aspects of these two disorders.

In their preliminary results, as presented at the Fifth Paris Appeal Congress in Belgium in 2015 – based on the analysis of 839 originally enrolled cases of which 810 met the inclusion criteria and 727 were evaluable – 521 were diagnosed with EHS, 52 with MCS, and 154 with both EHS and MCS. Concomitant multiple food intolerance was found in 28.5%, 41.9%, and 70.4% of the cases in the three groups, respectively. Histamine levels were analyzed in the blood of patients, and 37%, 36.7% and 41.5% of the persons respectively in the three above individualized groups showed a significant increase in histaminemia (>10 nmol/L), meaning that a chronic inflammatory response can be detected in these patients.

They also measured nitrotyrosin (NTT), a marker of both peroxynitrite (ONOO.-) production and opening of the blood brain barrier (BBB). NTT was increased in the blood (>0.90 µg/mL) in 29.7%, 26%, and 28% of the cases in the three groups, respectively. Likewise protein S100B, another marker of BBB opening was found to be increased in the blood (>0.105 µg/L) in 14.7%, 19.7%, and 10.7% of their cases, respectively. Circulating antibodies against O-myelin, heat shock protein (Hsp) 27, and/or Hsp 70 protein were also found to be increased in 43.1%, 25%, and 52% of their cases, respectively, indicating that EHS and MCS are associated with some autoimmune response. Since most patients reported chronic insomnia and fatigue, they also determined the 24-h urine melatonin/creatinine ratio and found it was decreased (<0.8) in all investigated cases.

Finally, in order to gain further information about the underlying mechanisms of EHS and MCS, they serially measured the brain blood flow in the temporal lobes of each patient by using pulsed brain echodoppler. They found that both EHS and MCS were associated with a hypoperfusion in the capsulo-thalamic area of the brain, suggesting that the inflammatory process may in fact involve the limbic system and the thalamus. Both EHS and MCS thus appear to paint a common picture of inflammation-related hyper-histaminemia, oxidative stress, autoimmune response, and BBB opening, and a deficit in melatonin excretion. According to Belpomme and Irigaray, EHS and MCS probably share a common pathological mechanism mainly involving the central nervous system (145).

While a 2006 study by Regel et al. (146) described no exposure effects, two provocation studies on exposure of "electrosensitive" individuals and control subjects to mobile phone base station signals (GSM, UMTS or both) found a significant decline in well-being after UMTS exposure in the individuals reporting sensitivity (147, 148). Most so-called provocation studies with EHS show no effects. However, all these studies used a very limited number of exposure conditions. Taking in account the strong dependence of EMF effects on a variety of physical and biological variables (73), available provocation studies are scientifically difficult to interpret and, in fact, are not suitable to disprove causality.

There is increasing evidence in the scientific literature of various subjective and objective physiological alterations, e.g. heart-rate variability (HRV) as apparent in some persons with EHS claiming to suffer after exposure to certain frequencies of EMR like DECT or Wi-Fi (149–153).

Analysis of the data available on the exposure of people living near mobile phone base stations has yielded clear indications of adverse health effects like fatigue, depression, difficulty in concentrating, headaches, dizziness, etc. (154–158).

The frequency spectrum between ELF and RF is referred as kHz range or intermediate frequency range. Residential exposures in this range are often due to "dirty power"/ "dirty electricity" originating from voltage and/or current perturbations from diverse sources like electronic power supplies for TVs, monitors, PCs, motor drives, inverters, dimmers, CFLs, phase-angle control devices, as well as sparking and arcing from switching operations and from electric motors with brushes. The kHz waves/transients travel along the electric wiring and grounding systems (conducted emissions) and radiate electric and/or magnetic fields into free space (radiated emissions), leading to human exposures in the vicinity.

Epidemiological evidence links dirty electricity to most of the diseases of civilization including cancer, cardiovascular disease, diabetes, suicide, and attention deficit hyperactivity disorder in humans (159).

When it comes to health effects of static magnetic fields, this type of EMF exposure is frequently underestimated. Blackman reports in the 2007 BioInitiative Report (9): "The magnetic field of the earth at any given location has a relatively constant intensity as a function of time. However, the intensity value, and the inclination of the field with respect to the gravity vector, varies considerable over the face of the earth. More locally, these features of the earth's magnetic field can also vary by more than 20% inside man-made structures, particularly those with steel support structures. There are many reports of EMF-caused effects being dependent on the static magnetic field intensity (cf. Blackman et al., 1985) and of its orientation, with respect to an oscillating magnetic field (Blackman et al., 1990; Blackman et al., 1996). One aspect common to many of these reports is that the location in the active frequency band is determined by the intensity of the static magnetic field. There have been many attempts to explain this phenomenon but none has been universally accepted. However, it is clear that if a biological response depends on the static magnetic field intensity, and even its orientation with respect to an oscillating field, then the conditions necessary to reproduce the phenomenon are very specific and might easily escape detection (cf. Blackman and Most, 1993). The consequences of these results are that there may be exposure situations that are truly detrimental (or beneficial) to organisms but that are insufficiently common on a large scale that they would not be observed in epidemiological studies; they need to be studied under controlled laboratory conditions to determine impact on health and wellbeing".

On July 8, 2015, a court in Toulouse, France, ruled in favor of a woman with the diagnosis "syndrome of hypersensitivity to electromagnetic radiation" and determined her disability to be 85% with substantial and lasting restrictions on access to employment (160).

Possible mechanism of EHS

Based on the scientific literature on interactions of EMF with biological systems, several mechanisms of interaction are possible. A plausible mechanism at the intracellular and intercellular level, for instance, is an interaction via the formation of free radicals or oxidative and nitrosative stress (161–169). A review by Pall (12, 170, 171) provides substantial evidence for a direct interaction between static and time varying electric fields, static and time varying magnetic fields and electromagnetic radiation with voltage-gated calcium channels (VGCCs). The increased intracellular Ca^{2+} produced by such VGCC activation may lead to multiple regulatory responses, including increased nitric oxide levels produced through the action of the two Ca^{2+}/calmodulin-dependent nitric oxide synthases, nNOS and eNOS. In most pathophysiological contexts, nitric oxide reacts with superoxide to form peroxynitrite, a potent nonradical oxidant, which can produce radical products, including hydroxyl and NO_2 radicals.

Peroxynitrite is by far the most damaging molecule in our body. Although not a free radical in nature, peroxynitrite is much more reactive than its parent molecules NO and O_{2^-}. The half-life of peroxynitrite is short (10–20 ms), but sufficiently long to cross biological membranes, diffuse one to two cell diameters, and allow significant interactions with most critical biomolecules and structures (cell membranes, nucleus DNA, mitochondrial DNA, cell organelles), and a large number of essential metabolic processes (165). Elevated nitrogen monoxide, formation of peroxynitrite, and induction of oxidative stress can be associated with chronic inflammation, damage of mitochondrial function and structure, as well as loss of energy, e.g. via the reduction of adenosine triphosphate (ATP).

The importance of ATP has been shown for CFS (172) and for stress control (173). Those patients describe the same symptoms as those suffering from CMI. This could indicate similarities in the pathomechanisms. Similar disturbances in neurotransmitter expression had been described both with chronic exposure to EMF (174) and in CMI patients (163, 175).

Redmayne and Johansson (176) published a review considering the evidence for an association between myelin integrity and exposure to low-intensity radiofrequency electromagnetic fields (RF-EMFs) typical in the modern world, pointing to that RF-EMF-exposed animals/humans show: 1) significant morphological lesions in the myelin sheath of rats; 2) a greater risk of multiple sclerosis in a study subgroup; 3) effects in proteins related to myelin production; and 4) physical symptoms in individuals with the functional impairment electrohypersensitivity, many of which are the same as if myelin were affected by RF-EMF exposure, giving rise to symptoms of demyelination. In the latter, there are exceptions; headache is common only in electrohypersensitivity, while ataxia is typical of demyelination but infrequently found in the former group. Overall, evidence from in vivo and in vitro and epidemiological studies suggests an association between RF-EMF exposure and either myelin deterioration or a direct impact on neuronal conduction, which may account for many electrohypersensitivity symptoms. The most vulnerable are likely to be those in utero through to at least mid-teen years, as well as ill and elderly individuals.

Complaints in chronic fatigue syndrome (CFS), fibromyalgia (FM), multiple chemical sensitivity (MCS), posttraumatic stress disorder (PTSD) and Gulf War syndrome (GWS) are almost the same. But the cardinal symptoms are different. Meanwhile, they are summarized as chronic multisystem illnesses (CMI) (175). In all of them, various disturbances of functional cycles have been shown as activation of nitrogen oxide and peroxynitrite, chronic inflammation by activation of NF-kB, IFN-y, IL-1, IL-6, and interaction with neurotransmitter expression (163, 175, 177). We recommend classifying EHS as part of CMI (170, 178) leading to a functional impairment (EHS), but still recognizing that the underlying cause remains only the environment (see Figure 1).

Other diseases that require attention with respect to EMF

There is some evidence that transient electromagnetic fields (dirty electricity), in the kilohertz range on electrical wiring, may be contributing to elevated blood sugar levels among diabetics and pre-diabetics. In an electromagnetically clean environment, Type 1 diabetics required less insulin and Type 2 diabetics had lower levels of plasma glucose. Dirty electricity, generated by electronic equipment and wireless devices, is ubiquitous in the environment. Exercise on a treadmill, which produced dirty electricity, increased plasma glucose. These findings may explain why brittle diabetics have difficulty regulating blood sugar. Based on estimates of people who suffer from symptoms of electrohypersensitivity (3%–35%), as many as 5–60 million diabetics worldwide may be affected (179).

The Bioinitiative Report 2012 (10) concluded: Fetal (in-utero) and early childhood exposures to cell phone radiation and wireless technologies in general may be a risk factor for hyperactivity, learning disorders and behavioral problems in school. Common sense measures to limit both ELF-EMF and RF EMF in these populations is needed, especially with respect to avoidable exposures like incubators that can be modified; and where education of the pregnant mother with respect to laptop computers, mobile phones and other sources of ELF-EMF and RF EMF are easily instituted.

This section deserves special attention in order to respond timely to the rapid technological development leading to more and more complex EMF exposures.

Recommendations for action

EUROPAEM has developed guidelines for differential diagnosis and potential treatment of EMF-related health problems with the aim to improve/restore individual health outcomes and to propose strategies for prevention.

Evidence of treatment strategies for EMF-related illness including EHS

There are only a few studies assessing evidence-based therapeutic approaches to EHS. The interdisciplinary based assessing and counseling of EHS in the Swiss environmental pilot project performed in 2001 showed in an evaluation interview half a year after counseling, that 45% of persons with EHS had benefitted from realizing certain advice, for example, changing the bedroom (128, 129).

In the 2005 Swiss questionnaire study of physicians working with complementary therapeutic tools, two-thirds chose exposure reduction as a principal tool,

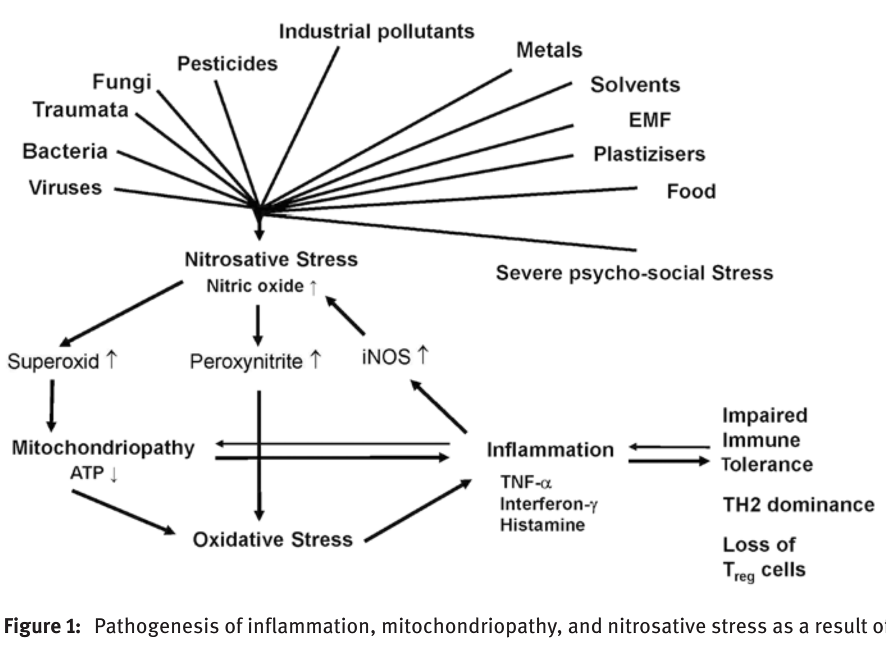

Figure 1: Pathogenesis of inflammation, mitochondriopathy, and nitrosative stress as a result of the exposure to trigger factors (177).

whereas complementary therapeutics were only chosen as a supplement (132).

Since 2008, the Swiss Society of Doctors for the Environment has run a small interdisciplinary environmental medicine counseling structure for persons with EHS, which is embedded in everyday practice with a central coordination and consultation office as well as a network of general practitioners interested in environmental medicine who perform environmental medical assessments and consultations based on a standard protocol. If necessary, environmental experts are consulted and home inspections are conducted. The aim of the assessments is to detect or rule out common diseases and to analyze the impact of suspected environmental burdens on the complaints in order to find individual therapeutic approaches. The main instrument of the assessment is an extensive medical and psycho-social history with an additional environmental history, including a systematic questionnaire and environmental key questions.

In the first years, the project was scientifically assessed. In a questionnaire one year after counseling, 70% of the persons recommended the interdisciplinary-based counseling structure and 32% of them considered the counseling as being helpful. Therefore, a model based on such an interdisciplinary concept, embedded in the family doctor's holistic and lasting concept of treatment, seems to be promising for a better therapeutic approach to EHS, also including accessibility measures targeted at the actual environment (180).

In Finland, psychotherapy is the officially recommended therapy of EHS. In a questionnaire study of EHS people in Finland, symptoms, perceived sources and treatments, the perceived efficacy of medical and complementary alternative treatments (CAM) in regards to EHS were evaluated by multiple choice questions. According to 76% of the 157 respondents, the reduction or avoidance of EMF helped in their full or partial recovery. The best treatments for EHS were given as weighted effects: "dietary change" (69.4%), "nutritional supplements" (67.8%), and "increased physical exercise" (61.6%). The official treatment recommendations of psychotherapy (2.6%) were not significantly helpful, or for medication (–4.2%) even detrimental. The avoidance of electromagnetic radiation and fields effectively removed or lessened the symptoms in persons with EHS (181, 182).

The prognosis of certain diseases can be influenced by EMF-reduction. For example, children who have leukemia and are in recovery have poorer survival rates if their ELF magnetic field exposure at home (or where they are recovering) is between 1 mG [0.1 μT] and 2 mG [0.2 μT] or above 2 mG [0.2 μT] in one study, over 3 mG [0.3 μT] in another study (9).

Response of physicians to this development

In cases of unspecific health problems (see Questionnaire) for which no clearly identifiable cause can be found – beside other factors like chemicals, nonphysiological metals, mold – EMF exposure should, in principle, be taken into consideration as a potential cause or cofactor, especially if the person presumes it.

