Bilaga 2

INSÄNDARE

Elöverkänsligheten omöjliggjorde en normal skolgång

Av Anonym 16-åring

När jag är på cykeltur händer det att jag möter skolbussen. Först blir jag förvånad, men så inser jag att det är en helt vanlig skoldag för mina jämnåriga.

Senast jag gick i skolan på heltid var i årskurs 2 för snart 8 år sedan. Jag älskade skolan, och bad fröken om extra läxor. Sedan dess har jag, förgäves, längtat och drömt om att få gå en vanlig skolvecka på samma villkor som mina klasskamrater. Ibland har jag kunnat gå deltid i skolan, ibland inte alls. Skolan har värderat tekniken högre än mig.

Mobiler, datorer och trådlösa nätverk har använts trots att mikrovågorna de avger orsakar mig svåra symtom. Det är absurt att ha en skolmiljö som är skuld till dåligt arbetsminne, koncentrationssvårigheter och huvudvärk mm. Sveriges skolor borde koppla upp datorerna via sladd, och tillsammans pressa på industrin att ta fram väl avskärmad teknik. Elöverkänslighetssymtom, dåligt arbetsminne, sömnsvårigheter och psykisk ohälsa är vanligt idag, men många har inte sett sambandet än.

Förra året slutade jag 9:an, men kvar är sorgen för att skolan inte var öppen för mig. Min förhoppning om en skola för alla hann inte bli verklighet under min skoltid. ■

Minst 200.000 svenskar, eller 3,1% av Sveriges vuxna befolkning, uppgav i en hälsoenkät att de är överkänsliga för elektriska/magnetiska fält (Miljöhälsorapport 2001/Hälsoenkät 1999). Enligt Socialstyrelsen senaste rapport från 2009 har vi nu c:a 3.2% elöverkänsliga, vilket med en befolkning på 9 miljoner blir nära 300 000 drabbade, 0.4% eller c:a 36 000 hade svåra besvär. (Socialstyrelsens Miljöhälsorapport 2009/Hälsoenkät 2007, du hittar hela rapporten på www.socialstyrelsen.se)

Bilaga 3

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Electromagnetic hypersensitivity – an increasing challenge to the medical profession

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Abstract

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

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

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

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

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

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

Background

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

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

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

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

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

Historical aspects

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

In the 1980s, symptoms from cathode ray tube (CRT) computer screens appeared among office workers, most of whom were women. They showed symptoms that included flushing, burning, and tingling in the skin, especially on the face. When it worsened, they could develop eczema and swollen faces, with dilated blood vessels and vesicles, which was usually diagnosed as Rosacea. Björn Lagerholm, a Swedish dermatologist, histologically found a similarity between skin biopsies from these women and those from heavily UV-radiated skin. He compared it with elastosis solaris, seen in elderly people after long sun-bathing or working out in the sun. The term "screen dermatitis" was suggested. If the affected office workers went on working in front of CRT screens, they could develop more symptoms – headaches, dizziness, tiredness, and light and noise sensitivity. Both at work and at home, they could become sensitive to fluorescent light, the stove, TV, and other electric devices (5).

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

Reference values

The reference values for RF-EMF were recommended in 1998 by the International Commission on Non-Ionizing Radiation Protection to 2–10 W/m² for frequencies between 10 MHz and 300 GHz. Up to 400 MHz, the recommendation is 2 W/m². The formula: frequency/2×10⁸ is used for frequencies between 400 and 2000 MHz. Above 2000 MHz up to 300 GHZ, the recommended reference value is 10 W/m² (7). These reference values protect against injuries caused by a heating effect over 1°C after an exposure of 30 min, and with a safety factor of 50 for general public. Injuries caused by other biological mechanisms than heating or from chronic effects of EMF exposure are not believed to exist. Sweden and many other countries apply these reference values. Other countries, like Russia, Poland, Italy, and India have chosen lower reference values down to 0.1 W/m². Some of the researchers behind the BioInitiative Report in 2012 suggest 3 μW/m² as a reference value, because research work on biological effects has shown some influence of RF-EMF down to 30 μW/m² (8).

Measurements of outdoor exposure in Sweden in 2013 showed a median power density for RF fields between 30 MHz and 3 GHz to be 16 μW/m² in rural areas, 270 μW/m² in urban areas, and 2400 μW/m² in city areas (9).

Wi-Fi in schools

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

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

Methods

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

Results

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

Provocation studies

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

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

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

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

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

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

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

Case reports

Case 1

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

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

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

Case 2

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

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

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

Case 3

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

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

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

Discussion

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

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

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

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

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

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

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

Conclusions

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

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

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Article note: From: The Fifth Congress of the Paris Appeal: Environmental idiopathic intolerance: what role for EMFs and multiple chemicals? 18 May 2015, Brussels, Belgium.

Bilaga 4

5G-appellen

Vetenskapsmän och läkare varnar för allvarliga hälsoeffekter av 5G-utbyggnad - begär moratorium

13 september 2017

Vi, undertecknade mer än 180 vetenskapsmän och läkare från 36 nationer, rekommenderar moratorium för utbyggnaden av 5G för telekommunikation tills potentiella risker för människors hälsa och miljön har undersökts fullt ut av forskare utan kopplingar bindningar till industrin. 5G kommer att kraftigt öka exponeringen för radiofrekventa elektromagnetiska fält (RF-EMF) utöver den redan i dag befintliga från 2G, 3G, 4G, WiFi etc. RF-EMF har visat sig vara skadligt för både människor och miljö.
(Obs: Blå länkar nedan är referenser.)

5G leder till massiv ökning av påtvingad exponering för strålning från trådlös teknik

5G-tekniken är endast effektiv över kort avstånd. Den tränger dåligt genom fast material. Många nya antenner kommer att krävas och fullskaligt genomförande kommer att resultera i antenner vart 10:e till 12:e hus i tätorter, vilket därmed **massivt ökar den påtvingade strålningen.**

Med "den allt mer omfattande användningen av trådlös teknik" kan ingen undvika att bli exponerad. Utöver det ökade antalet 5G-sändare, även inomhus, i butiker och på sjukhus, kommer enligt uppskattningar 10-20 miljarder anslutningar (till kylskåp, tvättmaskiner, övervaknings-kameror, självstyrande bilar och bussar etc.) att bli delar i "Sakernas Internet". Sammantaget kan detta väsentligt öka alla EU-medborgares sammanlagda långvariga exponering för RF-EMF-strålning.

Skadliga effekter av RF-EMF-exponering redan bevisade

Över 220 forskare från mer än 40 länder har uttryckt att de är "allvarligt oroliga" över den allstädes närvarande och ökande exponeringen för EMF (elektromagnetiska fält) som alstras av elektriska och trådlösa enheter, redan före tillskottet av strålning från 5G. Forskarna hänvisar till det faktum att "många nya vetenskapliga publikationer har visat att EMF påverkar levande organismer vid nivåer långt under de flesta internationella och nationella gränsvärden". Effekterna innefattar ökad cancerrisk, cellulära stresseffekter, ökning av skadliga fria radikaler, genetiska skador, strukturella och funktionella förändringar i fortplantningssystemet, inlärnings- och minnesproblem, neurologiska störningar och negativa effekter på det allmänna välbefinnandet hos människor. Skadorna når långt utöver mänskligheten, eftersom det finns alltfler belägg för skadliga effekter på både växter och djur.

Sedan forskarnas varningar år 2015, har ytterligare forskning övertygande bekräftat allvarliga hälsorisker från RF-EMF från trådlös teknik. Världens största studie (25 miljoner US-dollar) från National Toxicology Program (NTP) visade statistiskt signifikant ökning av förekomsten av hjärn- och hjärtcancer hos djur exponerade för RF-EMF trots att strålningen var under ICNIRPs (International Commission on Non-Ionizing Radiation Protection) gränsvärden, vilka tillämpas av de flesta länder. Dessa resultat stöds av resultat från epidemiologiska studier på människor och risk för hjärntumörer av RF-EMF-strålning. Ett stort antal granskade vetenskapliga rapporter visar att strålning från EMF skadar människors hälsa.

Världshälsoorganisationen (WHO) cancerforskningsorganisation International Agency for Research on Cancer (IARC), konstaterade 2011 att EMF med frekvenserna 30 KHz – 300 GHz är "möjligen cancerframkallandde" för människor (Grupp 2B). Emellertid bekräftar nya studier, som ovan nämnda NTP-studien och

flera epidemiologiska undersökningar inklusive de senaste undersökningarna om risk för hjärntumör av mobilanvändning, att RF-EMF-strålning är "cancerframkallande för människan".

EUROPA EM-EMF rapporten från 2016 konstaterar att det "finns starka belägg för att *långvarig exponering för vissa EMF är en riskfaktor för sjukdomar* t.ex. vissa cancerformer, Alzheimers sjukdom och manlig infertilitet ... Vanliga symtom på EHS (elöverkänslighet) innefattar huvudvärk, koncentrationssvårigheter, sömnstörningar, depression, brist på energi, trötthet och influensaliknande symptom."

En allt större del av den europeiska befolkningen är drabbad av sådan ohälsa som i vetenskaplig litteratur sedan många år har kopplats till exponering för EMF och strålning från trådlös teknik. I den Internationella Vetenskapliga Deklarationen om elöverkänslighet (EHS) och multipel kemisk känslighet (MCS), Bryssel 2015, förklaras att: "På basen av vår nuvarande vetenskapliga kunskap uppmanar vi därför alla nationella och internationella organ och institutioner ... att erkänna EHS och MCS som verkliga medicinska sjukdomar, som *kan leda till omfattande folkhälsoproblem* under många år framöver, dvs i alla länder som tillåter obegränsad användning av trådlös teknik och marknadsförda kemiska ämnen ... *att inte vidta åtgärder leder till kostnader för samhället* och är inte längre ett alternativ ... vi varnar enhälligt för *en allvarlig fara för folkhälsan* ... att stora *förebyggande åtgärder vidtas och prioriteras för att förhindra en* ***kommande världsomspännande epidemi.***"

Försiktighetsåtgärder

Försiktighetsprincipen (UNESCO) antogs av EU 2005: *"När mänskliga aktiviteter kan leda till moraliskt oacceptabla skador som är vetenskapligt trovärdiga men osäkra, ska åtgärder vidtas för att undvika eller minska dessa skador."*

Resolution 1815 (Europarådet, 2011): *"Vidta alla rimliga åtgärder för att minska exponeringen för elektromagnetiska fält,* särskilt för radiofrekvenser från mobiltelefoner, och särskilt exponeringen för barn och ungdomar som verkar löpa större risker för hjärntumör... Rådet rekommenderar kraftfullt tillämpning att försiktighetsprincipen ALARA (As Low as Reasonable Achievable) både för så kallade termiska effekter som icke-termiska eller biologiska effekter av elektromagnetiska fält eller strålning" och att (8.5) "förbättra metoder för och kvaliteten på de riskbedömningar som görs".

Nürnberg-koden (1949) gäller för alla experiment på människor och därmed även utrullningen av 5G med nya och högre frekvenser av RF-EMF. Alla sådana experiment: "bör baseras på tidigare kunskaper (t ex en förväntan härledd från djurförsök) som motiverar experimentet. Inget experiment bör genomföras, där det finns en *a priori anledning att tro att dödsfall eller invalidiserande skador* kommer att uppstå. Förutom möjligen i experiment där de experimenterande läkarna också själva tjänar som försökspersoner (Nürnbergkod punkt 3-5). Redan publicerade vetenskapliga studier visar att det nu finns "a priori anledning att tro" att hälsofarorna är reella.

Europeiska miljöbyrån (EEA) varnar för "strålningsrisk från vanliga apparater", även om strålningen underskrider WHO / ICNIRP-normerna.. EEA påpekar också följande: "Det finns många tidigare exempel på att försiktighetsprincipen inte tillämpats, vilket har *resulterat i allvarliga och ofta irreversibla skador för människors hälsa och miljön*... den skadliga exponeringen kan bli omfattande innan man har 'övertygande bevis" för skada av långvarig exponering och en biologisk förklaring [mekanism] för hur denna skada orsakas."

"Säkerhetsriktlinjerna" skyddar industrin - inte hälsan och miljön

De nuvarande "säkerhetsriktlinjerna" från ICNIRP är helt föråldrade. Alla bevis på skador som anges ovan har nämligen uppstått trots att strålningen är under ICNIRPs "riktlinjer". Därför behövs nya riktlinjer. Anledningen till de vilseledande riktlinjerna är "ICNIRP-medlemmarnas intressekonflikter i form av deras relationer med telekommunikations- eller elektronikföretag vilket undergräver den opartiskhet som bör gälla för utarbetande av exponeringsstandarder för allmänhetens exponering för RF-EMF... För att utvärdera cancerrisker är det nödvändigt att inkludera forskare med kompetens inom medicin, särskilt onkologi" (cancerforskning).

De nuvarande riktlinjerna från ICNIRP / WHO för RF-EMF bygger på ett ett föråldrat antagande att "den kritiska effekten av RF-EMF-exponering för människors hälsa och säkerhet är *uppvärmning* av exponerad vävnad." Men forskare har bevisat att många olika typer av sjukdomar och skador uppstår helt utan uppvärmning ("icke-termisk effekt") vid strålningsnivåer långt under ICNIRP-riktlinjerna.

Vi uppmanar EU:

1) Att vidta alla rimliga åtgärder för att stoppa 5G RF-EMF-expansionen tills oberoende forskare kan garantera att 5G och de totala strålningsnivåerna som orsakas av RF-EMF (5G tillsammans med 2G, 3G, 4G och WiFi) inte kommer att vara skadliga för EU-medborgare, särskilt barn, foster och gravida, eller för miljön.
2) Att rekommendera att alla EU-länder, särskilt deras strålsäkerhetsmyndigheter, följer Resolution 1815 och informerar medborgare, inklusive lärare och läkare om hälsorisker från RF-EMF-strålning, hur och varför man ska undvika trådlös kommunikation, särskilt i/nära t.ex., daghem, skolor, hem, arbetsplatser, sjukhus och äldreomsorg.
3) Att omedelbart utse en arbetsgrupp inom EU bestående av oberoende, verkligt opartiska forskare inom EMF- och hälsa utan intressekonflikter[1] för att omvärdera hälsoriskerna och att:
   a) besluta om nya, säkra gränsvärden för "maximala totala exponering" för all trådlös kommunikation inom EU,
   b) studera den totala och kumulativa exponeringen som påverkar EU-medborgarna,
   c) skapa regler som ska tillämpas inom EU för att undvika exponering som överstiger EU:s nya gränsvärden för maximala totala exponering för alla typer av EMF så att man skyddar medborgare, särskilt barn, foster och gravida kvinnor.
4) Att förhindra att elektronik/telekomindustrin genom sina lobbyorganisationer övertalar EU-tjänstemän att fatta beslut om att ytterligare öka RF-strålning, inklusive 5G i Europa.
5) Att stöda och genomföra kabelburen digital telekommunikation istället för trådlös.

Vi förväntar oss ett svar från EU senast den 31 oktober 2017 om vilka åtgärder ni kommer att vidta för att skydda EU-invånarna mot RF-EMF och speciellt 5G-strålning. Denna appell och ert svar kommer att offentliggöras.

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Undertecknare:

[1] Undvik liknande misstag som när Kommissionen (2008/721/EC) utsåg industrivänliga medlemmar till SCENIHR, vilka till EU överlämnade en missvisande SCENIHR rapport om hälsorisker, som gav telekomindustrin fria händer at bestråla EU-medborgare. Rapporten citeras nu av strålsäkerhetsmyndigheter inom EU.

The endorsements are personal and not necessarily supported by the affiliated universities or organizations.

EU and European Nations

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Bilaga 5

EMFscientist.org

Till:
Mr. Ban Ki Moon, FN:s Generalsekreterare;
Dr. Margaret Chan, Generaldirektör WHO;
FN:s medlemsstater

Internationell appell

Forskare kräver skydd mot hälsorisker vid exponering för icke-joniserande elektromagnetisk strålning.

Vi är vetenskapsmän som forskar på biologiska effekter och hälsoeffekter av icke-joniserande elektromagnetiska fält (EMF). Baserat på tillgänglig förhandsgranskad och publicerad vetenskaplig forskning är vi allvarligt oroade över den ökande och utbredda exponeringen för elektromagnetiska fält som alstras av elektriska och trådlösa produkter. Dessa inkluderar, men är inte begränsade till, radiofrekvent strålning (RF-EMF) som avges från till exempel mobiltelefoner, trådlösa telefoner och deras basenheter, WiFi, smarta elmätare, babyvakter samt elektriska apparater och infrastrukturer som används vid distribution av el vilka genererar extremt lågfrekventa elektromagnetiska fält (ELF EMF).

Vetenskaplig grund för vår gemensamma oro:

Många nya vetenskapliga publikationer har visat att EMF påverkar levande organismer vid nivåer långt under de flesta internationella och nationella riktlinjer. Effekter inkluderar ökad cancerrisk, cellulär stress, ökning av skadliga fria radikaler, genetiska skador, strukturella och funktionella förändringar i det reproduktiva systemet, försämring av inlärning och minne, neurologiska sjukdomar, och negativa effekter på allmänt välbefinnande hos människor. Skador berör inte bara människor, eftersom det finns en växande mängd belägg för skador på både växt- och djurliv.

Mot bakgrund av dessa fynd vädjar vi till Förenta Nationerna (FN) och alla medlemsstater i världen, att uppmana Världshälsoorganisationen (WHO) att utöva ett starkt ledarskap för att främja utarbetande av mer skyddande riktlinjer för EMF, uppmuntra till försiktighetsåtgärder, och informera allmänheten om hälsorisker, särskilt om riskerna för barn och foster. Genom att inte vidta åtgärder, underlåter WHO att fullgöra sin roll som den mest framstående internationella folkhälsoorganisationen

Otillräckliga internationella riktlinjer för icke-joniserande EMF

De olika organisationer som rekommenderar säkerhetsstandarder har misslyckats med att införa tillräckliga riktlinjer för att skydda allmänheten, i synnerhet barnen som är mer känsliga för effekterna av elektromagnetiska fält.

