**Electrohypersensitivity Abstracts (December 14, 2017)**

**Andersson B, Berg M, Arnetz BB, Melin L, Langlet I, Lidén S. A cognitive-behavioral treatment of patients suffering from "electric hypersensitivity". Subjective effects and reactions in a double-blind provocation study. J Occup Environ Med. 38(8):752-758, 1996.**

This study tested psychological treatment of patients with "electric hypersensitivity." Seventeen patients were randomly assigned to a treatment group or a waiting-list control group in a pretest-posttest control group design. The patients were also taking part in double-blind provocation tests before and after the treatment. Subjective ratings of symptoms were registered and blood samples were taken and analyzed for "stress-related" variables, such as prolactin, cortisol, dehydroepiandrosterone, and cholesterol levels. The patients in the experimental group reduced their evaluations of the disability more than the control group did. This indicates that psychological treatment may be of value in this disease. However, none of the psychophysiological measures or the subjective reactions to the provocation test showed any significant between-group difference. The conclusion from the provocation test is that this group of alleged hypersensitive patients did not react to the electromagnetic fields.

**Andrianome S , Gobert J, Hugueville L, Stéphan-Blanchard E, Telliez F, Selmaoui B. An assessment of the autonomic nervous system in the electrohypersensitive population: a heart rate variability and skin conductance study. J Appl Physiol (1985).123(5):1055-1062, 2017.**

The aim of the study was twofold: first, to compare the activity of the autonomic nervous system (ANS) between the population self-declared as electrohypersensitive (EHS) and their matched control individuals without intended exposure to electromagnetic fields (EMF). The second objective was to determine whether acute exposure to different radiofrequency signals modifies ANS activity in EHS. For that purpose, two different experiments were undertaken, in which ANS activity was assessed through heart rate variability (HRV) and skin conductance (SC). In the first experiment, a comparison between the EHS group ($n$ = 30) and the control group ($n$ = 25) showed that the EHS has an increased number of responses to auditory stimuli as measured by skin conductance activity, and that none of the short-term heart rate variability parameters differ between the two matched study groups. The second experiment, performed in a shielded chamber, involved 10 EHS from the first experiment. The volunteers participated in two different sessions (sham and exposure). The participants were consecutively exposed to four EMF signals (GSM 900, GSM 1800, DECT, and Wi-Fi) at environmental level (1 V/m). The experiment was double blinded and counterbalanced. The HRV variables studied did not differ between the two sessions. Concerning electrodermal activity, the data issued from skin conductance and tonic activity did not differ between the sessions, but showed a time variability. In conclusion, the HRV and SC profiles did not significantly differ between the EHS and control populations under no exposure. Exposure did not have an effect on the ANS parameters we have explored. **NEW & NOTEWORTHY** This study provided analysis on the skin conductance parameters using a newly developed method (peak/min, extraction of skin conductance responses) that had not been performed previously. Additionally, the skin conductance signal was decomposed, considering tonic and phasic activities to be a distinct compound. Moreover, this is the first time a study has been designed into two steps to understand whether the autonomic nervous system is disturbed in the EHS population.

**Anttila K. Mycotoxins, fungus and 'electrohypersensitivity'. Med Hypotheses. 55(3):208-214, 2000.**

'Electrohypersensitivity' is often explained as a psychological syndrome. Our modern environment contains a lot of different substances and some of them are toxic. Mycotoxins are types of toxins that are biologically very active and that affect living organisms. Mycotoxins and fungi capable of producing toxins have been detected in ventilation systems, water damage and in foodstuff. Many of those displaying symptoms caused by electromagnetic fields have fungus infections or have been living in fungus-contaminated environments for long periods. In animal studies mycotoxins have shown the same effects as those seen in the 'electrohypersensitivity' syndrome. Phototoxic reactions are well known in veterinary medicine and in medical science, so the question is whether the 'electrohypersensitivity' syndrome is caused by 'phototoxic' reactions?

**Augner C, Gnambs T, Winker R, Barth A. Acute effects of electromagnetic fields emitted by GSM mobile phones on subjective well-being and physiological reactions: a meta-analysis. Sci Total Environ. 424:11-15, 2012.**

The potential effects of radiofrequency electromagnetic fields (RF-EMF) emitted by GSM mobile phones on subjective symptoms, well-being and physiological parameters have been investigated in many studies. However, the results have been ambiguous. The current meta-analysis aims to clarify whether RF-EMF have an influence on well-being in self-reported sensitive persons, as well as in non-sensitive people. A literature search revealed 17 studies including 1174 participants. The single effects for various subjective and objective outcomes were meta-analytically combined to yield a single population parameter. Dependant variables were subjective (e.g. headaches) and objective parameters (e.g. heart rate variability) of well-being. The results show no significant impact of short-term RF-EMF exposure on any parameter. Future research should focus on the possible effects of long-term exposure.

**Baliatsas C, van Kamp I, Kelfkens G, Schipper M, Bolte J, Yzermans J, Lebret E. Non-specific physical symptoms in relation to actual and perceived proximity to mobile phone base stations and powerlines. BMC Public Health. 11:421, 2011.**

BACKGROUND: Evidence about a possible causal relationship between non-specific physical symptoms (NSPS) and exposure to electromagnetic fields (EMF) emitted by sources such as mobile phone base stations (BS) and powerlines is insufficient. So far little epidemiological research has been published on the contribution of psychological components to the occurrence of EMF-related NSPS. The prior objective of the current study is to explore the relative importance of actual and perceived proximity to base stations and psychological components as determinants of NSPS, adjusting for demographic, residency and area characteristics. METHODS: Analysis was performed on data obtained in a cross-sectional study on environment and health in 2006 in the Netherlands. In the current study, 3611 adult respondents (response rate: 37%) in twenty-two Dutch residential areas completed a questionnaire. Self-reported instruments included a symptom checklist and assessment of environmental and psychological characteristics. The computation of the distance between household addresses and location of base stations and powerlines was based on geo-coding. Multilevel regression models were used to test the hypotheses regarding the determinants related to the occurrence of NSPS. RESULTS: After adjustment for demographic and residential characteristics, analyses yielded a number of statistically significant associations: Increased report of NSPS

was predominantly predicted by higher levels of self-reported environmental sensitivity; perceived proximity to base stations and powerlines, lower perceived control and increased avoidance (coping) behavior were also associated with NSPS. A trend towards a moderator effect of perceived environmental sensitivity on the relation between perceived proximity to BS and NSPS was verified ($p = 0.055$). There was no significant association between symptom occurrence and actual distance to BS or powerlines. CONCLUSIONS: Perceived proximity to BS, psychological components and socio-demographic characteristics are associated with the report of symptomatology. Actual distance to the EMF source did not show up as determinant of NSPS.

**Baliatsas C, Van Kamp I, Lebret E, Rubin GJ. Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF): A systematic review of identifying criteria. BMC Public Health. 2012 Aug 11;12:643. doi: 10.1186/1471-2458-12-643.**

BACKGROUND: Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) remains a complex and unclear phenomenon, often characterized by the report of various, non-specific physical symptoms (NSPS) when an EMF source is present or perceived by the individual. The lack of validated criteria for defining and assessing IEI-EMF affects the quality of the relevant research, hindering not only the comparison or integration of study findings, but also the identification and management of patients by health care providers. The objective of this review was to evaluate and summarize the criteria that previous studies employed to identify IEI-EMF participants. METHODS: An extensive literature search was performed for studies published up to June 2011. We searched EMBASE, Medline, Psychinfo, Scopus and Web of Science. Additionally, citation analyses were performed for key papers, reference sections of relevant papers were searched, conference proceedings were examined and a literature database held by the Mobile Phones Research Unit of King's College London was reviewed. RESULTS: Sixty-three studies were included. "Hypersensitivity to EMF" was the most frequently used descriptive term. Despite heterogeneity, the criteria predominantly used to identify IEI-EMF individuals were: 1. Self-report of being (hyper)sensitive to EMF. 2. Attribution of NSPS to at least one EMF source. 3. Absence of medical or psychiatric/psychological disorder capable of accounting for these symptoms 4. Symptoms should occur soon (up to 24 hours) after the individual perceives an exposure source or exposed area. (Hyper)sensitivity to EMF was either generalized (attribution to various EMF sources) or source-specific. Experimental studies used a larger number of criteria than those of observational design and performed more frequently a medical examination or interview as prerequisite for inclusion. CONCLUSIONS: Considerable heterogeneity exists in the criteria used by the researchers to identify IEI-EMF, due to explicit differences in their conceptual frameworks. Further work is required to produce consensus criteria not only for research purposes but also for use in clinical practice. This could be achieved by the development of an international protocol enabling a clearly defined case definition for IEI-EMF and a validated screening tool, with active involvement of medical practitioners.

**Belpomme D, Campagnac C, Irigaray P. Reliable disease biomarkers characterizing and identifying electrohypersensitivity and multiple chemical sensitivity as two etiopathogenic aspects of a unique pathological disorder. Rev Environ Health. 2015 Dec 1;30(4):251-71. doi: 10.1515/reveh-2015-0027.**

Much of the controversy over the causes of electro-hypersensitivity (EHS) and multiple chemical sensitivity (MCS) lies in the absence of both recognized clinical criteria and objective biomarkers for widely accepted diagnosis.

Since 2009, we have prospectively investigated, clinically and biologically, 1216 consecutive EHS and/or MCS-self reporting cases, in an attempt to answer both questions. We report here our preliminary data, based on 727 evaluable of 839 enrolled cases: 521 (71.6%) were diagnosed with EHS, 52 (7.2%) with MCS, and 154 (21.2%) with both EHS and MCS. Two out of three patients with EHS and/or MCS were female; mean age (years) was 47. As inflammation appears to be a key process resulting from electromagnetic field (EMF) and/or chemical effects on tissues, and histamine release is potentially a major mediator of inflammation, we systematically measured histamine in the blood of patients. Near 40% had a increase in histaminemia (especially when both conditions were present), indicating a chronic inflammatory response can be detected in these patients. Oxidative stress is part of inflammation and is a key contributor to damage and response. Nitrotyrosin, a marker of both peroxynitrite (ONOO°-) production and opening of the blood-brain barrier (BBB), was increased in 28% the cases. Protein S100B, another marker of BBB opening was increased in 15%. Circulating autoantibodies against O-myelin were detected in 23%, indicating EHS and MCS may be associated with autoimmune response. Confirming animal experiments showing the increase of Hsp27 and/or Hsp70 chaperone proteins under the influence of EMF, we found increased Hsp27 and/or Hsp70 in 33% of the patients. As most patients reported chronic insomnia and fatigue, we determined the 24 h urine 6-hydroxymelatonin sulfate (6-OHMS)/creatinin ratio and found it was decreased (<0.8) in all investigated cases. Finally, considering the self-reported symptoms of EHS and MCS, we serially measured the brain blood flow (BBF) in the temporal lobes of each case with pulsed cerebral ultrasound computed tomosphygmography. Both disorders were associated with hypoperfusion in the capsulothalamic area, suggesting that the inflammatory process involve the limbic system and the thalamus.

Our data strongly suggest that EHS and MCS can be objectively characterized and routinely diagnosed by commercially available simple tests. Both disorders appear to involve inflammation-related hyper-histaminemia, oxidative stress, autoimmune response, capsulothalamic hypoperfusion and BBB opening, and a deficit in melatonin metabolic availability; suggesting a risk of chronic neurodegenerative disease. Finally the common co-occurrence of EHS and MCS strongly suggests a common pathological mechanism.

**Belyaev IY, Hillert L, Protopopova M, Tamm C, Malmgren LO, Persson BR, Selivanova G, Harms-Ringdahl M. 915 MHz microwaves and 50 Hz magnetic field affect chromatin conformation and 53BP1 foci in human lymphocytes from hypersensitive and healthy persons. Bioelectromagnetics. 26(3):173-184, 2005.**

We used exposure to microwaves from a global system for mobile communication (GSM) mobile phone (915 MHz, specific absorption rate (SAR) 37 mW/kg) and power frequency magnetic field (50 Hz, 15 muT peak value) to investigate the response of lymphocytes from healthy subjects and from persons reporting hypersensitivity to electromagnetic field (EMF). The

hypersensitive and healthy donors were matched by gender and age and the data were analyzed blind to treatment condition. The changes in chromatin conformation were measured with the method of anomalous viscosity time dependencies (AVTD). 53BP1 protein, which has been shown to colocalize in foci with DNA double strand breaks (DSBs), was analyzed by immunostaining in situ. Exposure at room temperature to either 915 MHz or 50 Hz resulted in significant condensation of chromatin, shown as AVTD changes, which was similar to the effect of heat shock at 41 degrees C. No significant differences in responses between normal and hypersensitive subjects were detected. Neither 915 MHz nor 50 Hz exposure induced 53BP1 foci. On the contrary, a distinct decrease in background level of 53BP1 signaling was observed upon these exposures as well as after heat shock treatments. This decrease correlated with the AVTD data and may indicate decrease in accessibility of 53BP1 to antibodies because of stress-induced chromatin condensation. Apoptosis was determined by morphological changes and by apoptotic fragmentation of DNA as analyzed by pulsed-field gel electrophoresis (PFGE). No apoptosis was induced by exposure to 50 Hz and 915 MHz microwaves. In conclusion, 50 Hz magnetic field and 915 MHz microwaves under specified conditions of exposure induced comparable responses in lymphocytes from healthy and hypersensitive donors that were similar but not identical to stress response induced by heat shock.

**Belyaev IY, Markovà E, Hillert L, Malmgren LO, Persson BR. Microwaves from UMTS/GSM mobile phones induce long-lasting inhibition of 53BP1/gamma-H2AX DNA repair foci in human lymphocytes. Bioelectromagnetics 30:129-41, 2009.**

We have recently described frequency-dependent effects of mobile phone microwaves (MWs) of global system for mobile communication (GSM) on human lymphocytes from persons reporting hypersensitivity to electromagnetic fields and healthy persons. Contrary to GSM, universal global telecommunications system (UMTS) mobile phones emit wide-band MW signals. Hypothetically, UMTS MWs may result in higher biological effects compared to GSM signal because of eventual "effective" frequencies within the wideband. Here, we report for the first time that UMTS MWs affect chromatin and inhibit formation of DNA double-strand breaks co-localizing 53BP1/gamma-H2AX DNA repair foci in human lymphocytes from hypersensitive and healthy persons and confirm that effects of GSM MWs depend on carrier frequency. Remarkably, the effects of MWs on 53BP1/gamma-H2AX foci persisted up to 72 h following exposure of cells, even longer than the stress response following heat shock. The data are in line with the hypothesis that the type of signal, UMTS MWs, may have higher biological efficiency and possibly larger health risk effects compared to GSM radiation emissions. No significant differences in effects between groups of healthy and hypersensitive subjects were observed, except for the effects of UMTS MWs and GSM-915 MHz MWs on the formation of the DNA repair foci, which were different for hypersensitive ($P < 0.02$[53BP1]//0.01[gamma-H2AX]) but not for control subjects ($P > 0.05$). The non-parametric statistics used here did not indicate specificity of the differences revealed between the effects of GSM and UMTS MWs on cells from hypersensitive subjects and more data are needed to study the nature of these differences.

**Belyaev I, Dean A, Eger H, Hubmann G, Jandrisovits R, Kern M, Kundi M, Moshammer H, Lercher P, Müller K, Oberfeld G, Ohnsorge P, Pelzmann P, Scheingraber C, Thill R. EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses.Rev Environ Health. Publ online 2016 Jul 25. doi: 10.1515/reveh-2016-0011.**

Chronic diseases and illnesses associated with unspecific symptoms are on the rise. In addition to chronic stress in social and work environments, physical and chemical exposures at home, at work, and during leisure activities are causal or contributing environmental stressors that

deserve attention by the general practitioner as well as by all other members of the health care community. It seems certainly necessary now to take "new exposures" like electromagnetic field (EMF) into account. Physicians are increasingly confronted with health problems from unidentified causes.