A central approach for a causal attribution of symptoms is the assessment of variation in health problems depending on time and location and individual susceptibility, which is particularly relevant for environmental causes such as EMF exposure.

Regarding such disorders as male infertility, miscarriage, Alzheimer's, ALS, blood sugar fluctuations, diabetes, cancer, hyperactivity, learning disorders and behavioral problems in school, it would be important to consider a possible link with EMF exposure. This offers an opportunity to causally influence the course of the disease.

How to proceed if EMF-related health problems are suspected

The recommended approach to diagnosis and treatment is intended as an aid and should, of course, be modified to meet the needs of each individual case (see Figure 2).

1. History of health problems and EMF exposure
2. Examination and findings
3. Measurement of EMF exposure
4. Prevention or reduction of EMF exposure
5. Diagnosis
6. Treatment

History of health problems and EMF exposure

In order to put later findings into a larger context, a general medical history is necessary. In the next steps, we focus only on EMF-related health effects.

A questionnaire to take a systematic history of health problems and EMF exposure, compiled by the EUROPAEM EMF Working Group, is available in the Annex of this EMF Guideline.

The questionnaire consists of three sections:

a) List of symptoms
b) Variation of health problems depending on time, location, and circumstances
c) Assessment of certain EMF exposures that can be estimated by questionnaire

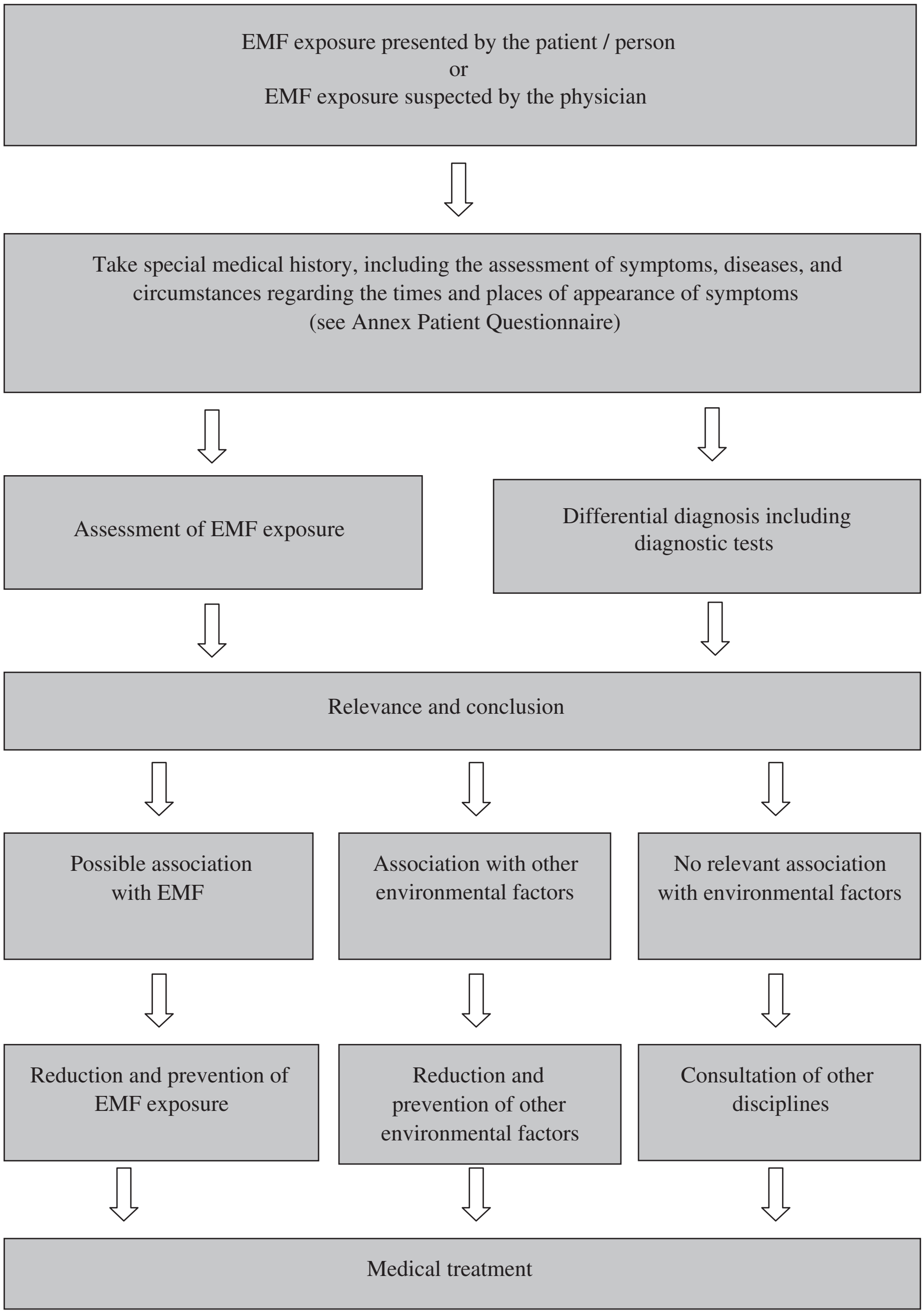

Figure 2: Flowchart for the handling of EMF-related health problems

List of symptoms

The list of symptoms in the questionnaire serves to systematically quantify health problems regardless of their causes. It also includes questions as to when the health problems first occurred. Most EMF-related symptoms are nonspecific and fall within the scope of health problems due to inadequate regulation (decompensation), e.g. sleep problems, fatigue, exhaustion, lack of energy, restlessness, heart palpitations, blood pressure problems, muscle and joint pain, headaches, increased risk for infections, depression, difficulty concentrating, disturbances of coordination, forgetfulness, anxiety, urinary urgency, anomia (difficulty finding words), dizziness, tinnitus, and sensations of pressure in the head and ears.

The health problems may range in severity from benign, temporary symptoms, such as slight headaches or paresthesia around the ear, e.g. when using a cell phone, or flu-like symptoms after maybe some hours of whole body EMF exposure, to severe, debilitating symptoms that drastically impair physical and mental health. It has to be stressed that, depending on the individual state of susceptibility, EHS symptoms often occur only occasionally, but over time they may increase in frequency and severity. On the other hand, if a detrimental EMF exposure is sufficiently reduced, the body has a chance to recover and EHS symptoms will be reduced or will vanish.

Variation of health problems depending on time, location, and circumstances

The answers to questions of when and where the health problems occur or recede, and when and where the symptoms increase or are particularly evident, provide only indications. They must be interpreted by the investigator (e.g. regarding the correct attribution between location/EMF sources and health problems). Special attention should be drawn to sleeping areas, because of the duration of influence and the vital role of sleep for regeneration.

Assessment of certain EMF exposures that can be estimated by questionnaire

The assessment of EMF exposure usually starts with certain questions of usual EMF sources. Regardless of whether or not the patient suspects EMF exposure as a cause, these questions should be used to assess the existing exposure level, at least as a rough estimate. It is important to note that only certain types of EMF exposure can be assessed by means of questions, such as the use of compact fluorescent lamps (CFLs), cell phones, and cordless phones. Detection of other types of EMF exposure, e.g. due to RF transmitter sites or the electric or magnetic fields from electric wiring, generally requires measurements. In principle, questions should be asked to assess EMF exposure at home and at work and when on holidays and so on, keeping in mind that the degree of EMF exposure may vary at different times.

Examination and findings

We do not have any clinical findings yet that are specific to EMF, which makes diagnosis and differential diagnosis a considerable challenge.

A method that has proven useful is to use stress-associated findings for diagnosis and followup and to evaluate them synoptically. Basic diagnostic tests should be carried out as a first step, followed by measurements of EMF exposure as a second step. The core diagnosis should focus on investigations of nitric oxide production (nitrotyrosine), mitochondriopathy (intracellular ATP), oxidative stress-lipid peroxidation (MDA-LDL) and inflammation (TNF-alpha, INF-G (IP-10), IL-1b).

Then additional diagnostic tests can be considered.

Functional tests

Basic diagnostic tests

– Blood pressure and heart rate (in all cases resting heart rate in the morning while still in bed), including self-monitoring, possibly several times a day, e.g. at different locations and with journaling of subjective well-being for a week.

Additional diagnostic tests

– 24-h blood pressure monitoring (absence of nighttime decline)
– 24-h ECG (heart rhythm diagnosis)
– 24-h heart rate variability (HRV) (autonomous nervous system diagnosis)
– Ergometry under physical stress
– Sleep EEG at home

Laboratory tests

Basic diagnostic tests

– Blood
  – Bilirubin
  – Blood count and differential blood count
  – BUN
  – Cholesterol, LDL, HDL, triglycerides
  – Creatinine kinases (CK-MB, CK-MM)
  – CRP
  – Cystatin C (glomerular filtration rate)
  – Electrolytes
  – Fasting blood glucose
  – Ferritin
  – HBA1c
  – Histamine and diaminoxidase (DAO)
  – INF-G (IP-10)
  – Interleukin-1 (e.g. IL-1a, IL-1b)
  – Intracellular ATP
  – Liver enzymes (e.g. ALT, AST, GGT, LDH, AP)
  – Magnesium (whole blood)
  – malondialdehyde-LDL
  – Nitrotyrosine
  – Potassium (whole blood)
  – Selenium (whole blood)
  – TSH
  – Tumor necrosis factor alpha (TNFα)
  – Vitamin D
  – Zinc (whole blood)

- Standard urine
  - Leucocytes, erythrocytes, albumin, urobilinogen, pH, bacteria, glucose, microalbumin
- Second morning urine
  - 6-OH melatonin sulfate
  - Adrenaline
  - Dopamine
  - Noradrenaline
  - Noradrenaline/adrenaline quotient
  - Serotonin
- Saliva
  - Cortisol (8 a.m., 12 a.m., and 8 p.m.)

Additional diagnostic tests
- Urine
  - Metals
- Second morning urine
  - Gamma-aminobutyric acid (GABA)
  - Glutamate
  - Kryptopyrrole
- Saliva
  - Dehydroepiandrosterone DHEA (8 a.m. and 8 p.m.)
- Blood
  - 8-hydroxydeoxyguanosine (DNA oxidation)
  - Biotin
  - Differential lipid profile
  - Folate
  - Holotranscobolamin
  - Homocysteine
  - Interferon-gamma (IFNγ)
  - Interleukin-10 (IL-10)
  - Interleukin-17 (IL-17)
  - Interleukin-6 (IL-6)
  - Interleukin-8 (IL-8)
  - Intracellular glutathione (redox balance)
  - Lactate, pyruvate incl. ratio
  - Lipase
  - NF-kappa B
  - Ubiquinone (Q10)
  - Vitamin B6 (whole blood)

Provocation tests

Special facilities with the use of a variety of signals, e.g. DECT or Wi-Fi exposure (e.g. 20–60 min, depending on the individual regulation capacity, susceptibility, and observed response)
- Heart rate variability (HRV) (autonomous nervous system diagnosis)
- Microcirculation
- Oxidative stress (lipid peroxidation, malondialdehyde-LDL)

Individual susceptibility
- Blood (genetic parameters and actual function)
  - Glutathione S transferase M1 (GSTM1) – detoxification
  - Glutathione S transferase T1 (GSTT1) – detoxification
  - Superoxide dismutase 2 (SOD2) – protection of mitochondria
  - Catechol-O-methyltransferase (COMT) – stress control

Measurement of EMF exposure

The evolutionary development of the human species took place under the presence of the natural electromagnetic spectrum (Earth's magnetic field, Earth's electric field, spherics, Schumann resonance). Those influences have been part of our biosphere like the oxygen content in the air or the visible light spectrum, and they have been integrated into the biological functions.

By now, nearly all nonionizing parts of the electromagnetic spectrum are filled with artificial, technical EMF sources due to electrification and (wireless) communication technologies, but are very rarely found in nature (see Figure 3). EMF measurements and/or exposure damages are usually not covered by statutory health care insurance.

In general, a wide variety of EMF exposure types should be considered: cordless phones (DECT), wireless Internet access (Wi-Fi), electrical wiring and electrical devices in buildings, compact fluorescent lamps (CFLs), mobile phone base stations, radio and TV transmitters, high-voltage power lines or transformer stations, and "dirty electricity".

In the sleeping area, the most important exposure point is the head and trunk region followed by all other points with chronic or high exposure.

EMF measurements should be planned and carried out by specially trained and experienced testing specialists and always in accordance with relevant standards, e.g. the VDB Guidelines of the German Association of Building Biology Professionals (184). In addition to the measurement results, the measurement report should also include suggestions on how to possibly reduce the EMF exposure.

To clarify certain issues, personal dosimeters with a data logging function are available to measure ELF magnetic fields and radio-frequency radiation.

After the measurements have been commissioned by the person and carried out, the results should be discussed with a physician familiar with the EMF issue.

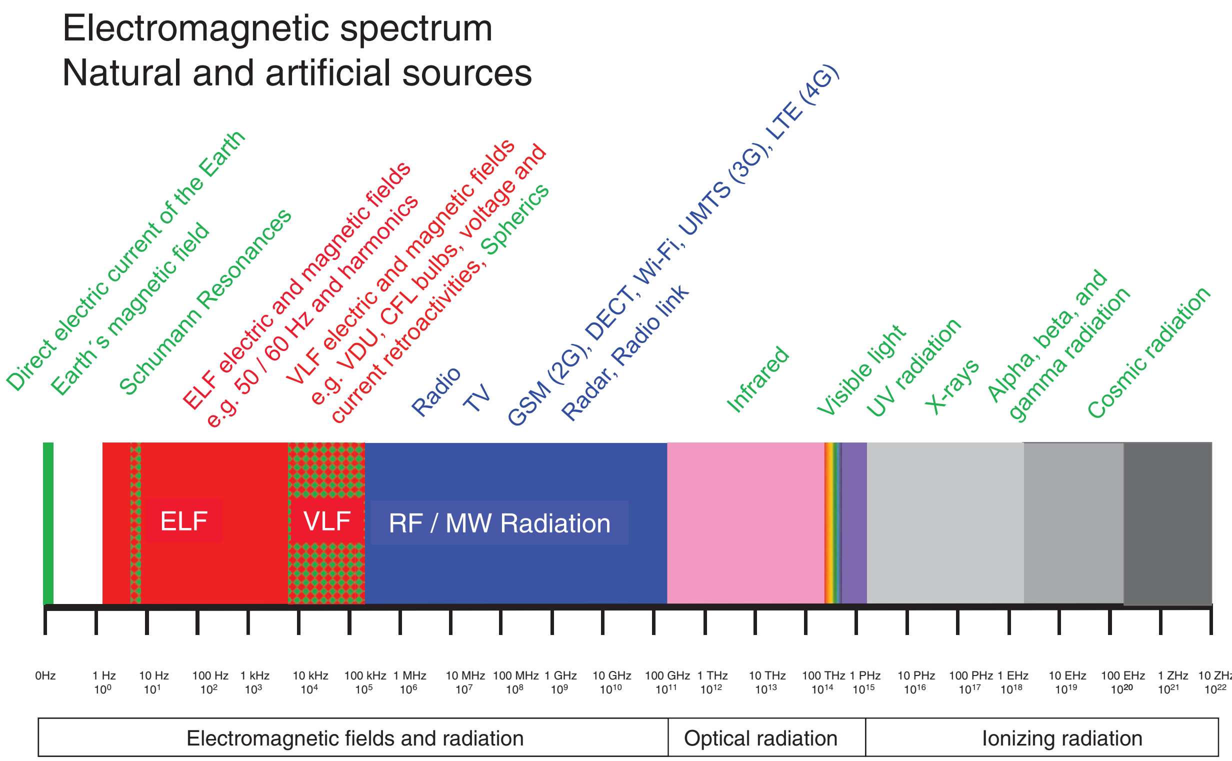

Figure 3: Examples of natural (green) and artificial (red and blue) EMF sources along the electromagnetic spectrum (183).