Den Internationella kommissionen för skydd mot icke-joniserande strålning (ICNIRP) rekommenderade 1998 "Riktlinjer för begränsning av exponering för tidsvarierande

5. allmänheten får heltäckande information om de potentiella hälsoriskerna med elektromagnetiska fält samt utbildas om åtgärder för att minska hälsoriskerna;

6. vårdpersonal utbildas om de biologiska effekterna av elektromagnetiska fält och om behandling av patienter med elektromagnetisk känslighet;

7. regeringar finansierar sådan utbildning och forskning om elektromagnetiska fält och hälsa, som är oberoende av industrin, och ålägger industrin att samarbeta med forskare;

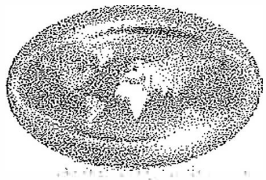
8. media avslöjar experternas finansiella relationer med industrin när deras åsikter om hälso- och säkerhetsaspekter med teknik som avger EMF återges; och

9. vita-zoner (strålningsfria områden) inrättas.

Releasedatum: 11 maj 2015

Frågor kan ställas via Elizabeth Kelley, M.A., direktör, EMFScientist.org, e-post: info@EMFScientist.org

Fotnot: Undertecknarna av denna appell har uttryckt sin personliga bedömning och därmed uppgett sin professionella tillhörighet, vilket inte nödvändigtvis innebär att bedömningen är representativ för arbetsgivaren eller den organisation de är knutna till.



To: His Excellency Ban Ki-moon, Secretary-General of the United Nations
Honorable Dr. Margaret Chan, Director-General of the World Health Organization
U.N. Member States

International Appeal:
Scientists call for Protection from Non-ionizing Electromagnetic Field Exposure

We are scientists engaged in the study of biological and health effects of non-ionizing electromagnetic fields (EMF). Based upon peer-reviewed, published research, we have serious concerns regarding the ubiquitous and increasing exposure to EMF generated by electric and wireless devices. These include– but are not limited to–radiofrequency radiation (RFR) emitting devices, such as cellular and cordless phones and their base stations, Wi-Fi, broadcast antennas, smart meters, and baby monitors as well as electric devices and infra-structures used in the delivery of electricity that generate extremely-low frequency electromagnetic field (ELF EMF).

Scientific basis for our common concerns

Numerous recent scientific publications have shown that EMF affects living organisms at levels well below most international and national guidelines. Effects include increased cancer risk, cellular stress, increase in harmful free radicals, genetic damages, structural and functional changes of the reproductive system, learning and memory deficits, neurological disorders, and negative impacts on general well-being in humans. Damage goes well beyond the human race, as there is growing evidence of harmful effects to both plant and animal life.

These findings justify our appeal to the United Nations (UN) and, all member States in the world, to encourage the World Health Organization (WHO) to exert strong leadership in fostering the development of more protective EMF guidelines, encouraging precautionary measures, and educating the public about health risks, particularly risk to children and fetal development. By not taking action, the WHO is failing to fulfill its role as the preeminent international public health agency.

Inadequate non-ionizing EMF international guidelines

The various agencies setting safety standards have failed to impose sufficient guidelines to protect the general public, particularly children who are more vulnerable to the effects of EMF.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) established in 1998 the "Guidelines For Limiting Exposure To Time-Varying Electric, Magnetic, and Electromagnetic Fields

Release date: May 11, 2015

All inquiries, including those from qualified scientists who request that their name be added to the Appeal, may be made by contacting Elizabeth Kelley, M.A., Director, EMFscientist.org, at info@EMFscientist.org.

Note: the signatories to this appeal have signed as individuals, giving their professional affiliations, but this does not necessarily mean that this represents the views of their employers or the professional organizations they are affiliated with.

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BioInitiative Report 2012

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I. ALLMÄN SAMMANFATTNING

A. Inledning

Arbetsgruppen inom *BioInitiative* konstaterade år 2007 att då gällande allmänna gränsvärden var otillräckliga för att värna människors hälsa, och enades om att nya biologiskt baserade gränsvärden var nödvändiga redan då för fem år sedan. *BioInitiative Report* utarbetades av drygt ett dussin världserkända experter inom vetenskap och folkhälsa. Dessutom bidrog ytterligare flera granskare med värdefulla faktauppgifter och synpunkter.

Experterna drog slutsatsen att från folkhälsosynpunkt ligger det inte i allmänhetens intresse att vänta. År 2007 var de befintliga vetenskapliga rönen, kopplat till de enorma befolkningsmängder som befann sig i riskzonen, tillräckliga för att motivera kraftiga förebyggande åtgärder med avseende på radiofrekvent strålning (RFR/Radio Frequency Radiation) och lägre gränsvärden beträffande extremt lågfrekventa fält (ELF) och övriga elektromagnetiska fält (EMF). Rekommendationerna för ELF var biologiskt baserade och speglar de ELF-nivåer som i upprepade studier kunnat förknippas med ökad risk för barncancer, och dessutom tillfördes en säkerhetsfaktor som är jämförbar med vad som brukar användas för gränsvärden. Konsekvenserna för folkhälsan om ingenting förändras bedömdes år 2007 som oacceptabla.

Vad har hänt fem år senare – 2012? I 24 vetenskapliga avsnitt diskuterar de medverkande författarna (till *The Bioinitiative Report*) resultaten och betydelsen av ungefär 1800 nya studier. Framförallt rapporterar dessa studier om avvikande gentranskription (avsnitt 5 i huvudrapporten); genotoxicitet samt enkel- och dubbelsträngsbrott på DNA (avsnitt 6); stressproteiner till följd av den fraktalantennliknande strukturen hos DNA (avsnitt 7); kondensering av kromatin och förlust av förmågan att reparera DNA i humana stamceller (avsnitt 6 och 15); minskad aktivitet av antioxidanter – särskilt melatonin (avsnitt 5, 9, 13, 14, 15, 16 och 17); neurotoxicitet hos människor och djur (avsnitt 9); carcinogenicitet hos människor (avsnitt 11,12,13, 14, 15, 16 och 17); allvarliga effekter på spermiers morfologi och funktion hos människor och djur (avsnitt 18); effekter på foster, nyfödda och avkommor (avsnitt 18 och 19); effekter på utvecklingen av hjärna och kranium hos avkommor till djur som utsatts för mobilstrålning under dräktigheten (avsnitt 5 och 18); och samband mellan autismspektrumstörningar och exponering för EMF/RFR. Denna sammanfattning ger endast några korta glimtar av de vetenskapliga belägg som rapporten *BioInitiative 2012* lägger fram.

Det finns allt starkare vetenskapliga belägg för hälsorisker vid ständig exponering för lågintensiva elektromagnetiska fält och trådlösa tekniker (baserade på radiofrekvent strålning, t ex. mikrovågsstrålning). De nivåer där effekter har rapporterats är hundratals gånger lägre än vad som hade rapporterats 2007. Omfattningen av möjliga hälsoeffekter som är följden av ständig exponering har vidgats. Det har tillkommit ett stort antal studier som undersökt effekter av mobiltelefoner (i livrem eller byxfickor, enbart strålande i standby-läge) och bärbara datorer; på spermakvalitet och spermiers rörlighet, samt förekomst av döda spermier (av betydelse för fertilitet och reproduktion). Det finns också minst ett dussin nya studier på foster, spädbarn, småbarn och skolbarn, som är betydelsefulla. Det finns nu fler belägg för att mikrovågsexponering kan skada DNA, störa reparationsmekanismer hos DNA, framkalla toxicitet på det humana genomet (gener), mer oroande effekter på nervsystemet (neurologi) samt fler och bättre studier av effekter av basstationer för mobiltelefoni (trådlösa sändare och mobilmaster) som rapporterar om hälsoeffekter vid ännu lägre strålningsnivåer än tidigare.

Några mycket stora och betydelsefulla studier om risker för hjärntumörer vid mobiltelefonanvändning har slutförts. Enligt Världshälsoorganisationen WHO:s studie *Interphone Final Report*, som omfattade 13 länder (2010), finns det belägg (även om det starkt opponerades av motsträviga delar av forskningskommittén) för att mobilanvändning under 10 år eller mer, med cirka 1640 timmars kumulativ användning av mobiler eller trådlösa telefoner, innebär ungefär fördubblad risk att drabbas av gliom. Gliom är aggressiva, maligna tumörer där den genomsnittliga överlevnadstiden efter diagnos är cirka 400 dagar. Att hjärntumörer har uppmärksammats i epidemiologiska undersökningar efter endast tio år är anmärkningsvärt. Exponering för röntgen eller annan joniserande strålning kan också orsaka hjärntumörer men då tar det nästan 15-20 år innan tumörerna uppmärksammas, vilket gör radiofrekvent/mikrovågsstrålning från mobiler till en mycket stark cancerframkallande faktor. Studier av Lennart Hardell och hans forskarlag vid Örebro universitet har senare (efter 2010) visat att barn som börjar använda mobiler i tidiga år löper mer än femfaldigad (> 500 %) risk att ha utvecklat gliom när de når åldersintervallet 20-29 år. Detta måste beaktas vid alla insatser för folkhälsan.

Nyligen, 2011, klassificerade WHO:s cancerforskningsorgan IARC radiofrekvent strålning (RFR) som möjligen cancerframkallande för människor (grupp 2B), samma klassificering som IARC 2001 beslutade för ELF-EMF. Beläggen för den radiofrekventa strålningens carcinogenicitet baserades i första hand på studier på mobiler och hjärntumörer, och enligt WHO:s regelverk är det tillämpbart för all exponering för radiofrekventa fält (det syftar på själva exponeringen, inte endast på apparater, mobiler eller trådlösa telefoner som avger RFR).

B. Varför ska vi ta hänsyn till detta?

Insatserna är mycket höga. Exponering för elektromagnetiska fält (både extremt lågfrekventa fält från kraftledningar och elektriska installationer; och radiofrekvent strålning, RFR) har kunnat kopplas till en mångfald av ohälsosamma effekter som har signifikant betydelse för folkhälsan. De allvarligaste hälsoeffekterna som har rapporterats i samband med extremt lågfrekventa fält och/eller radiofrekvent strålning är leukemier och hjärntumörer hos både barn och vuxna; och ökad risk för neurodegenerativa sjukdomar som Alzheimers och amyotrofisk lateralskleros (ALS). Dessutom finns det rapporter om ökad risk för bröstcancer hos både män och kvinnor, genotoxiska effekter (DNA-skador, kromatinkondensering, bildning av mikrokärnor, försämrad förmåga att reparera DNA i humana stamceller), patologiskt läckage i blod-hjärnbarriären, förändrade immunfunktioner exempelvis ökning av allergiska och inflammatoriska reaktioner, missfall, och effekter på hjärta och kärl. Insomni (sömnlöshet) har rapporterats i studier på människor som vistas i miljöer med mycket lågintensiv radiofrekvent strålning, från wifi eller mobilsändare. Övergående effekter på kognition, minne och inlärningsförmåga, beteende, reaktionstid, uppmärksamhet och koncentrationsförmåga, och förändrat mönster av hjärnvågor (EEG-förändringar) har också rapporterats i den vetenskapliga litteraturen. Biofysikaliska mekanismer som är tänkbara orsaker till sådana effekter finns beskrivna i flera artiklar och översikter (Sage, 2012).

Enbart traditionell vetenskaplig konsensus och praxis kan inte svara för beslutsunderlaget vid folkhälsofrågor – snarare är det en av flera röster som är viktiga att lyssna till när beslut ska tas för att värna folkhälsan. Givetvis är vetenskapliga överväganden viktiga, men det innebär inget exklusivt privilegium för vetenskapens företrädare att ensamma fatta beslut för hela samhället om förändringar i folkhälsans intresse eller för barnens bästa.

C. Är kunskapen tillräcklig för att motivera åtgärder?

Människor utgör bioelektriska system. Våra hjärtan och hjärnor regleras med inre bioelektriska signaler. Exponeringar för elektromagnetiska fält (EMF) i miljön kan påverka fundamentala biologiska processer i människokroppen. I vissa fall kan det innebära obehag, sömnstörningar eller förlorat välbefinnande (försämrade mentala funktioner eller påverkad ämnesomsättning), i andra fall kan det handla om allvarligare sjukdomar som cancer eller Alzheimers sjukdom. Det kan störa förmågan att bli gravid, eller att föda ett fullgånget barn, eller medföra en dålig utveckling av barnets hjärna. Exponeringarna kan orsaka långsiktiga försämringar av barnets utveckling, med sämre utsikter att göra sig själv rättvisa som vuxen. Användningen av vanlig trådlös utrustning som bärbara datorer och mobiler innebär ett behov av skyndsam handling eftersom exponeringarna är ett vardagligt inslag och förekommer överallt. Vi behöver fastställa om och när dessa exponeringar är hälsovådliga. Om inte kommer framtidens barn att födas av föräldrar som är dränkta av trådlös exponering.

Sedan andra världskriget har bakgrundsnivån av EMF ökat exponentiellt, allra senast genom de allt mer populära trådlösa teknikerna som mobiler (sex miljarder år 2011-12, en ökning från två miljarder 2006), trådlösa telefoner, wifi, wimax och 4G. Några länder håller helt och hållet på att gå över från trådbunden telefoni till trådlös, vilket påtvingar en omedveten befolkning exponering för trådlösa tekniker. Samtidigt har denna exponering klassificerats som en möjlig hälsorisk av världens främsta auktoritet inom cancerbedömning – WHO:s cancerforskningsorgan IARC. Flera decennier av internationell vetenskaplig forskning bekräftar att EMF har en biologisk effekt hos djur och människor. Nu har vågskålen tydligt tippat över mot "förmodat möjliga negativa effekter" av oavbruten exponering för EMF. Det är svårt att dra andra slutsatser när bioeffekter som nu tydligt kan konstateras får följder som patologiskt läckage i blod-hjärnbarriären (toxiner släpps in i hjärnvävnad), oxidativa skador på DNA och människans arvsmassa, hämning av normal DNA-reparation i stamceller, störningar av spermiebildningen, låg spermakvalitet eller lågt antal friska spermier, förändring av fostrets hjärnutveckling vilket kan ha en fundamental koppling till den epidemiska ökningen av autism och skolbarns problem med minne, uppmärksamhet, koncentrationsförmåga och beteende, samt sömnlöshet som försvagar hälsa och läkning på flera sätt.

I dagens värld exponeras alla för två typer av EMF: (1) extremt lågfrekventa elektromagnetiska fält (ELF) från elektriska utrustningar och kraftledningar och (2) radiofrekvent strålning (RFR) från trådlösa apparater – mobiler och trådlösa telefoner, mobilsändare och master, samt TV- och radiomaster. I denna rapport används termen EMF för elektromagnetiska fält generellt, och termerna ELF och RFR för de specifika strålningskategorierna. I båda fallen handlar det om icke-joniserande strålning vilket innebär att den inte har tillräckligt med energi för att bryta loss elektroner från atomer och därmed jonisera (ladda) atomerna, vilket röntgenstrålar och andra former av joniserande strålning har.

II. VETENSKAPLIG SAMMANFATTNING

A. Belägg för effekter på spermier och reproduktion

Flera laboratorier, över hela världen, har i upprepade studier kunnat påvisa effekter på spermiers kvalitet, rörlighet och patologi hos män som använt mobiler, handdatorer eller personsökare, och särskilt de som burit apparaterna i livrem eller fickor (referenser i avsnitt 18 – Agarwal et al, 2008; Agarwal et al, 2009; Wdoviak et al, 2007; De Iuliis et al, 2009; Fejes et al, 2005; Aitken et al, 2005; Kumar 2012). Andra studier visar att mobilanvändning, exponering för mobilstrålning eller att förvara en mobil i närheten av testiklarna, påverkar spermiers mängd, rörlighet, livsduglighet och morfologi (Aitken et al, 2004; Agarwal et al, 2007; Erogul et al, 2006). I några få djurstudier har mobilstrålningens effekter på honors fertilitet undersökts. Panagopoulous et al (2012) rapporterar om hämmad utveckling och storlek av äggstockar, och för tidig celldöd i äggstocksfolliklar (förstadier till äggceller) och näringsceller hos bananfluga (*Drosophila melanogaster*). Gul et al (2009) rapporterar att råttor som under dräktigheten exponerats för standby-nivåer av RFR (mobiler i vänteläge men inte aktivt sändande) får avkomma med minskat antal äggstocksfolliklar. Magras och Xenos (1997) rapporterar om irreversibel infertilitet hos möss efter fem (5) generationers RFR-exponering från mobilsändare på mindre än 10 milliwatt per kvadratmeter (< 10 mW/m²).

SPERMIER OCH DERAS DNA SKADAS

Spermier skadas av mobilstrålning vid mycket låga intensiteter (3,4 – 700 µW/m²). En veritabel flod av nya studier har rapporterat om skador på spermier från både människa och djur, vilket väcker betydande oro för fertilitet, fortplantning och barnens hälsa (oreparerade mutationer i spermier). Exponeringsnivåerna motsvarar dem från en mobil i byxfickan eller en trådlöst uppkopplad dator i knät. Spermier saknar förmåga att reparera DNA-skador.

B. Belägg för att barn är mer sårbara

Många studier har rapporterat att barn är mer känsliga för mängder av miljögifter. (Barouki et al, 2012; Preston, 2004; WHO, 2002; Gee, 2009; Sly och Carpenter 2012). Vissa studier har visat att foster och små barn är känsligare än vuxna för miljögifter. Detta stämmer överens med ett stort antal studier som visar att foster och små barn är mer känsliga än äldre personer för kemikalier och joniserande strålning. Det amerikanska miljöskyddsinstitutet EPA (US Environmental Protection Agency) har föreslagit en tiofaldig minskning av exponering för carcinogener under de första två levnadsåren och en trefaldig minskning för levnadsåren tre till fem. Vid dessa riskjusteringar har man inte tagit hänsyn till fosterstadiet och möjligheten att utvidga skyddet även till foster bör beaktas på grund av fostrets snabba organutveckling.