Studies, empirical observations, and patient reports clearly indicate interactions between EMF exposure and health problems. Individual susceptibility and environmental factors are frequently neglected. New wireless technologies and applications have been introduced without any certainty about their health effects, raising new challenges for medicine and society. For instance, the issue of so-called non-thermal effects and potential long-term effects of low-dose exposure were scarcely investigated prior to the introduction of these technologies. Common EMF sources include Wi-Fi access points, routers and clients, cordless and mobile phones including their base stations, Bluetooth devices, ELF magnetic fields from net currents, ELF electric fields from electric lamps and wiring close to the bed and office desk. On the one hand, there is strong evidence that long-term-exposure to certain EMF exposures is a risk factor for diseases such as certain cancers, Alzheimer's disease and male infertility. On the other hand, the emerging electromagnetic hypersensitivity (EHS) is more and more recognized by health authorities, disability administrators and case workers, politicians, as well as courts of law.

We recommend treating EHS clinically as part of the group of chronic multisystem illnesses (CMI) leading to a functional impairment (EHS), but still recognizing that the underlying cause remains the environment. In the beginning, EHS symptoms often occur only occasionally, but over time they may increase in frequency and severity. Common EHS symptoms include headaches, concentration difficulties, sleeping problems, depression, lack of energy, fatigue and flu-like symptoms.

A comprehensive medical history, which should include all symptoms and their occurrences in spatial and temporal terms and in the context of EMF exposures, is the key to the diagnosis. The EMF exposure can be assessed by asking for typical sources like Wi-Fi access points, routers and clients, cordless and mobile phones and measurements at home and at work. It is very important to take the individual susceptibility into account.

The primary method of treatment should mainly focus on the prevention or reduction of EMF exposure, that is, reducing or eliminating all sources of EMF at home and in the workplace. The reduction of EMF exposure should also be extended to public spaces such as schools, hospitals, public transport, and libraries to enable persons with EHS an unhindered use (accessibility measure). If a detrimental EMF exposure is reduced sufficiently, the body has a chance to recover and EHS symptoms will be reduced or even disappear. Many examples have shown that such measures can prove effective. Also the survival rate of children with leukemia depends on ELF magnetic field exposure at home.

To increase the effectiveness of the treatment, the broad range of other environmental factors that contribute to the total body burden should also be addressed. Anything that supports a balanced homeostasis will increase a person's resilience against disease and thus against the adverse effects of EMF exposure. There is increasing evidence that EMF exposure has a major impact on the oxidative and nitrosative regulation capacity in affected individuals. This concept also may explain why the level of susceptibility to EMF can change and why the number of symptoms reported in the context of EMF exposures is so large. Based on our current understanding, a treatment approach that minimizes the adverse effects of peroxynitrite - as has been increasingly used in the treatment of multisystem disorders - works best.

This EMF Guideline gives an overview of the current knowledge regarding EMF-related health risks and provides concepts for the diagnosis and treatment and accessibility measures of EHS to improve and restore individual health outcomes as well as for the development of strategies for prevention.

**Bensefa-Colas L, Dupas D. [Idiopathic environmental intolerance: 2 disabling entities to recognize]. Rev Prat. 64(3):358-362, 2014. [Article in French]**

Idiopathic environmental intolerance is characterized by a variety of non-specific symptoms involving several organs within the same individual, and attributed to the exposure to chemical odors (multiple chemical sensitivities) or to the exposure to electromagnetic fields (electromagnetic hypersensitivity). Symptoms occur following an exposure to agents generally regarded as harmless due to the low levels of exposure, and they do not answer to any definition of organic diseases. The lack of established etiology renders treatment difficult. It is important for practitioner to recognize such disorders and assess the social and professional impact so as to improve patients' quality of life.

**Bergdahl J, Tillberg A, Stenman E. Odontologic survey of referred patients with symptoms allegedly caused by electricity or visual display units. Acta Odontol Scand. 56(5):303-307, 1998.**

Twenty-eight consecutive patients with symptoms allegedly caused by electricity or visual display units were odontologically investigated according to a specially designed registration form including an anamnestic interview and a clinical protocol. The most common oral and general symptoms reported were burning mouth, craniomandibular dysfunction symptoms, skin complaints, and fatigue. Oral symptoms such as craniomandibular dysfunction and general symptoms such as eye complaints and dizziness scored highest on a visual analog scale regarding mean symptom intensity. The patients reported various numbers of medical diagnoses, such as allergic rhinitis or asthma and hypothyroidism. Various dental diseases were found; the most common were temporomandibular joint and masticatory muscle dysfunctions, lesions in the oral mucosa, and periodontal diseases. Urinary-Hg (U-Hg) analysis showed a mean U-Hg concentration of 8.5 nmol Hg/L urine, and none of the patients exceeded the limit of 50 nmol Hg/L urine. The U-Hg concentration was positively correlated with the number of amalgam fillings ($P < 0.01$) and craniomandibular disorders ($P < 0.05$). No or low secretion of the minor mucous glands was found in 43% of the patients. One patient showed hypersensitivity to gold and cobalt. The present study showed that various odontologic factors might be involved in some of these patients' suffering. Thus, it is important that professionals from other disciplines collaborate with dentistry if these patients are to be properly investigated.

**Blettner M, Schlehofer B, Breckenkamp J, Kowall B, Schmiedel S, Reis U, Potthoff P, Schüz J, Berg-Beckhoff G. Mobile phone base stations and adverse health effects: phase 1 of a population-based, cross-sectional study in Germany. Occup Environ Med. 66(2):118-123, 2009.**

**OBJECTIVE:** The aim of this first phase of a cross-sectional study from Germany was to investigate whether proximity of residence to mobile phone base stations as well as risk perception is associated with health complaints. **METHODS:** The researchers conducted a population-based, multi-phase, cross-sectional study within the context of a large panel survey regularly carried out by a private research institute in Germany. In the initial phase, reported on in this paper, 30,047 persons from a total of 51,444 who took part in the nationwide survey also

answered questions on how mobile phone base stations affected their health. A list of 38 health complaints was used. A multiple linear regression model was used to identify predictors of health complaints including proximity of residence to mobile phone base stations and risk perception. **RESULTS:** Of the 30,047 participants (response rate 58.6%), 18.7% of participants were concerned about adverse health effects of mobile phone base stations, while an additional 10.3% attributed their personal adverse health effects to the exposure from them. Participants who were concerned about or attributed adverse health effects to mobile phone base stations and those living in the vicinity of a mobile phone base station (500 m) reported slightly more health complaints than others. **CONCLUSIONS:** A substantial proportion of the German population is concerned about adverse health effects caused by exposure from mobile phone base stations. The observed slightly higher prevalence of health complaints near base stations can not however be fully explained by attributions or concerns.

**Bortkiewicz A, Zmyślony M, Szyjkowska A, Gadzicka E. [Subjective symptoms reported by people living in the vicinity of cellular phone base stations: review]. Med Pr. 55(4):345-351, 2004. [Article in Polish]**

The problem of health effects of electromagnetic fields (EMF) emitted by cellular phone base stations evokes much interest in view of the fact that people living in their vicinity are fated to continuous exposure to EMF. None of the studies carried out throughout the world have revealed excessive values of standards adopted by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). A questionnaire was used as a study tool. The results of the questionnaire survey reveal that people living in the vicinity of base stations report various complaints mostly of the circulatory system, but also of sleep disturbances, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite, headache and vertigo. The performed studies showed the relationship between the incidence of individual symptoms, the level of exposure, and the distance between a residential area and a base station. This association was observed in both groups of persons, those who linked their complaints with the presence of the base station and those who did not notice such a relation. Further studies, clinical and those based on questionnaires, are needed to explain the background of reported complaints.

**Carpenter DO. Excessive exposure to radiofrequency electromagnetic fields may cause the development of electrohypersensitivity. Altern Ther Health Med. 20(6):40-42, 2014.** (no abstract available)

**Carpenter DO. The microwave syndrome or electro-hypersensitivity: historical background. Rev Environ Health. 2015 Nov 10. doi: 10.1515/reveh-2015-0016. [Epub ahead of print]**

Microwave generating equipment first became common during World War 2 with the development of radar. Soviet bloc countries reported that individuals exposed to microwaves frequently developed headaches, fatigue, loss of appetite, sleepiness, difficulty in concentration, poor memory, emotional instability, and labile cardiovascular function, and established stringent exposure standards. For a variety of reasons these reports were discounted in Western countries, where the prevailing belief was that there could be no adverse health effects of electromagnetic fields (EMFs) that were not mediated by tissue heating. The reported Soviet effects were at lower intensities than those that cause heating. However, there were several accidental exposures of radar operators in Western countries that resulted in persistent symptoms similar to those described above. The Soviets irradiated the US Embassy in Moscow with microwaves during the period 1953-1975, and while no convincing evidence of elevated

cancer rates was reported, there were reports of "microwave illness." Officials passed these complaints off as being due to anxiety, not effects of the microwave exposure. There is increasing evidence that the "microwave syndrome" or "electro-hypersensitivity" (EHS) is a real disease that is caused by exposure to EMFs, especially those in the microwave range. The reported incidence of the syndrome is increasing along with increasing exposure to EMFs from electricity, WiFi, mobile phones and towers, smart meters and many other wireless devices. Why some individuals are more sensitive is unclear. While most individuals who report having EHS do not have a specific history of an acute exposure, excessive exposure to EMFs, even for a brief period of time, can induce the syndrome.

**Dahmen N, Ghezel-Ahmadi D, Engel A. Blood laboratory findings in patients suffering from self-perceived electromagnetic hypersensitivity (EHS). Bioelectromagnetics. 30(4):299-306, 2009.**

Risks from electromagnetic devices are of considerable concern. Electrohypersensitive (EHS) persons attribute a variety of rather unspecific symptoms to exposure to electromagnetic fields. The pathophysiology of EHS is unknown and therapy remains a challenge. We hypothesized that some electrosensitive individuals are suffering from common somatic health problems. Toward this end we analysed clinical laboratory parameters including thyroid-stimulating hormone (TSH), alanine transaminase (ALT), aspartate transaminase (AST), creatinine, hemoglobine, hematocrit and c-reactive protein (CRP) in subjects suffering from EHS and in controls that are routinely used in clinical medicine to identify or screen for common somatic disorders. One hundred thirty-two patients (n = 42 males and n = 90 females) and 101 controls (n = 34 males and n = 67 females) were recruited. Our results identified laboratory signs of thyroid dysfunction, liver dysfunction and chronic inflammatory processes in small but remarkable fractions of EHS sufferers as potential sources of symptoms that merit further investigation in future studies. In the cases of TSH and ALT/AST there were significant differences between cases and controls. The hypotheses of anaemia or kidney dysfunction playing a major role in EHS could be unambiguously refuted. Clinically it is recommended to check for signs of treatable somatic conditions when caring for individuals suffering from self-proclaimed EHS.

**De Luca et al 2014. Metabolic and Genetic Screening of Electromagnetic Hypersensitive Subjects as a Feasible Tool for Diagnostics and Intervention. Mediators of Inflammation. Volume 2014, Article ID 924184. Open**
Access http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4000647/pdf/MI2014-924184.pdf

Study of self-reported hypersensitivity to electromagnetic fields in California

**Dieudonné M. Does electromagnetic hypersensitivity originate from nocebo responses? Indications from a qualitative study. Bioelectromagnetics. 2015 Sep 15. doi: 10.1002/bem.21937. [Epub ahead of print]**

Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF) is a condition in which symptoms are attributed to electromagnetic field (EMF) exposure. As electro-hypersensitive (EHS) people have repeatedly been observed, during provocation trials, to report symptoms following perceived rather than actual exposure, the hypothesis has been put forward that IEI-EMF originates from psychological mechanisms, especially nocebo responses. This paper examines this hypothesis, using data from a qualitative study aimed at understanding how EHS people come to regard themselves as such.

Forty self-diagnosed EHS people were interviewed.

A typified model of their attribution process was then elaborated, inductively, from their narratives. This model is linear and composed of seven stages: (1) onset of symptoms; (2) failure to find a solution; (3) discovery of EHS; (4) gathering of information about EHS; (5) implicit appearance of conviction; (6) experimentation; (7) conscious acceptance of conviction.

Overall, symptoms appear before subjects start questioning effects of EMF on their health, which is not consistent with the hypothesis that IEI-EMF originates from nocebo responses to perceived EMF exposure. However, such responses might occur at the sixth stage of the process, potentially reinforcing the attribution. It remains possible that some cases of IEI-EMF originate from other psychological mechanisms.

**Dömötör Z, Szemerszky R, Köteles F. Nature relatedness is connected with modern health worries and electromagnetic hypersensitivity. J Health Psychol. 2017 Mar 1:1359105317699681. doi: 10.1177/1359105317699681.**

Although nature relatedness is considered a positive characteristic, its relationship to constructs involving worries about the negative effects of artificial environmental factors is also feasible. A questionnaire assessing modern health worries, electrosensitivity, somatosensory amplification, spirituality, and nature relatedness was completed by 510 individuals. Nature relatedness was related to electrosensitivity, modern health worries, and spirituality. In a binary logistic regression analysis, somatosensory amplification, modern health worries, and nature relatedness were associated with electrosensitivity, and nature relatedness moderated the connection between modern health worries and electrosensitivity. In naive representations, "natural" might be associated with health, whereas "modern" and "artificial" evoke negative associations. https://www.ncbi.nlm.nih.gov/pubmed/28810440

**Eltiti S, Wallace D, Zougkou K, Russo R, Joseph S, Rasor P, Fox E. Development and evaluation of the electromagnetic hypersensitivity questionnaire. Bioelectromagnetics. 28(2):137-151, 2007.**

Electromagnetic hypersensitivity (EHS) syndrome is usually defined as a condition where an individual experiences adverse health effects that he or she believes is due to exposure to objects that emit electromagnetic fields. The aim of this study was to develop a questionnaire that would identify the key symptoms associated with EHS and determine how often these symptoms occur in the general population of the United Kingdom. In the pilot study, an EHS questionnaire was developed and tested. In Study 1 the EHS questionnaire was revised and sent to a randomly selected sample of 20,000 people. Principal components analysis of the symptoms resulted in eight subscales: neurovegetative, skin, auditory, headache, cardiorespiratory, cold related, locomotor, and allergy related symptoms. Study 2 established the validity of the questionnaire in that EHS individuals showed a higher severity of symptoms on all subscales compared to the control group. The two key results of this study were the development of a scale that provides an index of the type and intensity of symptoms commonly experienced by people believing themselves to be EHS and a screening tool that researchers can use to pre-select the most sensitive individuals to take part in their research.

**Eltiti S, Wallace D, Ridgewell A, Zougkou K, Russo R, Sepulveda F, Mirshekar-Syahkal D, Rasor P, Deeble R, Fox E. Does short-term exposure to mobile phone base station signals increase symptoms in individuals who report sensitivity to electromagnetic fields? A double-blind randomized provocation study. Environ Health Perspect. 115(11):1603-1608, 2007.**

BACKGROUND: Individuals with idiopathic environmental illness with attribution to electromagnetic fields (IEI-EMF) believe they suffer negative health effects when exposed to electromagnetic fields from everyday objects such as mobile phone base stations. OBJECTIVES: This study used both open provocation and double-blind tests to determine if sensitive and control individuals experience more negative health effects when exposed to base station-like signals compared with sham. METHODS: Fifty-six self-reported sensitive and 120 control participants were tested in an open provocation test. Of these, 12 sensitive and 6 controls withdrew after the first session. The remainder completed a series of double-blind tests. Subjective measures of well-being and symptoms as well as physiological measures of blood volume pulse, heart rate, and skin conductance were obtained. RESULTS: During the open provocation, sensitive individuals reported lower levels of well-being in both the global system for mobile communication (GSM) and universal mobile telecommunications system (UMTS) compared with sham exposure, whereas controls reported more symptoms during the UMTS exposure. During double-blind tests the GSM signal did not have any effect on either group. Sensitive participants did report elevated levels of arousal during the UMTS condition, whereas the number or severity of symptoms experienced did not increase. Physiological measures did not differ across the three exposure conditions for either group. CONCLUSIONS: Short-term exposure to a typical GSM base station-like signal did not affect well-being or physiological functions in sensitive or control individuals. Sensitive individuals reported elevated levels of arousal when exposed to a UMTS signal. Further analysis, however, indicated that this difference was likely to be due to the effect of order of exposure rather than the exposure itself.