EMF guidance values

In each case, the following aspects should be individually taken into account when evaluating EMF measurement results (73):

- The person's individual susceptibility
- The person's individual total body burden (e.g. exposure to noise, chemicals)
- Duration of EMF exposure
- EMF exposure during the night and day
- Multiple exposure to different EMF sources
- Signal intensity (W/m², V/m, A/m)
- Signal characteristics (was taken into account in the EMF guidance values – see Supplement 3)
  - Frequency
  - Risetime (ΔT) of bursts, transients, etc.
  - Frequency and periodicity of bursts, e.g. certain GSM base stations (8.3 Hz), Wi-Fi networks (10 Hz), DECT cordless phones (100 Hz)
  - Type of modulation (frequency modulation, amplitude modulation, phase modulation)

Regardless of the ICNIRP recommendations for specific acute effects, the following guidance values apply to sensitive locations with long-term exposure of more than 20 h per week (185). They are based on epidemiological studies (9, 10, 73, 186–189), empirical observations, and measurements relevant in practice (190, 191) as well as recommendations by the Parliamentary Assembly of the Council of Europe (26). The proposed guidance values are based on scientific data including a preventive component and aim to help restore health and well-being in already compromised patients/functionally impaired persons.

Basic measurements

ELF magnetic fields (extremely low frequency) (ELF MF)

Measurement specifications

Frequency range:	50/60 Hz mains electricity, up to 2 kHz 16.7 Hz railroad systems in Austria, Germany, Switzerland, Sweden, and Norway
Type of measurement:	Magnetic induction or flux density [T; mT; µT; nT]
Field probe:	Isotropic magnetic field probe (three orthogonal axes)
Detector mode:	RMS (root mean square)
Measurement volume:	Short-term: Bed: Complete sleeping area of bed Short-term: Workplace: Complete working space of workplace (e.g. sitting position) Long-term: e.g. point close to the head/trunk in bed or at workplace

Measurement period:	Short-term measurements to identify field sources Long-term measurements during sleep and work shift
Basis for evaluation:	Long-term measurements: maximum (MAX) and arithmetic mean (AVG)

Precautionary guidance values

In areas where people spend extended periods of time (>4 h per day), minimize exposure to ELF magnetic fields to levels as low as possible or below the precautionary guidance values specified below.

ELF magnetic field	Daytime exposure	Nighttime exposure	Sensitive populations
Arithmetic mean (AVG)	**100 nT** (1 mG)[1),2)]	**100 nT** (1 mG)[1),2)]	**30 nT** (0.3 mG)[4)]
Maximum (MAX)	**1000 nT** (10 mG)[2),3)]	**1000 nT** (10 mG)[2),3)]	**300 nT** (3 mG)[4)]

Based on: [1)]BioInitiative (9, 10); [2)]Oberfeld (189); [3)]NISV (192); [4)]precautionary approach by a factor 3 (field strength).

Evaluation guidelines specifically for sleeping areas

Higher frequencies than the mains electricity at 50/60 Hz and distinct harmonics should be evaluated more critically. See also the precautionary guidance values for the intermediate frequency range further below. If applicable, mains current (50/60 Hz) and traction current (16.7 Hz) should be assessed separately but added (squared average). Long-term measurements should be carried out especially at nighttime, but at least for 24 h.

ELF electric fields (extremely low frequency) (ELF EF) Measurement specifications

Frequency range:	50/60 Hz mains electricity, up to 2 kHz 16.7 Hz railroad systems in Austria, Germany, Switzerland, Sweden, and Norway
Type of measurement:	Electric field [V/m] without ground reference (potential-free) and/or body-current [A/m²] see separate paragraph
Field probe:	Isotropic electric field probe (three orthogonal axes)
Detector mode:	RMS (root mean square)
Measurement volume:	Bed: nine points across sleeping area Workplace: Complete working space (e.g. sitting position three or six points)
Measurement period:	Spot measurements to asses the exposure as well as to identify field sources. Since electric field exposure levels in the ELF frequency range usually do not change, long-term measurements are not needed.
Basis for evaluation:	Spot measurements (maximum) at relevant points of exposure

Precautionary guidance values

In areas where people spend extended periods of time (>4 h per day), minimize exposure to ELF electric fields to levels as low as possible or below the precautionary guidance values specified below.

ELF electric field	Daytime exposure	Nighttime exposure	Sensitive populations
Maximum (MAX)	**10 V/m**[1),2)]	**1 V/m**[2)]	**0.3 V/m**[3)]

Based on: [1)]NCRP Draft Recommendations on EMF Exposure Guidelines: Option 2, 1995 (188); [2)]Oberfeld (189); [3)]precautionary approach by a factor 3 (field strength).

Evaluation guidelines specifically for sleeping areas

Higher frequencies than the mains electricity at 50/60 Hz and distinct harmonics should be evaluated more critically. See also the precautionary guidance values for the intermediate frequency range further below.

Radio-frequency electromagnetic radiation (RF EMR) Measurement specifications

Frequency range:	Radio and TV broadcast transmitters Mobile phone base stations, e.g. TETRA (400 MHz), GSM (900 and 1800 MHz), UMTS (2100 MHz), LTE (800, 900, 1800, 2500–2700 MHz), Cordless phone base stations, e.g. DECT (1900) Wi-Fi access points and clients (2450 and 5600 MHz) WiMAX (3400–3600 MHz) (above frequencies in MHz refer to European networks)
Type of measurement:	Electric field [V/m] -> calculated power density [W/m²; mW/m²; μW/m²]
Field probe:	Isotropic, biconical, logarithmic-periodic antennas
Detector mode:	Peak detector with max hold
Measurement volume:	Point of exposure across bed and working space
Measurement period:	Usually short-term measurements to identify RF field sources (e.g. acoustic analysis) and peak readings
Basis for evaluation:	Band-specific or frequency-specific spot measurements (peak detector with max hold) of common signals at relevant points of exposure (e.g. with spectrum analyzer or at least band-specific RF meter)

Precautionary guidance values for selected RF sources

In areas where people spend extended periods of time (>4 h per day), minimize exposure to radio-frequency electromagnetic radiation to levels as low as possible or below the *precautionary guidance values specified below. Frequencies to be measured should be adapted to each individual case.*

The specific guidance values take the signal characteristics of risetime (ΔT) and periodic ELF "pulsing" into account (191). *Note: Rectangular signals show short rise-times and consist of a broad spectrum of frequencies. The body current density increases with increasing frequency in an approximately linear relationship* (*Vignati and Giuliani, 1997*).

RF source Max Peak/Peak Hold	Daytime exposure	Nighttime exposure	Sensitive populations[1)]
Radio broadcast (FM)	**10,000 µW/m²**	**1000 µW/m²**	**100 µW/m²**
TETRA	**1000 µW/m²**	**100 µW/m²**	**10 µW/m²**
DVBT	**1000 µW/m²**	**100 µW/m²**	**10 µW/m²**
GSM (2G) 900/1800 MHz	**100 µW/m²**	**10 µW/m²**	**1 µW/m²**
DECT (cordless phone)	**100 µW/m²**	**10 µW/m²**	**1 µW/m²**
UMTS (3G)	**100 µW/m²**	**10 µW/m²**	**1 µW/m²**
LTE (4G)	**100 µW/m²**	**10 µW/m²**	**1 µW/m²**
GPRS (2.5G) with PTCCH* (8.33 Hz pulsing)	**10 µW/m²**	**1 µW/m²**	**0.1 µW/m²**
DAB+ (10.4 Hz pulsing)	**10 µW/m²**	**1 µW/m²**	**0.1 µW/m²**
Wi-Fi 2.4/5.6 GHz (10 Hz pulsing)	**10 µW/m²**	**1 µW/m²**	**0.1 µW/m²**

*PTCCH, Packet Timing Advance Control Channel.
Based on: BioInitiative (9, 10); Kundi and Hutter (186); Leitfaden Senderbau (187); Belyaev (73); PACE (26). [1)]Precautionary approach by a factor 3 (field strength)=factor 10 power density.

Conversion	**mW/m²**	10	1	0.1	0.01	0.001	0.0001
of RF	**µW/m²**	10,000	1000	100	10	1	0.1
measurement	**µW/cm²**	1	0.1	0.01	0.001	0.0001	0.00001
units	**V/m**	1.9	0.6	0.19	0.06	0.019	0.006

Additional measurements

Body-current (extremely low frequency) (ELF BC)

The type of body current measurement has been developed in Germany (193) and is used by so-called electrobiologists (194). The methodology offers the possibility to assess directly the relevant effect – the body current – caused by electric and magnetic fields (195). To date, the effects of electric fields on human health with a view to their distribution and relevance to increase the body current density are massively underestimated. We strongly recommend to perform epidemiological studies (e.g. intervention, case-control, cohort) for the health endpoints discussed and – besides other EMF exposures – to take the following measurements in this order: 1) body current (A/m²), 2) electric field (V/m) without ground reference (potential-free) without and with a person or a 3D dummy (not grounded!) to simulate the conductive body. In order to distinguish as to whether the measured body currents are caused by electric or magnetic fields, the magnetic fields have to be measured as well in all three axes. Long-term measurements of ELF magnetic fields should be performed with an isotropic magnetic field probe (three orthogonal axes) according to the corresponding paragraph in this chapter.

Measurement specifications

Frequency range:	50/60 Hz mains electricity, up to 2 kHz 16.7 Hz railroad systems in Austria, Germany, Switzerland, Sweden, and Norway
Type of measurement:	Body-current [A/m²]
Field probe:	Magnetic field probe (one orthogonal axis)
Detector mode:	RMS (root mean square)
Measurement volume:	10 specific points close to the body (head, trunk and limbs)
Measurement period:	Spot measurements to asses the exposure as well as to identify field sources. As electric field exposure levels in the ELF frequency range usually do not change, long-term measurements are not needed.
Basis for evaluation:	Spot measurements (maximum) at relevant points of exposure

Precautionary guidance values

In areas where people spend extended periods of time (>4 h per day), minimize exposure to ELF body-current to levels as low as possible or below the precautionary guidance values specified below.

ELF body-current	Daytime exposure	Nighttime exposure	Sensitive populations
Maximum(MAX)	**0.25 µA/m²** [1)]	**0.25 µA/m²** [1)]	**0.05 µA/m²** [2),3)]

Based on: [1)]0.25 µA/m² corresponds to 100 nT (RMS, AVG); [2)]0.05 µA/m² corresponds to 20 nT (RMS, AVG), Arbeitskreis Elektrobiologie (194), based on empirical observations; [3)]precautionary approach by a factor 5 (field strength).

Evaluation guidelines specifically for sleeping areas

Higher frequencies than the mains electricity at 50/60 Hz and distinct harmonics should be evaluated more critically.

See also the precautionary guidance values for the intermediate frequency range further below.

Magnetic fields in the intermediate frequency range (VLF) (IF MF)
Measurement specifications

Frequency range:	3 kHz–3 MHz Frequency-specific measurements (spectrum analyzer/EMF meter), e.g. "dirty power," powerline communication (PLC), radio-frequency identification transmitters (RFID), compact fluorescent lamps (CFL)
Type of measurement:	Magnetic field [A/m] -> calculated magnetic induction [T; mT; µT; nT]
Field probe:	Isotropic or anisotropic magnetic field probe
Detector mode:	RMS (root mean square)
Measurement volume:	Point of exposure across bed and working space
Measurement period:	Short-term measurements to identify field sources Long-term measurements during sleep and work shift
Basis for evaluation:	Long-term measurements: RMS detector arithmetic mean and maximum at relevant points of exposure

Precautionary guidance values

In areas where people spend extended periods of time (>4 h per day), minimize exposure to intermediate frequency magnetic fields to levels as low as possible or below the precautionary guidance values specified below.

[4]The body current density increases with increasing frequency in an approximately linear relationship (Vignati and Giuliani, 1997). Therefore, the guidance value of the magnetic field in the intermediate frequency range should be lower than the one of the 50/60 Hz magnetic field, e.g. assuming 100 nT RMS/100=1 nT.

IF magnetic field	Daytime exposure	Nighttime exposure	Sensitive populations
Arithmetic mean	**1 nT** (0.01 mG)[1),2)]	**1 nT** (0.01 mG)[1),2)]	**0.3 nT** (0.003 mG)[4)]
Maximum	**10 nT** (0.1 mG)[2),3)]	**10 nT** (0.1 mG)[2),3)]	**3 nT** (0.03 mG)[4)]

Based on: [1)]BioInitiative (9, 10); [2)]Oberfeld (189); [3)]NISV (192); [4)]precautionary approach by a factor 3 (field strength).

Electric fields in the intermediate frequency range (VLF) (IF EF)
Measurement specifications

Frequency range:	3 kHz–3 MHz Frequency-specific measurements (spectrum analyzer/EMF meter), e.g. "dirty power," powerline communication (PLC), radio-frequency identification transmitters (RFID), compact fluorescent lamps (CFL)
Type of measurement:	Electric field [V/m]
Field probe:	Isotropic, biconical, logarithmic-periodic electric field probe
Detector mode:	RMS arithmetic mean
Measurement volume:	Point of exposure across bed and working space
Measurement period:	Short-term measurements to identify field sources Long-term measurements during sleep and work shift
Basis for evaluation:	Long-term measurements: arithmetic mean at relevant points of exposure

Precautionary guidance values

In areas where people spend extended periods of time (>4 h per day), minimize exposure to intermediate frequency electric fields to levels as low as possible or below the precautionary guidance values specified below.

[4]The body current density increases with increasing frequency in an approximately linear relationship (Vignati and Giuliani 1997). Therefore, the guidance value of the magnetic field in the intermediate frequency range should be lower than the one of the 50/60 Hz magnetic field, e.g. assuming 10 V/m RMS arithmetic mean/100=0.1 V/m.

IF electric field	Daytime exposure	Nighttime exposure	Sensitive populations
Arithmetic mean	**<0.1 V/m**[1),2)]	**<0.01 V/m**[2)]	**<0.003 V/m**[3)]

Based on: [1)]NCRP Draft Recommendations on EMF Exposure Guidelines: Option 2, 1995 (188); [2)]Oberfeld (189); [3)]precautionary approach by a factor 3 (field strength).