Den amerikanska expertgruppen "The President's Cancer Panel" (2012) konstaterade att barn *"löper särskilt hög risk beroende på deras mindre kroppsstorlek och snabba kroppsutveckling – två faktorer som förstärker deras känslighet för kända carcinogener, exempelvis strålning"*.

Det amerikanska barnläkaresällskapet "The American Academy of Pediatrics" framför i ett brev den 12 december 2012 till kongressledamoten Dennis Kucinich: *"Barn är oproportionerligt påverkade av miljöexponeringar, exempelvis mobilstrålning. Skillnaderna i bentäthet och vätskemängden i ett barns hjärna jämfört med en vuxens hjärna kan medföra att barn absorberar mer radiofrekvent energi djupare i sina hjärnor än vuxna. Det är ett grundvillkor att varje ny standard för mobiltelefoner och annan trådlös utrustning måste inbegripa ett skydd för de yngsta och mest känsliga individerna för att garantera att de får ett livslångt skydd."*

Frågeställningar kring barns exponering för RFR är av avgörande betydelse. Det finns överväldigande belägg för att barn är känsligare än vuxna för många olika exponeringar (Sly och Carpenter, 2012), t ex. RFR, och de konsekvenser som bör uppmärksammas mest är cancer och effekter på neuronal utveckling. Ändå placerar föräldrar trådlösa babyvakter i barnsängar, och ger mycket små barn trådlöst uppkopplade leksaker, vanligtvis utan någon som helst insikt om de möjliga riskerna. Ett växande problem är att alla undervisningsdatorer i skolor blir trådlöst uppkopplade. Trådbundna undervisningsdatorer ökar däremot inte radiofrekvent exponering och ger säker åtkomst till internet (Sage och Carpenter, Bioinitiative 2012 Report).

C. Belägg för effekter på foster och nyfödda

Effekter på fosterutvecklingen när livmodern har exponerats för mobilstrålning har sedan 2006 observerats i studier på både människa och djur. Exponeringskällorna omfattar helkroppsexponering för RFR från basstationer och wifi, användning av trådlösa datorer, kuvöser med mycket höga ELF/EMF-nivåer vilket medför förändringar av hjärtrytmvariablilitet (HRV; hjärtkoherens) och sänkta melatoninnivåer hos nyfödda, magnetröntgenexponering av foster i gravida kvinnor, och ELF/EMF-exponering av mödrar vilket kan kopplas till ökad benägenhet hos barn att drabbas av leukemi och astma. Divan et al (2008) har funnit att barn som fötts av mödrar som använt mobiler under graviditeten, utvecklar mer beteendeproblem vid tiden för skolstart än barn till mödrar som inte använt mobiler under graviditeten. Hos barn till mödrar som använt mobiler under graviditeten var emotionella störningar 25 % vanligare, hyperaktivitet 35 %, uppförandestörningar 49 % och relationsstörningar

34 % vanligare (Divan et al, 2008). Aldad et al (2012) har visat att mobilstrålning signifikant påverkar fostrets hjärnutveckling och kan kopplas till ADHD-liknande beteende hos avkomman till dräktiga möss. Hos exponerade möss har man kunnat påvisa dosberoende skador på det signalsystem i pannloben där pyramidceller använder glutamat som signalsubstans. Författarna konstaterar att beteendeeffekterna var följden av förändrad neuronal utveckling på fosterstadiet (in utero). Musungar var hyperaktiva och hade skadade minnesfunktioner och beteendeproblem, liknande dem hos människobarn i studien av Divan et al (2008). Fragopoulou et al (2012) rapporterar att utvecklingen av hjärnans astrocyter, studerad med proteomik (läran om cellernas proteiner), påverkas negativt av strålning från DECT-telefoner och mobilstrålning.

"Exponering av foster (in utero) och små barn för mobilstrålning och trådlösa tekniker generellt kan utgöra en riskfaktor för hyperaktivitet, inlärningsstörningar och beteendeproblem i skolåldern. Åtgärder behövs för att begränsa ELF/EMF och radiofrekvent strålning för dessa grupper, särskilt enkla åtgärder som att undvika modifierade kuvöser och utbildning av gravida kvinnor om risker med bärbara datorer, mobiler och andra källor till ELF/EMF och radiofrekvent strålning. Försiktighetsprincipen kan erbjuda den grund för beslutsfattande där riskreducerande åtgärder kan vidtas för att förhindra hög exponering av barn och gravida kvinnor."
(Bellieni och Pinto, 2012)

D. Belägg för samband med autism (autismspektrumstörningar, ASD)

Läkare bör uppmärksamma EMF/RFR som tänkbar miljöfaktor vid kliniska utvärderingar av ASD och för att utveckla behandlingsmanualer. Att minska eller ta bort EMF eller stressfaktorer i form av radiofrekvent strålning från omgivningen är en rimlig försiktighetsåtgärd med tanke på bevistyngden för ett samband med ASD.

Flera tusen vetenskapliga studier över fyra årtionden talar för att EMF och RFR har allvarliga biologiska effekter och hälsokonsekvenser. Studierna rapporterar om genotoxicitet, enkel- och dubbelsträngsbrott på DNA, kondensering av kromatin, förlust av förmågan att reparera DNA i humana stamceller, minskad mängd antioxidanter (särskilt melatonin), onormal gentranskription, neurotoxicitet, carcinogenicitet, skador på spermiers struktur och funktion, beteendeeffekter, och effekter på hjärnans utveckling i foster vars mödrar använt mobiler under graviditeten. Exponering för mobiler har kunnat förknippas med förändrad hjärnutveckling hos musfoster och ADHD-liknande beteende hos musungar.

Flera onormala fysiologiska processer och beteendestörningar hos människor med ASD påminner om sådant som kan relateras till biologisk påverkan och hälsoeffekter av EMF/RFR-exponering. Både biomarkörer, sjukdomsmarkörer och deras kliniska symtom visar nämligen slående likheter. Flera studier på cell- och molekylnivå har hos personer med ASD påvisat oxidativ stress och skador orsakade av fria radikaler, och dessutom brist på antioxidanter såsom glutation (en peptid). Ökade intracellulära halter av kalcium vid ASD kan ha ett samband med genetiska mutationer, men oftare är det nog en följd av inflammation eller kemikalieexponering. Andra effekter som kan förekomma är peroxidation av fettsyror i cellmembranen, störd kalciummetabolism, förändrad EEG-aktivitet (hjärnaktivitet) och därav sömnstörning, beteendestörning och nedsatt immunförsvar, patologiskt läckage i kritiska barriärer mellan mage och blod samt mellan blod och hjärna. Mitokondrier kan ha nedsatt funktion och olika störningar av immunsystemet kan förekomma. Förändringar i hjärnan och autonoma nervsystemet kan studeras med elektrofysiologi och epileptiska anfall är betydligt mer vanliga hos personer med ASD än bland befolkningen i stort. Sömnrubbningar och höga stressnivåer är näst intill en självklarhet vid ASD. Det är också väldokumenterat att alla dessa företeelser kan vara en följd av, eller modifierade av, exponering för EMF eller RFR.

- Barn med neurologiska problem som rör kognition, inlärning, uppmärksamhet, minne, eller beteende måste så långt det är möjligt ha tillgång till trådbundna (inte trådlösa) miljöer för undervisning, vistelse och sömn.
- Vissa undervisningsrum bör reserveras för strålningsfri utrustning för att reducera stressfaktorer som kan hämma social utveckling, kunskapsinhämtning och beteendemässig anpassning.
- Alla barn måste få ett rimligt skydd mot den fysiologiska stressfaktor som påtagligt förhöjd EMF/RFR (mobilstrålning i skolor eller hemmiljöer) innebär.
- Skolor som nu överväger att införa fullständigt trådlösa undervisningsmiljöer bör kraftfullt uppmanas att behålla trådbundna uppkopplingar eftersom de högst sannolikt innebär bättre inlärnings- och undervisningsmiljöer, och förebygger oönskade hälsoeffekter bland både elever och lärarkår.
- Den trådlösa teknologins inverkan på vård- och undervisningsmiljöer bör övervakas med avancerade mät- och analystekniker som baseras på insikter om de icke-linjära effekterna av RFR, och med digitala tekniker som är lämpliga för att urskilja de effekterna.
- Det finns tillräckligt starka vetenskapliga belägg för att förorda trådbunden uppkoppling till internet och trådbunden utrustning för undervisning, framför dyra och potentiellt ohälsosamma trådlösa lösningar som så småningom kan behöva bytas ut.
- Mobilfria undervisningslokaler bör rimligtvis kunna erbjudas alla elever/studenter som vill avstå från miljöer med mobilstrålning.

(Herbert och Sage; 2012 – Avsnitt 20)

Allmänheten behöver bli medveten om att dessa risker existerar, att övergång till trådlös teknik inte kan förutsättas vara riskfri, och att det är väl värt uppoffringen att minimera exponeringar (trots att tekniken innebär fördelar ur undervisningsperspektiv) eftersom det innebär en gynnsammare miljö för undervisning och beteendeutveckling.

För att minska sårbarheten för exponeringarna förespråkas rekommendationer ur ett bredare perspektiv – att minska allostatisk belastning (när stressreaktioner bryter ner kroppen) och att bygga upp återhämtningsförmågan genom högkvalitativt näringsintag, att minska exponeringen för toxiner och smittämnen, samt undvika stress. Allt detta kan med tillgänglig kunskap genomföras på ett tryggt sätt.

E. Belägg för elöverkänslighet

Den omstridda frågan om elöverkänslighet är ett medicinskt tillstånd eller inte, och vilka testmetoder som kan lyfta fram biomarkörer för diagnostik och behandling, har utretts närmare i flera nya studier som presenteras i avsnitt 24 – *Key Scientific Evidence and Public Health Recommendations.* Det är uppenbart att allt fler människor över hela världen får allvarliga och hämmande symtom som har ett samband med exponering för EMF och RFR. Det finns föga anledning att tvivla på det. Den fortsatta massiva utbyggnaden av trådlösa tillämpningar, särskilt "smarta" elmätare, har utlöst tusentals klagomål över hälsoproblem och livshämmande symtom när dessa elmätare har installerats i hemmiljöer.

McCarty et al (2011) har studerat elöverkänslighet hos en patient (en kvinnlig läkare). Patienten kunde inte avgöra närvaro eller frånvaro av EMF-exponering, vilket i stort sett uteslöt risken för bias (förutfattad mening). I flera försök var elfälten antingen av- eller påslagna och patienten upplevde och rapporterade tillfällig smärtkänsla, obehag, överhoppade hjärtslag, muskelryckningar och/eller stark huvudvärk när ett pulsmodulerat fält (100 millisekunders pulsduration vid 10 Hz) var påslaget, men inga eller endast svaga symtom när det var avslaget. Symtomen från kontinuerliga fält var mindre påtagliga än vid pulsmodulerade fält. Skillnaden i symtom mellan påslagna eller inte påslagna fält var signifikant vid $p < 0,05$. Författarna drar slutsatsen att elöverkänslighet är ett neurologiskt syndrom, och statistiskt tillförlitliga kroppsliga (somatiska) reaktioner kan framkallas hos denna patient vid exponering för elektriska fält på 60 Hz vid 300 Volt per meter (V/m). En av medförfattarna var Andrew Marino som i en annan artikel (2012) svarade på kommentarer om hans och McCartys studie med att *"elöverkänslighet kan uppkomma som ett verkligt miljöorsakat neurologiskt syndrom. Vi tillämpade ett empiriskt förhållningssätt och kunde påvisa ett orsakssamband ($p < 0,05$) som tillåter oss att fastställa att elöverkänslighet är en realitet – ett nytt neurologiskt syndrom."*

Ett forskarlag där Sandström, Hansson Mild och Lyskov ingick, producerade mellan 1994 och 2003 ett antal artiklar om elöverkänslighet (Lyskov et al, 1995; Lyskov et al, 1998; Sandström et al, 1994; Sandström et al, 1995; Sandström et al, 1997; Sandström et al, 2003). Sandström et al 2003 visade att hjärtrytmrubbningar, t ex störningar av hjärtfrekvensens dygnsrytm, är vanligt förekommande hos elöverkänsliga som också visade vissa karakteristiska EKG-avvikelser: *"EHS patients had a disturbed pattern of circadian rythms of HRF and showed a relatively 'flat' representation of hourly-recorded spectral power of the HF component of HRV."* Forskarna påvisade också en obalans i det autonoma nervsystemet, med tendens till överaktivitet och förhöjd känslighet för yttre faktorer: *"EHS patients have a dysbalance of the autonomic nervous system (ANS) regulation with a trend to hyper-sympathotonia, as measured by heart rate (HR) and electrodermal activity, and a hyperreactivity to different external physical factors, as measured by brain evoked potentials and sympathetic skin responses to visual and audio stimulation."*
(Lyskov et al 2001 a,b; Sandström et al, 1997)

Dessa studier tyder på att individer som rapporterar att de är elöverkänsliga kan ha en avvikande funktion i det autonoma nervsystemet, vilket kan styrkas med mätmetoder som HRV (hjärtfrekvensenvariabilitet).

F. Belägg för effekter av radiofrekvent strålning (RFR) från mobilmaster

Exponering för mycket låga RFR-nivåer kan förknippas med bioeffekter och ohälsa. Minst fem nya studier av radiofrekvent strålning (RFR) från basstationer har rapporterat om bioeffekter i strålningsområdet mellan 0,01 och 0,5 mW/m², vilket innebär lägre nivåer än vad som rapporterades 2007 (0,5 till 1 mW/m² var området under vilket inga effekter då, 2007, hade observerats). Studier har rapporterat om huvudvärk, koncentrationsproblem och beteendestörningar hos barn och ungdomar, samt sömnstörningar, huvudvärk och koncentrationsproblem hos vuxna. De officiella gränsvärdena är 1000 – 10 000 ggr högre än de som nu ofta rapporteras orsaka bioeffekter i studier om mobilbasstationers strålning.

G. Belägg för effekter på blod-hjärnbarriären

Ett forskarlag från Lunds universitet med Leif Salford, Bertil Persson och Henrietta Nittby har utfört ett pionjärarbete om effekter av mycket låga RFR-nivåer på människohjärnans skyddsbarriär – den som skyddar hjärnan från stora molekyler, droger och toxiner som finns i blodet.

Blod-hjärnbarriären kan vara i fara
Blod-hjärnbarriären (BHB) är ett skyddsvärn som hindrar ett flöde av oönskade substanser från att nå känslig hjärnvävnad. Om RFR från mobiler orsakar ökat läckage i BHB kan det leda till skador på hjärnans nervceller eller funktioner. Flera forskningsstudier har visat att mycket lågintensiva RFR-exponeringar kan påverka BHB – de flesta är djurstudier. Sammanfattningsvis är det mer sannolikt än osannolikt att icke-termisk EMF från mobiler och basstationer har biologiska effekter. En enda tvåtimmarsexponering för mobilstrålning kan leda till ökat läckage i BHB och 50 dagar efter exponeringen har nervskador konstaterats och vid den senare tidpunkten har även läckage av albumin (det vanligast förekommande blodproteinet) påvisats. De RFR-nivåer som är tillräckliga för att påverka BHB har visat sig vara så låga som 0,001 W/kg, eller mindre än exponeringen från en mobil på armlängds avstånd. Det amerikanska gränsvärdet (upprättat av US FCC) för SAR är 1,6 W/kg, vilket innebär den energi som kroppen tar upp varje sekund per kilogram. Motsvarande europeiska gränsvärde (upprättat av ICNIRP) är 2,0 W/kg. Det innebär att effekterna på blod-hjärnbarriären uppträder vid nivåer som ligger ungefär 1000 ggr lägre än de nivåer som gränsvärdena i USA och Europa tillåter.
(Salford et al, 2012)

H. Belägg för samband med hjärntumörer

Ett forskarlag från Örebro universitet som leds av Lennart Hardell, en onkolog och medicinsk forskare som har åstadkommit en extraordinär produktion av arbeten om miljögifter av olika slag, exempelvis samband mellan radiofrekvent-/mikrovågsstrålning och cancer. I gruppens rapport från 2012 sägs sammanfattningsvis:

"Det finns ett konsekvent mönster av ett samband mellan ökad risk för gliom (hjärntumör) och acusticusneurinom (hörselnervstumör), och användning av mobiler och sladdlösa telefoner. Fynden kommer framförallt från två forskningscentra – Hardells forskargrupp i Sverige och WHO-studien Interphone. Inget konsekvent mönster för riskökning har dock konstaterats för meningiom (hjärnhinnetumör). Om riskökningarna hade varit följden av ett systematiskt fel i studierna skulle det också ha varit fallet för meningiom. Tumörtyperna visar också olika riskmönster vilket styrker orsakssambanden för gliom och acusticusneurinom. Sammanslagningar av Hardellgruppens och Interphones studier, s.k. metaanalyser, visar också en riskökning för gliom och acusticusneurinom. Det faktum att tumörerna är vanligast i den mest exponerade delen av hjärnan ger ytterligare stöd för den ökade risken, likaså om hänsyn tas till den totala exponeringstiden och den tid det tar för en tumör att utvecklas tills den kan diagnostiseras. Dessutom ger riskkalkyler baserade på uppskattningar av den absorberade dosen ytterligare tyngd åt fynden."