**Eltiti S, Wallace D, Ridgewell A, Zougkou K, Russo R, Sepulveda F, Fox E. Short-term exposure to mobile phone base station signals does not affect cognitive functioning or physiological measures in individuals who report sensitivity to electromagnetic fields and controls. Bioelectromagnetics. 30(7):556-563, 2009.**

Individuals who report sensitivity to electromagnetic fields often report cognitive impairments that they believe are due to exposure to mobile phone technology. Previous research in this area has revealed mixed results, however, with the majority of research only testing control individuals. Two studies using control and self-reported sensitive participants found inconsistent effects of mobile phone base stations on cognitive functioning. The aim of the present study was to clarify whether short-term (50 min) exposure at 10 mW/m(2) to typical Global System for Mobile Communication (GSM) and Universal Mobile Telecommunications System (UMTS) base station signals affects attention, memory, and physiological endpoints in sensitive and control participants. Data from 44 sensitive and 44 matched-control participants who performed the digit symbol substitution task (DSST), digit span task (DS), and a mental arithmetic task (MA), while being exposed to GSM, UMTS, and sham signals under double-blind conditions were analyzed. Overall, cognitive functioning was not affected by short-term exposure to either GSM or UMTS signals in the current study. Nor did exposure affect the physiological measurements of blood volume pulse (BVP), heart rate (HR), and skin conductance (SC) that were taken while participants performed the cognitive tasks.

**Flodin U, Seneby A, Tegenfeldt C. Provocation of electric hypersensitivity under everyday conditions. Scand J Work Environ Health. 26(2):93-98, 2000.**

OBJECTIVES: In most previous provocation studies subjects suffering from "electric hypersensitivity" have not been able to determine correctly whether or not they have been subjected to a sham or true provocation to magnetic or electric fields. However, an often-discussed weakness is that most of the earlier provocation studies have been performed in a laboratory situation, often with simulated fields, which may not be representative of conditions prevailing in the homes or workplaces of the patients. Criticism has also been put forth about neglect of the long latency period of symptoms. Therefore, a provocation study was performed in the homes or workplaces of the patients, where we also studied the symptoms and on-off answer 24 hours after the exposure. METHODS: Fifteen subjects selected as having fast and distinct reactions from electric equipment were provoked on 4 occasions: mainly 2 true and 2 sham provocations. The intervals between exposure were a few or more days in order to provide the subjects with an opportunity to recover before the next provocation. A control group of healthy subjects with normal hearing and vision verified that the provocations were performed in a blind manner. RESULTS: The patients suffering from "electric hypersensitivity" were no better than the control group in deciding whether or not they were exposed to electric and magnetic fields. CONCLUSIONS: Exposure to electric and magnetic fields per se does not seem to be a sufficient cause of the symptoms experienced by this patient group.

**Frei P, Mohler E, Braun-Fahrländer C, Fröhlich J, Neubauer G, Röösli M; QUALIFEX-team. Cohort study on the effects of everyday life radio frequency electromagnetic field exposure on non-specific symptoms and tinnitus. Environ Int. 38(1):29-36, 2012.**

**BACKGROUND:** There is public concern regarding potential health effects of radio frequency electromagnetic fields (RF-EMF) exposure, as produced by mobile phones or broadcast transmitters. The objective of this study was to investigate the association between RF-EMF exposure and non-specific symptoms and tinnitus in a prospective cohort study. **METHODS:** In 2008, 1375 randomly selected participants from Basel, Switzerland, were enrolled in a questionnaire survey with follow-up after one year (participation rate 82%). A score for somatic complaints (von Zerssen list) and headache (HIT-6) was assessed. Far-field environmental RF-EMF exposure was predicted using a validated prediction model. Regarding near-field exposure, self-reported mobile and cordless phone use as well as mobile phone operator data were collected. In multivariate regression models, we investigated whether exposure at baseline (cohort analysis) or changes in exposure between baseline and follow-up (change analysis) were related to changes in health scores. **RESULTS:** For participants in the top decile of environmental far-field RF-EMF exposure at baseline, in comparison to participants exposed below the median value, the change in the von Zerssen- and HIT-6-scores between baseline and follow-up was -0.12 (95%-CI: -1.79 to 1.56) and -0.37 (95%-CI: -1.80 to 1.07) units, respectively. Exposure to near-field sources and a change in exposure between baseline and follow-up were not related to non-specific symptoms. Similarly, no association between RF-EMF exposure and tinnitus was observed. **CONCLUSIONS:** In this first cohort study using objective and well-validated RF-EMF exposure measures, we did not observe an association between RF-EMF exposure and non-specific symptoms or tinnitus.

**Frick U, Rehm J, Eichhammer P. Risk perception, somatization, and self report of complaints related to electromagnetic fields--a randomized survey study. Int J Hyg Environ Health. 205(5):353-360, 2002.**

Exposure to electromagnetic fields (EMF) as well as EMF-related complaints has increased over the past decades. However, it is unclear whether these complaints are related to the

electromagnetic or other physical properties of these fields per se, to salience of EMF in media, or to both. What is the prevalence of EMF-related complaints in the general population? What are the influencing factors on this prevalence? Does reporting of EMF-related symptoms depend on cognitive factors? To answer these questions, a survey with random variation of three cognitive factors was performed. As expected, EMF-related complaints were reported more by females and people with higher somatization tendency. Age had no significant linear effect on EMF-related complaints. The cognitive condition of threat produced a significant contrast effect among people with high somatization tendency on EMF-related complaints. Cognition can influence reporting of EMF-related effects. Thus, in future research of such effects, psychologically influencing factors should be included. Also risk communication should incorporate knowledge about social cognition.

**Frick U, Kharraz A, Hauser S, Wiegand R, Rehm J, Kovatsits U, Eichhammer P. Comparison perception of singular transcranial magnetic stimuli by subjectively electrosensitive subjects and general population controls. Bioelectromagnetics. 26(4):287-298, 2005.**

Transcranial magnetic stimulation of the dorsolateral prefrontal cortex by single pulses of varying field intensities was used to measure thresholds of individual perception and motor response in three groups of subjects: subjectively electrosensitive people, general population controls with a high burden of complaints related to electromagnetic field (EMF) exposure in the literature (highest decile in complaint burden), and general population controls with a low burden of complaints (lowest decile in complaint burden). The major study endpoint was the ability of the subjects to differentiate between real magnetic stimulation and a sham condition. There were no significant differences between groups in the thresholds, neither of detecting the real magnetic stimulus nor in motor response. But the three groups differed significantly in differentiating between stimulation and sham condition, with the subjectively electrosensitive people having the lowest ability to differentiate and the control group with high level of EMF-related complaints having the best ability to differentiate. Differences between groups were mostly due to false alarm reactions in the sham condition reported by subjectively electrosensitives (SES). We found no objective correlate of the self perception of being "electrosensitive." Overall, our experiment does not support the hypothesis that subjectively electrosensitive patients suffer from a physiological hypersensitivity to EMFs or stimuli. Further research should focus on disposing factors explaining the unspecific sensory hyperresponsiveness of subjectively electrosensitive subjects.

**Furubayashi T, Ushiyama A, Terao Y, Mizuno Y, Shirasawa K, Pongpaibool P, Simba AY, Wake K, Nishikawa M, Miyawaki K, Yasuda A, Uchiyama M, Yamashita HK, Masuda H, Hirota S, Takahashi M, Okano T, Inomata-Terada S, Sokejima S, Maruyama E, Watanabe S, Taki M, Ohkubo C, Ugawa Y. Effects of short-term W-CDMA mobile phone base station exposure on women with or without mobile phone related symptoms. Bioelectromagnetics. 30(2):100-113, 2009.**

To investigate possible health effects of mobile phone use, we conducted a double-blind, cross-over provocation study to confirm whether subjects with mobile phone related symptoms (MPRS) are more susceptible than control subjects to the effect of electromagnetic fields (EMF) emitted from base stations. We sent questionnaires to 5,000 women and obtained 2,472 valid responses from possible candidates; from these, we recruited 11 subjects with MPRS and 43 controls. There were four EMF exposure conditions, each of which lasted 30 min: continuous, intermittent, and sham exposure with and without noise. Subjects were exposed to EMF of 2.14

GHz, 10 V/m (W-CDMA), in a shielded room to simulate whole-body exposure to EMF from base stations, although the exposure strength we used was higher than that commonly received from base stations. We measured several psychological and cognitive parameters pre- and post-exposure, and monitored autonomic functions. Subjects were asked to report on their perception of EMF and level of discomfort during the experiment. The MPRS group did not differ from the controls in their ability to detect exposure to EMF; nevertheless they consistently experienced more discomfort, regardless of whether or not they were actually exposed to EMF, and despite the lack of significant changes in their autonomic functions. Thus, the two groups did not differ in their responses to real or sham EMF exposure according to any psychological, cognitive or autonomic assessment. In conclusion, we found no evidence of any causal link between hypersensitivity symptoms and exposure to EMF from base stations.

**Gangi S, Johansson O. Skin changes in "screen dermatitis" versus classical UV- and ionizing irradiation-related damage--similarities and differences. Exp Dermatol. 6(6):283-291, 1997.**

An increasing number of persons say that they get cutaneous problems as well as symptoms from certain internal organs, such as the central nervous system (CNS) and the heart, when being close to electric equipment. A major group of these patients are the users of video display terminals (VDTs), who claim to have subjective and objective skin- and mucosa-related symptoms, such as pain, itch, heat sensation, erythema, papules, and pustules. The CNS symptoms are, e.g. dizziness, tiredness, and headache. Erythema, itch, heat sensation, edema and pain are also common symptoms of sunburn (UV dermatitis). Alterations have been observed in cell populations of the skin of patients suffering from so-called "screen dermatitis" similar to those observed in the skin damaged due to ultraviolet (UV) light or ionizing radiation. In "screen dermatitis" patients a much higher number of mast cells have been observed. It is known that UVB irradiation induces mast cell degranulation and release of TNF-alpha. The high number of mast cells present in the "screen dermatitis" patients and the possible release of specific substances, such as histamine, may explain their clinical symptoms of itch, pain, edema and erythema. The most remarkable change among cutaneous cells, after exposure with the above-mentioned irradiation sources, is the disappearance of the Langerhans' cells. This change has also been observed in "screen dermatitis" patients, again pointing to a common cellular and molecular basis. The results of this literature study demonstrate that highly similar changes exist in the skin of "screen dermatitis" patients, as regards the clinical manifestations as well as alterations in the cell populations, and in skin damaged by UV light or ionizing radiation.

**Gangi S, Johansson O. A theoretical model based upon mast cells and histamine to explain the recently proclaimed sensitivity to electric and/or magnetic fields in humans. Med Hypotheses. 54(4):663-671, 2000.**

The relationship between exposure to electromagnetic fields (EMFs) and human health is more and more in focus. This is mainly because of the rapid increasing use of such EMFs within our modern society. Exposure to EMFs has been linked to different cancer forms, e.g. leukemia, brain tumors, neurological diseases, such as Alzheimer's disease, asthma and allergy, and recently to the phenomena of 'electrosupersensitivity' and 'screen dermatitis'. There is an increasing number of reports about cutaneous problems as well as symptoms from internal organs, such as the heart, in people exposed to video display terminals (VDTs). These people suffer from subjective and objective skin and mucosa-related symptoms, such as itch, heat sensation, pain, erythema, papules and pustules. In severe cases, people can not, for instance,

use VDTs or artificial light at all, or be close to mobile telephones. Mast cells (MCs), when activated, release a spectrum of mediators, among them histamine, which is involved in a variety of biological effects with clinical relevance, e.g. allergic hypersensitivity, itch, edema, local erythema and many types of dermatoses. From the results of recent studies, it is clear that EMFs affect the MC, and also the dendritic cell, population and may degranulate these cells. The release of inflammatory substances, such as histamine, from MCs in the skin results in a local erythema, edema and sensation of itch and pain, and the release of somatostatin from the dendritic cells may give rise to subjective sensations of on-going inflammation and sensitivity to ordinary light. These are, as mentioned, the common symptoms reported from patients suffering from 'electrosupersensitivity'/'screen dermatitis'. MCs are also present in the heart tissue and their localization is of particular relevance to their function. Data from studies made on interactions of EMFs with the cardiac function have demonstrated that highly interesting changes are present in the heart after exposure to EMFs. One could speculate that the cardiac MCs are responsible for these changes due to degranulation after exposure to EMFs. However, it is still not known how, and through which mechanisms, all these different cells are affected by EMFs. In this article, we present a theoretical model, based upon observations on EMFs and their cellular effects, to explain the proclaimed sensitivity to electric and/or magnetic fields in humans.

**Genuis SJ, Lipp CT. Electromagnetic hypersensitivity: fact or fiction? Sci Total Environ. 414:103-112, 2012.**

As the prevalence of wireless telecommunication escalates throughout the world, health professionals are faced with the challenge of patients who report symptoms they claim are connected with exposure to some frequencies of electromagnetic radiation (EMR). Some scientists and clinicians acknowledge the phenomenon of hypersensitivity to EMR resulting from common exposures such as wireless systems and electrical devices in the home or workplace; others suggest that electromagnetic hypersensitivity (EHS) is psychosomatic or fictitious. Various organizations including the World Health Organization as well as some nation states are carefully exploring this clinical phenomenon in order to better explain the rising prevalence of non-specific, multi-system, often debilitating symptoms associated with non-ionizing EMR exposure. As well as an assortment of physiological complaints, patients diagnosed with EHS also report profound social and personal challenges, impairing their ability to function normally in society. This paper offers a review of the sparse literature on this perplexing condition and a discussion of the controversy surrounding the legitimacy of the EHS diagnosis. Recommendations are provided to assist health professionals in caring for individuals complaining of EHS.

**Ghezel-Ahmadi D, Engel A, Weidemann J, Budnik LT, Baur X, Frick U, Hauser S, Dahmen N. Heavy metal exposure in patients suffering from electromagnetic hypersensitivity. Sci Total Environ. 408(4):774-778, 2010.**

BACKGROUND: Risks from electromagnetic devices are of considerable concern. Electrohypersensitive (EHS) persons attribute a variety of rather unspecific symptoms to the exposure to electromagnetic fields. The pathophysiology of EHS is unknown and therapy remains a challenge. OBJECTIVES: Heavy metal load has been discussed as a potential factor in the symptomatology of EHS patients. The main objective of the study was to test the hypothesis of a link between EHS and heavy metal exposure. METHODS: We measured lead, mercury and cadmium concentrations in the blood of 132 patients (n=42 males and n=90 females) and 101 controls (n=34 males and n=67 females). RESULTS: Our results show that

heavy metal load is of no concern in most cases of EHS but might play a role in exceptional cases. CONCLUSIONS: The data do not support the general advice to heavy metal detoxification in EHS.

**Gibson PR, Kovach S, Lupfer A. Unmet health care needs for persons with environmental sensitivity. J Multidiscip Healthc. 8:59-66, 2015.**

Studies of unmet health care needs have shown that women, people with poor health, and people with lower socioeconomic status are more likely to report having unmet health care needs. In this study, we examined the types of and reasons for unmet health care needs in 465 people with environmental sensitivities. A second area of inquiry involved negative reactions to general anesthesia. Results showed that the most common barriers to receiving care were the inability to find a provider who understands environmental sensitivities and a lack of accessibility due to chemical and electromagnetic exposures in health care environments. Lower income and poorer health (longer illness, a worsening or fluctuating course of illness, and a higher level of disability) were significantly correlated with the total number of reported unmet health care needs. Some people with environmental sensitivities reported having negative reactions to anesthesia of long duration; most common were nausea and vomiting, fatigue, and reduced cognitive ability.