Static magnetic fields
Measurement specifications

Frequency range:	0 Hz
Type of measurement:	Magnetic induction or flux density [T; mT; µT; nT]

Field probe:	Anisotropic magnetic field probe (for one spatial axis – vertical) or Isotropic magnetic field probe (three orthogonal axes)
Detector mode:	RMS (root mean square)
Measurement volume:	Point of exposure across bed and working space
Measurement period:	Short-term measurements to identify field sources that distort the Earth's magnetic field
Basis for evaluation:	Spot measurements (RMS maximum) at relevant points of exposure

Precautionary guidance values

In areas where people spend extended periods of time (>4 h per day), minimize exposure to static magnetic fields that distort the naturally occurring Earth's magnetic field to levels as low as possible.

Evaluation guidelines specifically for sleeping areas

First determine the natural background level in a reference location, e.g. close to the bed. The field probe must not be moved during the measurement process in order to prevent false readings due to induced currents by the Earth's magnetic field. The guidance values below are meant in addition to the Earth's magnetic field.

Static magnetic field	No anomaly	Slight anomaly	Significant anomaly	Extreme anomaly
Deviation from natural background	**≤1 µT** ≤10 mG	**1–2 µT** 10–20 mG	**2–10 µT** 20–100 mG	**>10 µT** >100 mG

Based on: Building Biology Evaluation Guidelines (SBM-2015) (190), which are based on empirical observations.

Static electric fields
Measurement specifications

Frequency range:	0 Hz
Type of measurement:	Electric field [V/m]
Field probe:	Anisotropic or isotropic electric field probe
Detector mode:	RMS (root mean square)
Measurement volume:	Point of exposure across bed and working space
Measurement period:	Short-term measurements to identify field sources
Basis for evaluation:	Spot measurements (maximum) at relevant points of exposure

Precautionary guidance values

In areas where people spend extended periods of time (>4 h per day), minimize exposure to static electric fields that exceed the naturally occurring fair-weather atmospheric electric field.

Evaluation guidelines specifically for sleeping areas

Static electric field	No anomaly	Slight anomaly	Significant anomaly	Extreme anomaly
Maximum	**<100 V/m**	**100–500 V/m**	**500–2000 V/m**	**>2000 V/m**

Based on: Building Biology Evaluation Guidelines (SBM-2015) (190), which are based on empirical observations.

Prevention or reduction of EMF exposure

Preventing or reducing EMF exposure after consulting a testing specialist is advantageous for several reasons:

a) To prevent and reduce risks to individual and public health,
b) To identify any links to health problems,
c) To causally treat the EMF-related health problems.

There are numerous potential causes of relevant EMF exposures, and this EMF Guideline can only give a few examples. Further information can be found, for instance, in the document "Options to Minimize EMF/RF/Static Field Exposures in Office Environments" (196) and "Elektrosmog im Alltag" (197). For detailed information on physics, properties and measurement of EMF, see Virnich (198); regarding reduction of radio-frequency radiation (RFR) in homes and offices, see Pauli and Moldan (199).

In most cases, it will be necessary to consult an expert (e.g. building biology testing specialist, EMF/RF engineer) and/or electrician who will advise the person on what measures could be taken to reduce EMF exposure.

EMF exposure reduction – First steps

As a first step, it might be useful to recommend to persons that they take certain actions (also as preventive measures) to eliminate or reduce typical EMF exposures, which may help alleviate health problems within days or weeks. The following actions may be suggested:

Preventing exposure to radio-frequency radiation (RFR)

– Disconnect (unplug) the power supply of all DECT cordless phone base stations. So called "ECO Mode" or "zero-emission" DECT phones are only conditionally recommended because the exposure by the handset is not or not substantially reduced. Therefore, the use of "traditional" corded phones is recommended.

- Disconnect (unplug) the power supply to all Wi-Fi access points or Wi-Fi routers. Many LAN routers now come equipped with additional Wi-Fi. Call the provider of the LAN router and ask to have the Wi-Fi deactivated. It is usually also possible to do so online by following the provider's instructions.
- Avoid wearing the cell phone/smartphone close to the body.
- Deactivate all nonessential wireless cell phone apps, which cause periodic radiation exposure.
- Keep cell phones/smartphones in "airplane mode" whenever possible.
- In case of external RF radiation sources, rooms – especially sleeping rooms – facing away from the source should be chosen.
- Avoid powerline communication for Internet access (dLAN) and instead use a hardwired Ethernet cable (LAN).
- Avoid exposure to RF radiation (e.g. Bluetooth, Wi-Fi) at home (e.g. home entertainment, headsets), in offices, and in cars.

Preventing exposure to ELF electric and magnetic fields

- Move the bed or desk away from the wiring in the walls and power cords. A minimum distance of 30 cm (1 ft) from the wall is recommended.
- Another simple complementary action is to disconnect the power supply to the bedroom (turn off circuit breaker or fuse) for the nighttime while sleeping; try it for a test phase of, e.g. 2 weeks. In general, this measure is not always successful because circuits of adjacent rooms contribute to the electric field levels. ELF electric field measurements are required to know exactly which circuit breakers need to be disconnected.
  The benefits should be weighed against the potential risk of accidents; therefore, the use of a flashlight for the test phase should be recommended.
- Disconnect the power supply to all nonessential electric circuits, possibly in the entire apartment or house. (N.B. See note above.)
- Avoid using an electric blanket during sleep; not only turn it off, but also disconnect it.

Preventing exposure to static magnetic fields

- Sleep in a bed and mattress without metal.
- Avoid to sleep close to iron materials (radiator, steel, etc.)

EMF exposure reduction – second steps

As a second step, EMF measurements and mitigation measures should be carried out. Typical examples are:

- Measure the ELF electric field in the bed or the body current density of the person while in bed. Based on the measurement results, have automatic demand switches in those circuits installed that increase the exposure.
- Measure the ELF electric field at all other places that are used for extended periods at home and at work. If necessary, choose lamps used close to the body with a shielded electric cable and a grounded lamp fixture (metal). Especially in lightweight construction (wood, gypsum board), electrical wiring without grounding (two-slot outlets) might have to be replaced with grounded electrical wiring or shielded electrical wiring. In special cases, the whole building might have to have shielded wiring and shielded outlets installed.
- Measure the ELF magnetic field close to the bed, e.g. for 24 h. If net currents are detected, the electrical wiring and grounding system of the building must be corrected as to reduce the magnetic fields.
- Install a residual current device (RCD) or ground-fault circuit interrupter (GFCI) to prevent electric shocks (safety measure).
- Measure radio-frequency radiation and mitigate high exposure levels by installing certain RF shielding materials for the affected walls, windows, doors, ceilings, and floors.
- Measure dirty electricity/dirty power (electric and magnetic fields in the intermediate frequency range) and identify the sources in order to remove them. If this is not possible, appropriate power filters in line with the source may be used.

Diagnosis

We will have to distinguish between EHS and other EMF-related health problems like certain cancers, Alzheimer's, ALS, male infertility etc. that might have been induced, promoted, or aggravated by EMF exposure. An investigation of the functional impairment EHS and other EMF-related health problems will largely be based on a comprehensive case history, focusing, in particular, on correlations between health problems and times, places, and circumstances of EMF exposure, as well as the progression of symptoms over time and the individual susceptibility. In addition, measurements of EMF exposure and the results of additional diagnostic tests (laboratory tests, cardiovascular system) serve to support the diagnosis. Moreover, all other potential causes should be excluded as far as possible.

In 2000 the Nordic Council of Ministers (Finland, Sweden, and Norway) adopted the following ICD-10 code for EHS: Chapter XVIII, Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, code R68.8 “Other specified general symptoms and signs” (Nordic ICD-10 Adaptation, 2000) (200).

Regarding the current International Classification of Diseases (ICD), ICD-10-WHO 2015, we recommend at the moment:

a) Electromagnetic hypersensitivity (EHS): to use the existing diagnostic codes for the different symptoms **plus** code R68.8 “Other specified general symptoms and signs” **plus** code Z58.4 “Exposure to radiation” and/ or Z57.1 “Occupational exposure to radiation”.
b) EMF-related health problems (except EHS): to use the existing diagnostic codes for the different diseases/ symptoms **plus code** Z58.4 “Exposure to radiation” and/or Z57.1 “Occupational exposure to radiation”.

Regarding the next ICD-update (ICD-11 WHO) to be published 2018), we recommend to:

a) Create ICD codes for all chronic environmentally induced chronic multisystem illnesses (CMI) like multiple chemical sensitivity (MCS), chronic fatigue syndrome (CFS), fibromyalgia (FM), and electromagnetic hypersensitivity (EHS).
b) Expand Chapter XIX, Injury, poisoning and certain other consequences of external causes (T66-T78) to include/distinguish effects of EMF (static magnetic field, static electric field, ELF magnetic field, ELF electric field, VLF/LF magnetic field, VLF/LF electric field, Radio-frequency electromagnetic radiation) infrared, visible light, UV-light and ionizing radiation.
c) Expand Chapter XXI, Factors influencing health status and contact with health services (Z00-Z99) to include/ distinguish factors as EMF (static magnetic field, static electric field, ELF magnetic field, ELF electric field, VLF/LF magnetic field, VLF/LF electric field, Radio-frequency electromagnetic radiation), infrared, visible light, UV-light, and ionizing radiation.

Treatment/accessibility measure

The primary method of treatment should mainly focus on the prevention or reduction of EMF exposure that is reducing or eliminating all sources of EMF at home and in the workplace. The reduction of EMF exposure should also be extended to schools, hospitals, public transport, public places like libraries, etc. in order to enable EHS persons an unhindered use (accessibility measure). Many examples have shown that such measures can prove effective. With respect to total body load of other environmental influences, they must also be regarded.

Beside EMF reduction, other measures can and must be considered. These include a balanced homeostasis in order to increase the “resistance” to EMF. There is increasing evidence that a main effect of EMF on human beings is the reduction of oxidative and nitrosative regulation capacity. This hypothesis also explains observations of changing EMF sensitivity and the large number of symptoms reported in the context of EMF exposure. From the current perspective, it appears useful to recommend a treatment approach, as those gaining ground for multisystem disorders, that aims at minimizing adverse peroxynitrite effects.

It should be stressed, that psychotherapy has the same significance as in other diseases. Products that are offered in the form of plaques and the like to “neutralize” or “harmonize” electrosmog should be evaluated with great restraint.

In summary, the following treatment and accessibility measures appear advantageous, depending on the individual case:

Reduction of EMF exposure

This should include all types of EMF exposures relevant to the person, especially during sleep and at work. For more information, see e.g. “Options to Minimize EMF/RF/Static Field Exposures in Office Environment” (196) and “Elektrosmog im Alltag” (197).

Environmental Medicine treatments

Until now, no specific treatment of EHS has been established. Controlled clinical trials would be necessary to assess optimal treatment and accessibility measures. Actual data indicate that the functional deficits, which can be found in persons with EHS, correspond to those we can find in CMI such as MCS, CFS, and FM. The target of the therapy is the regulation of the physiological dysfunction detected by diagnostic steps (Examination and findings). The main therapeutic target includes both general and adjuvant procedures and specific treatments. The latter are challenging and need special knowledge and experience in clinical environmental medicine treatments. Main therapeutic targets include:

– **Control of total body burden**
  Besides the reduction of EMF exposure, the reduction of the total body burden by various

environmental pollutants (home, working place, school, hobby), food additives, and dental materials is indicated.

- **Reduction of oxidative and/or nitrosative stress**
  Reactive oxygen species (ROS) and reactive nitrogen species (RNS) are free radicals naturally produced in cells. Scavengers guarantee the balance between the production of free radicals and the rate of their removal. Many biologically important compounds with antioxidant (AO) function have been identified as endogenous and exogenous scavengers. Among the endogenous AO, we distinguish between enzymatic AO (catalase, glutathione peroxidase, glutathione reductase, superoxide dismutase) and nonenzymatic AO (bilirubin, ferritin, melatonin, glutathione, metallothionin, N-acetyl cysteine (NAC), NADH, NADPH, thioredoxin, 1,4,-bezoquinine, ubiquinone, uric acid). They interact with exogenous dietary and/or synthetic AO (carotenoids, retinoids, flavonoids, polyphenols, glutathione, ascorbic acid, tocopherols). The complex regulation and use of these substances is the therapeutic challenge (163, 201).
- **Regulation of intestinal dysfunction**
  Endogenous and exogenous scavengers act synergistically to maintain the redox homeostasis. Therefore, dietary or natural antioxidants play an important role to stabilize this interaction.
  Treatment of a leaky gut, food intolerance, and food allergy is a prerequisite for maintaining redox homeostasis (202) and also requires special knowledge and experience.
- **Optimizing nutrition**
  Bioactive food is the main source of antioxidant components such as vitamin C, vitamin E, NAC, carotenoids, CoQ10, alpha-lipoic acid, lycopene, selenium, and flavonoids (203, 204). For instance, the regeneration of vitamin E by glutathione or vitamin C is needed to prevent lipid peroxidation. The dietary antioxidants only can have beneficial effects on the redox system if they are present in sufficient concentration levels (201). Alpha-lipoic acid acts directly and indirectly as a scavenger of free radicals including peroxynitrite, singlet oxygen, superoxide, peroxyl radicals, and the breakdown radicals of peroxynitrite (163). It had been shown that the number of free electrons in micronutrients determines how effective they are. In organic food, the number of free electrons is higher than in conventionally produced food (205). Especially in the case of food intolerances, the tailored substitution of micronutrients in the form of supplements is necessary.
- **Control of (silent) inflammation**
  Elevated nitric oxide levels and the reaction with superoxide always leads to elevated peroxynitrate levels, which induce ROS levels as no other substance does ($NO/ONOO^-$ cycle). As a result, the nuclear factor κB (NF-κB) is activated, inducing inflammatory cytokines such as tumor necrosis factor α (TNF-α), interleukin-1β (IL-1β), interleukin-6 (IL-6), interkeukin-8 (IL-8), and interferon gamma (IFNγ) and activating various NO synthases (163). Tocopherols (206, 207), carotinoids at low concentration levels (208), vitamin C (209, 210), NAC (211), curcumin (212), resveratrol (213, 214), flavonoids (215) have shown to interrupt this inflammatory cascade at various points.
- **Normalization of mitochondrial function**
  Mitochondrial function may be disturbed in two ways. First: the high amount of free radicals may block production of adenosine triphosphate (ATP), leading to muscle pain and fatigue. Second: in the case of silent (smoldering) inflammation, the demand for more energy is elevated by 25% (167), causing a high consumption of ATP. In this case, NADH, L-carnitine and CoQ10 are essential for ATP synthesis.
  Due to the lack of ATP, the stress regulation of catecholamines especially norepinephrine (NE) is reduced because catabolism of NE by S-adenosylmethionine is ATP dependent (216–218). Furthermore, stress regulation has a high demand for folate, vitamin B6, and methylcobalamine. Genetic polymorphisms of COMT and MTHFR influence the individual need for those substances (173, 219).
- **Detoxification**
  In humans, the accumulation of environmental toxicants has an individual profile of many different inorganic and organic chemicals, which make up the total body load (220).
  Among the inorganic substances, metals and their salts play the dominant role and might be of importance to persons with EHS. Elemental mercury (Hg°) and other heavy metals such as lead (Pb) accumulate in the brain (221), especially at chronic low dose exposure. They may have toxic effects and can induce various immune reactions (222, 223). Whereas, generally, no specific active substance exists for the detoxification of chemicals, there are two groups of substances with more specific effects that can be used for the detoxification of metals.
  1. Substances with nonspecific physiological effects:
     Glutathione, NAC, alpha-lipoic acid, vitamin C and selenium.