"Det finns rimlig grund för att dra slutsatsen att RF-EMF är biologiskt aktivt och har potentiell möjlighet att orsaka hälsoeffekter. Resultat från epidemiologiska studier tyder på att RF-EMF bör klassificeras som cancerframkallande. Mot bakgrund av vår egen forskning och översikter av andra forskningsfynd är de nu gällande säkerhetsgränser och referensnivåer som upprättats av US FCC/IEE och ICNIRP inte tillräckliga för att skydda folkhälsan. Gränsvärdena behöver revideras."
(Hardell et al, 2012; avsnitt 11)

I. Belägg för genetiska skador (genotoxicitet)

De finns flera hundra publicerade vetenskapliga arbeten som rapporterar att EMF (ELF/RFR) kan påverka oxidativa processer i cellerna (oxidativa skador). Ökad aktivitet av fria radikaler och enzymförändringar som påverkar cellernas oxidativa processer är de tydligaste effekter som observerats i cell- och djurstudier efter EMF-exponering. Åldrande kan vara en faktor som gör individer känsligare för de oxidativa effekterna som induceras av ELF/EMF, beroende på att den antioxidativa kapaciteten avtar med åldern. Ett flertal genetiska studier rapporterar om DNA-skador och förlorad förmåga att reparera dessa skador.

Åttiosex (86) nya studier om genotoxiska effekter av RFR har granskats (studierna publicerades mellan 2007 och mitten av 2012). Av dessa redovisar 54 (63 %) effekter av RFR och 32 (37 %) rapporterar inga effekter (Lai, 2012). Under samma tidsperiod publicerades också 43 studier av genotoxiska effekter av ELF/EMF, vilka likaså har granskats. Av dessa redovisar 35 (81 %) effekter och 8 (19 %) rapporterar inga effekter.
(Lai, 2012 – avsnitt 6)

J. Belägg för effekter på nervsystemet

Faktorer som verkar direkt eller indirekt kan orsaka morfologiska, kemiska eller elektriska förändringar av nervsystemet, vilket kan leda till neurologiska effekter. Såväl radiofrekvent strålning, extremt lågfrekventa fält (ELF) och övriga elektromagnetiska fält (EMF) kan påverka neurologiska funktioner och beteende hos djur och människor.

"Från och med år 2007 till och med halvårsskiftet 2012 har det tillkommit 155 nya artiklar som rapporterar om studier på neurologiska effekter av radiofrekvent strålning. Av dessa artiklar beskrev 98 (63 %) effekter, medan 57 (37 %) inte påvisade några effekter.
Under samma period tillkom 69 nya artiklar om studier på neurologiska effekter av ELF och EMF, bland annat två artiklar om statiska fält. I 64 (93 %) av dessa beskrevs effekter och fem (7 %) artiklar kunde inte påvisa effekter."
(Lai, 2012 – avsnitt 9)

K. Belägg för samband med cancer (barnleukemi)

Med totalt 42 publicerade epidemiologiska studier till dags dato är lågfrekventa EMF (exempelvis kraftledningar) bland de mest grundligt studerade miljöfaktorerna. Förutom joniserande strålning finns det ingen miljöfaktor som har ett så säkerställt samband med barnleukemi.

"Det finns tillräckliga belägg från epidemiologiska studier för att exponering för EMF (lågfrekventa magnetfält) innebär en ökad cancerrisk som inte kan förklaras med slump, bias eller andra felkällor. Därför kan, enligt IARC:s stadgar, sådana exponeringar klassificeras som en "Grupp 1 carcinogen" (cancerframkallande). Än så länge har ingen annan riskfaktor identifierats som gör det möjligt att åsidosätta eller förneka behovet av minskad exponering. Ett steg i riktning mot försiktighetsåtgärder borde vara att införa ett gränsvärde som garanterar att exponering från kraftledningar i genomsnitt hamnar under 1 mGauss (mått på magnetisk flödestäthet, 1 mG motsvarar 0,1 mT). Det värdet är godtyckligt valt och motiveras enbart av att det i flera studier har utgjort referensvärde."
(Kundi, 2012 – avsnitt 12)

L. Melatonin, bröstcancer och Alzheimers sjukdom

Elva av de 13 publicerade epidemiologiska studierna (i både hem- och arbetsmiljöer) tyder på att höga magnetfält (extremt lågfrekventa fält, ELF) kan orsaka sänkt melatoninproduktion. De två negativa studierna (som inte visade detta samband) hade avgörande brister som kan förklara de negativa avvikelserna. Det finns tillräckliga belägg för slutsatsen att långvarig exponering för relativt höga nivåer av ELF magnetfält verkligen orsakar sänkt melatoninproduktion. Det har dock inte undersökts i vad mån andra faktorer (t. ex. medicinering) har betydelse för den melatonineffekten. Nyligen genomförda laboratorieförsök har visat att exponering för ELF MF (magnetfält) kan sänka melatoninaktiviteten genom att utöva effekt på MT1 (viktig melatoninreceptor). Fem longitudinella studier (studier där människor följs under lång tid) har studerat låg melatoninproduktion som en riskfaktor för bröstcancer. Resultatet av studierna talar starkt för att låg melatoninproduktion är en riskfaktor för bröstcancer åtminstone hos dem som har passerat övergångsåldern.
(Davinopour och Sobel, 2012 – avsnitt 13)

Alzheimers sjukdom: Det finns nu starka belägg för att höga plasmanivåer av beta-amyloid är en riskfaktor för Alzheimers sjukdom, och att medelhög till hög exponering för magnetfält kan ge förhöjda plasmanivåer av beta-amyloid. Höga nivåer av beta-amyloid i hjärnan är också en riskfaktor för Alzheimers, och medelhög till hög exponering för magnetfält kan antagligen öka hjärncellers produktion av beta-amyloid. Det finns åtskilliga djur- och in vitro-studier som talar för att melatonin skyddar mot Alzheimers. Därför är det sannolikt möjligt att låga melatoninnivåer innebär ökad risk för Alzheimers.

Det finns nu tolv studier av samband mellan magnetfältsexponering och Alzheimers eller demens. Nio av dessa studier tyder på ett sådant samband, medan tre bedöms vara negativa (visar inget samband). De tre negativa studierna har allvarliga brister beträffande klassificeringen av magnetfält, vilket fått till följd att försökspersoner som utsatts för ganska låg exponering har bedömts vara betydligt mer exponerade. Vad gäller radiofrekvent strålning bedöms studierna som otillräckliga för att bedöma om strålningen har betydelse för utveckling av Alzheimers sjukdom.
(Davinopour och Sobel, 2012 – avsnitt 13)

M. Stress, stressproteiner och DNA som fraktalantenn

Vilken miljöfaktor som helst (EMF, joniserande strålning, kemikalier, tungmetaller etc) som genererar stressproteiner går inte att anpassa sig till och är skadlig, om den är ständigt närvarande. Vetenskapliga arbeten av Martin Blank och Reba Goodman vid Columbia University har visat att produktion av stressproteiner utlöses av lågfrekventa magnetfält och radiofrekvent strålning som ligger långt under nuvarande gränsvärden. Dessutom framhåller de att DNA faktiskt är en utmärkt fraktalantenn som är mycket känslig för svaga elektromagnetiska fält, vilket kan utlösa cellulära processer som får till följd att individen hamnar i oavbruten stress. Den dagliga närvaron av ELF-EMF och RFR kan försätta människokroppen i ett tillstånd av "stressproteinreaktion" (rubbning av homeostasen, den biologiska jämvikten) vilket närmast är förnedrande. Denna ständigt pågående exponering kan så småningom resultera i kronisk ohälsa.

"Det verkar som att DNA-molekylen är särskilt känslig för att skadas av EMF beroende på att den packas ihop i cellens kärna så att den liknar en lindad spole. Den ovanliga strukturen ger DNA egenskaper som liknar en fraktalantenns och med det följer en känslighet för ett brett spektrum av frekvenser. Att DNA har en sådan reaktionsbenägenhet och sårbarhet för EMF understryker det angelägna behovet att revidera gränsvärdena för EMF-exponering för att skydda allmänheten. Nyligen genomförda studier har också undersökt egenskaper hos stressproteiner för att utarbeta behandlingar som ska begränsa skador av fria radikaler och den åldersrelaterade förlusten av muskelstyrka."
(Blank, 2012 – Avsnitt 7)

"EMF skadar celler vid exponeringsnivåer som ligger på en miljarddel av det som krävs för uppvärmningseffekter. Gränsvärden som baseras på uppvärmningseffekter är irrelevanta och kan inte skydda mot exponering för EMF. Det är därför angeläget att snarast revidera gränsvärden för EMF-exponering. Biologiskt baserade gränsvärden för EMF-exponering bör utarbetas utifrån forskningsresultat om stressreaktioner."
(Blank, 2012 – Avsnitt 7)

N. Effekter av svaga fält på icke-linjära biologiska oscillatorer och synkroniserad nervaktivitet

En hypotes för en rimlig biologisk mekanism som kan förklara bioeffekter (förutom cancer) av mycket svaga elektromagnetiska fält, kan finnas i de effekter av svaga fält såsom puls- eller ELF-modulerad radiofrekvent strålning som kan störa synkroniserad nervaktivitet. Elektriska rytmer i våra hjärnor kan påverkas av yttre signaler. Detta stämmer överens med kända effekter av svaga fält på sammankopplade biologiska oscillatorer (periodiska biologiska aktiviteter) i levande vävnad. Biologiska system i hjärta, hjärna och mage är beroende av samverkande celler som fungerar enligt principerna för icke-linjära, sammankopplade biologiska oscillatorer för att kunna synkronisera aktiviteter, och de är även beroende av exakt anpassning till signaler från miljön, som kan vara ytterst svaga (Buzsaki, 2006, Strogatz, 2003). Nyckeln till synkroniseringen är att cellaktiviteter samordnas med elektriska signaler. På så sätt kan också flera biologiska oscillatorer sammankopplas till större enheter vars aktiviteter självsynkroniseras. Vissa celler (t ex. hjärtats pacemakerceller) har förmåga att generera signaler med en viss rytmicitet vilket leder till synkronisering av flera celler. Sådana celler kan störas av artificiella signaler från omgivningen, vilket kan leda till desynkronisering av nervaktiviteter som reglerar viktiga funktioner (t ex. ämnesomsättning) i hjärnan, magen och hjärtat, och dygnsrytmer som styr sömn och hormoncykler (Strogatz, 1987). Hjärnan innehåller flera oscillatorer som skickar signaler med olika frekvenser, vilka en efter en samordnas till synkronisering. Strogatz har studerat dessa biologiska cykler och funnit att yttre faktorer kan störa cyklerna.

"Biologiska rytmer kan påverkas av en mångfald av faktorer, och dessa störningar kan åstadkomma allvarliga förändringar av hjärnans prestationsförmåga."
(Buzsaki, 2006)

III. EXPONERING FÖR ELEKTROMAGNETISKA FÄLT OCH FÖLJDER FÖR FOLKHÄLSAN

Oavbruten exponering för lågintensiv och ELF-modulerad radiofrekvent strålning vid de nivåer som idag är vanliga i stadsmiljöer ökar riskerna för både sjukdomar och dödsfall (Sage och Huttunen, 2012). Daglig exponering för radiofrekvent strålning påverkar människors homeostas. Exponeringen kan påverka och skada gener, trigga epigenetiska effekter (exempelvis avaktivera gener) och orsaka nya mutationer. Exponeringen kan också störa normala hjärt- och hjärnfunktioner; påverka dygnsrytmer som reglerar sömn, läkning, återhämtning och hormonbalanser; försämra korttidsminne, koncentrationsförmåga, inlärningsförmåga; påverka beteende; framkalla avvikande immunologiska, allergiska och inflammatoriska reaktioner; förändra hjärnans ämnesomsättning; försämra fertiliteten (skada spermier och öka risken för missfall); och utlösa produktion av stressproteiner. Exponeringar som nu är vanliga i hem- och skolmiljöer kan mycket väl bli fysiologiskt vanebildande och de effekterna är särskilt allvarliga hos unga (Sage och Huttunen, 2012).

IV. REKOMMENDERADE ÅTGÄRDER

A. Förebyggande åtgärder för minskad exponering av mikrovågsstrålning

MIKROVÅGSSTRÅLNING ÄR KLASSIFICERAT SOM MÖJLIGEN CANCERFRAMKALLANDE – VARFÖR GÖR INTE BESLUTSFATTARNA NÅGOT?

I maj 2011 klassificerade Världshälsoorganisationens, WHO:s, cancerforskningsorgan IARC radiofrekventa elektromagnetiska fält som "Möjligen cancerframkallande". Klassificeringen gäller för radiofrekvent strålning i allmänhet och täcker alla mikrovågssändande apparater och exponeringskällor (mobiler och sladdlösa telefoner, wifi, bärbara datorer, trådlösa surfzoner, babyvakter etc.) IARC:s expertgrupp hade kunnat klassificera radiofrekvent strålning i "Grupp 4 – Inte carcinogent" om underlagen tydligt hade visat att radiofrekvent strålning inte är cancerframkallande. De hade också kunnat välja "Grupp 3 – Otillräckliga belägg" som en provisorisk lösning. IARC valde ingendera.

NYA GRÄNSVÄRDEN MÅSTE UPPRÄTTAS – HÄLSOMYNDIGHETER MÅSTE AGERA NU

De befintliga gränsvärdena (framtagna av US FCC och ICNIRP) räcker inte till för att skydda folkhälsan mot oavbruten exponering för mikrovågsstrålning. Om ingen kursändring sker beträffande de befintliga och föråldrade gränsvärdena, kommer dröjsmålet att innebära ännu större konsekvenser för folkhälsan, allrahelst som allt fler trådlösa applikationer påverkar allt fler människor över hela världen.

VETENSKAPLIGT BELAGDA TRÖSKELVÄRDEN PLUS SÄKERHETSMARGINAL = NYA VÄLGRUNDADE GRÄNSVÄRDEN

Hälsomyndigheter och organisationer som beslutar om gränsvärden för elektromagnetiska fält och radiofrekvent strålning bör snarast anta nya, biologiskt relevanta säkerhetsgränser som motsvarar de lägsta nivåerna för hälsoeffekter som observerats i de senaste studierna, plus en ännu lägre nivå som extra säkerhetsmarginal. De nu gällande gränsvärdena är alltför höga med flera tiopotenser, för att kunna förebygga bioeffekter och minimera eller förhindra ohälsoeffekter. De flesta gränsvärden är mer än tusentals gånger för höga för att skydda en frisk befolkning, och ger ännu mindre skydd för känsligare delar av befolkningen.

KÄNSLIGA BEFOLKNINGSGRUPPER MÅSTE SKYDDAS

Gränsvärdena behöver vara lägre för de delar av befolkningen som är extra känslig än för den friska och vuxna befolkningen. De känsligare grupperna omfattar foster, spädbarn, barn, äldre, de som har kroniska sjukdomar och de som har utvecklat el-överkänslighet.

SKYDDA UPPVÄXANDE GENERATIONER – BARNEN

Starka säkerhetsåtgärder och tydliga varningar till allmänheten är nödvändiga för att undvika en global epidemi av hjärntumörer till följd av den ökande användningen av främst mobiler och trådlösa telefoner. För att skydda foster och nyfödda kan många enkla åtgärder vidtas som att undvika babyvakter i barnsängar och kuvöser med trådlös utrustning. Gravida kvinnor bör också informeras om vikten av att undvika bärbara datorer, mobiler och andra källor till mikrovågsstrålning och magnetfält. Bärbara datorer och annan trådlös utrustning måste bannlysas från skolor.

HUR SKA VETENSKAPLIGA RESULTAT BEDÖMAS OCH ANVÄNDAS?

Vid bedömning av vetenskapliga rön måste befolkningens hälsa sättas i första rummet. Det får inte negligeras med motiveringar som att vissa rön ännu inte är helt säkerställda och måste verifieras i nya studier.

VARNINGAR OM TRÅDLÖS TEKNOLOGI MÅSTE NÅ ALLA

Den fortsatta utvecklingen av trådlösa teknologier och utrustningar utgör en stor risk för den globala folkhälsan. Därför måste betydligt lägre exponeringsnivåer tillämpas och tydliga varningar om användning av trådlösa teknologier spridas.

MIKROVÅGSSTRÅLNING ÄR EN TOXISK EXPONERING SOM KAN FÖRHINDRAS

Vi har kunskaper och möjligheter att skona en global befolkning från hälsoeffekter som annars kan bestå i flera generationer, genom att minska exponeringen för magnetfält och radiofrekvent strålning. Omedelbara och förebyggande åtgärder som minskar onödig exponering för mikrovågsstrålning kommer att leda till minskad sjukdomsbörda och färre fall av för tidig död.

B. Fastställande av nya tröskelvärden för effekter av radiofrekvent strålning

I avsnitt 24 konstateras att den radiofrekventa strålningens tröskelvärden för bioeffekter och hälsoeffekter motiverar nya och lägre gränsvärden för radiofrekvent strålning. Vid nya epidemiologiska studier och laboratorieförsök har man funnit effekter på människor vid lägre exponeringsnivåer när studierna har genomförts under längre tid (oavbruten exponering). Oroväckande iakttagelser tyder på att spermier kan skadas av mobiler även om mobilerna endast varit i standby-läge, och att människor kan få hälsoproblem av nya typer av trådlösa sändare som avger pulsade radiofrekventa fält (exv. "smarta" elmätare). I båda fallen har effekter rapporterats även när den tidsviktade genomsnittsnivån av radiofrekvent strålning varit obetydlig.

Det ser allt mer rimligt ut att den avgörande faktorn för biologiska effekter är den oregelbundna (intermittenta) pulsen i radiofrekvent strålning och inte SAR-värdet. Till exempel skrev Hansson Mild et al (2012) att sömn och testiklarnas funktion inte kan påverkas av en GSM-mobil eftersom *"exponeringen i standby kan anses som försumbar"*. Det kan vara så att vi, som art betraktad, är mer lättpåverkade än vi har anat för oregelbundna, mycket lågintensiva, radiofrekventa signaler, som då kan påverka viktiga aktiviteter i levande vävnader. Det är ett misstag att tro att effekter omöjligen kan förekomma bara för att vi inte kan förklara hur det kan komma sig eller för att det stör vår mentala föreställning av hur saker och ting ligger till.

Detta belyser vilken begränsning det innebär att inte ta hänsyn till den pulsmodulerade radiofrekventa strålningens karaktär (oregelbundna, mikrosekundlånga pulser) när gränsvärden diskuteras. Dessa signaler har biologisk aktivitet. Även om de enskilda radiofrekventa pulserna betraktas som obetydliga är de uppenbarligen inte obetydliga för människokroppen och dess funktioner.