**Gobba F. [Subjective non-specific symptoms related with electromagnetic fields: description of 2 cases]. Epidemiol Prev. 26(4):171-175, 2002. [Article in Italian]**

In Italy, as in other countries, an apparently increasing number of subjects is reporting a variety of subjective symptoms that the subjects themselves refer to the exposure to electric, magnetic or electromagnetic fields (EMF) from nearby electric appliances, cellular phones, antennas, etc. Terms like electricity hypersensitivity (EHS), EMF hypersensitivity, or other similar, are frequently adopted to describe such symptoms; nevertheless, up to now, these terms are not entered the medical terminology. No accepted diagnostic criteria or procedures for the diagnosis of EHS are currently available. Furthermore, apart from the subject's self-attribution of the symptoms to EMFs, no direct cause-effect relationship between EHS symptoms and electromagnetic fields has been proved; additionally, evidence of a possible pathogenetic mechanism is lacking. In this paper, two cases developing symptoms of EHS ascribed to overhead power line in the proximity of their house are discussed. Nervous system (asthenia, depression, paraesthesias etc.), cardiovascular system (cardiac palpitations) and the skin (tingling, itching, etc.), are mostly (but not exclusively) involved. Based on available scientific knowledge, the rationale for an approach to subjects claiming for EHS is discussed. The establishment of a National archive for the collection of cases is needed.

**Gómez-Perretta C, Navarro EA, Segura J, Portolés M. Subjective symptoms related to GSM radiation from mobile phone base stations: a cross-sectional study. BMJ Open. 3(12):e003836, 2013.**

**OBJECTIVES:** We performed a re-analysis of the data from Navarro et al (2003) in which health symptoms related to microwave exposure from mobile phone base stations (BSs) were explored, including data obtained in a retrospective inquiry about fear of exposure from BSs. **DESIGN:** Cross-sectional study. **SETTING:** La Ñora (Murcia), Spain. **PARTICIPANTS:** Participants with known illness in 2003 were subsequently disregarded: 88 participants instead of 101 (in 2003) were analysed. Since weather circumstances can influence exposure, we restricted data to measurements made under similar weather conditions. **OUTCOMES AND**

**METHODS:** A statistical method indifferent to the assumption of normality was employed: namely, binary logistic regression for modelling a binary response (eg, suffering fatigue (1) or not (0)), and so exposure was introduced as a predictor variable. This analysis was carried out on a regular basis and bootstrapping (95% percentile method) was used to provide more accurate CIs. **RESULTS:** The symptoms most related to exposure were lack of appetite (OR=1.58, 95% CI 1.23 to 2.03); lack of concentration (OR=1.54, 95% CI 1.25 to 1.89); irritability (OR=1.51, 95% CI 1.23 to 1.85); and trouble sleeping (OR=1.49, 95% CI 1.20 to 1.84). Changes in -2 log likelihood showed similar results. Concerns about the BSs were strongly related with trouble sleeping (OR =3.12, 95% CI 1.10 to 8.86). The exposure variable remained statistically significant in the multivariate analysis. The bootstrapped values were similar to asymptotic CIs. **CONCLUSIONS:** This study confirms our preliminary results. We observed that the incidence of most of the symptoms was related to exposure levels-independently of the demographic variables and some possible risk factors. Concerns about adverse effects from exposure, despite being strongly related with sleep disturbances, do not influence the direct association between exposure and sleep.

**Hagström M, Auranen J, Johansson O, Ekman R. Reducing electromagnetic irradiation and fields alleviates experienced health hazards of VDU work. Pathophysiology. 19(2):81-87, 2012**

Word Heath Organisation (WHO) outlined in 2005 recommendations, how to treat people suffering from the functional impairment electrohypersensitivity in its document "Electromagnetic fields and public health". Unfortunately the reduction of electromagnetic fields was not considered as a treatment option. The aim of the current study was to shield the computer user from the emitted electromagnetic irradiation and fields and to correlate that to the subjective symptoms reported by electrohypersensitive volunteers. The irradiation of the shielding cabinets was recorded. They housed either separate computer screens or whole laptops. When the volunteers had used the shielding cabinet for 1-7 years, they were able work with their computers whole working day, Those who had used the shielding cabined for 2-3 months were partially symptom free. The person who had used the cabinet only for 1 week reported some alleviation of her nausea. In conclusion: it seems that reducing the electromagnetic irradiation of the computer can lessen the symptoms of electrohypersensitivity and permit working without problems. Further studies are needed to clarify how the symptoms of different organ systems recover and make computer users to work also professionally.

**Hagström M, Auranen J, Ekman R. Electromagnetic hypersensitive Finns: Symptoms, perceived sources and treatments, a questionnaire study. Pathophysiology. 2013 Apr 1. pii: S0928-4680(13)00002-3.**

The aim was to analyze the subjective experiences of Finns who describe themselves as suffering from electromagnetic hypersensitivity (EHS), their symptoms, self-perceived sources of the health complaints and the effectiveness of medical and complementary alternative therapies. A total of 395 questionnaires were mailed to self-diagnosed EHS persons. Of the participants 345 belonged to a Finnish self-help group and 50 came from outside of the group. The return rate of the study was 52.1% (206) and 80.9% of the respondents were women. Before the onset of EHS the most common health complaints were different types of allergies (35.1%, 68). During the acute phase of EHS the most common symptoms were nervous system related: "stress" (60.3%, 117), "sleeping disorders" (59.3%, 115) and "fatigue" (57.2%, 111). The sources that were most often reported to have triggered EHS were: "personal computers" (50.8%, 94) and "mobile phones" (47.0%, 87). The same devices were also claimed to cause the most symptoms during the acute phase. After the acute phase of EHS had passed, the

respondents still claimed to react to these same digital and wireless devices while their reactions to basic electrical appliances were reduced. According to 76% of 157 respondents the reduction or avoidance of electromagnetic fields (EMF) helped in their full or partial recovery. The best treatments for EHS were given as: "dietary change" (69.4%), "nutritional supplements" (67.8%) and "increased physical exercise" (61.6%). The official treatment recommendations of psychotherapy (2.6%) and medication (-4.2%) were not significantly helpful. According to the present results the official treatment protocols should take better account the EHS person's own experiences. The avoidance of electromagnetic radiation and fields effectively removed or lessened the symptoms in EHS persons.

**Hardell L, Carlberg M, Söderqvist F, Hardell K, Björnfoth H, van Bavel B, Lindström G. Increased concentrations of certain persistent organic pollutants in subjects with self-reported electromagnetic hypersensitivity--a pilot study. Electromagn Biol Med. 27(2):197-203, 2008.**

Electromagnetic hypersensitivity (EHS) is used for a variety of subjective symptoms related to exposure to electromagnetic fields (EMF). The aim of this pilot study was to analyze the concentrations of certain persistent organic pollutants (POPs) in subjects with self-reported EHS. In total, 13 EHS subjects and 21 controls were included, all female. The concentration of several POPs was higher in EHS subjects than in controls. Lower concentrations were found for hexachlorobenzene and two types of chlordanes. The only significantly increased odds ratios (ORs) were found for polybrominated diphenyl ether (PBDE) #47 yielding OR=11.7, 95% confidence interval (CI)=1.45-94.7 and the chlordane metabolite MC6 with OR=11.2, 95% CI=1.18-106. The results were based on low numbers and must be interpreted with caution. This hypothesis generating study indicates the necessity of a larger investigation on this issue.

**Havas M  Radiation from wireless technology affects the blood, the heart, and the autonomic nervous system. Rev Environ Health. 28(2-3):75-84, 2013.**

Exposure to electrosmog generated by electric, electronic, and wireless technology is accelerating to the point that a portion of the population is experiencing adverse reactions when they are exposed. The symptoms of electrohypersensitivity (EHS), best described as rapid aging syndrome, experienced by adults and children resemble symptoms experienced by radar operators in the 1940s to the 1960s and are well described in the literature. An increasingly common response includes clumping (rouleau formation) of the red blood cells, heart palpitations, pain or pressure in the chest accompanied by anxiety, and an upregulation of the sympathetic nervous system coincident with a downregulation of the parasympathetic nervous system typical of the "fight-or-flight" response. Provocation studies presented in this article demonstrate that the response to electrosmog is physiologic and not psychosomatic. Those who experience prolonged and severe EHS may develop psychologic problems as a consequence of their inability to work, their limited ability to travel in our highly technologic environment, and the social stigma that their symptoms are imagined rather than real.

**Havas M, Marrongelle J. Replication of heart rate variability provocation study with 2.4-GHz cordless phone confirms original findings. Electromagn Biol Med. 32(2):253-266, 2013.**

This is a replication of a study that we previously conducted in Colorado with 25 subjects designed to test the effect of electromagnetic radiation generated by the base station of a cordless phone on heart rate variability (HRV). In this study, we analyzed the response of 69

subjects between the ages of 26 and 80 in both Canada and the USA. Subjects were exposed to radiation for 3-min intervals generated by a 2.4-GHz cordless phone base station (3-8 μW/cm²). A few participants had a severe reaction to the radiation with an increase in heart rate and altered HRV indicative of an alarm response to stress. Based on the HRV analyses of the 69 subjects, 7% were classified as being "moderately to very" sensitive, 29% were "little to moderately" sensitive, 30% were "not to little" sensitive and 6% were "unknown". These results are not psychosomatic and are not due to electromagnetic interference. Twenty-five percent of the subjects' self-proclaimed sensitivity corresponded to that based on the HRV analysis, while 32% overestimated their sensitivity and 42% did not know whether or not they were electrically sensitive. Of the 39 participants who claimed to experience some electrical hypersensitivity, 36% claimed they also reacted to a cordless phone and experienced heart symptoms and, of these, 64% were classified as having some degree of electrohypersensitivity (EHS) based on their HRV response. Novel findings include documentation of a delayed response to radiation. Orthostatic HRV testing combined with provocation testing may provide a diagnostic tool for some sufferers of EHS when they are exposed to electromagnetic emitting devices. The protocol used underestimates reaction to electromagnetic radiation for those who have a delayed autonomic nervous system reaction and it may under diagnose those who have adrenal exhaustion as their ability to mount a response to a stressor is diminished.

**Hedendahl L, Carlberg M, Hardell L. Electromagnetic hypersensitivity - an increasing challenge to the medical profession. Rev Environ Health. 2015;30(4):209-15.**

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.

**Heuser G, Heuser SA. Functional brain MRI in patients complaining of electrohypersensitivity after long term exposure to electromagnetic fields. Rev Environ Health. 32(3):291-299, 2017.**

**INTRODUCTION:** Ten adult patients with electromagnetic hypersensitivity underwent functional magnetic resonance imaging (fMRI) brain scans. All scans were abnormal with abnormalities which were consistent and similar. It is proposed that fMRI brain scans be used as a diagnostic aid for determining whether or not a patient has electromagnetic hypersensitivity. Over the years we have seen an increasing number of patients who had developed multi system complaints after long term repeated exposure to electromagnetic fields (EMFs). These complaints included headaches, intermittent cognitive and memory problems, intermittent disorientation, and also sensitivity to EMF exposure. Regular laboratory tests were within normal limits in these patients. The patients refused to be exposed to radioactivity. This of course ruled out positron emission tomography (PET) and single-photon emission computed tomography (SPECT) brain scanning. This is why we ordered fMRI brain scans on these patients. We hoped that we could document objective abnormalities in these patients who had often been labeled as psychiatric cases. **MATERIALS AND METHODS:** Ten patients first underwent a regular magnetic resonance imaging (MRI) brain scan, using a 3 Tesla Siemens Verio MRI open system. A functional MRI study was then performed in the resting state using the following sequences: A three-dimensional, T1-weighted, gradient-echo (MPRAGE) Resting state network. The echo-planar imaging (EPI) sequences for this resting state blood oxygenation level dependent (BOLD) scan were then post processed on a 3D workstation and the independent component analysis was performed separating out the various networks. Arterial spin labeling. Tractography and fractional anisotropy.**RESULTS:** All ten patients had abnormal functional MRI brain scans. The abnormality was often described as hyper connectivity of the anterior component of the default mode in the medial orbitofrontal area. Other abnormalities were usually found. Regular MRI studies of the brain were mostly unremarkable in these patients. **CONCLUSION:** We propose that functional MRI studies should become a diagnostic aid when evaluating a patient who claims electrohypersensitivity (EHS) and has otherwise normal studies. Interestingly, the differential diagnosis for the abnormalities seen on the fMRI includes head injury. It turns out that many of our patients indeed had a history of head injury which was then followed sometime later by the development of EHS. Many of our patients also had a history of exposure to potentially neurotoxic chemicals, especially mold. Head injury and neurotoxic chemical exposure may make a patient more vulnerable to develop EHS.

**Hietanen M, Hämäläinen AM, Husman T. Hypersensitivity symptoms associated with exposure to cellular telephones: no causal link. Bioelectromagnetics. 23(4):264-270, 2002.**

The hypothesis that there exist hypersensitive persons who perceive subjective symptoms from radiofrequency (RF) fields emitted by hand held mobile phones (cellular phones) was tested using double blind provocation experiments. We also tested whether sensitive subjects are able to determine whether the phone is on or off by sensing RF fields. The study group consisted of 20 volunteers (13 women and 7 men) who reported themselves as being sensitive to cellular phones. The RF exposure sources were one analogue NMT phone (900 MHz) and two digital

GSM phones (900 and 1800 MHz). The duration of a test session was 30 min, and three or four sessions were performed in random order for each subject during 1 day. The subjects were asked to report symptoms or sensations as soon as they perceived any abnormal feelings. In addition, the subjects' blood pressure, heart rate, and breathing frequency were monitored every 5 min. The results of the study indicated that various symptoms were reported, and most of them appeared in the head region. However, the number of reported symptoms was higher during sham exposure than during real exposure conditions. In addition, none of the test persons could distinguish real RF exposure from sham exposure. Hence, we conclude that adverse subjective symptoms or sensations, though unquestionably perceived by the test subjects, were not produced by cellular phones.

**Hillert L, Kolmodin Hedman B, Dölling BF, Arnetz BB. Cognitive behavioural therapy for patients with electric sensitivity - a multidisciplinary approach in a controlled study. Psychother Psychosom. 67(6):302-310, 1998.**

BACKGROUND: Electric sensitivity is a syndrome that still lacks diagnostic criteria and proven aetiology. The suffering of afflicted persons motivates development and evaluation of effective handling and treatments. The aim of the study was to evaluate the effect of cognitive behavioural therapy in patients with electric sensitivity. METHODS: Cognitive behavioural treatment, as part of a multidisciplinary treatment package for patients with electric sensitivity, was evaluated in a controlled trial. Ten patients who received treatment were compared to 12 controls. Outcome measures included different dimensions such as symptoms, beliefs, behaviour, and biochemical measurements of stress-related variables. All outcome measures were collected prior to the study, post-treatment, and after an additional 6-month follow-up. RESULTS: The therapy group rated their electric sensitivity as significantly lower than did the control group at the 6-month follow-up, and reduction of self-rated discomforts from triggering factors was significant in the therapy group. There were no systematic changes in the biochemical variables. The symptom indices were significantly reduced over time, and ability to work continued to be good in both groups. CONCLUSION: The prognosis for this syndrome is good with early intervention and cognitive therapy may further reduce the perceived hypersensitivity. This may have important implications on handling of patients with electric sensitivity.

**Hillert L, Flato S, Georgellis A, Arnetz BB, Kolmodin-Hedman B. Environmental illness: fatigue and cholinesterase activity in patients reporting hypersensitivity to electricity. Environ Res. 85(3):200-206, 2001.**

The lack of a pathophysiological marker hinders studies on environmental illnesses of unknown origin. Hence, research focused on the identification of such a marker is a priority. This study investigated the nature and a possible etiology of fatigue in hypersensitivity to electricity (the most commonly reported environmental illness in Sweden). The aim was to test the hypothesis that perceived fatigue was due to alterations in cholinesterase activity. The study group consisted of 14 people who reported a hypersensitivity to electricity, including disabling fatigue. We assessed cholinesterase activity three times: twice based on current symptoms reported by the subjects (severe fatigue attributed to electromagnetic fields and absence of this symptom) and once at a randomly selected time. No significant reduction in acetylcholinesterase was identified in any subject. Examined on a group level, no significant reduction in activity was identified at the time of severe fatigue, and no correlation between reported degree of fatigue and cholinesterase activity was observed. Fatigue attributed to electromagnetic fields was nonphysical and showed a significant correlation to difficulties in concentrating. The results do

not support the hypothesis that a change in cholinesterase activity mediates fatigue in people reporting hypersensitivity to electricity.