2. Chelating agents for detoxification of metals (224–226)
   The most important chelating agents are:
   Sodium thiosulfate 10%
   DMPS (2,3-dimercapto-1-propanesulfonic acid)
   DMSA (meso-dimercaptosuccinic acid)
   EDTA (2,2′,2″,2‴-ethane-1,2-diyldinitrotetraacetic acid)

   It should be noted that these substances should be used only by those designated as experts in this particular field.

– **Adjuvant therapies**

1. Drinking water
For detoxification reasons, a higher intake of high-quality drinking water with low mineral content and no CO_2 is needed. The intake quantity should range from 2.5 to 3.0 L (10–12 8-oz glasses) daily.

2. Light
Most of the people in central and northern Europe are depleted of vitamin D. Sufficient natural daylight exposure during the vitamin D-producing months (spring to fall) is one important factor. At the same time, prevention of actinic damage to the skin is necessary.

3. Sauna
Sauna and therapeutic hyperthermia is an adjuvant therapy for the detoxification of almost all xenobiotics. These therapies have to be carefully used. An interaction with detoxifying drugs takes place. Sauna helps to regenerate tetrahydrobiopterin from dihydrobiopterin, which is essential for the metabolism of catecholamines and serotonin (163).

4. Oxygen
A part of persons with EHS suffer from mitochondrial dysfunction. Sufficient natural oxygen is helpful. As both hypoxia and hyperbaric oxygen can produce oxidative stress, hyperbaric oxygen therapy should only be performed if the persons are treated with sufficient antioxidants at the same time.

5. Exercise
The optimal amount of exercise is still being debated. A person's physical capacity should be assessed by ergometry in order to prescribe an individual exercise regime. Environmental medicine experience indicates that for sick people only low-impact aerobic exercise should be used. In general, start with a work load of 20–30 watts that often can be finished at 60–70 watts. Exercise on an ergometer allows better control of the consumption of energy compared to walking or running. No fatigue should result from exercising, at least after half an hour.

6. Sleep
Sleeping disorders are very common in persons with EHS. Sleep disturbance is associated with reduced melatonin level. In the case of chronic inflammation, the activation of IDO (indolamine-2,3-dioxygenase) reduces the production of serotonin and, in turn, it also reduces melatonin levels. EMF exposure might block the parasympathetic activity while sympathetic activity persists. Concerning sleep disturbances, any therapy has to follow the pathogenic causes. Optimal sleep is necessary to save energy and to regulate the functions of the immune and neuroendocrine systems.

7. Protection from blue light
Wavelengths of visible light below 500 nm are called "blue light". Low doses of blue light can increase feelings of well-being, but larger amounts can be harmful to the eyes. In natural daylight, the harmful effects of "blue light" are balanced out by the regenerative effect of the red and infrared content. The escalating use of electronic light sources – such as fluorescent tubes and compact fluorescent lamps (CFL), computer screens, laptops, tablets, smartphones, and certain LED bulbs – has increased our exposure to "blue light", which at this level is suspected of playing a role in the development of age-related macular degeneration and circadian misalignment via melatonin suppression, which is associated with the increased risk of sleep disturbance, obesity, diabetes mellitus, depression, ischemic heart disease, stroke, and cancer. Extended exposure to artificial "blue light" in the evening should therefore be limited. Antioxidants, especially melatonin (227, 228) and blue light screen filters (229–231) could be helpful.

Dental medicine
Dental medicine still works with toxic or immunoreactive materials, e.g. mercury, lead oxide, gold, and titanium. Environmental dental medicine demands that these materials not be used (232–235). The removal of toxic dental materials must take place under maximum safety conditions (avoid inhalation!). The elimination of particularly heavy metals from the body might be indicated. In general

terms, endoprosthetic materials should be inert with respect to immunoreactivity. Based on our current knowledge, zirconium dioxide seems to be a neutral material. However, mechanical abrasion of the coated surface by the dentist should be avoided.

Immunotoxic metals show a similar pathophysiology with respect to oxidative stress, mitochondriopathy, and inflammation.

Lifestyle coaching

Lifestyle coaching may include balanced exercise, nutrition, reduction of addictive substances, change of sleeping habits, etc. and stress reduction measures (reduction of general stress and work stress), as well as methods to increase stress resistance via, e.g. autogenic training, yoga, progressive muscle relaxation, breathing techniques, meditation, tai chi, and qigong.

Treatment of symptoms

A well-balanced treatment of symptoms is justified until the causes have been identified and eliminated. However, it is of paramount importance to realize that the reduction of symptoms may put the person at risk for an increased environmental EMF-load, thus generating possible future, long-term health effects, including neurological damage and cancer. It is a very difficult ethical task for the physician to risk such, and they must be pointed out – in an equally well-balanced way – to the patient in question. Ethically, to treat the symptoms is, of course, a very good start in the immediate sense but without a parallel environmental exposure reduction and lifestyle coaching it may prove counter-productive in the long run. For a standardly trained physician this might seem a very new way of reasoning, but is the only way to a successful and everlasting symptom alleviation and complete clinical remedy when dealing with chronic multisystem illnesses (CMI) and EHS.

References

1. Hänninen O, Knol AB, Jantunen M, Lim TA, Conrad A, et al. Environmental burden of disease in Europe: assessing nine risk factors in six countries. Environ Health Perspect 2014;122(5):439–46.
2. Bundespsychotherapeutenkammer. BPtK-Studie zur Arbeitsunfähigkeit – Psychische Erkrankungen und Burnout [Internet]. Berlin (DE): Bundespsychotherapeutenkammer, 2012:29. Report 2012. Available from: http://www.bptk.de/uploads/media/20120606_AU-Studie-2012.pdf.
3. Bundespsychotherapeutenkammer. BPtK-Studie zur Arbeits- und Erwerbsunfähigkeit – Psychische Erkrankungen und gesundheitsbedingte Frühverrentung [Internet]. Berlin (DE): Bundespsychotherapeutenkammer, 2013:66. Report 2013. Available from: http://www.bptk.de/uploads/media/20140128_BPtK-Studie_zur_Arbeits-und_Erwerbsunfaehigkeit_2013_1.pdf.
4. Fritze J. Psychopharmaka-Verordnungen: Ergebnisse und Kommentare zum Arzneiverordnungsreport 2011. Psychopharmakotherapie 2011;18:245–56.
5. Bundesinstitut für Arzneimittel und Medizinprodukte. Erstmals seit 20 Jahren kein Anstieg beim Methylphenidat-Verbrauch [Internet]. Bonn (DE): Bundesinstitut für Arzneimittel und Medizinprodukte, 2014 Apr 1. Pressemitteilung Nummer 05/14; Available from: https://www.bfarm.de/SharedDocs/Pressemitteilungen/DE/mitteil2014/pm05-2014.html.
6. Badura B, Ducki A, Schröder H, Klose J, Meyer M, editors. Fehlzeiten-Report 2012. Berlin, Heidelberg (DE): Springer Verlag, 2012:528 p.
7. OECD. Health at a Glance 2013: OECD Indicators [Internet]. Paris (FR): OECD Publishing, 2013 Nov 21. 212 p. DOI: 10.1787/health_glance-2013-en. Available from: http://dx.DOI.org/10.1787/health_glance-2013-en.
8. Pawankar R, Canonica GW, Holgate ST, Lockey RF, editors. WAO White book on Allergy 2011–2012 [Internet]. Milwaukee, WI (US): World Allergy Organization, 2013:228. Available from: http://www.worldallergy.org/UserFiles/file/WAO-White-Book-on-Allergy.pdf.
9. BioInitiative Working Group, Carpenter D, Sage C, editors. BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF). 2007. Available from: http://www.bioinitiative.org/.
10. BioInitiative Working Group, Carpenter D, Sage C, editors. BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF). 2012. Available from: http://www.bioinitiative.org/.
11. Levitt B, Lai H. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. Environ Rev 2010;18:369–95.
12. Pall ML. Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action. Rev Environ Health 2015;30(2):99–116.
13. International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Physics 1998;74(4):494–522.
14. International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz). Health Phys 2010;99(6):818–36.
15. Vecchia P. ICNIRP and international standards. London (GB): Conference EMF and Health, 2008:28. Available from: http://archive.radiationresearch.org/conference/downloads/021145_vecchia.pdf.
16. Panagopoulos DJ, Johansson O, Carlo GL. Evaluation of specific absorption rate as a dosimetric quantity for electromagnetic fields bioeffects. PLoS One 2013;8(6):e62663.

17. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Non-Ionizing Radiation, Part 1: Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields. Lyon (FR): International Agency for Research on Cancer (IARC), 2002:445. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, VOL 80. Available from: http://monographs.iarc.fr/ENG/Monographs/vol80/.
18. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields. Lyon (FR): International Agency for Research on Cancer (IARC), 2013:480. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol 102. Available from: http://monographs.iarc.fr/ENG/Monographs/vol102/.
19. European Environmental Agency. Radiation risk from everyday devices assessed [Internet]. Copenhagen (DK): 2007 Sept 17. Available from: www.eea.europa.eu/highlights/radiation-risk-from-everyday-devices-assessed.
20. European Environmental Agency. Health risks from mobile phone radiation – why the experts disagree [Internet]. Copenhagen (DK): 2011 Oct 12. Available from: http://www.eea.europa.eu/highlights/health-risks-from-mobile-phone.
21. European Environmental Agency. Late lessons from early warnings: science, precaution, innovation [Internet]. Copenhagen (DK): 2013 Jan 23. EEA Report No 1/2013. Available from: http://www.eea.europa.eu/publications/late-lessons-2.
22. EU Parliament. Report on health concerns associated with electromagnetic fields. Brussels (BE): Committee on the Environment, Public Health and Food Safety of the European Parliament. Rapporteur: Frederique Ries (2008/2211(INI) [Internet]. Available from: http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+REPORT+A6-2009-0089+0+DOC+PDF+V0//EN.
23. EU Parliament. European Parliament resolution of 2 April 2009 on health concerns associated with electromagnetic fields [Internet]). Brussels (BE): European Parliament, 2009 Apr 2. Available from: http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P6-TA-2009-0216+0+DOC+XML+V0//EN.
24. Fragopoulou A, Grigoriev Y, Johansson O, Margaritis LH, Morgan L, et al. Scientific panel on electromagnetic field health risks: consensus points, recommendations, and rationales. Environ Health 2010;25(4):307–17.
25. Dämvik M, Johansson O. Health risk assessment of electromagnetic fields: a conflict between the Precautionary Principle and environmental medicine methodology. Rev Environ Health 2010;25(4):325–33.
26. Council of Europe – Parliamentary Assembly. The potential dangers of electromagnetic fields and their effect on the environment. Resolution, Doc. 1815, Text adopted by the Standing Committee, acting on behalf of the Assembly, on 27 May 2011 [Internet]. Available from: http://assembly.coe.int/nw/xml/XRef/Xref-XML2HTML-en.asp?fileid=17994&lang=en.
27. Dean AL, Rea WJ. American Academy of Environmental Medicine Recommendations Regarding Electromagnetic and Radiofrequency Exposure [Internet]. Wichita, KS (US): Executive Committee of the American Academy of Environmental Medicine, 2012 July 12. Available from: https://www.aaemonline.org/pdf/AAEMEMFmedicalconditions.pdf.
28. Federal Public Service (FPS) Health, Food Chain Safety and Environment. New regulation for the sale of mobile phones as of 2014 [Internet]. Brussels (BE): Federal Public Service (FPS) Health, Food Chain Safety and Environment, 2014 Feb 07. Available from: http://health.belgium.be/eportal/19089508_EN?fodnlang=en#.VQ6qlo6GPN6.
29. Assemblée Nationale. PROPOSITION DE LOI relative à la sobriété, à la transparence, à l'information et à la concertation en matière d'exposition aux ondes électromagnétiques. Paris (FR): Assemblée Nationale, France, 2015 Jan 29. Available from: http://www.assemblee-nationale.fr/14/pdf/ta/ta0468.pdf.
30. Blank M, Havas M, Kelley E, Lai H, Moskowitz JM. International EMF Scientist Appeal [Internet]. 2015 May 11. Available from: https://www.emfscientist.org/index.php/emf-scientist-appeal.
31. Wertheimer N, Leeper E. Electrical wiring configurations and childhood cancer. Am J Epidemiol 1979;109(3):273–84.
32. Robinette CD, Silverman C, Jablon S. Effects upon health of occupational exposure to microwave radiation (radar). Am J Epidemiol 1980;112:39–53.
33. Ahlbom A, Day N, Feychting M, Roman E, Skinner J, et al. A pooled analysis of magnetic fields and childhood leukaemia. Br J Cancer 2000;83(5):692–8.
34. Greenland S, Sheppard AR, Kaune WT, Poole C, Kelsh MA. A pooled analysis of magnetic fields, wire codes, and childhood leukemia. Childhood Leukemia-EMF Study Group. Epidemiology 2000;11(6):624–34.
35. Kheifets L, Ahlbom A, Crespi CM, Draper G, Hagihara J, et al. Pooled analysis of recent studies on magnetic fields and childhood leukaemia. Br J Cancer 2010;103(7):1128–35.
36. Zhao L, Liu X, Wang C, Yan K, Lin X, et al. Magnetic fields exposure and childhood leukemia risk: a meta-analysis based on 11,699 cases and 13,194 controls. Leuk Res 2014;38(3):269–74.
37. Hardell L, Näsman A, Påhlson A, Hallquist A, Hansson Mild K. Use of cellular telephones and the risk for brain tumours: a case-control study. Int J Oncol 1999;15(1):113–6.
38. Coureau G, Bouvier G, Lebailly P, Fabbro-Peray P, Gruber A, et al. Mobile phone use and brain tumours in the CERENAT case-control study. Occup Environ Med 2014;71(7):514–22.
39. Hardell L, Carlberg M, Soderqvist F, Mild KH. Case-control study of the association between malignant brain tumours diagnosed between 2007 and 2009 and mobile and cordless phone use. Int J Oncol 2013;43(6):1833–45.
40. Hardell L, Carlberg M, Soderqvist F, Mild KH. Pooled analysis of case-control studies on acoustic neuroma diagnosed 1997–2003 and 2007–2009 and use of mobile and cordless phones. Int J Oncol 2013;43(4):1036–44.
41. Hardell L, Carlberg M. Using the Hill viewpoints from 1965 for evaluating strengths of evidence of the risk for brain tumors associated with use of mobile and cordless phones. Rev Environ Health 2013;28:97–106.
42. Hardell L, Carlberg M. Mobile phone and cordless phone use and the risk for glioma – Analysis of pooled case-control studies in Sweden, 1997–2003 and 2007–2009. Pathophysiology 2015;22(1):1–13.
43. Soffritti M, Giuliani L. ICEMS Position Paper on the Cerebral Tumor Court Case [Internet]. Rome (IT), Bolgna (IT), Chicago, IL (US): International Commission for Electromagnetic Safety, 2012 October 23. Available from: http://www.icems.eu/docs/Sentenza_integrale_n17438_13577519.pdf?f=/c/a/2009/12/15/MNHJ1B49KH.DTL.
44. Bak M, Dudarewicz A, Zmyślony M, Sliwinska-Kowalska M. Effects of GSM signals during exposure to event related potentials (ERPs). Int J Occup Med Environ Health 2010;23(2):191–9.