Av de skälen, och med tanke på parallella vetenskapliga arbeten om icke-linjära biologiska oscillatorer och om kopplade oscillatorer (Bezsaki, 2006; Strogaz, 2001, 2003), är det viktigt att tänka framåt beträffande konsekvenserna av de utbredda trådlösa systemen. Det är också viktigt att ompröva gränsvärden för att ta hänsyn till känsligheten i biologiska system när exponeringen är pulsad och därför kan te sig obetydlig när alla pulser läggs samman över tid, men där varje enskild puls kan vara högst betydlig för kroppens funktioner. Om det stämmer att svaga fält kan påverka den samordnade aktiviteten i hjärnans nervceller, och andra pacemakerceller och vävnader i hjärta och mage, då är det lättare att förstå hur levande vävnader kan reagera på mycket svag exponering för pulsad radiofrekvent strålning, och då finns grunden till insikt om vad som fordras av nya, biologiskt baserade gränsvärden.

En sänkning till en tusendel av rekommendationen i Bioinitiative 2007, från 1 mW/m² till ca 1 μW/m², för radiofrekvent strålning utomhus är motiverat för att skydda folkhälsan. Vi har utgått från de vetenskapliga rön som presenterats i denna rapport för att identifiera de lägsta nivåerna med biologisk effekt och har sedan lagt till en reduktionsfaktor för att få en säkerhetsmarginal. Här föreslås ett gränsvärde för utomhusexponering för pulsmodulerad radiofrekvent strålning som kan tillämpas på mobilmastantenner, wifi, wimax och andra liknande strålningskällor. Mer forskning behövs för att undersöka de biologiska effekterna av oregelbundna radiofrekventa pulser och hur ett skydd i form av gränsvärde kan tas fram.

Ett vetenskapligt referensvärde på 30 μW/m² för "lägsta observerade tröskelvärde för effekter" av radiofrekvent strålning är baserat på studier med mobilbasstationer. För att kompensera för bristen på studier av långtidsexponering (som en säkerhetsbuffert vid ständig exponering) och för bristen på studier på barn vilka utgör en känslig undergrupp, gjordes ytterligare en tiofaldig reducering vilket gav en nivå på 3 till 6 mikrowatt per kvadratmeter (3 – 6 μW/m²) vilket är en rimlig säkerhetsnivå för oavbruten exponering av pulsmodifierad radiofrekvent strålning. Men dessa tröskelvärden kan behöva ändras i framtiden när nya och bättre studier finns att tillgå.

Här följer vad författarna skrev 2007 (Carpenter och Sage, 2007, Bioinitiative Report) och det är fortfarande giltigt 2012:
Vi lämnar dörren öppen för framtida studier som kan sänka eller höja dagens tröskelvärden för effekter och vi är beredda att acceptera ny information som vägledning för nya säkerhetsåtgärder.

Bilaga 7

Parlamentariska församlingen

Europarådet

Resolution 1815 (2011)[1]

De potentiella riskerna med elektromagnetiska fält och deras inverkan på miljön

1. Den parlamentariska församlingen har flera gånger betonat vikten av staternas åtagande att skydda miljön och miljörelaterad hälsa, såsom fastslagits i många stadgar, konventioner, deklarationer och protokoll sedan FN-konferensen om den mänskliga miljön och Stockholmsdeklarationen (Stockholm 1972). Församlingen refererar till sitt tidigare arbete på detta område som **Rekommendation 1863** (2009) om miljö och hälsa: om att på ett bättre sätt förebygga miljörelaterade hälsorisker, **Rekommendation 1947** (2010) avseende buller och ljusföroreningar[2], **Rekommendation 1885** (2009) om att utarbeta av ett tilläggsprotokoll till den europeiska konventionen om mänskliga rättigheter angående rätten till en hälsosam miljö, **Rekommendation 1430** (1999) rörande tillgång till information, medborgardeltagande i miljörelaterat beslutsfattande samt i förekommande fall möjlighet till rättslig prövning – genomförandet av Århuskonventionen.

2. Möjlig hälsopåverkan av mycket lågfrekventa elektromagnetiska fält från kraftledningar och elektrisk utrustning är föremål för pågående forskning och förekommer ofta i den offentliga debatten. Enligt Världshälsoorganisationen (WHO) svarar i dag elektromagnetiska fält av alla frekvenser för en av de vanligaste och snabbast växande miljöeffekter som orsakar ökande oro och spekulationer hos allmänheten. Alla människor utsätts idag i varierande grad för elektromagnetiska fält, vars nivåer hela tiden ökar i takt med att tekniken utvecklas.

3. Mobiltelefoni har blivit en vardaglig företeelse runt om i världen. Den trådlösa tekniken bygger på ett omfattande nätverk av fasta antenner eller basstationer som kommunicerar med radiofrekventa signaler. I dag finns drygt 1,4 miljoner bas-stationer, vars antal nu ökar markant i och med införandet av 3G, tredje generationens teknik. Andra trådlösa nätverk med snabb uppkoppling till Internet och andra tjänster blir också allt vanligare i hemmen, på kontor och i det offentliga rummet (flygplatser, skolor, bostads- och stadsområden). Med denna utbyggnad av basstationer och lokala nätverk utsätts naturligtvis människor för ökad radiofrekvent strålning.

4. Medan å ena sidan elektriska och elektromagnetiska fält av vissa frekvensband bara har positiva effekter som används inom medicinen, förefaller icke-joniserande strålning på andra frekvenser ha mer eller mindre potentiellt skadliga effekter. Här rör det sig både om extremt låga frekvenser från elledningar, och höga som inom radar,

1 Text antagen av den *Permanenta Kommittén* på uppdrag av Parlamentariska församlingen, den 27 maj 2011 (se dok. 12608, betänkandet från Kommittén för miljö, jordbruk och lokala och regionala frågor, föredragande: Huss).

2 Störande artificiellt ljus. Övers. anm.

telekommunikation och mobiltelefoni. Det är fråga om en mer eller mindre potentiellt skadlig icke-termisk biologisk påverkan såväl på växter, insekter och djur som på den mänskliga kroppen, även när de utsätts för nivåer som är lägre än de officiella gränsvärdena.

5. När det gäller de officiella gränsvärdena för emission av elektromagnetiska fält av alla typer och frekvenser, rekommenderar Parlamentariska församlingen starkt att ALARA-principen tillämpas (= **a**s **l**ow **a**s **r**easonably **a**chievable[3]), och detta gäller då både de s.k. termiska och de icke-termiska eller biologiska effekterna av elektromagnetisk strålning. Dessutom skall försiktighetsprincipen tillämpas när vetenskaplig forskning inte med tillräcklig säkerhet kan fastslå skadeeffekter. Med tanke på människors ökande exponering för elektromagnetisk strålning, speciellt ungdomar och barn, skulle det kunna resultera i extremt höga mänskliga och ekonomiska kostnader om man inte beaktar tidiga varningar.

6. Parlamentariska församlingen beklagar att trots uppmaningar om att beakta försiktighetsprincipen, och trots alla rekommendationer, deklarationer och vissa framsteg inom lagstiftningsarbetet, råder det fortfarande en ganska ljum reaktion visavi kända och nya miljö- och hälsorisker. Förseningar är mer regel än undantag när det gäller att anta och genomföra effektiva förebyggande åtgärder. Att invänta hög bevisnivå från vetenskaplig och klinisk forskning innan man går till handling för att förhindra välkända risker, kan leda till utomordentligt höga framtida kostnader av både ekonomisk och mänsklig art, såsom det en gång skedde i frågan om asbest, blyad bensin och tobak.

7. Parlamentariska församlingen konstaterar också att problemet med elektromagnetiska fält eller vågor och deras eventuella följder för miljö och hälsa har tydliga paralleller med andra aktuella frågor, såsom licensiering av läkemedel, kemikalier, bekämpningsmedel, tungmetaller eller genmodifierade organismer. Därför menar man att den vetenskapliga expertisens trovärdighet och oberoende är avgörande för att uppnå en öppen och balanserad bedömning av möjliga negativa effekter på miljö och människors hälsa.

8. Med hänsyn till det ovan anförda rekommenderar Parlamentariska församlingen medlemsstaterna i Europarådet följande:

8.1. att allmänt:

8.1.1. vidtaga alla rimliga åtgärder för att minska exponering för elektromagnetiska fält, särskilt för radiofrekvenser från mobiltelefoner, och i synnerhet exponering när det gäller barn och ungdomar som förefaller att ha störst risk att utveckla hjärntumörer;

8.1.2. ompröva de nuvarande vetenskapliga normerna för exponering för elektromagnetiska fält som är satta av Internationella kommissionen för skyddet mot icke-joniserande strålning[4], vilka i dag har allvarliga brister; vidare att tillämpa ALARA-

3 Ung: "så lågt som rimligen är möjligt", övers. anm.

principen, som omfattar såväl termiska effekter som icke-termiska eller biologiska effekter av elektromagnetiska emissioner eller strålning;

8.1.3. införa informations- och upplysningskampanjer om riskerna med potentiellt skadliga långsiktiga biologiska effekter på miljö och människors hälsa, särskilt med inriktning på barn, tonåringar och unga människor i fertil ålder;

8.1.4. ägna särskild uppmärksamhet åt elöverkänsliga människor som lider av ett syndrom som medför överkänslighet mot elektromagnetiska fält och införa särskilda åtgärder för att skydda dem, inklusive att inrätta strålningsfria zoner som inte täcks av trådlösa nätverk;

8.1.5. i syfte att minska kostnader samt att spara energi och skydda miljö och människors hälsa, intensifiera forskning om nya typer av antenner, mobil- och DECT-telefonutrustning, samt att uppmuntra forskning inriktad på att utveckla telekommunikation som bygger på andra tekniker som är lika effektiva, men vars effekter är mindre negativa för miljö och hälsa;

8.2. i fråga om privat användning av mobiltelefoner, trådlösa DECT-telefoner, WiFi, WLAN och WIMAX för datorer och annan trådlös utrustning, som elektroniska barnvakter:

8.2.1. i överensstämmelse med försiktighetsprincipen, sätta förebyggande gränsvärden avseende långtidsexponering för mikrovågor i all inomhusmiljö, vilka inte får överstiga 0,6 volt per meter, och på medellång sikt minska det till 0,2 volt per meter;

8.2.2. genomföra lämplig riskbedömning för all ny typ av elektrisk utrustning innan licensiering;

8.2.3. införa tydlig märkning, som anger förekomst av mikrovågor eller elektromagnetiska fält, utsänd effekt eller SAR[5]-värdet för utrustningen samt eventuella hälsorisker i samband med dess användning;

8.2.4. öka medvetenheten om potentiella hälsorisker med trådlösa DECT- telefoner, babyvakter och andra hushållsapparater som avger kontinuerligt pulsade vågor, om dessa ständigt står i standby, och rekommendera användning av trådbundna, fasta telefoner i hemmet, eller, om det ej är möjligt, åtminstone rekommendera modeller som inte ständigt avger pulsade vågor;

8.3. angående skydd av barn:

8.3.1. att inom departement och ministerier (som utbildning, miljö och hälsa) utarbeta riktade informationskampanjer till lärare, föräldrar och barn för att göra dem uppmärksamma på de särskilda riskerna med tidig, ogenomtänkt och långvarig användning av mobiltelefoner och andra produkter som avger mikrovågor;

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4 International Commission on Non-Ionizing Radiation Protection = ICNIRP

5 Specific Absorption Rate = mått på den energi kroppen absorberar i t.ex. hjärnan, blod, hud och muskler vid bestrålning. Anges i Watt per kg (W/kg). Övers. anm.

8.3.2. för barn i allmänhet och speciellt i skolor och klassrum, prioritera trådbundna Internetanslutningar, samt att strikt reglera skolbarns användning av mobiltelefoner på skolområdet;

8.4. avseende planering av elledningar och länkantenner[6]/basstationer:

8.4.1. att vid stadsplanering se till att högspänningsledningar och andra elektriska installationer placeras på ett säkert avstånd från bostäder;

8.4.2. tillämpa strikta säkerhetsnormer för hälsoeffekter av elektriska system i nya bostäder;

8.4.3. sänka gränsvärdena för basstationsantenner i enlighet med ALARA-principen och installera system för heltäckande och kontinuerlig övervakning av alla typer av antenner;

8.4.4. bestämma placering av nya GSM, UMTS, WiFi eller WIMAX-antenner i samråd med lokala och regionala myndigheter, lokala invånare och sammanslutningar av engagerade medborgare, och inte endast med hänsyn till operatörernas önskemål;

8.5. om riskbedömning och försiktighetsåtgärder:

8.5.1. se till att riskbedömningen får en mer förebyggande inriktning;

8.5.2. förbättra riskbedömningars kvalitet genom att skapa en normativ riskskala i syfte att göra den framtagna risknivån obligatorisk, samt att ge i uppdrag att studera flera olika riskhypoteser och ställningstaganden, och därvid beakta överensstämmelse med verkliga förhållanden;

8.5.3. fästa avseende vid och skydda forskare som "höjer ett varnande finger" på ett tidigt stadium;

8.5.4. formulera en på mänskliga rättigheter inriktad definition av försiktighets- och ALARA-principerna;

8.5.5. öka offentlig finansiering av oberoende forskning, i synnerhet genom bidrag från industrin och beskattning av de produkter som är föremål för offentlig forskning i syfte att utvärdera hälsorisker;

8.5.6. skapa oberoende nämnder för tilldelning av offentliga medel;

8.5.7. se till att insyn i lobbygrupperna blir obligatorisk;

8.5.8. främja mångsidiga och fria, öppna debatter mellan alla typer av aktörer, inklusive från det civila samhället (Århus-konventionen).

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6 I originaltexten står det "Relay Antenna", det används vanligen om radiolänkantenner, men ibland även för vanlig basstationsantenn. I praktiken är de ofta placerade i samma mast. Övers. anm.

Bilaga 8

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EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses

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Abstract: Chronic diseases and illnesses associated with non-specific 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 necessary now to take "new exposures" like electromagnetic fields (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 electromagnetic field or EMF sources: Radio-frequency radiation (RF) (3 MHz to 300 GHz) is emitted from radio and TV broadcast antennas, Wi-Fi access points, routers, and clients (e.g. smartphones, tablets), cordless and mobile phones including their base stations, and Bluetooth devices. Extremely low frequency electric (ELF EF) and magnetic fields (ELF MF) (3 Hz to 3 kHz) are emitted from electrical wiring, lamps, and appliances. Very low frequency electric (VLF EF) and magnetic fields (VLF MF) (3 kHz to 3 MHz) are emitted, due to harmonic voltage and current distortions, from electrical wiring, lamps (e.g. compact fluorescent lamps), and electronic devices. On the one hand, there is strong evidence that long-term exposure to certain EMFs 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

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as courts of law. We recommend treating EHS clinically as part of the group of chronic multisystem illnesses (CMI), but still recognizing that the underlying cause remains the environment. In the beginning, EHS symptoms occur only occasionally, but over time they may increase in frequency and severity. Common EHS symptoms include headaches, concentration difficulties, sleep problems, depression, a 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 making the diagnosis. The EMF exposure is usually assessed by EMF measurements at home and at work. Certain types of EMF exposure can be assessed by asking about common EMF sources. 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 high EMF exposure at home and at 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. 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 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 range 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 illnesses – works best. This EMF Guideline gives an overview of the current knowledge regarding EMF-related health risks and provides recommendations for the diagnosis, treatment and accessibility measures of EHS to improve and restore individual health outcomes as well as for the development of strategies for prevention.

Keywords: accessibility measures; Alzheimer's disease; cancer; chronic multisystem illnesses (CMI); diagnosis; electric; electromagnetic field (EMF); electromagnetic hypersensitivity (EHS); infertility; leukemia; magnetic; medical guideline; nitrosative stress; non-ionizing; oxidative stress; peroxynitrite; prevention; radiation; static; therapy; treatment.

Current state of the scientific and political debate about EMF-related health problems 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, second-hand 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 increased 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 in 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 the Organization for Economic Co-operation and Development (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 have hardly been 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) play a causal role for EMF-related health effects (9–12), including exposure to radio-frequency radiation (RF), which emanates from, e.g. cordless phones (DECT), mobile phone base stations, and mobile 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 fields (EF) and magnetic fields (MF) including "dirty electricity", which emanate from disturbances on electric wiring, power lines, electric devices, and other equipment. For the society and the medical community, all of this raises new challenges.

While biophysical and biochemical mechanisms of biological effects of EMF at low-intensity levels are not exactly known, significant progress has been achieved in the last decades, and there are numerous data indicating that these mechanisms may overlap for ELF and RF effects (13–18). In the following sections, we provide some background information on important aspects of EMF biological effects. However, this must not be misunderstood as a full review of the evidence. We do not always strictly differentiate between RF and ELF fields because of the above mentioned overlap in biological mechanisms. It should also be mentioned here that very specific exposure conditions may trigger biological responses in one individual, but not in others. Anecdotal reports, however, indicate that such individual responsiveness or susceptibility does expand over time and the intolerance then extends over a broad range of exposure conditions.

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, or as stated by Hedendahl et al. (19): *"It is time to consider ELF EMF and RF EMF as environmental pollutants that need to be controlled"*.

Worldwide statements of organizations regarding EMF

The recommendations of the World Health Organization (WHO) regarding ELF electric and magnetic fields and RF radiation, compiled by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (20, 21), are based on currents induced in the body (ELF) and thermal effects (RF).

Thermal effects are defined as effects that originate in elevated temperatures from the absorption of electromagnetic energy. The specific absorption rate (SAR) is defined as the rate of absorption of electromagnetic energy in a unit mass of biological tissue. It is proportional to the incremental temperature increase in that tissue. Indeed while a significant temperature increase must be avoided as it can be of immediate adverse health consequences (tissue necrosis, cardiac stress, etc.) exposures can be without (measureable) temperature increase either because of heat dissipation or because the exposure is too low to be associated with relevant heating. The latter type of exposure is termed non-thermal. Biological and health-relevant effects at non-thermal levels have been shown and discussed by many research groups all over the world (9, 10, 22–24).