**Hillert L, Berglind N, Arnetz BB, Bellander T. Prevalence of self-reported hypersensitivity to electric or magnetic fields in a population-based questionnaire survey. Scand J Work Environ Health. 28(1):33-41, 2002.**

OBJECTIVES: The prevalence of medically unexplained symptoms attributed to exposure to electromagnetic fields is still largely unknown. Previous studies have investigated reported hypersensitivity to electricity in selected groups recruited from workplaces or outpatient clinics. The aim of this study was to estimate the prevalence of self-reported hypersensitivity to electric or magnetic fields in the general population and to describe characteristics of the group reporting such hypersensitivity with regard to demographics, other complaints, hypersensitivities, and traditional allergies. METHODS: A cross-sectional questionnaire survey was conducted in 1997 among 15,000 men and women between 19 and 80 years of age in Stockholm County. The response rate was 73%. RESULTS: One and a half percent of the respondents reported hypersensitivity to electric or magnetic fields. Prevalence was highest among women and in the 60- to 69-year age group. The hypersensitive group reported all symptoms, allergies, and other types of hypersensitivities included in the survey (as well as being disturbed by various factors in the home) to a significantly greater extent than the rest of the respondents. No specific symptom profile set off the hypersensitive group from the rest of the respondents. CONCLUSIONS: The results should be interpreted with caution. But they suggest that there is widespread concern among the general population about risks to health posed by electric and magnetic fields. More research is warranted to explore ill health among people reporting hypersensitivity to electric or magnetic fields.

**Huiberts A, Hjørnevik M, Mykletun A, Skogen JC. Electromagnetic hypersensitivity (EHS) in the media - a qualitative content analysis of Norwegian newspapers. JRSM Short Rep. 2013 Oct 4;4(11):2042533313487332**

**OBJECTIVES:** Electromagnetic hypersensitivity (EHS) is a condition characterized by experiencing symptoms after perceived exposure to weak electromagnetic fields (EMFs). There is substantial debate concerning the aetiology of EHS, but experimental data indicate no association between EHS and actual presence of EMFs. Newspapers play a key role in shaping peoples' understanding of health-related issues. The aim of this study was to describe the content of newspaper articles concerning aetiology and treatment of EHS. **DESIGN:** Qualitative content analysis of newspaper articles. **SETTING:** Norwegian newspaper articles were identified using a comprehensive electronic media archive. **PARTICIPANTS:** Norwegian newspaper articles published between 1 February 2006 and 11 August 2010. **MAIN OUTCOME MEASURES:** Statements coded according to source of information, whether it was pro or con scientific evidence on EHS aetiology, and type of intervention presented as treatment option for EHS. **RESULTS:** Of the statements concerning EHS aetiology (n = 196), 35% (n = 69) were categorized as pro evidence, 65% (n = 127) as con evidence. Of the statements about EHS interventions assessed, 78% (n = 99) were categorized as 'radiance reduction', 4% (n = 5) as 'complementary medicine', and 18% (n = 23) as 'other'. Cognitive behavioural therapy (CBT) and psychotropic drugs were never presented as possible treatment options for EHS. **CONCLUSIONS:** The newspaper media discourse of EHS aetiology and recommended treatment interventions is much in conflict with the current evidence in the field. The majority of statements concerning aetiology convey that EHS is related to the presence of weak EMFs, and radiance reduction as the most frequently conveyed measure to reduce EHS-related symptoms.

**Huss A, Röösli M. Consultations in primary care for symptoms attributed to electromagnetic fields--a survey among general practitioners. BMC Public Health. 6:267, 2006.**

BACKGROUND: Five percent of the Swiss population attribute symptoms to electromagnetic fields (EMF). General practitioners (GPs) might play a key role in recognising an emerging health risk, since they are the first to observe and follow up persons who attribute symptoms to EMF. It is unclear to what extent EMFs have become an issue in general practice and which experiences GPs report from the consultations. METHODS: We conducted telephone interviews in a random sample of GPs in Switzerland in order to assess the frequency of consultations in primary care due to EMF and the GPs' experience with these patients. RESULTS: 342 general practitioners were interviewed, corresponding to a response rate of 28.2%. 69% of the GPs reported at least one consultation due to EMF, but GPs with a certificate in complementary medicine were much more likely to report EMF consultations. The median of EMF consultation numbers within one year was three. An overview of the most recent EMF-related consultation per GP yielded sleep disorders, headaches and fatigue as the most often reported symptoms and mobile phone base stations, power lines and the own use of mobile phones as the main EMF sources suspected to be associated to symptoms. GPs judged the association between EMF and the symptoms to be plausible in 54% of the cases. There was no combination of symptoms and EMF sources that was remarkably and consistently judged to be a plausible cause of the symptoms. CONCLUSION: In our survey, GPs often judged the association between the health problems and the suspected exposure to be plausible. This plausibility assessment seems to be based on grounds of preventive positions in a situation of scientific uncertainty. More research effort is needed to obtain more insight on a potential association between long term EMF exposure and unspecific symptoms.

**Johansson A, Forsgren S, Stenberg B, Wilén J, Kalezic N, Sandström M. No effect of mobile phone-like RF exposure on patients with atopic dermatitis. Bioelectromagnetics. 29(5):353-362, 2008.**

This study investigates the effect of exposure to a mobile phone-like radiofrequency (RF) electromagnetic field on people with atopic dermatitis (AD). Fifteen subjects with AD were recruited and matched with 15 controls without AD. The subjects were exposed for 30 min to an RF field at 1 W/kg via an indoor base station antenna attached to a 900 MHz GSM mobile phone. Blood samples for ELISA analysis of the concentration of substance P (SP), tumor necrosis factor receptor 1 (TNF R1), and brain derived neurotrophic factor (BDNF) in serum were drawn before and after the provocation (exposure/sham). Baseline heart rate and heart rate variability, local blood flow, and electrodermal activity were also recorded. No significant differences between the subject groups were found for baseline neurophysiological data. The cases displayed a serum concentration of TNF R1 significantly higher than the control subjects and a significantly lower serum concentration of BDNF in the baseline condition. For SP there was no difference between groups. However, no effects related to RF exposure condition were encountered for any of the measured substances. As to symptoms, a possible correlation with exposure could not be evaluated, due to too few symptom reports. The result of the study does not support the hypothesis of an effect of mobile phone-like RF exposure on serum levels of SP, TNF R1, and BDNF in persons with AD.

**Johansson A, Nordin S, Heiden M, Sandström M. Symptoms, personality traits, and stress in people with mobile phone-related symptoms and electromagnetic hypersensitivity. J Psychosom Res. 68(1):37-45, 2010.**

OBJECTIVE: Some people report symptoms that they associate with electromagnetic field (EMF) exposure. These symptoms may be related to specific EMF sources or to electrical equipment in general (perceived electromagnetic hypersensitivity, EHS). Research and clinical observations suggest a difference between mobile phone (MP)-related symptoms and EHS with respect to symptom prevalence, psychological factors, and health prognosis. This study assessed prevalence of EMF-related and EMF-nonrelated symptoms, anxiety, depression, somatization, exhaustion, and stress in people with MP-related symptoms or EHS versus a population-based sample and a control sample without EMF-related symptoms. METHODS: Forty-five participants with MP-related symptoms and 71 with EHS were compared with a population-based sample (n=106) and a control group (n=63) using self-report questionnaires. RESULTS: The EHS group reported more symptoms than the MP group, both EMF-related and EMF-nonrelated. The MP group reported a high prevalence of somatosensory symptoms, whereas the EHS group reported more neurasthenic symptoms. As to self-reported personality traits and stress, the case groups differed only on somatization and listlessness in a direct comparison. In comparison with the reference groups, the MP group showed increased levels of exhaustion and depression but not of anxiety, somatization, and stress; the EHS group showed increased levels for all of the conditions except for stress. CONCLUSION: The findings support the idea of a difference between people with symptoms related to specific EMF sources and people with general EHS with respect to symptoms and anxiety, depression, somatization, exhaustion, and stress. The differences are likely to be important in the management of patients.

**Johansson O, Hilliges M, Han SW. A screening of skin changes, with special emphasis on neurochemical marker antibody evaluation, in patients claiming to suffer from "screen dermatitis" as compared to normal healthy controls. Exp Dermatol. 5(5):279-285, 1996.**

In the present study, facial skin from so-called "screen dermatitis" patients were compared with corresponding material from normal healthy volunteers. The aim of the study was to evaluate possible markers to be used for future double-blind or blind provocation investigations. Differences were found for the biological markers calcitonin gene-related peptide (CGRP), somatostatin (SOM), vasoactive intestinal polypeptide (VIP), peptide histidine isoleucine amide (PHI), neuropeptide tyrosine (NPY), protein S-100 (S-100), neuron-specific enolase (NSE), protein gene product (PGP) 9.5 and phenylethanolamine N-methyltransferase (PNMT). The overall impression in the blind-coded material was such that it turned out easy to blindly separate the two groups from each other. However, no single marker was 100% able to pin-point the difference, although some were quite powerful in doing so (CGRP, SOM, S-100). However, it has to be pointed out that we cannot, based upon the present results, draw any definitive conclusions about the cause of the changes observed. Whether this is due to electric or magnetic fields, a surrounding airborne chemical, humidity, heating, stress factors, or something else, still remains an open question. Blind or double-blind provocations in a controlled environment are necessary to elucidate possible underlying causes for the changes reported in this investigation.

**Johansson O. Electrohypersensitivity: state-of-the-art of a functional impairment. Electromagn Biol Med. 25(4):245-258, 2006.**

Recently, a new category of persons, claiming to suffer from exposure to electromagnetic fields, has been described in the literature. In Sweden, electrohypersensitivity (EHS) is an officially fully recognized functional impairment (i.e., it is not regarded as a disease). Survey studies

show that somewhere between 230,000-290,000 Swedish men and women report a variety of symptoms when being in contact with electromagnetic field (EMF) sources. The aim of our studies has been to investigate possible alterations, in the cellular and neuronal systems of these person' skin. As controls, age- and sex-matched persons, without any subjective or clinical symptoms or dermatological history, served. Immunohistochemistry using antisera to the previously characterized marker substances of interest has been utilized. In summary, it is evident from our preliminary data that various alterations are present in the electrohypersensitive person' skin. In view of recent epidemiological studies, pointing to a correlation between long-term exposure from power-frequent magnetic fields or microwaves and cancer, our data ought to be taken seriously and further analyzed.

**Johansson O. Electrohypersensitivity: a functional impairment due to an inaccessible environment. Rev Environ Health. 2015 Dec 1;30(4):311-21. doi: 10.1515/reveh-2015-0018.**

In Sweden, electrohypersensitivity is recognized as a functional impairment which implies only the environment as the culprit. The Swedish view provides persons with this impairment a maximal legal protection, it gives them the right to get accessibility measures for free, as well as governmental subsidies and municipality economic support, and to provide them with special Ombudsmen (at the municipality, the EU, and the UN level, respectively), the right and economic means to form disability organizations and allow these to be part of national and international counterparts, all with the simple and single aim to allow persons with the functional impairment electrohypersensitivity to live an equal life in a society based on equality. They are not seen as patients, they do not have an overriding medical diagnosis, but the 'patient' is only the inferior and potentially toxic environment. This does not mean that a subjective symptom of a functionally impaired can not be treated by a physician, as well as get sick-leave from their workplace as well as economic compensation, and already in the year 2000 such symptoms were identified in the Internal Code of Diagnoses, version 10 (ICD-10; R68.8/now W90), and have been since. But the underlying cause still remains only the environment. http://1.usa.gov/1YFwzkd

**Kim DW, Lee JH, Ji HC, Kim SC, Nam KC, Cha EJ. Physiological effects of RF exposure on hypersensitive people by a cell phone. Conf Proc IEEE Eng Med Biol Soc. 2008:2322-2325, 2008.**

Persons with electromagnetic hypersensitivity (EHS) complain of subjective symptoms such as headaches, insomnia, memory loss etc. resulting from radio frequency (RF) radiation by cellular phones. There have been various EHS provocation studies on heart rate, blood pressure, and subjective symptoms using GSM phones. However, there are few provocation studies on case-control study investigating simultaneously physiological parameters from CDMA phones. In this study, two volunteer groups of 18 self-declared EHS and 19 controls were exposed to both sham and real RF exposures by a CDMA cellular phone for half an hour each. We investigated the physiological parameters such as heart rates, respiration rates, and hear rate variability (HRV). In conclusion, the RF exposure by a CDMA cellular phone did not have any effects on the physiological parameters for both groups.

**Kim DW, Choi JL, Nam KC, Yang DI, Kwon MK. Origins of electromagnetic hypersensitivity to 60 Hz magnetic fields: A provocation study. Bioelectromagnetics. 2011 Oct 19. doi: 10.1002/bem.20711. [Epub ahead of print]**

With increasing electrical device usage, social concerns about the possible effects of 60 Hz electromagnetic fields on human health have increased. The number of people with self-

attributed electromagnetic hypersensitivity (EHS) who complain of various subjective symptoms such as headache and insomnia has also increased. However, it is unclear whether EHS results from physiological or other origins. In this double-blinded study, we simultaneously investigated physiological changes (heart rate, respiration rate, and heart rate variability), subjective symptoms, and perception of the magnetic field to assess origins of the subjective symptoms. Two volunteer groups of 15 self-reported EHS and 16 non-EHS individuals were tested with exposure to sham and real (60 Hz, 12.5 μT) magnetic fields for 30 min. Magnetic field exposure did not have any effects on physiological parameters or eight subjective symptoms in either group. There was also no evidence that the EHS group perceived the magnetic field better than the non-EHS group. In conclusion, the subjective symptoms did not result from the 60 Hz, 12.5 μT magnetic field exposures but from other non-physiological factors.

**Küçer N, Pamukçu T. Self-reported symptoms associated with exposure to electromagnetic fields: a questionnaire study. Electromagn Biol Med. 33(1):15-17, 2014.**

In the last years, it has been discussed frequently whether there are any harmful effects of electromagnetic fields on human health. Electromagnetic fields are generated by several natural and man-made sources. Part of the electromagnetic spectrum called Radiofrequency is used in communication systems such as mobile (cellular) phone and computer. The aim of our study was to explore different self-reported symptoms that may be associated with exposure to electromagnetic fields. This survey study was conducted, using a questionnaire, on 350 people aged +9 years in Turkey. The chi-square test was used for data analysis. Self-reported symptoms were headache, vertigo/dizziness, fatigue, forgetfulness, sleep disturbance-insomnia, tension-anxiety, joint and bone pain, lacrimation of the eyes, hearing loss and tinnitus. As a result of the survey, the study has shown that users of mobile phone and computer more often complained of headache, joint and bone pain, hearing loss, vertigo/dizziness, tension-anxiety symptoms according to time of daily usage ($p < 0.05$). In users of mobile phone and computer, women significantly ($p < 0.05$) complained more often of headache, vertigo/dizziness, fatigue, forgetfulness and tension-anxiety than men.

**Kwon MK, Nam KC, Lee da S, Jang KH, Kim DW. Effects of RF fields emitted from smart phones on cardio-respiratory parameters: a preliminary provocation study. Conf Proc IEEE Eng Med Biol Soc. 2011:1961-1964, 2011.**

This paper describes an experimental setup for evaluating the physiological effects of radiofrequency (RF) emitted from a Wideband Code Division Multiple Access (WCDMA) module with a 24 dBm at 1950 MHz for specific absorption rate (SAR(1g)) of 1.57 W/kg. This provocation study was executed in a double-blind study of two volunteer groups of 10 self-reported electromagnetic hypersensitivity (EHS) and 10 non-EHS subjects under both sham and real exposures in a randomly assigned and counter-balanced order. In the preliminary results, WCDMA RF exposure of 30 min did not have any effects on physiological changes in either group.