45. Maganioti AE, Hountala CD, Papageorgiou CC, Kyprianou MA, Rabavilas AD, et al. Principal component analysis of the P600 waveform: RF and gender effects. Neurosci Lett 2010;478(1): 19–23.
46. Hountala CD, Maganioti AE, Papageorgiou CC, Nanou ED, Kyprianou MA, et al. The spectral power coherence of the EEG under different EMF conditions. Neurosci Lett 2008;441(2): 188–92.
47. Croft RJ, Hamblin DL, Spong J, Wood AW, McKenzie RJ, et al. The effect of mobile phone electromagnetic fields on the alpha rhythm of human electroencephalogram. Bioelectromagnetics 2008;29(1):1–10.
48. Croft RJ, Leung S, McKenzie RJ, Loughran SP, Iskra S, et al. Effects of 2G and 3G mobile phones on human alpha rhythms: resting EEG in adolescents, young adults, and the elderly. Bioelectromagnetics 2010;31(6):434–44.
49. Leung S, Croft RJ, McKenzie RJ, Iskra S, Silber B, et al. Effects of 2G and 3G mobile phones on performance and electrophysiology in adolescents, young adults and older adults. Clin Neurophysiol 2011;122(11):2203–16.
50. Lustenberger C, Murbach M, Durr R, Schmid MR, Kuster N, et al. Stimulation of the brain with radiofrequency electromagnetic field pulses affects sleep-dependent performance improvement. Brain Stimul 2013;6(5):805–11.
51. Vecchio F, Babiloni C, Ferreri F, Curcio G, Fini R, et al. Mobile phone emission modulates interhemispheric functional coupling of EEG alpha rhythms. Eur J Neurosci 2007;25(6):1908–13.
52. Vecchio F, Buffo P, Sergio S, Iacoviello D, Rossini PM, et al. Mobile phone emission modulates event-related desynchronization of α rhythms and cognitive-motor performance in healthy humans. Clin Neurophysiol 2012;123(1):121–8.
53. Tombini M, Pellegrino G, Pasqualetti P, Assenza G, Benvenga A, et al. Mobile phone emissions modulate brain excitability in patients with focal epilepsy. Brain Stimul 2013;6(3):448–54.
54. Vecchio F, Tombini M, Buffo P, Assenza G, Pellegrino G, et al. Mobile phone emission increases inter-hemispheric functional coupling of electroencephalographic alpha rhythms in epileptic patients. Int J Psychophysiol 2012;84(2):164–71.
55. Perentos N, Croft RJ, McKenzie RJ, Cvetkovic D, Cosic I. Comparison of the effects of continuous and pulsed mobile phone like RF exposure on the human EEG. Australas Phys Eng Sci Med 2007;30(4):274–80.
56. Trunk A, Stefanics G, Zentai N, Kovács-Bálint Z, Thuróczy G, et al. No effects of a single 3G UMTS mobile phone exposure on spontaneous EEG activity, ERP correlates, and automatic deviance detection. Bioelectromagnetics 2013;34(1):31–42.
57. Kleinlogel H, Dierks T, Koenig T, Lehmann H, Minder A, et al. Effects of weak mobile phone – electromagnetic fields (GSM, UMTS) on well-being and resting EEG. Bioelectromagnetics 2008;29(6):479–87.
58. Kleinlogel H, Dierks T, Koenig T, Lehmann H, Minder A, et al. Effects of weak mobile phone – electromagnetic fields (GSM, UMTS) on event related potentials and cognitive functions. Bioelectromagnetics 2008;29(6):488–97.
59. Krause CM, Pesonen M, Haarala Björnberg C, Hämäläinen H. Effects of pulsed and nuous wave 902 MHz mobile phone exposure on brain oscillatory activity during cognitive processing. Bioelectromagnetics 2007;28(4):296–308.
60. Inomata-Terada S, Okabe S, Arai N, Hanajima R, Terao Y, et al. Effects of high frequency electromagnetic field (EMF) emitted by mobile phones on the human motor cortex. Bioelectromagnetics 2007;28(7):553–61.
61. Hung CS, Anderson C, Horne JA, McEvoy P. Mobile phone 'talk-mode' signal delays EEG-determined sleep onset. Neurosci Lett 2007;421(1):82–6.
62. Regel SJ, Tinguely G, Schuderer J, Adam M, Kuster N, et al. Pulsed radio-frequency electromagnetic fields: dose-dependent effects on sleep, the sleep EEG and cognitive performance. J Sleep Res 2007;16(3):253–8.
63. Lowden A, Akerstedt T, Ingre M, Wiholm C, Hillert L, et al. Sleep after mobile phone exposure in subjects with mobile phone-related symptoms. Bioelectromagnetics 2011;32(1):4–14.
64. Schmid MR, Loughran SP, Regel SJ, Murbach M, Bratic Grunauer A, et al. Sleep EEG alterations: effects of different pulse-modulated radio frequency electromagnetic fields. J Sleep Res 2012;21(1):50–8.
65. Schmid MR, Murbach M, Lustenberger C, Maire M, Kuster N, et al. Sleep EEG alterations: effects of pulsed magnetic fields versus pulse-modulated radio frequency electromagnetic fields. J Sleep Res 2012;21(6):620–9.
66. Loughran SP, McKenzie RJ, Jackson ML, Howard ME, Croft RJ. Individual differences in the effects of mobile phone exposure on human sleep: rethinking the problem. Bioelectromagnetics 2012;33(1):86–93.
67. Fritzer G, Göder R, Friege L, Wachter J, Hansen V, et al. Effects of short- and long-term pulsed radiofrequency electromagnetic fields on night sleep and cognitive functions in healthy subjects. Bioelectromagnetics 2007;28(4):316–25.
68. Mohler E, Frei P, Braun-Fahrländer C, Fröhlich J, Neubauer G, et al. Effects of everyday radiofrequency electromagnetic-field exposure on sleep quality: a cross-sectional study. Radiat Res 2010;174(3):347–56.
69. Mohler E, Frei P, Fröhlich J, Braun-Fahrländer C, Röösli M, et al. Exposure to radiofrequency electromagnetic fields and sleep quality: a prospective cohort study. PLoS One 2012;7(5):e37455.
70. Nakatani-Enomoto S, Furubayashi T, Ushiyama A, Groiss SJ, Ueshima K, et al. Effects of electromagnetic fields emitted from W-CDMA-like mobile phones on sleep in humans. Bioelectromagnetics 2013;34(8):589–98.
71. Pelletier A, Delanaud S, Décima P, Thuroczy G, de Seze R, et al. Effects of chronic exposure to radiofrequency electromagnetic fields on energy balance in developing rats. Environ Sci Pollut Res Int 2013;20(5):2735–46.
72. Mohammed HS, Fahmy HM, Radwah NM, Elsayed AA. Non-thermal continuous and modulated electromagnetic radiation fields effects on sleep EEG of rats. J Adv Res 2013;4(2):181–7.
73. Belyaev I. Dependence of non-thermal biological effects of microwaves on physical and biological variables: implications for reproducibility and safety standards [Internet]. In: Giuliani L, Soffritti M, editors. Non-thermal effects and mechanisms of interaction between electromagnetic fields and living matter. Bologna (IT): Ramazzini institute, 2010. European Journal of Oncology – Library Vol. 5. pp 187–218. Available from: http://www.icems.eu/papers.htm?f=/c/a/2009/12/15/MNHJ1B49KH.DTL.
74. Kitaoka K, Kitamura M, Aoi S, Shimizu N, Yoshizaki K. Chronic exposure to an extremely low-frequency magnetic field induces depression-like behavior and corticosterone secretion without enhancement of the hypothalamic-pituitary-adrenal axis in mice. Bioelectromagnetics 2013;34(1):43–51.

75. Szemerszky R, Zelena D, Barna I, Bárdos G. Stress-related endocrinological and psychopathological effects of short- and long-term 50Hz electromagnetic field exposure in rats. Brain Res Bull 2010;81(1):92–9.
76. Shin EJ, Jeong JH, Kim HJ, Jang CG, Yamada K, et al. Exposure to extremely low frequency magnetic fields enhances locomotor activity via activation of dopamine D1-like receptors in mice. J Pharmacol Sci 2007;105(4):367–71.
77. Shin EJ, Nguyen XK, Nguyen TT, Pham DT, Kim HC. Exposure to extremely low frequency magnetic fields induces fos-related antigen-immunoreactivity via activation of dopaminergic D1 receptor. Exp Neurobiol 2011;20(3):130–6.
78. Wang X, Liu Y, Lei Y, Zhou D, Fu Y, et al. Extremely low-frequency electromagnetic field exposure during chronic morphine treatment strengthens downregulation of dopamine D2 receptors in rat dorsal hippocampus after morphine withdrawal. Neurosci Lett 2008;433(3):178–82.
79. Ravera S, Bianco B, Cugnoli C, Panfoli I, Calzia D, et al. Sinusoidal ELF magnetic fields affect acetylcholinesterase activity in cerebellum synaptosomal membranes. Bioelectromagnetics 2010;31(4):270–6.
80. Fournier NM, Mach QH, Whissell PD, Persinger MA. Neurodevelopmental anomalies of the hippocampus in rats exposed to weak intensity complex magnetic fields throughout gestation. Int J Dev Neurosci 2012;30(6):427–33.
81. Balassa T, Szemerszky R, Bárdos G. Effect of short-term 50 Hz electromagnetic field exposure on the behavior of rats. Acta Physiol Hung 2009;96(4):437–48.
82. Dimitrijević D, Savić T, Anđelković M, Prolić Z, Janać B. Extremely low frequency magnetic field (50 Hz, 0.5 mT) modifies fitness components and locomotor activity of Drosophila subobscura. Int J Radiat Biol 2014;90(5):337–43.
83. Janać B, Selaković V, Rauš S, Radenović L, Zrnić M, et al. Temporal patterns of extremely low frequency magnetic field-induced motor behavior changes in Mongolian gerbils of different age. Int J Radiat Biol 2012;88(4):359–66.
84. Legros A, Corbacio M, Beuter A, Modolo J, Goulet D, et al. Neurophysiological and behavioral effects of a 60 Hz, 1800 μT magnetic field in humans. Eur J Appl Physiol 2012;112(5):1751–62.
85. Rauš S, Selaković V, Radenović L, Prolić Z, Janać B. Extremely low frequency magnetic field induced changes in motor behaviour of gerbils submitted to global cerebral ischemia. Behav Brain Res 2012;228(2):241–6.
86. Todorović D, Marković T, Prolić Z, Mihajlović S, Rauš S, et al. The influence of static magnetic field (50 mT) on development and motor behaviour of Tenebrio (Insecta, Coleoptera). Int J Radiat Biol 2013;89(1):44–50.
87. Che Y, Sun H, Cui Y, Zhou D, Ma Y. Effects of exposure to 50 Hz magnetic field of 1 mT on the performance of detour learning task by chicks. Brain Res Bull 2007;74(1–3):178–82.
88. Corbacio M, Brown S, Dubois S, Goulet D, Prato FS, et al. Human cognitive performance in a 3 mT power-line frequency magnetic field. Bioelectromagnetics 2011;32(8):620–33.
89. Cui Y, Ge Z, Rizak JD, Zhai C, Zhou Z, et al. Deficits in water maze performance and oxidative stress in the hippocampus and striatum induced by extremely low frequency magnetic field exposure. PLoS One 2012;7(5):e32196.
90. Duan Y, Wang Z, Zhang H, He Y, Lu R, et al. The preventive effect of lotus seedpod procyanidins on cognitive impairment and oxidative damage induced by extremely low frequency electromagnetic field exposure. Food Funct 2013;4(8):1252–62.
91. Fu Y, Wang C, Wang J, Lei Y, Ma Y. Long-term exposure to extremely low-frequency magnetic fields impairs spatial recognition memory in mice. Clin Exp Pharmacol Physiol 2008;35(7):797–800.
92. Harakawa S, Nedachi T, Hori T, Takahashi K, Tochio K, et al. Effect of electric field in conditioned aversion response. J Vet Med Sci 2008;70(6):611–3.
93. He LH, Shi HM, Liu TT, Xu YC, Ye KP, et al. Effects of extremely low frequency magnetic field on anxiety level and spatial memory of adult rats. Chin Med J (Engl) 2011;124(20):3362–6.
94. Liu T, Wang S, He L, Ye K. Chronic exposure to low-intensity magnetic field improves acquisition and maintenance of memory. Neuroreport 2008;19(5):549–52.
95. Sun H, Che Y, Liu X, Zhou D, Miao Y, et al. Effects of prenatal exposure to a 50-Hz magnetic field on one-trial passive avoidance learning in 1-day-old chicks. Bioelectromagnetics 2010;31(2):150–5.
96. Korpinar MA, Kalkan MT, Tuncel H. The 50 Hz (10 mT) sinusoidal magnetic field: effects on stress-related behavior of rats. Bratisl Lek Listy 2012;113(9):521–4.
97. Liu T, Wang S, He L, Ye K. Anxiogenic effect of chronic exposure to extremely low frequency magnetic field in adult rats. Neurosci Lett 2008;434(1):12–7.
98. Salunke BP, Umathe SN, Chavan JG. Involvement of NMDA receptor in low-frequency magnetic field-induced anxiety in mice. Electromagn Biol Med 2014;33(4):312–26.
99. Ross ML, Koren SA, Persinger MA. Physiologically patterned weak magnetic fields applied over left frontal lobe increase acceptance of false statements as true. Electromagn Biol Med 2008;27(4):365–71.
100. Davanipour Z, Tseng CC, Lee PJ, Markides KS, Sobel E. Severe Cognitive dysfunction and occupational extremely low frequency magnetic field exposure among elderly Mexican Americans. Br J Med Med Res 2014;4(8):1641–62.
101. Stevens P. Affective response to 5 microT ELF magnetic field-induced physiological changes. Bioelectromagnetics 2007;28(2):109–14.
102. Ishay JS, Plotkin M, Volynchik S, Shaked M, Schuss Z, et al. Exposure to an additional alternating magnetic field affects comb building by worker hornets. Physiol Chem Phys Med NMR 2007;39(1):83–8.
103. Sandyk R. Reversal of cognitive impairment in an elderly Parkinsonian patient by transcranial application of picotesla electromagnetic fields. Int J Neurosci 1997;91(1–2):57–68.
104. Hallberg Ö, Johansson O. Alzheimer mortality – why does it increase so fast in sparsely populated areas? Europ Biol Bioelectromag 2005;1:225–46.
105. Huss A, Spoerri A, Egger M, Röösli M; Swiss National Cohort Study. Residence near power lines and mortality from neurodegenerative diseases: longitudinal study of the Swiss population. Am J Epidemiol 2009;169(2):167–75.
106. Frei P, Poulsen AH, Mezei G, Pedersen C, Cronberg Salem L, et al. Residential distance to high-voltage power lines and risk of neurodegenerative diseases: a Danish population-based case-control study. Am J Epidemiol 2013;177(9):970–8.
107. Zhou H, Chen G, Chen C, Yu Y, Xu Z. Association between extremely low-frequency electromagnetic fields occupations and amyotrophic lateral sclerosis: a meta-analysis. PLoS One 2012;7(11):e48354.