The ICNIRP recommendations were adopted by the EU in its Council Recommendation of 1999, without considering long-term non-thermal effects. However, it should be stressed that at an international EMF conference in London (2008), Professor Paolo Vecchia, ICNIRP Chairman from 2004 to 2012, 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"* (25).

For all RF-based non-thermal EMF effects, SAR estimates are not an appropriate exposure metric, but instead either the field intensity or power density (PD) in combination with exposure duration should be used in safety standards (26, 14, 27). In contrast to the ICNIRP guidelines, the Russian safety standards, are based on non-thermal RF effects, which were obtained by several research institutes in the former Soviet Union during decades of studies on chronic exposures to RF (28, 29).

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 (ELF MF) as possibly carcinogenic to humans (Group 2B) in 2002 (30) and radio-frequency radiation in 2011 (24).

It should be noted that, during the last 20 years, more than 20 position papers and resolutions regarding EMF and health have been adopted by EMF researchers and physicians. These include the Vienna EMF Resolution, Austria, 1998; Stewart Report, UK, 2000; Salzburg Resolution, Austria, 2000; Freiburg Appeal, Germany, 2002; Catania Resolution, Italy, 2002; Irish Doctors' Environmental Association Statement, Ireland, 2005; Helsinki Appeal, Finland, 2005; Benevento Resolution, Italy, 2006; Venice Resolution, Italy, 2008; Porto Alegre Resolution, Brazil, 2009; Russian National Committee on Non-Ionizing Radiation Protection Resolution, Russia, 2001; International Doctors' Appeal, Europe, 2012; and the Report of the Standing Committee on Health, Canada, 2015 (31–34).

In August 2007 and December 2012, the BioInitiative Working Group, an international group of 29 experts with different competences, published two groundbreaking reports "BioInitiative 2007/resp. 2012 – A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)" edited by Cindy Sage and David O. Carpenter, calling for preventive measures against EMF exposure based on the available scientific evidence (9, 10). The BioInitiative reports are global milestones with respect to a comprehensive review of biological effects and health effects of low-intensity electromagnetic radiation as well as the conclusions and recommendations given for the public. The BioInitiative report 2012 includes sections on the evidence for effects on: gene and protein expression, DNA, immune function, neurology and behavior, blood-brain barrier, brain tumors and acoustic neuromas, childhood leukemia, melatonin, Alzheimer's disease, breast cancer, fertility and reproduction, fetal and neonatal disorders, autism, disruption by the modulating signal, EMF medical therapeutics, as well as sections on: statement of the problem, the existing public exposure standards, evidence for inadequacy of the standards, the precautionary principle, global public health examples, key scientific evidence and public health recommendations, and summary for the public and conclusions.

As 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 (35). This position was confirmed and elaborated more comprehensibly in further publications in 2011 and 2013 (36, 37).

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 (38). This was further strengthened in the European Parliament resolution of April 2009 (39).

At the meeting in November 2009 in Seletun, Norway, a scientific panel adopted a Consensus Agreement that recommends preventative and precautionary actions that are warranted now, given the existing evidence for potential global health risks from EMF exposure (40). Besides general and specific recommendations, e.g. for mobile and cordless phone use, the panel recommended exposure limits for ELF magnetic fields and radio-frequency radiation. It was stated by the panel: "Numeric limits recommended here 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 here".

Since 2007 the Highest Health Council of the Ministry of Health in Austria has recommended to take preventive action by reducing exposure levels from RF devices which may lead to long-term human exposure of at least a factor of 100 below the guideline levels of the European Commission and by issuing rules on how to reduce one's individual exposure to RF radiation from mobile phones (41).

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" (42). 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 (AAEM) published recommendations regarding EMF exposure in July 2012. The AAEM called for physicians to consider electromagnetic exposure in diagnosis and treatment and to recognize that EMF exposure *"may be an underlying cause of the patient's disease process"* (43).

Since 2014, the Belgian government has prohibited the advertising of mobile phones for children under the age of

7 and has required the specific absorption rate (SAR) of mobile 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 (44).

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 3 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 mobile phones, the SAR value must be clearly shown. In the future, any mobile 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 (45).

As of February 2016, 220 scientists from 42 countries have signed an international Appeal, directed to the United Nations (UN) and WHO, calling for protection from non-ionizing electromagnetic field exposure. The appeal addresses the scientifically proven effects on health and the inadequate international guidelines (ICNIRP) to date and their use by the WHO. In addition, nine requests were made, including 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"* (46).

In September 2015 an International Scientific Declaration on Electromagnetic Hypersensitivity and Multiple Chemical Sensitivity was published by the Scientific Committee following the 5th Paris Appeal Congress, which took place on 18 May 2015 at the Royal Academy of Medicine, Brussels, Belgium. It calls upon national and international agencies and organizations to recognize EHS and multiple chemical sensitivity as a disease and urges particularly the WHO to include EHS and MCS in the International Classification of Diseases. It also asks national and international agencies and organizations to adopt simple precautionary measures of prevention, to inform the public, and to appoint truly independent expert groups to evaluate these health risks based on scientific objectivity, which is not the case today (47).

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 (ELF MF) with "service drop" wires and the occurrence of childhood cancer (specifically leukemia and brain tumors) (48). At the same time Robinette et al. studied mortality in a cohort of Korean War veterans having been trained on military radars (RF) in the early 1950s (49). Both studies found indications of increased risks and initiated a new era of studying health-relevant effects from exposure to EMFs.

ELF MF

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 (50, 51) 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 (30). 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 (52, 53). The only study to date on the gene-environment interaction in relation to power-frequency MF reported a significant effect enhancement in children with a polymorphism in a DNA-repair gene (54). 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 (definitive) carcinogen (55).

The BioInitiative Report 2012 (56) stated: *"Children who have leukemia and are in recovery have poorer survival rates if their ELF exposure at home (or where they are recovering) is between 1mG [0.1 μT] and 2 mG [0.2 μT] in one study; over 3 mG [0.3 μT] in another study"* (56).

RF

There were several mechanisms identified which might be responsible for carcinogenic effects of RF (23). Epidemiological studies of RF before the general rise in exposure to mobile telecommunication devices was very restricted and only a few studies had been conducted in the vicinity of radio transmitters, radar stations, for occupational exposures, and 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 of Prof. Lennart Hardell (57), about 40 studies have been published. The majority of these studies investigated brain tumors, but salivary gland tumors, uveal melanoma, malignant melanoma of the skin, nerve sheath tumors, testicular cancer, and lymphoma were also studied. Many of these studies are inconclusive because exposure durations are too short; 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 (24). Since then, additional studies have corroborated the assumption of a causal relationship between mobile phone use and cancer (58–60). Hardell and Carlberg (61) 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 of glioma has increased further: in 2014, a study by Carlberg and Hardell (62) showed significantly decreased survival rates in patients with glioblastoma multiforme (astrocytoma grade IV) and the use of wireless phones and, in 2015, another pooled case-control study by Hardell and Carlberg (63) including latency periods of >25 years.

That also other tumors might be related to EMF exposure is exemplified by the observation in women who have worn their mobile phone in their bra for prolonged periods of time and later developed breast cancer at that site (64).

The Italian Supreme Court confirmed a previous decision by the Civil Court of Appeals of Brescia (no. 614 of 10 December 2009) that ruled that the National Institute for Workmen's Compensation (INAIL) must compensate a worker who had developed a tumor in the head due to long-term, heavy use of mobile phones while on the job. The case was an ipsilateral neuroma of the trigeminal nerve in a subject who had occupational exposure for >10 years, with >15,000 h on mobile and cordless phones. The court recognized that *"it is likely (qualified probability) that RF have a role which is at least contributory in the development of the origin of the tumor suffered by the subject"* (65).

Many modern devices emit EMF of different frequency ranges simultaneously. For example, mobile phones create EMF in RF, VLF, and ELF frequency ranges and also a static magnetic field; for a review see (23). Therefore, it is important to consider combined exposures for the assessment of health effects.

Genotoxic effects

Genotoxic effects of EMF dealing with DNA damage, mutations, chromatin structure, and DNA repair have recently been reviewed by Henry Lai in the Bioinititive Report (66) and by the IARC Working Group in the assessment of RF carcinogenicity (24). In general, about half of the available studies found genotoxicity (positive reports), although other studies did not (negative reports) (23). Of note, a similar ratio of positive and negative RF studies was reported for other biological endpoints (67–69). The evident reason for this eventual inconsistency is strong dependence of the EMF effects on a number of physical and biological parameters, which significantly varied between studies. These dependencies were established for both ELF (70–72) and RF effects (24, 27).

Among other parameters, in human lymphocytes, an individual variability in chromatin response to ELF has been reported, which might suggest a stronger response in cells from EHS individuals (72). The same research group performed comparative studies on genotoxicity with cells from EHS and carefully matched control subjects (73–75). The response of lymphocytes to RF from GSM mobile phones (915 MHz) and power-frequency magnetic fields (50 Hz) was investigated (73). The 53BP1 protein, which participates in the formation of DNA repair foci at the location of DNA double-strand breaks (DSB), was analyzed by immunostaining in situ. Exposure to either 915 MHz or 50 Hz significantly condensed chromatin and inhibited the formation of DNA repair foci. The EMF-induced responses in lymphocytes from healthy and hypersensitive donors were similar but not identical to the stress response induced by heat shock. The effects of GSM on chromatin and DNA repair foci in lymphocytes from EHS were further confirmed (74, 75). Although individual variability was observed, effects of RF from mobile phones strongly

depended on the carrier frequency/frequency channel (74–77). Regardless of the cell type (human lymphocytes, fibroblasts, or stem cells), the effects at the 905 MHz/GSM channel 74 on DNA repair foci and chromatin were consistently lower as compared to the effects at the 915 MHz/GSM channel 124. The data also indicated stronger effects of exposure to RF from UMTS mobile phone radiation at the frequency of 1947.4 MHz. These data provided evidence that different frequency channels of different types of mobile communications technologies should be tested separately in provocation studies with EHS. While some minor differences were detected, very similar ELF/RF effects were observed in cells from EHS and matched control subjects. It is likely that compensatory reactions at a more complex level of biological organization such as reactions of tissues, organs, and organ systems are less efficient in persons with EHS, thereby providing a stronger connection of the EMF cellular response with symptoms of hypersensitivity.

Neurological effects of EMF

Neurological and behavioral effects were among the earliest topics of research on potential adverse effects of ELF as well as RF EMFs (78, 79). Concerning epidemiological evidence, more than a decade before the seminal publication of Wertheimer and Leeper (48), Haynal and Regli reported in 1965 an approximately four-fold higher prevalence of a history of electrical engineering jobs in patients with amyotrophic lateral sclerosis (ALS) than in control subjects (80).

Functional, morphological, and biochemical changes at the cellular, tissue, and organism level, as well as behavioral changes have been studied under experimental conditions, and epidemiology has assessed the association between occupational and residential exposure to EMFs and neurodegenerative diseases as well as neurological symptoms.

Research has shown that EMFs (RF and ELF) have deleterious effects on brain neurons and brain functioning (81). Epidemiological research has also shown an increased risk for Alzheimer's and dementia from occupational and residential exposure to ELF.

Neurological effects of radio-frequency radiation

Early studies of RF are difficult to assess because the descriptions of exposure conditions are often insufficient to derive the relevant dosimetric quantities. As early as 1932, Schliephake (82) reported effects that he considered to be non-thermal: *„Es treten Erscheinungen auf, wie wir sie bei Neurasthenikern zu sehen gewohnt sind: starke Mattigkeit am Tag, dafür in der Nacht unruhiger Schlaf, zunächst ein eigenartig ziehendes Gefühl in der Stirn und Kopfhaut, dann Kopfschmerzen, die sich immer mehr steigern, bis zur Unerträglichkeit. Dazu Neigung zu depressiver Stimmung und Aufgeregtheit."* [*"Phenomena occur that we are accustomed to seeing in neurasthenics: pronounced fatigue during the day, however, restless sleep at night, in the beginning, a peculiar pulling sensation on the forehead and scalp, and then headaches that increase beyond the limit of tolerance. In addition, a tendency to depressive moods and agitation".*] Such symptoms, not unlike those later summarized as microwave or radio wave sickness syndrome, have been found in a substantial percentage of exposed workers in the Soviet Union (83) and also in individuals presenting as electrohypersensitive (see below).

Experimental research in humans was scarce before the advent of digital mobile telephony. Since the earliest studies (84, 85) on brain electrical activity, a large evidence base has been compiled that indicates subtle changes in CNS function after and during short-term exposure to different types of RF. Experimental investigations were predominantly about effects on EEG power spectra (e.g. 86–96), event related potentials (e.g. 97–104), sleep (e.g. 105–119) and cognitive function (e.g. 120–131). A few investigations were about effects on glucose metabolism (132, 133) and regional cerebral blood flow (134, 135), applying PET scan imaging. Animal studies covered a wide variety of behavioral aspects, ranging from learning and memory (e.g. 136–141) to anxiety-related behavior (142).

The reaction of the CNS to RF is not restricted to the presence of the exposure but persists for some time after the exposure, making short-term cross-over studies uninformative. The location of exposure could be of relevance under certain circumstances, but often effects are bilateral after unilateral exposure, suggesting involvement of subcortical structures. Effects on sleep may depend on individual characteristics, which led to the conclusion that conflicting results are not strong evidence against an effect (113). Pulsed RF is more effective than continuous waves, but there is some evidence of the importance of exposure characteristics including the site of coupling of the RF field and its modulation.

In the 2012 update of the BioInitiative Report, Henry Lai summarized the experimental evidence as follows (143): *"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. (b) *It may be more difficult to do human than animal experiments, since it is, in general, easier to control the variables and confounding factors in an animal experiment.* (c) *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 one time and testing was done during exposure. This raises the question of whether the effects of RFR are cumulative".*

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

Neurophysiological investigations of ELF EMFs were already conducted in the 1970s. Studies of chick and cat brain tissue (e.g. 144–146) revealed effects of weak ELF EMFs and ELF modulated RF fields that depended on intensity and frequency (so-called window effects). Adey proposed in 1981 (147) that effects are due to a primary interaction of EMFs at the cell membrane surface inducing a cascade of intracellular processes. This early insight has been corroborated by recent studies on various transmitter receptors in the brain such as N-methyl-D-aspartate receptors, dopamine and serotonin receptors (e.g. 148–151). Some of these more recent studies also reported frequency window effects as well as intensity window effects on the neurodevelopment in the rat (152).

Behavioral effects of ELF EMF have been studied at rather high levels in the 1970s and 1980s (e.g. 153, 154), while recent studies include low-level exposures and support effects on behavior at different levels of complexity. These include: changes in locomotor activity (e.g. 148, 149, 155, 156), anxiety (e.g. 157–159) and depression-like behavior (160, 161). *"Since 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".* (Lai, 2012, BioInitiative Report, section 9, Evidence for effects on neurology and behavior effects, 143). Also in humans, effects were reported at low levels (e.g. 162–164).

Neurodegenerative diseases

The most prevalent of neurodegenerative diseases is Alzheimer's disease with an estimated 45 million patients worldwide for 2015, followed by Parkinson's disease, Huntington's disease, amyothrophic lateral sclerosis (ALS), and other motoneuron diseases (MND). To date, the pathophysiology of these diseases is incompletely understood. In many of these diseases, atypical protein assemblies, mitochondrial dysfunction, and programmed cell death play a role and some genetic changes have been detected. As some such changes could be a consequence of oxidative stress (see below), disruption of calcium homoeostasis, and disturbance of intracellular signaling pathways, there is a theoretical possibility that EMFs could contribute to the risk of these diseases. Since the 1980s, more than 30 epidemiological studies assessing the potential relationship between exposure to ELF EMFs and neurodegenerative diseases have been conducted. In the last years, several meta-analyses have been published. Concerning Parkinson's disease, there is little evidence of an association (165). Concerning ALS, Zhou et al. (166) summarize their results as follows: *"Although there are potential limitations from study selection bias, exposure misclassification, and the confounding effect of individual studies in this meta-analysis, our data suggest a slight but significant ALS risk increase among those with job titles related to relatively high levels of ELF EMF exposure".* A review by Vergara et al. came to another conclusion (167): *"Our results do not support MF [magnetic fields] as the explanation for observed associations between occupational titles and MND".* This discrepancy can be resolved by discriminating between different methods of endpoint assessment (incidence, prevalence or mortality data) and the potential for misclassification due to various sources of exposure data used. If these factors are considered, there is a consistent relationship between ELF EMF from occupational exposure and ALS/MND, and also the few studies about residential exposure are in line with an increased risk from exposure to MF (168).

Blood-brain barrier

All exchanges between blood and brain are strictly regulated by the blood-brain barrier (BBB). The BBB prevents the passage of various molecules from the blood into the brain and vice versa. An increase in a normally low BBB permeability for hydrophilic and charged molecules could potentially be detrimental. While the data on ELF effects are very sparse, several research groups investigated whether RF affects the BBB. These data have recently been reviewed (169–171). Although some BBB studies reported negative data, other studies, including replicated studies with rats from the Swedish group of Leif Salford and Bertil Persson, suggested that RF from mobile phones may affect the BBB under specific exposure conditions (171). More recent studies showing EMF effects at specific conditions of

exposure (150, 172, 173) and not showing effects on the BBB under other conditions (174) are in line with this suggestion.

EMF and infertility and reproduction

Infertility and reproduction disorders are on the rise. Based on the BioInitiative Report (175), it should be concluded that men who use – and particularly those who wear a mobile phone, personal digital assistant (PDA) or pager on their belt or in a pocket – show adverse effects on sperm quality, motility, and pathology. The usage of mobile phones, the exposure to mobile phone radiation, or the storage of a mobile phone close to the testes of human males affects sperm count, motility, viability, and structure (176–184). 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 (182, 185–188).