**Kwon MK, Choi JY, Kim SK, Yoo TK, Kim DW. Effects of radiation emitted by WCDMA mobile phones on electromagnetic hypersensitive subjects. Environ Health. 11:69. 2012. doi: 10.1186/1476-069X-11-69.**

BACKGROUND: With the use of the third generation (3 G) mobile phones on the rise, social concerns have arisen concerning the possible health effects of radio frequency-electromagnetic fields (RF-EMFs) emitted by wideband code division multiple access (WCDMA) mobile phones

in humans. The number of people with self-reported electromagnetic hypersensitivity (EHS), who complain of various subjective symptoms such as headache, dizziness and fatigue, has also increased. However, the origins of EHS remain unclear. METHODS: In this double-blind study, two volunteer groups of 17 EHS and 20 non-EHS subjects were simultaneously investigated for physiological changes (heart rate, heart rate variability, and respiration rate), eight subjective symptoms, and perception of RF-EMFs during real and sham exposure sessions. Experiments were conducted using a dummy phone containing a WCDMA module (average power, 24 dBm at 1950 MHz; specific absorption rate, 1.57 W/kg) within a headset placed on the head for 32 min. RESULTS: WCDMA RF-EMFs generated no physiological changes or subjective symptoms in either group. There was no evidence that EHS subjects perceived RF-EMFs better than non-EHS subjects.CONCLUSIONS: Considering the analyzed physiological data, the subjective symptoms surveyed, and the percentages of those who believed they were being exposed, 32 min of RF radiation emitted by WCDMA mobile phones demonstrated no effects in either EHS or non-EHS subjects.

**Kwon MK, Kim SK, Koo JM, Choi JY, Kim DW. EHS subjects do not perceive RF EMF emitted from smart phones better than non-EHS subjects. Conf Proc IEEE Eng Med Biol Soc. 2012:2190-2193, 2012.**

As the use of smart phones increases, social concerns have arisen concerning the possible effects of radio frequency-electromagnetic fields (RF-EMFs) emitted from wideband code division multiple access (WCDMA) mobile phones on human health. The number of people with self-reported electromagnetic hypersensitivity (EHS) who complain of various subjective symptoms, such as headache, insomnia, etc., has also recently increased. However, it is unclear whether EHS subjects can detect RF-EMFs exposure or not. In this double-blind study, two volunteer groups of 17 EHS and 20 non-EHS subjects were investigated in regards to their perception of RF-EMFs with real and sham exposure sessions. Experiments were conducted using a WCDMA module inside a dummy phone with an average power of 24 dBm at 1950 MHz and a specific absorption rate of 1.57 W/kg using a dummy headphone for 32 min. In conclusion, there was no indication that EHS subjects perceive RF-EMFs better than non-EHS subjects.

**Landgrebe M, Frick U, Hauser S, Langguth B, Rosner R, Hajak G, Eichhammer P. Cognitive and neurobiological alterations in electromagnetic hypersensitive patients: results of a case-control study. Psychol Med. 38(12):1781-1791, 2008.**

BACKGROUND: Hypersensitivity to electromagnetic fields (EMF) is frequently claimed to be linked to a variety of non-specific somatic and neuropsychological complaints. Whereas provocation studies often failed to demonstrate a causal relationship between EMF exposure and symptom formation, recent studies point to a complex interplay of neurophysiological and cognitive alterations contributing to symptom manifestation in electromagnetic hypersensitive patients (EHS). However, these studies have examined only small sample sizes or have focused on selected aspects. Therefore this study examined in the largest sample of EHS EMF-specific cognitive correlates, discrimination ability and neurobiological parameters in order to get further insight into the pathophysiology of electromagnetic hypersensitivity. METHOD: In a case-control design 89 EHS and 107 age- and gender-matched controls were included in the study. Health status and EMF-specific cognitions were evaluated using standardized questionnaires. Perception thresholds following single transcranial magnetic stimulation (TMS) pulses to the dorsolateral prefrontal cortex were determined using a standardized blinded measurement protocol. Cortical excitability parameters were measured by TMS. RESULTS: Discrimination ability was significantly reduced in EHS (only 40% of the EHS but 60% of the

controls felt no sensation under sham stimulation during the complete series), whereas the perception thresholds for real magnetic pulses were comparable in both groups (median 21% versus 24% of maximum pulse intensity). Intra-cortical facilitation was decreased in younger and increased in older EHS. In addition, typical EMF-related cognitions (aspects of rumination, symptom intolerance, vulnerability and stabilizing self-esteem) specifically differentiated EHS from their controls. CONCLUSIONS: These results demonstrate significant cognitive and neurobiological alterations pointing to a higher genuine individual vulnerability of electromagnetic hypersensitive patients.

**Landgrebe M, Hauser S, Langguth B, Frick U, Hajak G, Eichhammer P. Altered cortical excitability in subjectively electrosensitive patients: results of a pilot study. J Psychosom Res. 62(3):283-288, 2007.**

OBJECTIVE: Hypersensitivity to electromagnetic fields is frequently claimed to be linked to a variety of unspecific somatic and/or neuropsychological complaints. Whereas provocation studies often failed to demonstrate a causal relationship between electromagnetic field exposure and symptom formation, neurophysiological examinations highlight baseline deviations in people claiming to be electrosensitive. METHODS: To elucidate a potential role of dysfunctional cortical regulations in mediating hypersensitivity to electromagnetic fields, cortical excitability parameters were measured by transcranial magnetic stimulation in subjectively electrosensitive patients (n=23) and two control groups (n=49) differing in their level of unspecific health complaints. RESULTS: Electrosensitive patients showed reduced intracortical facilitation as compared to both control groups, while motor thresholds and intracortical inhibition were unaffected. CONCLUSIONS: This pilot study gives additional evidence that altered central nervous system function may account for symptom manifestation in subjectively electrosensitive patients as has been postulated for several chronic multisymptom illnesses sharing a similar clustering of symptoms.

**Landgrebe M, Frick U, Hauser S, Hajak G, Langguth B. Association of tinnitus and electromagnetic hypersensitivity: hints for a shared pathophysiology? PLoS One. 4(3):e5026, 2009.**

BACKGROUND: Tinnitus is a frequent condition with high morbidity and impairment in quality of life. The pathophysiology is still incompletely understood. Electromagnetic fields are discussed to be involved in the multi-factorial pathogenesis of tinnitus, but data proofing this relationship are very limited. Potential health hazards of electromagnetic fields (EMF) have been under discussion for long. Especially, individuals claiming themselves to be electromagnetic hypersensitive suffer from a variety of unspecific symptoms, which they attribute to EMF-exposure. The aim of the study was to elucidate the relationship between EMF-exposure, electromagnetic hypersensitivity and tinnitus using a case-control design. METHODOLOGY: Tinnitus occurrence and tinnitus severity were assessed by questionnaires in 89 electromagnetic hypersensitive patients and 107 controls matched for age-, gender, living surroundings and workplace. Using a logistic regression approach, potential risk factors for the development of tinnitus were evaluated. FINDINGS: Tinnitus was significantly more frequent in the electromagnetic hypersensitive group (50.72% vs. 17.5%) whereas tinnitus duration and severity did not differ between groups. Electromagnetic hypersensitivity and tinnitus were independent risk factors for sleep disturbances. However, measures of individual EMF-exposure like e.g. cell phone use did not show any association with tinnitus. CONCLUSIONS: Our data indicate that tinnitus is associated with subjective electromagnetic hypersensitivity. An individual vulnerability probably due to an over activated cortical distress network seems to be responsible

for, both, electromagnetic hypersensitivity and tinnitus. Hence, therapeutic efforts should focus on treatment strategies (e.g. cognitive behavioral therapy) aiming at normalizing this dysfunctional distress network.

**Leitgeb N, Schröttner J. Electrosensibility and electromagnetic hypersensitivity. Bioelectromagnetics. 24(6):387-394, 2003.**

Electromagnetic sensibility, the ability to perceive electric and electromagnetic exposure, and electromagnetic hypersensitivity (EHS), developing health symptoms due to exposure to environmental electromagnetic fields, need to be distinguished. Increased electrosensibility is a necessary, however, not a sufficient condition for electromagnetic hypersensitivity. At an extended sample of the general population of 708 adults, including 349 men and 359 women aged between 17 and 60 years, electrosensibility was investigated and characterized by perception threshold and its standard deviation. By analyzing the probability distributions of the perception threshold of electric 50 Hz currents, evidence could be found for the existence of a subgroup of people with significantly increased electrosensibility (hypersensibility) who as a group could be differentiated from the general population. The presented data show that the variation of the electrosensibility among the general population is significantly larger than has yet been estimated by nonionizing radiation protection bodies, but much smaller than claimed by hypersensitivity self-aid groups. These quantitative results should contribute to a less emotional discussion of this problem. The investigation method presented, is capable of exclusion diagnostics for persons suffering from the hypersensitivity syndrome.

**Levallois P. Hypersensitivity of human subjects to environmental electric and magnetic field exposure: a review of the literature. Environ Health Perspect. 110 Suppl 4:613-618, 2002.**

Hypersensitivity to exposure to electric and magnetic fields (EMFs) has been reported for nearly 20 years; however, the literature on the subject is still very limited. Nearly all the literature published concerns a dermatological syndrome that consists of mainly subjective symptoms (itching, burning, dryness) and a few objective symptoms (redness, dryness) appearing after individuals begin working with video display units and decreasing during absence from work. Case-control studies as well as some good but limited double-blind trials have not found any clear relationship between this syndrome and exposure to EMFs. A "general syndrome" with more general symptoms has been rarely described but seems to have a worse prognosis. The symptoms often associated with skin disorders are mainly of neurasthenic type and can cover a lot of nonspecific symptoms present in other atypical syndromes such as multiple chemical sensitivity or chronic fatigue. Most of these symptoms are allegedly triggered by exposure to different sources of EMFs, but there have been no valid etiological studies published on this more general syndrome. It appears that the so-called hypersensitivity to environmental electric and magnetic fields is an unclear health problem whose nature has yet to be determined.

**Levallois P, Neutra R, Lee G, Hristova L. Study of self-reported hypersensitivity to electromagnetic fields in California. Environ Health Perspect. 110 Suppl 4:619-623, 2002.**

Cases of alleged hypersensitivity to electromagnetic fields (EMFs) have been reported for more than 20 years, and some authors have suggested some connection with the "multiple chemical sensitivity" illness. We report the results of a telephone survey among a sample of 2,072 Californians. Being "allergic or very sensitive" to being near electrical devices was reported by 68 subjects, resulting in an adjusted prevalence of 3.2% (95% confidence interval = 2.8, 3.7).

Twenty-seven subjects (1.3%) reported sensitivity to electrical devices but no sensitivity to chemicals. Characteristics of the people reporting hypersensitivity to EMFs were generally different from those of people reporting being allergic to everyday chemicals. Alleging environmental illness or multiple chemical sensitivity diagnosed by a doctor was the strongest predictor of reporting being hypersensitive to EMFs in this population. Other predictive factors apart from self-reporting chemical sensitivity were race/ethnicity other than White, Black, or Hispanic; having low income; and being unable to work. The perception of risk of exposure to EMFs through the use of hair dryers (vs. exposure to power and distribution lines) was the factor the most associated with self-reporting about hypersensitivity to EMFs. However, risk perception was not sufficient to explain the characteristics of people reporting this disorder.

**Lidén S, Reizenstein P, Sedvall G, Ehn L. [A study and treatment of a group of patients with electro-hypersensitivity. More than half of the patients were able to return to work]. Lakartidningen. 93(23):2265-2268, 1996.** [Article in Swedish] (no abstract available)

**Lonne-Rahm S, Andersson B, Melin L, Schultzberg M, Arnetz B, Berg M. Provocation with stress and electricity of patients with "sensitivity to electricity". J Occup Environ Med. 42(5):512-516, 2000.**

Twenty-four patients with self-reported "sensitivity to electricity" were divided into two groups and tested in a double-blind provocation study. These patients, who reported increased skin symptoms when exposed to electromagnetic fields, were compared with 12 age- and sex-matched controls. Both groups were exposed to 30-minute periods of high or low stress situations, with and without simultaneous exposure to electromagnetic fields from a visual display unit. The matched controls were tested twice and given the same exposure as the patients but had the fields turned on every time. Stress was induced by requiring the participants to act in accordance with a random sequence of flashing lights while simultaneously solving complicated mathematical problems. Blood samples were analyzed for levels of the stress-related hormones melatonin, prolactin, adrenocorticotrophic hormone, neuropeptide Y, and growth hormone, and the expression of different peptides, cellular markers, and cytokines (somatostatin, CD1, factor XIIIa, and tumor necrosis factor-alpha). Skin biopsies were also analyzed for the occurrence of mast cells. Stress provocation resulted in feelings of more intense mental stress and elevated heart rate. The patients reported increased skin symptoms when they knew or believed that the electromagnetic field was turned on. With the blind conditions there were no differences between "on" or "off." Inflammatory mediators and mast cells in the skin were not affected by the stress exposure or by exposure to electromagnetic fields. The main conclusion was that the patients did not react to the fields.

**Lyskov E, Sandström M, Hansson Mild K. Neurophysiological study of patients with perceived 'electrical hypersensitivity'. Int J Psychophysiol. 42(3):233-241, 2001.**

The aim of the present study was to investigate baseline neurophysiological characteristics of the central and autonomous regulation and their reactivity to different tests in a group of persons with so-called 'electrical hypersensitivity', which is often considered as a form of psychosomatic disorders. Twenty patients with combinations of neuroasthenic symptoms (general fatigue, weakness, dizziness, headache) and facial skin (itching, tingling, redness) have been

investigated. An equal number of symptom-free persons served as a control group. The examination comprised self-reported measures, testing of visual functions, measurements of blood pressure, heart rate and its variability, electrodermal activity, respiration, EEG and visual evoked potentials (VEP). Several variables were found to differ between the patient and the control groups. The mean value of heart rate in rest condition was higher in the patient group compared to the controls (mean value of inter-beat intervals were 0.80 and 0.90 s, respectively). Heart rate variability and response to standing test were decreased in the patient group compared to the controls. Patients had faster onset, higher amplitudes, and left-right hand asymmetry of the sympathetic skin responses. They had a higher critical fusion frequency (43 vs. 40 Hz), and a trend to increased amplitude of steady-state VEPs at stimulation frequencies of 30-70 Hz. The data indicated that the observed group of patients had a trend to hyper sympathotone, hyperresponsiveness to sensor stimulation and heightened arousal.

**Lyskov E, Sandström M, Mild KH. Provocation study of persons with perceived electrical hypersensitivity and controls using magnetic field exposure and recording of electrophysiological characteristics. Bioelectromagnetics. 22(7):457-462, 2001.**

The aim of the present study was to investigate possible neurophysiological effects of intermittent 15 sec on/off cycle, 60 Hz, 10 microT magnetic field exposure on patients with perceived "electromagnetic hypersensitivity" (EHS), and control subjects during rest and performance of a mental arithmetic task. Twenty participants (15 female, 5 male, 31-60 years old, mean 45.8 +/- 0.7 years) were invited from the group of EHS patients. Twenty volunteers (15 female, 5 male, 31-59 years old, mean 45.0 +/- 0.7 years?) served as a control group. The test protocol consisted of a set of examinations: EEG, visual evoked potentials, electrodermal activity, ECG, and blood pressure. The total duration of the test was 40 min, divided into two 10 min rest periods and two 10 min periods of mathematical performance. Magnetic field and sham exposures were presented randomly during these periods, resulting in four different conditions: Field-Rest, Sham-Rest, Field-Math, and Sham-Math. The data showed significant main effects of the Group factor (EHS vs. control subjects) on heart rate ($F(1,80) = 20.6$; $P < 0.01$), heart rate spectrum ratio ($F(1,80) = 9.5$; $P = 0.02$), and electrodermal activity ($F(1,76) = 4.2$; $P = 0.04$), whereas EEG characteristics did not differ between groups. The Condition factor (mathematical task vs. relaxed) showed main effects for heart rate ($F(1,80) = 14.8$; $P < 0.01$), heart rate spectrum ratio ($F(1,80) = 7.8$; $P = 0.06$), electrodermal activity ($F(1,76) = 56.8$; $P < 0.01$), and alpha and theta spectral bands of EEG. Magnetic field exposure did not affect autonomous system or electroencephalographic variables of either group. These data do not indicate that EHS patients or control are affected by low-level 60 Hz magnetic field exposure. However, persons reporting EHS differed from the control subjects in baseline values of investigated physiological characteristics. Perhaps EHS patients have a rather distinctive physiological predisposition to sensitivity to physical and psychosocial environmental stressors.