108. Vergara X, Kheifets L, Greenland S, Oksuzyan S, Cho YS, et al. Occupational exposure to extremely low-frequency magnetic fields and neurodegenerative disease: a meta-analysis. J Occup Environ Med 2013;55(2):135–46.
109. Kundi M, Hutter HP. Umwelthygienische Bewertung des Berichtes zur Bestimmung der Feldstärken niederfrequenter magnetischer Wechselfelder im Bereich der 110 kV Hochspannungsleitung im Siedlungsbereich der Gemeinde Kottingbrunn von Dr.-Ing. Dietrich Moldan vom 20.8.2014 [Internet]. Kottingbrunn (AT): Gemeinde Kottinbrunn, 2014:69–104. Available from: www.kottingbrunn.or.at/system/web/GetDocument.ashx?fileid=972861.
110. Agarwal A, Deepinder F, Sharma RK, Ranga G, Li J. Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study. Fertil Steril 2008;89(1):124–8.
111. Agarwal A, Desai NR, Makker K, Varghese A, Mouradi R, et al. Effect of radiofrequency electromagnetic waves (RF-EMF) from cellular phones on human ejaculated semen: an in vitro study. Fertil Steril 2009;92(4):1318–25.
112. Wdowiak A, Wdowiak L, Wiktor H. Evaluation of the effect of using mobile phones on male fertility. Ann Agric Environ Med 2007;14(1):169–72.
113. De Iuliis GN, Newey RJ, King BV, Aitken RJ. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. PLoS One 2009;4(7):e6446.
114. Fejes I, Zavacki Z, Szollosi J, Koloszar Daru J, Kovacs L, et al. Is there a relationship between cell phone use and semen quality? Arch Androl 2005;51(5):385–93.
115. Aitken RJ, Bennetts LE, Sawyer D, Wiklendt AM, King BV. Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline. Int J Androl 2005;28(3):171–9.
116. Aitken RJ, Koopman P, Lewis SEM. Seeds of concern. Nature 2004;432(7013):48–52.
117. Erogul O, Oztas E, Yildirim I, Kir T, Aydur E, et al. Effects of electromagnetic radiation from a cellular phone on human sperm motility: an in vitro study. Arch Med Res 2006;37(7):840–3.
118. Dasdag S. Whole-body microwave exposure emitted by cellular phones and testicular function of rats. Urol Res 1999;27(3):219–23.
119. Yan JG, Agresti M, Bruce T, Yan YH, Granlund A, et al. Effects of cellular phone emissions on sperm motility in rats. Fertil Steril 2007;88(4):957–64.
120. Otitoloju AA, Obe IA, Adewale OA, Otubanjo OA, Osunkalu VO. Preliminary study on the reduction of sperm head abnormalities in mice, Mus musculus, exposed to radiofrequency radiations from global system for mobile communication base stations. Bull Environ Contam Toxicol 2010;84(1):51–4.
121. Behari J, Kesari KK. Effects of microwave radiations on reproductive system of male rats. Embryo Talk 2006; 1(Suppl. 1):81–5.
122. Kumar S, Behari J, Sisodia R. Impact of microwave at X-band in the aetiology of male infertility. Electromagn Biol Med 2012;31(3):223–32.
123. Panagopoulos DJ. Effect of microwave exposure on the ovarian development of Drosophila melanogaster. Cell Biochem Biophys 2012;63(2):121–32.
124. Gul A, Celebi H, Ugras S. The effects of microwaves emitted by cellular phones on ovarian follicles in rats. Arch Gynecol Obstet 2009;280(5):729–33.
125. Magras IN, Xenos TD. RF Radiation-induced changes in the prenatal development of mice. Bioelectromagnetics 1997;18(6):455–61.
126. Röösli M, Moser M, Baldinini Y, Meier M, Braun-Fahrländer C. Symptoms of ill health ascribed to electromagnetic field exposure – a questionnaire survey. Int J Hyg Environ Health 2004;207(2):141–50.
127. Kato Y, Johansson O. Reported functional impairments of electrohypersensitive Japanese: a questionnaire survey. Pathophysiology 2012;19(2):95–100.
128. Huss A, Küchenhoff J, Bircher A, Heller P, Kuster H, et al. Symptoms attributed tot he environment- a systematic interdisciplinary assessment. Int J Hyg Environ Health 2004;207(3):245–54.
129. Huss A, Küchenhoff J, Bircher A, Niederer M, Tremp J, et al. Elektromagnetische Felder und Gesundheitsbelastungen – Interdisziplinäre Fallabklärungen im Rahmen eines umweltmediznischen Beratungsprojektes. Umweltmed Forsch Prax 2005;10(1):21–8.
130. Schreier N, Huss A, Röösli M. The prevalence of symptoms attributed to electromagnetic field exposure: a cross-sectional representative survey in Switzerland. Soz Praventivmed 2006;51(4):202–9.
131. Huss A, Röösli M. Consultations in primary care for symptoms attributed to electromagnetic fields–a survey among general practitioners. BMC Public Health 2006;6:267.
132. Ausfeld-Hafter B, Manser R, Kempf D, Brändli I. Komplementärmedizin. Eine Fragebogenerhebung in schweizerischen Arztpraxen mit komplementärmedizinischem Diagnostik- und Therapieangebot. Studie im Auftrag vom Bundesamt für Umwelt. Universität Bern. Kollegiale Instanz für Komplementärmedizin (KIKOM) [Internet]. Bern (CH): Bundesamt für Umwelt. 2006 Oct 5. Available from: http://www.bafu.admin.ch/elektrosmog/01095/01099/index.html?lang=de&download.
133. Leitgeb N, Schröttner J, Böhm M. Does “electromagnetic pollution” cause illness? An inquiry among Austrian general practitioners. Wien Med Wochenschr 2005;155(9–10):237–41.
134. World Health Organization. Factsheet Nr. 296, Elektromagnetische Felder und Öffentliche Gesundheit – Elektromagnetische Hypersensitivität (Elektrosensibilität) [Internet]. Genf (CH): WHO, 2005 Dec. Available from: http://www.who.int/peh-emf/publications/facts/ehs_fs_296_german.pdf.
135. Hug K, Röösli M. Strahlung von Sendeanlagen und Gesundheit. Bewertung von wissenschaftlichen Studien im Niedrigdosisbereich. Stand: Dezember 2012 [Internet]. Bern (CH): Bundesamt für Umwelt, 2013. Available from: http://www.bafu.admin.ch/publikationen/publikation/01739/index.html?lang=de.
136. Genius SJ, Lipp CT. Electromagnetic hypersensitivity: fact or fiction? Sci Total Environ 2012;414:103–12.
137. Johansson O. Electrohypersensitivity: state-of-the-art of a functional impairment. Electromagn Biol Med 2006;25(4):245–58.
138. Johansson O. Aspects of studies on the functional impairment electrohypersensitivity. In: Proceedings of Electromagnetic Phenomena and Health – A Continuing Controversy? In: Jamieson IA, Holdstock, editors. A one day international conference organised by the Electrostatics Group of the Institute of Physics and held at the Institute of Physics, London (UK) 2008 Sept 10. IOP Conference Series: Earth and Environmental Science, IoP Publishing, Bristol/Philadelphia, Volume 10:1–7.

139. Abelous D. France has its first radiation-free refuge in the Drôme [Internet]. EURRE/Drôme (FR): Agence France Presse (AFP), 2009 Oct 9. Available from: http://www.next-up.org/pdf/AFP_France_has_its_first_radiation_free_refuge_in_the_Drome_09_10_2009.pdf.
140. Ecoforma. Mit einem schadstofffreiem Haus gegen Schlafprobleme [Internet]. Sarleinsbach (AT): Ecoforma, 2014 Sept 9. Available from: http://www.ecoforma.co.at/holzbau-ecobau-lehrbaustelle.
141. Johansson O. Elöverkänslighet samt överkänslighet mot mobiltelefoner: Resultat från en dubbel-blind provokationsstudie av metodstudiekaraktär (Electrohypersensitivity and sensitivity to mobile telephones: Results from a double-blind provocation study of pilot character, in Swedish), Enheten för Experimentell Dermatologi, Karolinska Institutet, Stockholm, Rapport No. 2, 1995, ISSN 1400-6111.
142. Johansson O, Liu P-Y. "Electrosensitivity", "electrosupersensitivity" and "screen dermatitis": preliminary observations from on-going studies in the human skin. In: Simunic D, editor. Proceedings of the COST 244: Biomedical Effects of Electromagnetic Fields – Workshop on Electromagnetic Hypersensitivity. Brussels/Graz: EU/EC (DG XIII) 1995:52–57.
143. Johansson O, Gangi S, Liang Y, Yoshimura K, Jing C, et al. Cutaneous mast cells are altered in normal healthy volunteers sitting in front of ordinary TVs/PCs – results from open-field provocation experiments. J Cutan Pathol 2001;28(10):513–9.
144. Johansson O, Hilliges M, Björnhagen V, Hall K. Skin changes in patients claiming to suffer from "screen dermatitis": a two-case open-field provocation study. Exp Dermatol 1994;3(5):234–8.
145. Belpomme D, Irigary P. Electrohypersensitivity and multiple chemical sensitivity: two clinic-biological entities of the same disorder? [Internet]. Brussels [BE]: In: Idiopathic environmental intolerance: what role for electromagnetic fields and chemicals? 5th Paris Appeal Congress, Royal Academy of Medicine, Belgium, 2015 May 18:p 34. Available from: http://www.ehs-mcs.org/fichiers/1432301961_Paris_Appeal_2015.pdf.
146. Regel SJ, Negovetic S, Röösli M, Berdiñas V, Schuderer J, et al. UMTS base station-like exposure, well-being, and cognitive performance. Environ Health Perspect 2006;114(8):1270–5.
147. Zwamborn APM, Vossen SHJA, van Leersum BJAM, Ouwens MA, Mäkel WN. Effects of Global Communication system radio-frequency fields on Well Being and Cognitive Functions of human subjects with and without subjective complaints. The Hague (NL): TNO Physics and Electronics Laboratory, 2003 Sept, 86 p. TNO-report FEL-03-C148. Available from: http://www.salzburg.gv.at/tno_study_2003.pdf.
148. Eltiti S, Wallace D, Ridgewell A, Zougkou K, Russo R, et al. 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;115(11):1603–8.
149. McCarty DE, Carrubba S, Chesson AL, Frilot C, Gonzalez-Toledo E, et al. Electromagnetic hypersensitivity: evidence for a novel neurological syndrome. Int J Neurosci 2011;121(12):670–6.
150. Havas M, Marrongelle J, Pollner B, Kelley E, Rees CRG, et al. Provocation study using heart rate variability shows microwave radiation from 2.4 GHz cordless phone affects autonomic nervous system [Internet]. In: Giuliani L, Soffritti M, editors. Non-thermal effects and mechanisms of interaction between electromagnetic fields and living matter. Bologna (IT): Ramazzini institute, 2010. European Journal of Oncology – Library Vol. 5. pp 187–218. Available from: http://www.icems.eu/papers.htm?f=/c/a/2009/12/15/MNHJ1B49KH.DTL.
151. Havas M. Radiation from wireless technology affects the blood, the heart, and the autonomic nervous system. Rev Environ Health 2013;28(2–3):75–84.
152. Tuengler A, von Klitzing L. Hypothesis on how to measure electromagnetic hypersensitivity. Electromagn Biol Med 2013;32(3):281–90.
153. Klitzing L. Einfluss elektromagnetischer Felder auf kardiovaskuläre Erkrankungen. umwelt medizin gesellschaft 2014;27(1):17–21.
154. Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex. Pathol Biol (Paris) 2002;50(6):369–73.
155. Navarro EA, Segura J, Portolés M, Gómez-Perretta de Mateo C. The microwave syndrome: a preliminary study in Spain. Electromagn Biol Med 2003;22(2–3):161–9.
156. Hutter HP, Moshammer H, Wallner P, Kundi M. Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. Occup Environ Med 2006;63(5):307–13.
157. Abdel-Rassoul G, El-Fateh OA, Salem MA, Michael A, Farahat F, et al. Neurobehavioral effects among inhabitants around mobile phone base stations. Neurotoxicology 2007;28(2):434–40.
158. Blettner M, Schlehofer B, Breckenkamp J, Kowall B, Schmiedel S, et al. Mobile phone base stations and adverse health effects: phase 1 of a population-based, cross-sectional study in Germany. Occup Environ Med 2009;66(2):118–23.
159. Milham S, Stetzer D. Dirty electricity, chronic stress, neurotransmitters and disease. Electromagn Biol Med 2013;32(4):500–7.
160. Schlegel P. Elektrosensible Französin als Behinderte anerkannt [Internet]. Stuttgart (DE): Diagnose Funk, 2015 Sep 7. Available from: http://www.diagnose-funk.org/themen/mobilfunkversorgung/gesundheit-und-elektrosensibilitaet/elektrosensible-franzoesin-als-behinderte-anerkannt.php.
161. Friedmann J, Kraus S, Hauptmann Y, Schiff Y, Seger R. Mechanism of short-term ERK activation by electromagnetic fields at mobile phone frequencies. Biochem J 2007;405(3):559–68.
162. Simkó M. Cell type specific redox status is responsible for diverse electromagnetic field effects. Curr Med Chem 2007;14(10):1141–52.
163. Pall ML. Explaining "Unexplained Illnesses": Disease Paradigm for Chronic Fatigue Syndrome, Multiple Chemical Sensitivity, Fibromyalgia, Post-Traumatic Stress Disorder, Gulf War Syndrome, and Others. New York, NY (US), London (GB): Harrington Park Press/Haworth Press, 2007, ISBN 978-0-7890-2388-9.
164. Bedard K, Krause KH. The NOX Family of ROS-Generating NADPH oxidases: physiology and pathophysiology. Physiol Rev 2007;87(1):245–313.
165. Pacher P, Beckman JS, Liaudet L. Nitric oxide and peroxynitrite in health and disease. Physiol Rev 2007;87(1):315–424.
166. Desai NR, Kesari KK, Agarwal A. Pathophysiology of cell phone radiation: oxidative stress and carcinogenesis with focus on male reproductive system. Reprod Biol Endocrinol 2009;7:114.