There are also some studies of adverse birth outcomes in EMF-exposed women. A case-control study (189) and a population-based prospective cohort study (190) from California showed an association between miscarriage and the maximum value measured by a 24-h body-worn magnetic field dosimeter.

Electromagnetic hypersensitivity (EHS)

An increasing number of humans are continuously exposed in their daily life to increasing levels of a combination of static, ELF and VLF (very low frequencies, in general terms from 3 kHz to 3 MHz, in detailed terms from 3 kHz to 30 kHz) 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".

Some historical examples of EHS from as early as 1932 (82, 83) are given in the chapter "Neurological effects of radio-frequency radiation".

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 to, e.g. mobile phone base stations (74%), mobile 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 (191).

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 to the fact 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 patients with EHS should be advised medically, psychologically, and environmentally (192, 193).

A questionnaire study of Finns (n=206), who describe themselves as suffering from electromagnetic hypersensitivity (EHS), revealed that the most common symptoms were related to the nervous system: stress (60%), sleeping disorders (59%) and fatigue (57%). The sources that were most often reported to have triggered EHS were: personal computers (51%) and mobile phones (47%). For 76% of the participants the reduction or avoidance of electromagnetic fields (EMF) helped in their full or partial recovery (194).

A representative telephone survey (n=2048; age>14 years) carried out in Switzerland in 2004 yielded a frequency of 5% (95% CI 4% to 6%) for having symptoms attributed to electrosmog, so-called EHS. In n=107 EHS persons, the most common symptoms being sleep problems (43%), headache (34%), and concentration difficulties (10%). 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 to measures taken three times as often as the ones who still had symptoms (195).

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 patients with EHS (196).

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 (197).

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 (198).

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 and 49% considered themselves EHS. Every second respondent had medically diagnosed MCS (49%) and 27% had self-diagnosed MCS. The main EHS-related symptoms were fatigue, headache, concentration problems, sleep disorders, and dizziness. The most frequent causes included base stations, other persons' mobile phones, PC, power lines, television, own mobile phone, public transportation, cordless phones, air conditioner, and car. Suspected EMF source of EHS onset were: mobile phone base stations, PC, electric home appliances, medical equipment, mobile phones, power lines, and induction cookers (199).

In 2010, Khurana et al. reported that eight out of ten epidemiological studies that assessed health effects of mobile phone base stations reported an increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances within 500 m from base stations. None of the studies reported exposure levels above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting the health of human populations (200).

Carpenter reported in 2015 (201) a series of healthy people that developed EHS after a brief, high-intensity microwave radiation exposure. Typical symptoms included, for example, chronic headaches, irritability, and emotional lability, decreased libido, and memory problems, which in some patients, lasted for years.

Hedendahl et al. (19) reported two 15-year-old male students and one 47-year-old female teacher who experienced health effects like headaches, difficulties concentrating, tachycardia, poor memory, or dizziness when exposed to Wi-Fi in school. This example is mentioned to point specifically to the potential health impacts from increasing RF exposure of students and teachers by Wi-Fi.

The question, whether EHS is causally associated with EMF exposure is controversially discussed. 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, these studies have severe shortcomings that must be addressed: sequences of exposure conditions were often contiguous neglecting aftereffects of exposure; the exposure duration and the examined effects were short-term; the sham exposure was frequently under conditions that could provoke arousal in sensitive individuals; the time frame neglected the temporal conditions of symptom occurrence and disappearance, and/or the recruitment of persons with EHS was not medically assessed.

The WHO 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 at home (202). Based on the existing evidence and practical knowledge this view ignores a causal approach; see also (203).

The paper "Electromagnetic hypersensitivity: fact or fiction" by Genuis and Lipp (204) 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 facial skin samples of electrohypersensitive persons, a profound increase of mast cells has been found (205). From this and other earlier studies when EHS manifested itself often during exposure to EMFs from cathode ray tubes (CRT), it became 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 a similar nature were later demonstrated in an experimental situation, employing normal healthy volunteers in front of CRT monitors, including ordinary household television sets (206).

A French research group headed by Belpomme (207) investigated prospectively, since 2009, self-reported cases of EHS and/or MCS clinically and biologically in an attempt to establish objective diagnostic criteria and to elucidate the pathophysiological aspects of these two disorders. Based on 727 evaluable cases, the investigation showed a number of new and important insights such as:

(a) None of the biomarkers so far identified in the study are specific for EHS and/or MCS.
(b) Several biomarkers like histamine, nitrotyrosine, and circulating antibodies against O-myelin were

increased. The 24-h urine melatonin/creatinine ratio was decreased.

(c) EHS and MCS are genuine somatic pathological entities.

(d) Under the influence of EMFs and/or chemicals a cerebral hypoperfusion/hypoxia-related neuroinflammation may occur.

(e) EHS and/or MCS patients might be potentially at risk of chronic neurodegenerative diseases and cancer.

While a 2006 study by Regel et al. (208) 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 (209, 210). Most so-called provocation studies with EHS show no effects. However, all these studies used a very limited number of exposure conditions and most have methodological weaknesses. Taking in account the strong dependence of EMF effects on a variety of physical and biological variables (27), 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 RF like DECT or Wi-Fi (211–215). 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. (216–220). A synopsis of 30 studies on mobile phone base stations is given in the document "Leitfaden Senderbau" (221).

Residential EMF exposures in the VLF frequency 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, compact fluorescent lamps (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.

First 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 (222).

While the dependence of ELF effects on the local magnetic field has been reported by many research groups (13, 223), there are also a few studies which suggest that the RF effects are also dependent on slight changes in the local static magnetic field. In the review by Belyaev (224), a physical mechanism has been suggested to account for such effects (225). Slight changes in the local static magnetic field within 10 μT, which are usually observed within offices and homes due to ferromagnetic objects, were reported to induce biological effects that corresponded well to the predictions following from the mechanism of ion interference developed by Binhi (226).

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 (227).

In France, the first low-EMF zone has been established at Drôme in July 2009 (228). 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 (229). 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.

Possible mechanism of EHS

Based on the scientific literature on interactions of EMF with biological systems, several mechanisms of interaction are possible (14, 13, 22, 26). 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 (230–238). It has been shown in many reports reviewed by Georgiu (15) that reactive oxygen species (ROS) may be involved in radical pair reactions; thus, radical pairs may be considered as one of the mechanisms of transduction able to initiate EMF-induced oxidative stress. Furthermore, many of the changes observed in RF-exposed cells were prevented by (pre)treatment with antioxidants and radical scavengers (24). While the data from different studies should be interpreted with care in view of variations in physical and biological parameters, a majority of the studies have shown effects of ELF and RF on the oxidative stress (239).

The IARC monograph states: *"even small effects on radical concentration could potentially affect multiple biological functions"*, page 103 (24).

Yakymenko et al. (238) have summarized the current evidence: *"Analysis of the currently available peer-reviewed scientific literature reveals molecular effects induced by low-intensity RFR in living cells; this includes significant activation of key pathways generating reactive oxygen species (ROS), activation of peroxidation, oxidative damage of DNA and changes in the activity of antioxidant enzymes. It indicates that among 100 currently available peer-reviewed studies dealing with oxidative effects of low-intensity RFR, in general, 93 confirmed that RFR induces oxidative effects in biological systems. A wide pathogenic potential of the induced ROS and their involvement in cell signaling pathways explains a range of biological/health effects of low-intensity RFR, which include both cancer and non-cancer pathologies"*.

Reviews by Pall (12, 16, 240) provide 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 non-radical oxidant, which can produce radical products, including hydroxyl and NO_2 radicals.

Peroxynitrite is by far the most damaging molecule that occurs during metabolism in our body. Although not a free radical, peroxynitrite is much more reactive than its parent molecules NO and O_2^-. The half-life of peroxynitrite is comparatively long (10–20 ms), sufficient 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 (225). 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).

A significant increase of 3-nitrotyrosine was observed in the liver of Wistar rats exposed to ELF, suggesting a deteriorative effect on cellular proteins due to possible formation of peroxynitrite (241). Nitrotyrosin was found to be increased (>0.9 µg/mL) in 30% of the 259 tested EHS individuals (207).

A study by De Luca et al., in 2014 on 153 EHS and 132 controls showed metabolic pro-oxidant/pro-inflammatory alterations in EHS like decreased erythrocyte glutathione S-transferase (GST) activity, decreased reduced glutathione (GSH) levels, increased erythrocyte glutathione peroxidase (GPX) activity, an increased ratio of oxidized-CoQ10/total-CoQ10 in plasma, and a 10-fold increased risk associated with EHS for the detoxifying enzymes glutathione S transferase haplotype (null) GSTT1+(null) GSTM1 variants (242).

The importance of ATP has been shown for chronic fatigue syndrome (CFS) (243) and for stress control (244). Those patients describe the same symptoms as those suffering from CMI. This could indicate similarities in their pathomechanisms. Similar disturbances in neurotransmitter expression has been described both with chronic exposure to EMF (245) and in CMI patients (232, 246).

A study (247) proposed to investigate a possible association between RF exposure and myelin integrity via classical immunohistochemical markers for healthy and degenerated myelin, respectively, and for Schwann cells in general.

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. Meanwhile, they are summarized as chronic multisystem illnesses (CMI) (246). In all of them, various disturbances of functional cycles have been shown: activation of nitrogen oxide and peroxynitrite, chronic inflammation by activation of NF-kB, IFN-y, IL-1, IL-6, and interaction with neurotransmitter expression (232, 246, 248). We recommend classifying EHS as part of CMI (232, 249), but still recognizing that the underlying cause remains the environment (see Figure 1).

Other diseases that require attention with respect to EMF

Based on interactions between EMF exposure and biological responses that, e.g. lead to a disturbance of the oxidative/nitrosative homeostasis, a variety of diseases are possible and even expected to occur. Some examples are given here.

Havas reported in 2008 (250): *"Transient electromagnetic fields (dirty electricity), in the kilohertz range on electrical wiring, may be contributing to elevated blood sugar levels among diabetics and prediabetics. By closely following plasma glucose levels in four Type 1 and Type 2 diabetics, we find that they responded directly to the amount of dirty electricity in their environment. In an electromagnetically*

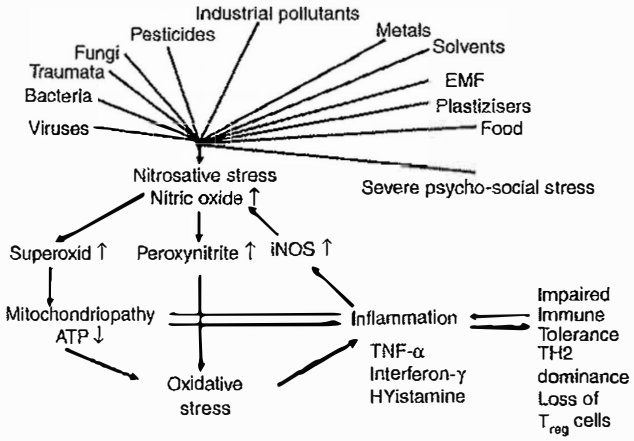

Figure 1: Pathogenesis of inflammation, mitochondriopathy, and nitrosative stress as a result of the exposure to trigger factors (248).

clean environment, Type 1 diabetics require less insulin and Type 2 diabetics have lower levels of plasma glucose. Dirty electricity, generated by electronic equipment and wireless devices, is ubiquitous in the environment. Exercise on a treadmill, which produces dirty electricity, increases plasma glucose. These findings may explain why brittle diabetics have difficulty regulating blood sugar. Based on estimates of people who suffer from symptoms of electrical hypersensitivity (3%–35%), as many as 5–60 million diabetics worldwide may be affected".

With respect to fetal and early childhood exposures to EMF, Sage in the BioInitiative Report 2012 (56) pointed out: *"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".*

In a 2013 review, Herbert and Sage (251, 252) reported remarkable similarities between pathophysiological phenomena found in autism spectrum conditions (ASCs) and the physiological impacts of ELF MF/RF, such as oxidative stress, free radical damage, malfunctioning membranes, mitochondrial dysfunction, inflammatory issues, neuropathological disruption and electrophysiological dysregulation, cellular stress proteins and deficiencies of antioxidants such as glutathione.

In a 6-year study, certain blood hormone levels were monitored in volunteers. Mobile phone use as well as close distances to mobile phone base stations were associated with decreased testosterone levels in males, as well as decreased ACTH, cortisol, T3 and T4 levels in males and females (253).

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. These recommendations are further outlined below.

These recommendations are preliminary and in large parts, although related to the whole body of evidence rooted in the experience of the team, cannot in every detail be strictly considered evidence-based.

Evidence of treatment strategies for EMF-related illness including EHS

There are only a few studies assessing 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 the persons with EHS had benefitted from realizing certain advice, e.g. changing the bedroom (192, 193).

In the 2005 Swiss questionnaire study of physicians working with complementary therapeutic tools, two-thirds chose exposure reduction as a principal tool, whereas complementary therapeutics were only chosen as a supplement (197).

Since 2008, the Swiss Society of Doctors for the Environment has run a small interdisciplinary environmental medicine counseling structure for patients 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 1 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 (254).

In Finland, psychotherapy is the officially recommended therapy for 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 (194, 255).

Response of physicians to this development

In cases of unspecific health problems (see Questionnaire) for which no clearly identifiable cause can be found – besides other factors like chemicals, non-physiological metals, molds – 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. Some people with EHS might be misdiagnosed with multiple sclerosis (MS) since many of the symptoms are similar. 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. Medical examinations and findings
3. Measurement of EMF exposure
4. Reduction and prevention of EMF exposure
5. Diagnosis
6. Treatment of the patient including the environment

History of health problems and EMF exposure

In order to put later findings into a larger context, a general medical history is necessary. Part of this history should include:

- Electrical trauma: multiple shocks, electrocution, struck by lightning.
- Chemical trauma: exposure to pesticides, metals, chlorinated hydrocarbons (PCBs, DDT, etc.)

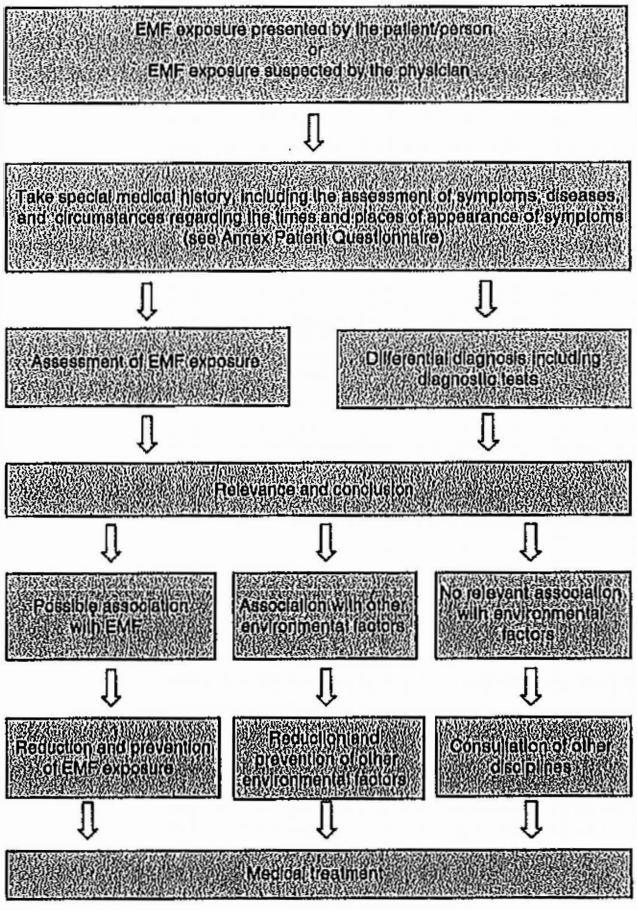

Figure 2: Flowchart for the handling of EMF-related health problems.

- Biological trauma in the form of a large load of parasites, fungal infections, viral infections, etc.
- Physical trauma to the central nervous system in the form of whiplash, other accidents, spinal problems
- Autoimmune disorders

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 evaluated by questionnaire

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 mobile 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 evaluated 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, mobile 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.

Medical examinations 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 follow-up 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), inflammation [TNF-alpha, IFN-gamma-inducible protein 10 (IP-10), IL-1b, histamine], and the melatonin status (24 h urine melatonin/creatinine ratio).

Then additional diagnostic tests can be considered. Due to the differences in normal ranges between labs and different practices as to the units of measurement in different countries, we do not provide levels to be considered relevant in EHS. It is recommended to interpret them in context, focusing not only on out-of-range values. For example, when several parameters are simultaneously close to the border of the normal ranges, this could be instructive for forming a therapeutic or diagnostic opinion.

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
  - ACTH
  - Bilirubin
  - Blood count and differential blood count
  - BUN
  - Cholesterol, LDL, HDL, triglycerides
  - Coenzyme-Q10 ratio for oxidized-CoQ10/total-CoQ10
  - Creatinine kinases (CK-MB, CK-MM)
  - High-sensitivity C-reactive protein (hs-CRP)
  - Cystatin C (glomerular filtration rate)
  - Electrolytes
  - Fasting blood glucose
  - Ferritin
  - Glutathione S-transferase (GST)
  - Reduced glutathione (GSH)
  - Glutathione peroxidase (GPX)
  - HBA_{1c}
  - Histamine and diaminoxidase (DAO)
  - IFN-gamma-inducible protein 10 (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 (MDA)-LDL
  - Nitrotyrosine (NTT)
  - Potassium (whole blood)
  - Prolactin
  - Selenium (whole blood)
  - Testosterone
  - TSH
  - T3, T4
  - Tumor necrosis factor alpha (TNFα)
  - Vitamin D3
  - Zinc (whole blood)
- Standard urine
  - Leucocytes, erythrocytes, albumin, urobilinogen, pH, bacteria, glucose, microalbumin
- Second morning urine
  - Adrenaline
  - Dopamine
  - Noradrenaline
  - Noradrenaline/adrenaline ratio
  - Serotonin
  - Beta-phenylethyleamine (PEA)
- 24-h urine
  - 6-OH melatonin sulfate
  - Creatinine
  - 6-OH melatonin sulfate/creatinine ratio
- Saliva
  - Cortisol (8 a.m., 12 a.m., and 8 p.m.)