**Manjunatha N, Jayaram N, Benegal V, Murthy P. Idiopathic environmental intolerance (electromagnetic hypersensitivity syndrome). Natl Med J India. 24(5):314, 2011. (Correspondence, no abstract available)**

**Markovà E, Hillert L, Malmgren L, Persson BR, Belyaev IY. Microwaves from GSM mobile telephones affect 53BP1 and gamma-H2AX foci in human lymphocytes from hypersensitive and healthy persons. Environ Health Perspect. 113(9):1172-1177, 2005.**

The data on biologic effects of nonthermal microwaves (MWs) from mobile telephones are diverse, and these effects are presently ignored by safety standards of the International Commission for Non-Ionizing Radiation Protection (ICNIRP). In the present study, we

investigated effects of MWs of Global System for Mobile Communication (GSM) at different carrier frequencies on human lymphocytes from healthy persons and from persons reporting hypersensitivity to electromagnetic fields (EMFs). We measured the changes in chromatin conformation, which are indicative of stress response and genotoxic effects, by the method of anomalous viscosity time dependence, and we analyzed tumor suppressor p53-binding protein 1 (53BP1) and phosphorylated histone H2AX (gamma-H2AX), which have been shown to colocalize in distinct foci with DNA double-strand breaks (DSBs), using immunofluorescence confocal laser microscopy. We found that MWs from GSM mobile telephones affect chromatin conformation and 53BP1/gamma-H2AX foci similar to heat shock. For the first time, we report here that effects of MWs from mobile telephones on human lymphocytes are dependent on carrier frequency. On average, the same response was observed in lymphocytes from hypersensitive and healthy subjects.

**McCarty DE, Carrubba S, Chesson AL, Frilot C, Gonzalez-Toledo E, Marino AA. Electromagnetic hypersensitivity: evidence for a novel neurological syndrome. Int J Neurosci. 121(12):670-676, 2011.**

OBJECTIVE: We sought direct evidence that acute exposure to environmental-strength electromagnetic fields (EMFs) could induce somatic reactions (EMF hypersensitivity). METHODS: The subject, a female physician self-diagnosed with EMF hypersensitivity, was exposed to an average (over the head) 60-Hz electric field of 300 V/m (comparable with typical environmental-strength EMFs) during controlled provocation and behavioral studies. RESULTS: In a double-blinded EMF provocation procedure specifically designed to minimize unintentional sensory cues, the subject developed temporal pain, headache, muscle twitching, and skipped heartbeats within 100 s after initiation of EMF exposure ($p < .05$). The symptoms were caused primarily by field transitions (off-on, on-off) rather than the presence of the field, as assessed by comparing the frequency and severity of the effects of pulsed and continuous fields in relation to sham exposure. The subject had no conscious perception of the field as judged by her inability to report its presence more often than in the sham control. DISCUSSION: The subject demonstrated statistically reliable somatic reactions in response to exposure to subliminal EMFs under conditions that reasonably excluded a causative role for psychological processes. CONCLUSION: EMF hypersensitivity can occur as a bona fide environmentally inducible neurological syndrome.

**Medeiros LN, Sanchez TG. Tinnitus and cell phones: the role of electromagnetic radiofrequency radiation. Brazilian Journal of Otorhinolaryngology. 82(1):97-104.January–February 2016. doi:10.1016/j.bjorl.2015.04.013**

Introduction Tinnitus is a multifactorial condition and its prevalence has increased on the past decades. The worldwide progressive increase of the use of cell phones has exposed the peripheral auditory pathways to a higher dose of electromagnetic radiofrequency radiation (EMRFR). Some tinnitus patients report that the abusive use of mobiles, especially when repeated in the same ear, might worsen ipsilateral tinnitus. Objective The aim of this study was to evaluate the available evidence about the possible causal association between tinnitus and exposure to electromagnetic waves. Methods A literature review was performed searching for the following keywords: tinnitus, electromagnetic field, mobile phones, radio frequency, and electromagnetic hypersensitivity. We selected 165 articles that were considered clinically relevant in at least one of the subjects. Results EMRFR can penetrate exposed tissues and safety exposure levels have been established. These waves provoke proved thermogenic effects and potential biological and genotoxic effects. Some individuals are more sensitive to

electromagnetic exposure (electrosensitivity), and thus, present earlier symptoms. There may be a common pathophysiology between this electrosensitivity and tinnitus. Conclusion There are already reasonable evidences to suggest caution for using mobile phones to prevent auditory damage and the onset or worsening of tinnitus.

**Meg Tseng MC, Lin YP, Cheng TJ. Prevalence and psychiatric comorbidity of self-reported electromagnetic field sensitivity in Taiwan: a population-based study. J Formos Med Assoc. 110(10):634-641, 2011.**

**BACKGROUND/PURPOSE:** Psychological factors have been implicated in the etiology of idiopathic environmental illness in many studies. Few studies have ever reported psychiatric morbidity among individuals with electromagnetic hypersensitivity. We aimed to estimate the prevalence and identify the associated factors of self-reported electromagnetic field sensitivity (SREMFS) in adults of Taiwan. **METHODS:** A total of 1251 adults selected from a nationwide Computer-Assisted Telephone Interviewing system received a telephone survey about the perception of risk from various environmental agents and their effects on health and well-being. **RESULTS:** The estimated prevalence of people with SREMFS was 13.3 % (95% confidence interval: 11.2-15.3). People aged >65 years were associated with a lower risk of reporting sensitivity to electromagnetic fields, whereas people with a very poor self-reported health status, those who were unable to work, and those who had psychiatric morbidity were associated with a higher risk of having SREMFS. **CONCLUSION:** The prevalence of SREMFS in the general population of Taiwan is higher than that reported in western countries. People with psychiatric morbidity are more likely to report sensitivity to electromagnetic fields. The cross-sectional design precludes the causal inference of all identified correlates and electromagnetic field sensitivity.

**Mortazavi SM, Ahmadi J, Shariati M. Prevalence of subjective poor health symptoms associated with exposure to electromagnetic fields among university students. Bioelectromagnetics. 28(4):326-330, 2007.** Erratum in Bioelectromagnetics. 28(5):392, 2007.

The number of people complaining about different symptoms that may be associated with exposure to electromagnetic fields (EMF) has increased rapidly during past years. Students use both mobile phones and video display terminals frequently. The purpose of this study was to investigate the association of mobile phone use and EMF health hazards. Basic demographic data and self-reported symptoms were sought using a questionnaire administered to all apparently healthy students at Rafsanjan University of Medical Sciences (RUMS) and Vali-e-Asr University (VAU). Questions about some major confounding factors such as age, gender, amount of video display terminal work were also included. Exact Fischer Test was used for data analysis. Among self-reported symptoms, headache (53.5%), fatigue (35.6%), difficulties in concentration (32.5%), vertigo/dizziness (30.4%), attention disorders (28.8%), nervousness (28.1%), palpitation (14.7%), low back pain (14.3%), myalgia (12.4%), and tinnitus (9.9%) were the main self-reported symptoms. No significant differences in the prevalence of these symptoms were found between CRT users and those who did not use CRTs. A significant association was found between cordless phone use and difficulties in concentration ($P < .05$) or attention disorders ($P < .05$). However, after correction of the gender role, these differences were not significant. No association was found between mobile phone use and the above-mentioned symptoms. No significantly higher prevalence of self-reported symptoms was found in individuals who had used mobile phones, video display terminals or cordless phones more frequently than others. Mass-media's lack of interest in the possible hazards of exposure to EMF in developing countries can explain the difference observed between the results of this study and those of other researchers in some developed countries who have shown an

association between EMF exposure and the prevalence of self-reported subjective symptoms. This finding can confirm the results obtained in provocative studies which indicated the role of psychological factors in electromagnetic hypersensitivity. More research is needed to clarify whether daily environmental EMF may cause health problems.

**Mortazavi SM, Mahbudi A, Atefi M, Bagheri Sh, Bahaedini N, Besharati A. An old issue and a new look: electromagnetic hypersensitivity caused by radiations emitted by GSM mobile phones. Technol Health Care. 19(6):435-443, 2011.**

University students use mobile phones frequently. We previously showed that there was no association between mobile phone use and EMF health hazards among university students. As our previous study was based only on self-reported symptoms this double-blind study was designed to answer two basic questions. Firstly, are self-reported hypersensitive individuals capable of sensing whether there is a real/sham microwave exposure? Secondly, do hypersensitive patients show alterations in their biological parameters such as heart rate, respiration, and blood pressure during microwave exposure? The study consisted of a preliminary screening phase and two subsequent complementary phases. In the 1st phase, 700 students were screened for EMF hypersensitivity. Fifty two participants were hypersensitive individuals but after applying the exclusion criteria only 28 students were invited to take part in the 2nd and 3rd phase of the study, but only 20 students (71.4%) declared their informed consent. In the 2nd phase, these self reported hypersensitive participants, were exposed/sham exposed to microwave radiation emitted from a mobile phone for 10 minutes and they were asked if they could sense the existence of microwave radiation. In the 3rd phase, all students were connected to ICU monitoring devices and their basic physiological parameters were recorded precisely. Among self-reported symptoms reported in our previous study, in this study only problem in concentration ($P < 0.05$) and low back pain ($P < 0.05$) were associated with mobile phone use. Furthermore, there was a significant association between the location of mobile phone during talk and the overall score of the severity of the symptoms ($P < 0.001$). When the participants were asked to report their perception about the real and sham exposures, only 5 students (25%) could discriminate the real exposure/sham exposure phases. This relative frequency can be only due to chance. In the 3rd phase all of the 20 participants were connected to intensive care unit monitors and the changes in their heart rate, respiration, and blood pressure during real/sham exposure were recorded. No statistically significant changes between the means of these parameters in real/sham exposure were observed. Our findings clearly confirm the results obtained in other provocative studies. These data also indicate the possible role of psychological factors in electromagnetic hypersensitivity.

**Mueller CH, Krueger H, Schierz C. Project NEMESIS: perception of a 50 Hz electric and magnetic field at low intensities (laboratory experiment). Bioelectromagnetics. 23(1):26-36, 2002.**

The Electrical Hypersensitivity Syndrome (EHS) is a condition where people suffer from various nonspecific health symptoms attributed to an assumed adverse effect of electric and magnetic fields (EMF). Many EHS patients report the ability to consciously perceive EMF at very low intensities. The existence of a direct EMF perception could be the key to explain at least partially the aetiology of EHS through stress mechanisms and allow the comparison with well known environmental stressors such as noise or odor. The double blind laboratory experiment tested the hypothesis that there are subjects with the ability to perceive 50 Hz EMF at 100 V/m and 6 microT (EMF sensitive) and to investigate the prevalence of EMF sensitivity in a group consisting of subjects with or without self-reported EHS. A total of 63 volunteers, 49 with EHS

and 14 controls, took part in the EMF perception experiment, where 10 sham and 10 exposed 2 min blocks had to be judged in randomized sequence (field on/field off). Seven out of 63 subjects reached a statistically significant result which points to the existence of a small EMF sensitive subgroup within the study group. There was no relevant difference between the subjects with self reported EHS and those without in terms of the success rate in the field perception experiment, as well as the number and types of symptoms encountered during the test. The results of the EMF perception experiment suggest that EHS is not a prerequisite for the ability to consciously perceive weak EMF and vice versa.

**Nam KC, Kim SW, Kim SC, Kim DW. Effects of RF exposure of teenagers and adults by CDMA cellular phones. Bioelectromagnetics. 27(7):509-514, 2006.**

Many cellular phone provocation studies have been conducted since the question of increased health risk from extended usage of cellular phones became a social issue. Internationally, most studies have been conducted regarding the effects of GSM cellular phones on blood pressure and heart rate of adult volunteers. On the other hand, very few provocation studies have been conducted regarding the physiological effects of CDMA phones on teenagers. In this study, two volunteer groups consisting of 21 teenagers and 21 adults were exposed to 300 mW of radio frequency (RF) electromagnetic field emitted by a CDMA cellular phone for half an hour. Physiological parameters such as systolic and diastolic blood pressures, heart rate, respiration rate, and skin resistance were simultaneously measured. All the parameters for both groups were unaffected during the exposure except for decreased skin resistance of the teenager group ($P < .0001$). For the regrouped 23 male and 19 female subjects, all the parameters for both groups were unaffected during the exposure except for decreased skin resistance of the male subjects ($P = .0026$). Those resistances at 10 min after the terminated exposure returned to the resistances at rest regardless of the different groups of age and sex.

**Nam KC, Lee JH, Noh HW, Cha EJ, Kim NH, Kim DW. Hypersensitivity to RF fields emitted from CDMA cellular phones: a provocation study. Bioelectromagnetics. 30(8):641-650, 2009.**

With the number of cellular phone users rapidly increasing, there is a considerable amount of public concern regarding the effects that electromagnetic fields (EMFs) from cellular phones have on health. People with self-attributed electromagnetic hypersensitivity (EHS) complain of subjective symptoms such as headaches, insomnia, and memory loss, and attribute these symptoms to radio frequency (RF) radiation from cellular phones and/or base stations. However, EHS is difficult to diagnose because it relies on a person's subjective judgment. Various provocation studies have been conducted on EHS caused by Global System for Mobile Communications (GSM) phones in which heart rate and blood pressure or subjective symptoms were investigated. However, there have been few sham-controlled provocation studies on EHS with Code Division Multiple Access (CDMA) phones where physiological parameters, subjective symptoms, and perception of RF radiation for EHS and non-EHS groups were simultaneously investigated. In this study, two volunteer groups of 18 self-reported EHS and 19 non-EHS persons were tested for both sham and real RF exposure from CDMA cellular phones with a 300 mW maximum exposure that lasted half an hour. We investigated not only the physiological parameters such as heart rate, respiration rate, and heart rate variability (HRV), but also various subjective symptoms and the perception of EMF. In conclusion, RF exposure did not have any effects on physiological parameters or subjective symptoms in either group. As for EMF perception, there was no evidence that the EHS group better perceived EMF than the non-EHS group.

**Nam KC, Choi JL, Kwon MK, Jang KH, Kim DW. Physiological variables and subjective symptoms by 60 Hz magnetic field in EHS and non-EHS persons. Conf Proc IEEE Eng Med Biol Soc. 2011:1925-1928, 2011.**

Electromagnetic hypersensitivity (EHS) is a set of claims of adverse medical symptoms self attributed by exposure to electromagnetic field. In this study, we simultaneously investigated both physiological changes (heart rate, respiration rate, and heart rate variability) and subjective symptoms to determine the origin of EHS. Two volunteer groups (15 self-reported EHS and 16 non-EHS participants) were tested under both sham and real exposure to 12.5 μT magnetic fields at 60 Hz that lasted a half an hour. The magnetic field exposure did not have any effect on physiological variables or subjective symptoms in either group. We conclude that the subjective symptoms did not result from exposure to 12.5 μT magnetic field at 60 Hz.

**Nieto-Hernandez R, Rubin GJ, Cleare AJ, Weinman JA, Wessely S. Can evidence change belief? Reported mobile phone sensitivity following individual feedback of an inability to discriminate active from sham signals. J Psychosom Res. 65(5):453-460, 2008.**

OBJECTIVE: In this study, we tested whether providing individuals, who described being sensitive to mobile phone signals, with accurate feedback about their ability to discriminate an active mobile phone signal from a sham signal had any impact on their subsequent symptom levels or their perceived sensitivity to mobile phones. METHODS: Sixty-nine participants who reported sensitivity to mobile phones took part in a double-blind, placebo-controlled provocation study. Perceived sensitivity to mobile phones was assessed using a version of the Sensitive Soma Assessment Scale (SSAS) and the severity of any symptoms attributed to mobile phones was recorded. Both the overall ("negative") findings of the provocation study and the participant's own individual results (''correct'' or ''incorrect'' at detecting a mobile phone signal) were then described to them. Six months later, perceived sensitivity and symptom severity were measured again. RESULTS: Fifty-eight participants (84%) received feedback and participated in the 6-month follow-up. No significant differences in SSAS scores or in symptom severity scores were found between individuals told that they were correct (n=31) or incorrect (n=27) in their ability to detect mobile phone signals in the provocation study. CONCLUSION: The provision of accurate feedback was insufficient to change attributions or reduce symptoms in this study. However, an overtly negative reaction to feedback was not observed among most participants, and some participants were willing to consider that factors other than electromagnetic field may be relevant in causing or exacerbating their symptoms. Discussing possible psychological factors with electromagnetic hypersensitivity patients may be beneficial for some.