167. Straub RH, Cutolo M, Buttgereit F, Pongratz G. Energy regulation and neuroendocrine-immune control in chronic inflammatory diseases. J Intern Med 2010;267(6):543–60.
168. Gye MC, Park CJ. Effect of electromagnetic field exposure on the reproductive system. Clin Exp Reprod Med 2012;39(1):1–9.
169. Yakymenko I, Tsybulin O, Sidorik E, Henshel D, Kyrylenko O, et al. Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation. Electromagn Biol Med 2015;19:1–16.
170. Pall ML. Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. J Cell Mol Med 2013;17(8):958–65.
171. Pall ML. Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. J Chem Neuroanat 2015. pii: S0891-0618(15)00059-9. DOI: 10.1016/j.jchemneu.2015.08.001. [Epub ahead of print].
172. Myhill S, Booth NE, McLaren-Howard J. Chronic fatigue syndrome and mitochondrial dysfunction. Int J Clin Exp Med 2009;2(1):1–16.
173. Müller KE. Stressregulation und Mitochondrienfunktion. Zs f Orthomol Med 2012;1:1–13.
174. Buchner K, Eger H. Veränderung klinisch bedeutsamer Neurotransmitter unter dem Einfluss modulierter hochfrequenter Felder – Eine Langzeiterhebung unter lebensnahen Bedingungen. umwelt medizin gesellschaft 2011;24(1):44–57.
175. Hill HU, Huber W, Müller KE. Multiple-Chemikalien-Sensitivität (MCS) – Ein Krankheitsbild der chronischen Multisystemerkrankungen, umweltmedizinische, toxikologische und sozialpolitische Aspekte. Aachen (DE): Shaker-Verlag, 2010 Apr, 3rd edition, 500p. ISBN: 978-3-8322-9046-7.
176. Redmayne M, Johansson O. Could myelin damage from radiofrequency electromagnetic field exposure help explain the functional impairment electrohypersensitivity? A review of the evidence. J Toxicol Environ Health B Crit Rev 2014;17(5):247–58.
177. Von Baehr V. Rationelle Labordiagnostik bei chronisch entzündlichen Systemerkrankungen. umwelt medizin gesellschaft 2012;25(4):244–7.
178. Warnke U, Hensinger P. Steigende „Burn-out“-Inzidenz durch technisch erzeugte magnetische und elektromagnetische Felder des Mobil- und Kommunikationsfunks. umwelt-medizin-gesellschaft 2013;26(1):31–8.
179. Havas M. Dirty electricity elevates blood sugar among electrically sensitive diabetics and may explain brittle diabetes. Electromagn Biol Med 2008;27(2):135–46.
180. Steiner E, Aufdereggen B, Bhend H, Gilli Y, Kälin P, et al. Erfahrungen des Pilotprojektes „Umweltmedizinisches Beratungsnetz“ des Vereins Aerztinnen und Aerzte für Umweltschutz (AefU). Therapeutische Umschau 2013;70(12):739–45.
181. Hagström M, Auranen J, Johansson O, Ekman R. Reducing electromagnetic irradiation and fields alleviates experienced health hazards of VDU work. Pathophysiology 2012;19(2):81–7.
182. Hagström M, Auranen J, Ekman R. Electromagnetic hypersensitive Finns: symptoms, perceived sources and treatments, a questionnaire study. Pathophysiology 2013;20(2):117–22.
183. Oberfeld G. Die Veränderung des EMF Spektrums und ihre Folgen. In: Baubiologische EMF-Messtechnik. München, Heidelberg (DE): Hüthig & Pflaum Verlag, 2012. ISBN 1438-8707.
184. Berufsverband Deutscher Baubiologen. VDB-Richtlinien, Physikalische Untersuchungen, Band 1: Fürth (DE): Verlag AnBUS eV, 2006. 2nd Edition. Available at: http://www.baubiologie.net/publikationen/vdb-richtlinien.html.
185. Bundesamt für Umwelt. Orte mit empfindlicher Nutzung (OMEN) [Internet]. Bern (CH): Bundesamt für Umwelt, 2010 Mar 4. Available from: http://www.bafu.admin.ch/elektrosmog/07136/07420/index.html?lang=de.
186. Kundi M, Hutter HP. Mobile phone base stations – Effects on wellbeing and health. Pathophysiology 2009;16(2–3):123–35.
187. Molla-Djafari H, Witke J, Poinstingl G, Brezansky A, Hutter HP, et al. Leitfaden Senderbau -Vorsorgeprinzip bei Errichtung, Betrieb, Um- und Ausbau von ortsfesten Sendeanlagen. Wien (AT): Ärztinnen und Ärzte für eine gesunde Umwelt e.V. (Hrsg.), 2014 Oct. 2. Auflage, 42 p, Available from: www.aegu.net/pdf/Leitfaden.pdf.
188. National Council on Radiation Protection and Measurements (NCRP). Draft Report of NCRP Scientific Committee 89-3 on Extremely Low Frequency Electric and Magnetic Fields [Internet]. 1995 Jun 13. Available from: http://www.salzburg.gv.at/ncrp_draft_recommendations_on_emf_exposure_guidelines_1995.pdf.
189. Oberfeld G. Umweltverträglichkeitsgutachten für die Umweltverträglichkeitsprüfung nach UVP-G 2000 für das Vorhaben 380 kV Freileitung von St. Peter am Hart zum Umspannwerk Salzach Neu (Salzburgleitung), Befund und Gutachten Umweltmedizin (Salzburg) [Internet] Salzburg (AT): Land Salzburg, 2006, p241-360. Available from: http://www.salzburg.gv.at/salzburgleitung-uvg-endvers.pdf.
190. Baubiologie Maes/Institut für Baubiologie + Nachhaltigkeit (IBN). Baubiologische Richtwerte für Schlafbereiche (Ergänzung zum SBM-2015). Neuss, Rosenheim (DE): Baubiologie Maes, IBN., 2015 May, 3 p. Available from: http://www.maes.de/3%20STANDARD/maes.de%20STANDARD-2015%20RICHTWERTE.PDF.
191. Virnich M. Gutachten über die messtechnische Untersuchung der Charakteristik von Funksignalen [Internet]. Salzburg (AT): Land Salzburg, 2015 Jun 26, 141 p. Available from: http://www.salzburg.gv.at/elektrosmog_und_gesundheit/technik.htm.
192. Der Schweizerische Bundesrat. Verordnung über den Schutz vor nichtionisierender Strahlung (NISV) vom 23. Dezember 1999 [Internet]. Bern (CH): Der Schweizerische Bundesrat, 2012 Jul 1. Available from: https://www.admin.ch/opc/de/classified-compilation/19996141/index.html.
193. Zeisel L. Ein Meßverfahren zur Bestimmung der Körperbelastung durch das elektrische Wechselfeld bei tiefen Frequenzen. Wohnung und Gesundheit 1993;69:20.
194. Arbeitskreis Elektrobiologie eV. Available from: http://www.elektrobiologie.com/index.html.
195. Gralla F. Estimation of 50-Hz electrically vs. magnetically generated body currents in sleeping subjects. Electromagnetic Biology and Medicine Jan 1997;16(3):235–41.
196. Gustavs K. Options to inimize non-ionizing electromagnetic radiation exposures (EMF/RF/Static fields) in office environments [Internet]. Victoria, BC (CA): Katharina Consulting, 2008 Nov 14. Available from: http://www.katharinaconsulting.com/s/2008_Gustavs_Low_EMF_Office_Environment.pdf.

197. Oberfeld G, Gutbier J. Elektrosmog im Alltag [Internet]. Stuttgart (DE): Diagnose Funk, 2013 Nov 10, 44 p. Available from: http://www.salzburg.gv.at/df_ratgeber_1.pdf.
198. Virnich M. Baubiologische EMF-Messtechnik – Grundlagen der Feldtheorie, Praxis der Feldmesstechnik. München, Heidelberg (DE): Hüthig & Pflaum Verlag, 2012. ISBN 1438-8707.
199. Pauli P, Moldan D. Reduzierung hochfrequenter Strahlung im Bauwesen: Baustoffe und Abschirmmaterialien. Fürth (DE): Hrsg. Berufsverband Deutscher Baubiologen VDB e.V., Verlag AnBUS e.V. 2015. ISBN 978-3-9814025-9-9.
200. Levy F, Wannag A, editors. Nordic Adaptation of Classification of Occupationally Related Disorders (Diseases and Symptoms) to ICD-10 [Internet]. Oslo (NO): Nordic council of ministers, 2000, 53 p. DIVS: 2000:839, ISBN: 92-893-0559-2. Available from: http://www.nordclass.se/ICD-10_Nordic%20 Occupational_2000.pdf.
201. Bansal M, Kaushal N. *Oxidative stress mechanisms and their modulation*. New Delhi (IN): Springer, 2014:167 p.
202. Brostoff J, Challacombe S. *Food allergy and intolerance*. London (GB): Ballière Tindall, 1987.
203. Andrè CM, Larondelle Y, Eners D. Dietary antioxidants and oxidative stress from a human and plant perspective, a review. Curr Nutr Food Sci 2010;6(1):2–12.
204. Bouayed J, Bohn T. Exogenous antioxidants-double edged swords in cellular redox state; health beneficial effects at physiological doses versus deleterious effects at high doses. Oxid Med Cell Longev 2010;3(4):228–37.
205. Hoffmann W, Staller B. Prävention durch richtige Ernährung. umwelt medizin gesellschaft 2012;25(2):115–7.
206. Suzuki YJ, Packer L. Inhibition of NFkB activation by vitamin E derivates. Biochem Biophys Res Commun 1993;193(1):277–83.
207. Zingg JM. Modulation of signal transduction by vitamin E. Mol Aspects Med 2007;28(5–6):481–506.
208. Yeh SL, Wang HM, Chen PY, Wu TC. Interaction of ß-Carotin and flavonoids on the secretion of inflammatory mediators in an in vitro system. Chem Biol Interact 2009;179(2–3): 386–93.
209. Cárcamo JM, Pedraza A, Bórquez-Ojeda O, Golde DW. Vitamin C suppresses TNF alpha-induced NF kappa B activation by inhibiting I kappa B alpha phosphorylation.Biochemistry 2002;41(43):12995–3002.
210. Cárcamo JM, Pedraza A, Bórquez-Ojeda O, Zhang B, Sanchez R, et al. Vitamin C is a kinase inhibitor: dehydroascorbic acid inhibits IkappaBalpha kinase beta. Mol Cell Biol 2004; 24(15):6645–52.
211. Kyaw M, Yoshizumi M, Tsuchya K, Suzaki Y, Abe S, et al. Antioxidants inhibit endothelin-1 (1-31)-induced proliferation of vascular smooth muscle cells via the inhibition of mitogen-activated protein (MAP) kinase and activator protein-1 (AP-1). Biochem Pharmacol 2002;64(10):1521–31.
212. Lubbad A, Oriowo MA, Khan I. Curcumin attenuates inflammation through inhibition of TLR-4 receptor in experimental Colitis. Mol Cell Biochem 2009;322(1–2): 127–35.
213. Woo JH, Lim JH, Kim YH, Soh SI, Min DS, et al. Resveratrol inhibits phorbol myristate acetate-induced matrix metalloproteinase-9 expression by inhibiting JNK and PKC delta signal transduction. Oncogene 2004;23(10):1845–53.
214. Nonn L, Duong D, Pechl DM. Chemopreventive antiinflammatory activities of curcumin and other phytochemicals mediated by MAP kinase phosphatase-5 in prostata cells. Carcinogenesis 2007;28(6):1188–96.
215. Khan N, Mukhtar H. Multitargeted therapy of cancer by green tee polyphenols. Cancer Lett 2008;269(2):269–80.
216. Roskoski R. Biochemistry. Philadelphia, PA, USA: W.B. Saunders Company, 1996:530.
217. Devlin TM, editor. Textbook of Biochemistry with Clinical Correlations. 5th ed. New York, NY (US): Wiley-Liss, 2002.
218. Rassow J, Hauser K, Netzker, Deutzmann R. Biochemie. 2nd ed. Stuttgart (DE): Thieme, 2008:872.
219. Müller KE. Genetische Polymorphismen der Catechol-O-Methyltransferase (COMT). umwelt medizin gesellschaft 2007;20(4):282–8.
220. Rea WJ. Chemical Sensitivity, Vol. 2: Sources of Total Body Load. 1st ed. Boca Raton, FL (US): CRC Press/Lewis Publishers, 1994:569.
221. Schäfer SG, Elsenhans B, Forth W, Schümann K. Metalle. In: Marquardt H, Schäfer SG, editors. Lehrbuch der Toxikologie. Heidelberg (DE): Spektrum Akademischer Verlag, 1997:504–49.
222. Goyer RA, Cherian GM, editors. Toxicology of Metals. Berlin, Heidelberg (DE): Springer-Verlag, 1995:467.
223. Müller KE. Immuntoxikologie der Metalle. umwelt medizin gesellschaft 2004;17(4):299–301.
224. Aposian HV, Malorino RM, Gonzales-Ramirez D, Zuniga-Charles M, Xu Z, et al. Mobilization of heavy metals by newer, therapeutically useful chelating agents. Toxicology 1995;97(1–3):23–38.
225. Flora SJ, Pachauri V. Chelation in Metal Intoxication. Int J Environ Res Public Health 2010;7(7):2745–88.
226. Jennrich P. Detoxifikation von Schwermetallen. umwelt medizin gesellschaft 2012;25(4):24–7.
227. Rózanowska M, Jarvis-Evans J, Korytowski W, Boulton ME, Burke JM, Sarna T. Blue-light induced reactivity of retinal age pigment. In vitro generation of oxygen-reactive species. J Biol Chem 1995;270(32):18825–30.
228. Tolentino M, Morgan G. Popularity of electronic devices, “greener” light bulbes increases blue light exposure. Pri Care Optometry News 2012;18–9.
229. van der Lely S, Frey S, Garbazza C, Wirz-Justice A, Jenni OG, et al. Blue blocker glasses as a countermeasure for alerting effects of evening light-emitting diode screen exposure in male teenagers. J Adolesc Health 2015;56(1):113–9.
230. Narimatsu T, Negishi K, Miyake S, Hirasawa M, Osada H, et al. Blue light-induced inflammatory marker expression in the retinal pigment epithelium-choroid of mice and the protective effect of a yellow intraocular lens material in vivo. Exp Eye Res 2015;132:48–51.
231. Nishi T, Saeki K, Obayashi K, Miyata K, Tone N, et al. The effect of blue-blocking intraocular lenses on circadian biological rhythm: protocol for a randomised controlled trial (CLOCK-IOL colour study). BMJ Open 2015;5(5):e007930.
232. Mutter J, Naumann J, Schneider R, Walach H, Haley B. Mercury and autism: accelerating evidence? Neuro Endocrinol Lett 2005;26(5):439–46.

233. Mutter J, Naumann J, Guethlin C. Comments on the article "the toxicology of mercury and its chemical compounds" by Clarkson and Magos (2006). Crit Rev Toxicol 2007;37(6):537–49; discussion 551–2.
234. Mutter J, Curth A, Naumann J, Deth R, Walach H. Does inorganic mercury play a role in Alzheimer's disease? A systematic review and an integrated molecular mechanism. J Alzheimers Dis 2010;22(2):357–74.
235. Geier DA, King PG, Sykes LK, Geier MR. A comprehensive review of mercury provoked autism. Indian J Med Res 2008;128(4):383–411.

Supplemental Material: The online version of this article (DOI: 10.1515/reveh-2015-0033) offers supplementary material, available to authorized users.