Additional diagnostic tests

- Urine
  - Metals (depending on case history, e.g. mercury, cadmium, lead, arsenic, aluminum)
- Second morning urine
  - Gamma-aminobutyric acid (GABA)
  - Glutamate
  - Cryptopyrrole
- Saliva
  - Dehydroepiandrosterone DHEA (8 a.m. and 8 p.m.)
  - Alpha-amylase
- Blood
  - 8-Hydroxydeoxyguanosine (DNA oxidation)
  - Biotin
  - Differential lipid profile
  - Folate
  - Holotranscobolamin
  - Homocysteine
  - Interferon-gamma (IFN-γ)
  - 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
  - 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, oxo-LDL)
- For diabetics, plasma glucose
- Live blood analysis (red blood cell aggregation in the form of rouleaux, blood viscosity, macrophage activity, lysis of red blood cell membrane)
- For people with neurological problems and problems with fine or gross motor coordination, a video of them walking before and after provocation and a photograph taken of a sample of handwriting before and after provocation.

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 (14).

By now, nearly all non-ionizing 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 (static fields, ELF, VLF, and RF) should be considered.

- ELF magnetic fields may originate from, e.g. 12 V transformers, transformer stations, net currents on the electric wiring, water pipes, and other conductive materials, infrared heaters, heating blankets and different types of power lines.
- ELF electric fields may originate from, e.g. electrical wiring, lamps, and appliances.
- VLF magnetic fields ("dirty power") and/or VLF electric fields ("dirty electricity") may be emitted from electronic

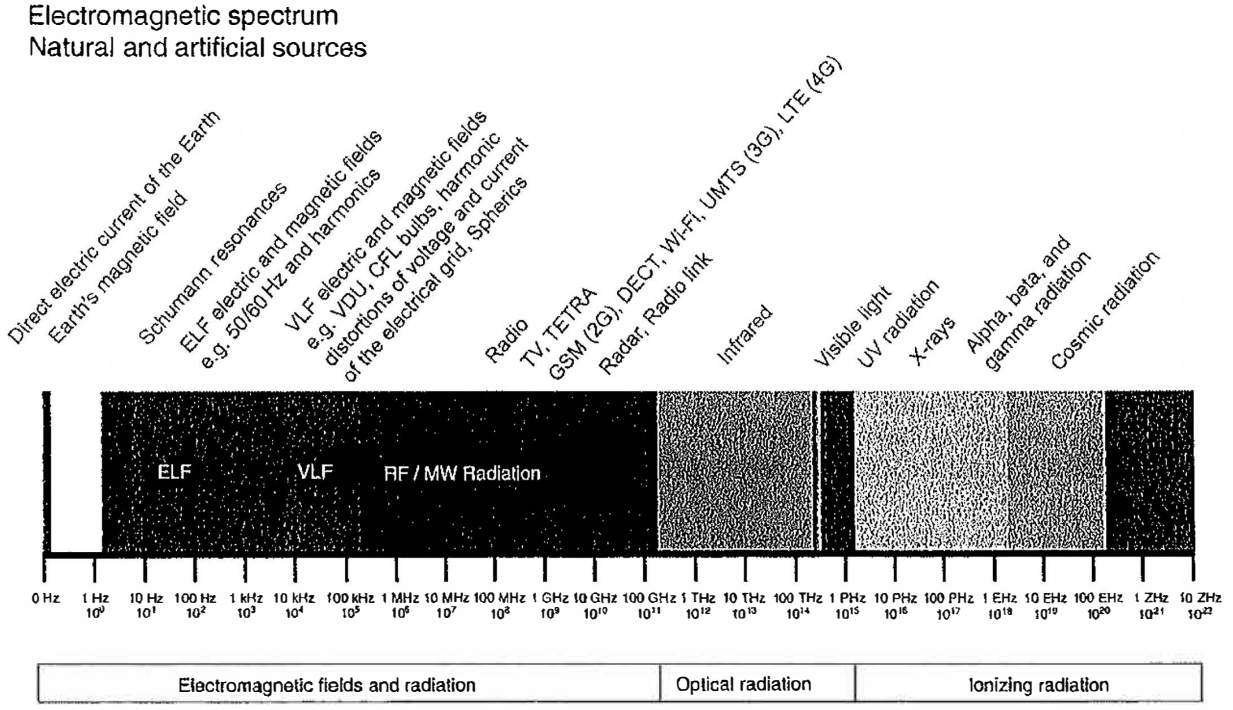

Figure 3: Examples of natural (green) and artificial (red and blue) EMF sources along the electromagnetic spectrum (256).

devices like energy-efficient lighting, electronic transformers, induction cooker, variable speed frequency drives, light dimmer switches, power line communication (PLC) connected to the electrical grid. These devices use current and/or voltage in short pulses that might produce harmonics and VLF transients on the electrical circuits, earthed materials and the ground.
- Typical RF radiation sources include, e.g. cordless phones (DECT), wireless Internet access (Wi-Fi), mobile phones and their base stations, radio and TV broadcast antennas, radar (military, airport, marine, and weather), Bluetooth, and the microwave ovens.

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 (257). 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.

EMF guidance values

In each case, the following aspects should be individually taken into account when evaluating EMF measurement results (27, 26):

- A person's individual susceptibility, which, e.g. may be based on previous history of trauma (electrical, chemical, biological and physical).
- A person's individual total body burden (e.g. exposure to noise, chemicals like neurotoxins)
- Duration of EMF exposure
- EMF exposure during the night and day
- Multiple exposure to different EMF sources
- Signal intensity: watt/m² (W/m²), volt/m (V/m), ampere/m (A/m)
- Signal characteristics were taken into account in the EMF guidance values – see Supplement 3 (258)
  - 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 (Tables 1–3, 5 and 6) apply to sensitive locations with long-term exposure of more than 20 h per week (259). They are based on epidemiological studies (9, 10, 27, 221, 260–262), empirical observations, and measurements relevant in practice (258, 263), as well as recommendations by the Seletun Statement (40) and the Parliamentary Assembly of the Council of Europe (42). 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. All levels provided are for incident intensities and whole-body exposure.

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, 400 Hz on airplanes
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: Bed: Short-term measurements across entire sleeping area. Workplace: Short-term measurements across entire work area (e.g. sitting position). Long-term measurements: 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.

Table 1: Precautionary guidance values for ELF magnetic fields.

ELF magnetic field	Daytime exposure	Nighttime exposure	Sensitive populations
Arithmetic mean (AVG)	100 nT (1 mG)[1),2),3)]	100 nT (1 mG)[1),2),3)]	30 nT (0.3 mG)[5)]
Maximum (MAX)	1000 nT (10 mG)[2),4)]	1000 nT (10 mG)[2),4)]	300 nT (3 mG)[5)]

Based on: [1)]BioInitiative (9, 10); [2)]Oberfeld (262); [3)]Seletun Statement (40), [4)]NISV (264); [5)]Precautionary approach by a factor of 3 (field strength). See also IARC 2002 (30), Blank and Goodman (17), and TCO Development (265).

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 VLF 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)
Field probe: Isotropic electric field probe (three orthogonal axes)
Detector mode: RMS (root mean square)
Measurement volume: Bed: Nine points across sleeping area. Workplace: Across entire work area (e.g. sitting position three or six points)
Measurement period: Spot measurements to assess 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.

Table 2: Precautionary guidance values for ELF electric fields.

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 (261); [2)]Oberfeld (262); [3)]Precautionary approach by a factor of 3 (field strength). See also TCO Development (265).

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 VLF frequency range further below.

Radio-frequency radiation (RF) Measurement specifications

Frequency range: Radio and TV broadcast antennas, 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: Usually electric field [V/m] -> calculated power density [W/m²; mW/m²; µW/m²]; for conversion units see Table 4.
Field probe: Isotropic, biconical or logarithmic-periodic antennas
Detector mode: Peak detector with max hold
Measurement volume: Point of exposure across bed and workplace
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 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 (258). Note: Rectangular signals show short risetimes and consist of a broad spectrum of frequencies. The current density induced in the human body increases with increasing frequency in an approximately linear relationship (266).

Table 3: Precautionary guidance values for radio-frequency radiation.

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 (260); Leitfaden Senderbau (221); PACE (42); Seletun Statement (40). [1)]Precautionary approach by a factor of 3 (field strength)= a factor of 10 (power density). See also IARC 2013 (24) and Margaritis et al. (267).

Table 4: Conversion of radio-frequency radiation measurement units.

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

Magnetic fields in the VLF range (VLF 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 workplace
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
Note: If an elevated exposure is detected, power quality analyzers and oscilloscopes can be used on the actual wiring to trace the source of the dirty power.

Precautionary guidance values

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

Table 5: Precautionary guidance values for VLF magnetic fields.

VLF magnetic field	Daytime exposure	Nighttime exposure	Sensitive populations
Arithmetic mean (AVG)	1 nT (0.01 mG)[1)]	1 nT (0.01 mG)[1)]	0.3 nT (0.003 mG)[2)]
Maximum (MAX)	10 nT (0.1 mG)[1)]	10 nT (0.1 mG)[1)]	3 nT (0.03 mG)[2)]

Based on: [1)]The current density induced in the human body increases with increasing frequency in an approximately linear relationship (266). Therefore, the guidance value of the magnetic field in the VLF frequency range should be lower than the one of the 50/60 Hz magnetic field, e.g. for 100 nT RMS/100=1 nT. For the rationale of 100 nT (avg) and 1 µT (max), see section ELF magnetic fields. [2)]Precautionary approach by a factor of 3 (field strength). See also TCO Development (265).

Electric fields in the VLF range (VLF EF) Measurement specifications

Frequency range: 3 kHz–3 MHz. Frequency-specific measurements (spectrum analyzer/EMF meter), e.g. "dirty electricity", 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 workplace
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
Note: If an elevated exposure is detected, power quality analyzers and oscilloscopes can be used on the actual wiring to trace the source of the dirty power.

Precautionary guidance values

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

Table 6: Precautionary guidance values for VLF electric fields.

VLF electric field	Daytime exposure	Nighttime exposure	Sensitive populations
Arithmetic mean (AVG)	0.1 V/m[1)]	0.01 V/m[1)]	0.003 V/m[2)]

Based on: [1)]The current density induced in the human body increases with increasing frequency in an approximately linear relationship (266). Therefore, the guidance value of the electric field in the VLF frequency range should be lower than the one of the 50/60 Hz electric field, e.g. for 10 V/m/100 = 0.1 V/m. For the rationale of 10 V/m and 1 V/m, see section ELF electric fields. [2)]Precautionary approach by a factor of 3 (field strength). See also TCO Development (265).

Reduction and prevention 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" (268) and "Elektrosmog im Alltag"

(269). For detailed information on physics, properties, and measurement of EMF, see Virnich (270); regarding reduction of radio-frequency radiation (RF) in homes and offices, see Pauli and Moldan (271).

In most cases, it will be necessary to consult an expert (e.g. qualified EMF/RF engineer/ consultant) 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, recommendations are given (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 (RF)

- Keep mobile phone/smartphone and cordless phone calls short; use the speakerphone function or a hands-free kit.
- Avoid wearing the mobile phone/smartphone close to the body.
- Deactivate all non-essential wireless mobile phone apps, which cause periodic radiation exposure.
- Keep mobile phones/smartphones in "airplane mode" whenever possible or deactivate mobile data, Wi-Fi, Bluetooth and near field communication (NFC) in the smartphone settings.
- 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 still present. A "traditional" corded phone is recommended instead.
- 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.
- In case of external RF radiation sources, rooms – especially bedrooms – 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. wireless devices like, home entertainment, headsets, baby monitors, computer games, printers, keyboards, mouse, home surveillance systems) at home, in offices, and in cars.
- Avoid exposure to energy-efficient lighting (compact fluorescent lamps as well as some LEDs generate high frequency transients). These types of lamps can be replaced with incandescent or line-voltage halogen incandescent lamps until good-quality lighting energy-efficient lamps become commercially available.

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.
- As magnetic fields can pass through walls, make certain that there are no magnetic sources immediately beneath or above a bed or in an adjacent room.
- 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 non-essential 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.
- Avoid extended exposures close to running electric motors. As a first step, keep a minimum distance of 1.5 m (5 ft). As a second step, establish a safe distance based on magnetic field measurements.

Preventing exposure to static magnetic/static electric fields

- Sleep in a bed and mattress without metal.
- Avoid sleeping close to iron materials (radiator, steel, etc.)
- Wearing synthetic clothing and, e.g. rubber-soled shoes and not regularly being in contact with the earth can result in build up of static electricity. Cotton clothing and leather-soled shoes will help avoid static electricity.

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. Based on the measurement results, install automatic demand switches in those circuits 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, shielded wiring and shielded outlets may have to be installed in the whole building.
- 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 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. For example, in a multiunit setting (condominiums or highrise apartments, townhomes), proximity to neighbors can contribute to inhome exposure.
- Measure dirty electricity/dirty power (electric and magnetic fields in the VLF 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 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 unspecific 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) (272).

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 to be published in 2018 (ICD-11 WHO), we recommend:

(a) To create ICD codes for all environmentally induced chronic multisystem illnesses (CMI) like multiple chemical sensitivity (MCS), chronic fatigue syndrome (CFS), fibromyalgia (FM), and electromagnetic hypersensitivity (EHS) on the basis of their clinical and pathological description (204, 207).
(b) To 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 magnetic field, VLF electric field, radio-frequency radiation), infrared radiation, visible light, UV radiation and ionizing radiation.
(c) To 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 magnetic field, VLF electric field, radio-frequency radiation), infrared radiation, visible light, UV radiation, and ionizing radiation.

Treatment of the patient including the environment

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 humans is the reduction of their 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. Based on currently available knowledge it appears useful to recommend a treatment approach, as those gaining ground for multisystem illnesses, that aims at minimizing adverse peroxynitrite effects. Measures that enhance the immune system and reduce stress in combination with detoxification will promote EHS recovery.

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. Psychological stress generated by a lack of understanding or support by family, friends and physicians can exacerbate the symptoms of EHS as can stressing about exposure. For rapid recovery, the treatments need to apply to the body, mind and spirit of the individual.

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 – see Chapter "Reduction of EMF Exposure". For more information, see e.g. "Options to Minimize EMF/RF/Static Field Exposures in Office Environment" (268) and "Elektrosmog im Alltag" (269).

Environmental medicine treatments

Until now, no specific treatment of EHS has been established. The following paragraphs are recommendations based on the combined experience of the team. They can be considered either as an attempt to restore the full regulative capacity of the patients, as general advice for healthy living (that could and should be adapted to the cultural and individual situation of the patient), or as a more targeted approach to address the specific problems of EHS individuals according to the experience of the team.

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 patients 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 (see chapter 2 "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, workplace, 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 non-enzymatic 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 (232, 273).
- **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 (274) 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 (275, 276). 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 (273). Alpha-lipoic acid acts directly and indirectly as a scavenger of free radicals including, singlet oxygen, superoxide, peroxyl radicals, and the breakdown radicals of peroxynitrite (232). It has 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 (277). 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), interleukin-8 (IL-8), and interferon gamma (IFN-γ) and activating various NO synthases (232). Tocopherols (278, 279), carotenoids at low concentration levels (280), vitamin C (281, 282), NAC (283), curcumin (284), resveratrol (285, 286), flavonoids (287) 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% (236), 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 (288–290). 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 (244, 291).
- **Detoxification**
  In humans, the accumulation of environmental toxins has an individual profile of many different inorganic and organic chemicals, which make up the total body load (292).
  Among the inorganic substances, metals and their salts play the dominant role and might be of importance to patients with EHS. Elemental mercury (Hg^0) and other heavy metals such as lead (Pb) accumulate in the brain (293), especially at chronic low dose exposure. They may have toxic effects and can induce various immune reactions (294, 295). Whereas no specific active substance generally 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 (296–298): the most important chelating agents are sodium thiosulfate 10%, DMPS (2,3-dimercapto-1-propanesulfonic acid), DMSA (meso-dimercaptosuccinic acid), and EDTA (2,22,23,232-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. In addition to natural sunlight, light therapy and low level lasers can promote healing, reduce inflammation, promote circulation, and enhance cellular ATP production.

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 (299). However, not all saunas are alike. Traditional saunas or infrared saunas with low electric and low magnetic fields that do not use toxic glues and chemically treated wood are recommended.

4. Oxygen

A part of patients 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 patients 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 workload 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

Sleep problems are very common in patients with EHS. Sleep disturbance is associated with a 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 an 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 (300, 301), and blue light screen filters (302–304) could be helpful.

8. Exposure to the natural electromagnetic fields of the Earth.

Most people in urban centers are disconnected from the Earth's natural grounding/magnetic fields by walking with rubber-soled shoes, wearing synthetic clothing, driving in metal boxes with rubber wheels, and living and working in concrete buildings that are permeated with artificial electromagnetic fields and radiation. Spending time in the woods, walking barefoot along a beach, lying on the grass, sitting on rocks, or strolling outside after a rain shower help ground a person and help balance the often enhanced positively charged ions that are associated with ill health.

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 (305–308). 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 sleep 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. The treating physician faces a very difficult ethical task when doing so, and the associated risks must be pointed out – in an equally well-balanced way – to the patient in question. From an ethical perspective, treating the symptoms is, of course, a very good start to provide immediate relief, but – without a concurrent environmental exposure reduction and lifestyle coaching – it may prove counter-productive in the long run. For a conventionally trained physician, this might seem a very new way of reasoning, but it is the only way to successfully and effectively alleviate symptoms and to achieve complete clinical recovery when dealing with chronic multisystem illnesses (CMI) and EHS. Though even if the causes are not known at the outset, it is already important at this stage to provide advice on how to reduce a person's exposure to electromagnetic fields and other environmental stressors to prevent further damage and promote healing.

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