**Nordin S, Neely G, Olsson D, Sandström M. Odor and Noise Intolerance in Persons with Self-Reported Electromagnetic Hypersensitivity. Int J Environ Res Public Health. 11(9):8794-8805, 2014.**

Lack of confirmation of symptoms attributed to electromagnetic fields (EMF) and triggered by EMF exposure has highlighted the role of individual factors. Prior observations indicate intolerance to other types of environmental exposures among persons with electromagnetic hypersensitivity (EHS). This study assessed differences in odor and noise intolerance between persons with EHS and healthy controls by use of subscales and global measures of the Chemical Sensitivity Scale (CSS) and the Noise Sensitivity Scale (NSS). The EHS group scored significantly higher than the controls on all CSS and NSS scales. Correlation coefficients between CSS and NSS scores ranged from 0.60 to 0.65 across measures. The findings suggest an association between EHS and odor and noise intolerance, encouraging further investigation of individual factors for understanding EMF-related symptoms.

**Redmayne M, Johansson O. Could myelin damage from radiofrequency electromagnetic field exposure help explain the functional impairment electrohypersensitivity? A review of the evidence. J Toxicol Environ Health B Crit Rev. 17(5):247-258, 2014.**

Myelin provides the electrical insulation for the central and peripheral nervous system and develops rapidly in the first years of life, but continues into mid-life or later. Myelin integrity is vital to healthy nervous system development and functioning. This review outlines the development of myelin through life, and then considers the evidence for an association between myelin integrity and exposure to low-intensity radiofrequency electromagnetic fields (RF-EMFs) typical in the modern world. In RF-EMF peer-reviewed literature examining relevant impacts such as myelin sheath, multiple sclerosis, and other myelin-related diseases, cellular examination was included. There are surprisingly little data available in each area, but considered together a picture begins to emerge in RF-EMF-exposed cases: (1) significant morphological lesions in the myelin sheath of rats; (2) a greater risk of multiple sclerosis in a study subgroup; (3) effects in proteins related to myelin production; and (4) physical symptoms in individuals with functional impairment electrohypersensitivity, many of which are the same as if myelin were affected by RF-EMF exposure, giving rise to symptoms of demyelination. In the latter, there are exceptions; headache is common only in electrohypersensitivity, while ataxia is typical of demyelination but infrequently found in the former group. Overall, evidence from in vivo and in vitro and epidemiological studies suggests an association between RF-EMF exposure and either myelin deterioration or a direct impact on neuronal conduction, which may account for many electrohypersensitivity symptoms. The most vulnerable are likely to be those in utero through to at least mid-teen years, as well as ill and elderly individuals.

**Regel SJ, Negovetic S, Röösli M, Berdiñas V, Schuderer J, Huss A, Lott U, Kuster N, Achermann P. UMTS base station-like exposure, well-being, and cognitive performance. Environ Health Perspect. 114(8):1270-1275, 2006.**

BACKGROUND: Radio-frequency electromagnetic fields (RF EMF) of mobile communication systems are widespread in the living environment, yet their effects on humans are uncertain despite a growing body of literature. OBJECTIVES: We investigated the influence of a Universal Mobile Telecommunications System (UMTS) base station-like signal on well-being and cognitive performance in subjects with and without self-reported sensitivity to RF EMF. METHODS: We performed a controlled exposure experiment (45 min at an electric field strength of 0, 1, or 10 V/m, incident with a polarization of 45 degrees from the left back side of the subject, weekly intervals) in a randomized, double-blind crossover design. A total of 117 healthy subjects (33 self-reported sensitive, 84 nonsensitive subjects) participated in the study. We assessed well-being, perceived field strength, and cognitive performance with questionnaires and cognitive tasks and conducted statistical analyses using linear mixed models. Organ-specific and brain tissue-specific dosimetry including uncertainty and variation analysis was performed. RESULTS: In both groups, well-being and perceived field strength were not associated with actual exposure levels. We observed no consistent condition-induced changes in cognitive performance except for two marginal effects. At 10 V/m we observed a slight effect on speed in one of six tasks in the sensitive subjects and an effect on accuracy in another task in nonsensitive subjects. Both effects disappeared after multiple end point adjustment. CONCLUSIONS: In contrast to a recent Dutch study, we could not confirm a short-term effect of UMTS base station-like exposure on well-being. The reported effects on brain functioning were marginal and may have occurred by chance. Peak spatial absorption in brain tissue was considerably smaller than during use of a mobile phone. No conclusions can be drawn

regarding short-term effects of cell phone exposure or the effects of long-term base station-like exposure on human health.

**Riddervold IS, Pedersen GF, Andersen NT, Pedersen AD, Andersen JB, Zachariae R, Mølhave L, Sigsgaard T, Kjaergaard SK. Cognitive function and symptoms in adults and adolescents in relation to rf radiation from UMTS base stations. Bioelectromagnetics. 29(4):257-267, 2008.**

There is widespread public concern about the potential adverse health effects of mobile phones in general and their associated base stations in particular. This study was designed to investigate the acute effects of radio frequency (RF) electromagnetic fields (EMF) emitted by the Universal Mobile Telecommunication System (UMTS) mobile phone base stations on human cognitive function and symptoms. Forty adolescents (15-16 years) and 40 adults (25-40 years) were exposed to four conditions: (1) sham, (2) a Continuous Wave (CW) at 2140 MHz, (3) a signal at 2140 MHz modulated as UMTS and (4) UMTS at 2140 MHz including all control features in a randomized, double blinded cross-over design. Each exposure lasted 45 min. During exposure the participants performed different cognitive tasks with the Trail Making B (TMB) test as the main outcome and completed a questionnaire measuring self reported subjective symptoms. No statistically significant differences between the UMTS and sham conditions were found for performance on TMB. For the adults, the estimated difference between UMTS and sham was -3.2% (-9.2%; 2.9%) and for the adolescents 5.5% (-1.1%; 12.2%). No significant changes were found in any of the cognitive tasks. An increase in 'headache rating' was observed when data from the adolescents and adults were combined (P = 0.027), an effect that may be due to differences at baseline. In conclusion, the primary hypothesis that UMTS radiation reduces general performance in the TMB test was not confirmed. However, we suggest that the hypothesis of subjective symptoms and EMF exposure needs further research.

**Röösli M, Moser M, Baldinini Y, Meier M, Braun-Fahrländer C. Symptoms of ill health ascribed to electromagnetic field exposure--a questionnaire survey. Int J Hyg Environ Health. 207(2):141-150, 2004.**

From June 2001, health questionnaires were distributed to people who complained about symptoms of ill health which they ascribed to exposure to electromagnetic fields (EMF). The objective of the survey was to gain a better knowledge of the anxieties of complainants, to obtain hints of possible problems and of actions that should be taken to solve the problems. The survey was not designed to establish a causal association between exposure to EMF and symptoms of ill health. Within one year, 429 questionnaires were returned of which 394 persons reported symptoms. The average age of the complainants was 51.0 years and 57 percent were female. The complainants were older, had a higher educational level and were more likely to be married compared to the general Swiss population. A mean of 2.7 different symptoms were reported. Sleep disorders (58%), headaches (41%), nervousness or distress (19%), fatigue (18%), and concentration difficulties (16%) were most common complaints. Complainants related their symptoms most frequently to exposure to mobile phone base stations (74%), followed by mobile phones (36%), cordless phones (29%) and power lines (27%). No distinct symptoms related to a specific field source could be identified. Eighty-five percent of the people who consulted a public authority because of their symptoms were unsatisfied with the response, whereas consultation of self-help groups or building ecologists usually fulfilled expectations. Two thirds of complainants had taken some action to reduce their symptoms. The most

common measure was to avoid exposure if possible. Removing or disconnecting indoor sources was judged to be the most effective action.

**Röösli M. Radiofrequency electromagnetic field exposure and non-specific symptoms of ill health: a systematic review. Environ Res. 107(2):277-287, 2008.**

This article is a systematic review of whether everyday exposure to radiofrequency electromagnetic field (RF-EMF) causes symptoms, and whether some individuals are able to detect low-level RF-EMF (below the ICNIRP [International Commission on Non-Ionizing Radiation Protection] guidelines). Peer-reviewed articles published before August 2007 were identified by means of a systematic literature search. Meta-analytic techniques were used to pool the results from studies investigating the ability to discriminate active from sham RF-EMF exposure. RF-EMF discrimination was investigated in seven studies including a total of 182 self-declared electromagnetic hypersensitive (EHS) individuals and 332 non-EHS individuals. The pooled correct field detection rate was 4.2% better than expected by chance (95% CI: -2.1 to 10.5). There was no evidence that EHS individuals could detect presence or absence of RF-EMF better than other persons. There was little evidence that short-term exposure to a mobile phone or base station causes symptoms based on the results of eight randomized trials investigating 194 EHS and 346 non-EHS individuals in a laboratory. Some of the trials provided evidence for the occurrence of nocebo effects. In population based studies an association between symptoms and exposure to RF-EMF in the everyday environment was repeatedly observed. This review showed that the large majority of individuals who claims to be able to detect low level RF-EMF are not able to do so under double-blind conditions. If such individuals exist, they represent a small minority and have not been identified yet. The available observational studies do not allow differentiating between biophysical from EMF and nocebo effects.

**Röösli M, Moser M, Baldinini Y, Meier M, Braun-Fahrländer C. Symptoms of ill health ascribed to electromagnetic field exposure--a questionnaire survey. Int J Hyg Environ Health. 207(2):141-150, 2004.**

From June 2001, health questionnaires were distributed to people who complained about symptoms of ill health which they ascribed to exposure to electromagnetic fields (EMF). The objective of the survey was to gain a better knowledge of the anxieties of complainants, to obtain hints of possible problems and of actions that should be taken to solve the problems. The survey was not designed to establish a causal association between exposure to EMF and symptoms of ill health. Within one year, 429 questionnaires were returned of which 394 persons reported symptoms. The average age of the complainants was 51.0 years and 57 percent were female. The complainants were older, had a higher educational level and were more likely to be married compared to the general Swiss population. A mean of 2.7 different symptoms were reported. Sleep disorders (58%), headaches (41%), nervousness or distress (19%), fatigue (18%), and concentration difficulties (16%) were most common complaints. Complainants related their symptoms most frequently to exposure to mobile phone base stations (74%), followed by mobile phones (36%), cordless phones (29%) and power lines (27%). No distinct symptoms related to a specific field source could be identified. Eighty-five percent of the people who consulted a public authority because of their symptoms were unsatisfied with the response, whereas consultation of self-help groups or building ecologists usually fulfilled expectations. Two thirds of complainants had taken some action to reduce their symptoms. The most common measure was to avoid exposure if possible. Removing or disconnecting indoor sources was judged to be the most effective action.

**Rubin GJ, Das Munshi J, Wessely S. Electromagnetic hypersensitivity: a systematic review of provocation studies. Psychosom Med. 67(2):224-232, 2005.**

OBJECTIVES: The objectives of this study were to assess whether people who report hypersensitivity to weak electromagnetic fields (EMFs) are better at detecting EMF under blind or double-blind conditions than nonhypersensitive individuals, and to test whether they respond to the presence of EMF with increased symptom reporting. METHODS: An extensive systematic search was used to identify relevant blind or double-blind provocation studies. This involved searching numerous literature databases and conference proceedings, and examining the citations of reviews and included studies. The results of relevant studies were tabulated and metaanalyses were used to compare the proportions of "hypersensitive" and control participants able to discriminate active from sham EMF exposures. RESULTS: Thirty-one experiments testing 725 "electromagnetically hypersensitive" participants were identified. Twenty-four of these found no evidence to support the existence of a biophysical hypersensitivity, whereas 7 reported some supporting evidence. For 2 of these 7, the same research groups subsequently tried and failed to replicate their findings. In 3 more, the positive results appear to be statistical artefacts. The final 2 studies gave mutually incompatible results. Our metaanalyses found no evidence of an improved ability to detect EMF in "hypersensitive" participants. CONCLUSIONS: The symptoms described by "electromagnetic hypersensitivity" sufferers can be severe and are sometimes disabling. However, it has proved difficult to show under blind conditions that exposure to EMF can trigger these symptoms. This suggests that "electromagnetic hypersensitivity" is unrelated to the presence of EMF, although more research into this phenomenon is required.

**Rubin GJ, Das Munshi J, Wessely S. A systematic review of treatments for electromagnetic hypersensitivity. Psychother Psychosom. 75(1):12-18, 2006.**

BACKGROUND: Electromagnetic hypersensitivity (EHS) is a poorly understood condition in which patients report symptoms following perceived exposure to weak electromagnetic fields (EMFs) such as those produced by mobile phones or visual display units. Little is known about the aetiology of the condition although experimental data suggest that EMFs are an unlikely causal agent. In this systematic review we assessed the efficacy of any treatment for people reporting EHS. METHODS: Twelve literature databases were examined to identify relevant studies. We also hand-searched conference proceedings and examined the reference sections of reviews and other papers. Only clinical trials that compared the efficacy of a potential treatment for EHS against a control condition were included in the review. RESULTS: Nine controlled clinical trials were identified, examining the effects of cognitive behavioural therapy (4 studies), visual display unit screen filters (2 studies), 'shielding' EMF emitters (1 study), supplementary antioxidant therapy (1 study) and acupuncture (1 study). The quality of these studies was limited. Nevertheless, their results suggest that cognitive behavioural therapy is more effective than providing no treatment. None of the other therapies have had their efficacy adequately demonstrated. CONCLUSIONS: The evidence base concerning treatment options for EHS is limited and more research is needed before any definitive clinical recommendations can be made. However, the best evidence currently available suggests that cognitive behavioural therapy is effective for patients who report being hypersensitive to weak EMFs.

**Rubin GJ, Cleare AJ, Wessely S. Psychological factors associated with self-reported sensitivity to mobile phones. J Psychosom Res. 64(1):1-9; discussion 11-12, 2008**

OBJECTIVE: Some people report symptoms associated with mobile phone use. A minority also report "electrosensitivity," experiencing symptoms following exposure to other electrical devices. Research suggests that electromagnetic fields do not trigger these symptoms. In this study, we examined the differences between these two "sensitive" groups and healthy controls. METHODS: Fifty-two people who reported sensitivity to mobile phones, 19 people who reported sensitivity to mobile phones and "electrosensitivity," and 60 nonsensitive controls completed a questionnaire assessing the following: primary reason for using a mobile phone, psychological health, symptoms of depression, modern health worries (MHW), general health status, symptom severity, and the presence of other medically unexplained syndromes. RESULTS: Perceived sensitivity was associated with an increased likelihood of using a mobile phone predominantly for work (3% of controls, 13% of those sensitive to mobile phones, and 21% of those reporting "electrosensitivity") and greater MHW concerning radiation [mean (S.D.) on a scale of 1-5: 2.0 (1.0), 2.7 (0.9), and 4.0 (0.8), respectively]. Participants who reported "electrosensitivity" also experienced greater depression, greater worries about tainted food and toxic interventions, worse general health on almost every measure, and a greater number of other medically unexplained syndromes compared to participants from the other two groups. No group differences were observed with regards to psychiatric cases. CONCLUSIONS: The data illustrate that patients reporting "electrosensitivity" experience substantially worse health than either healthy individuals or people who report sensitivity to mobile phones but who do not adopt the label "electrosensitivity." Clinicians and researchers would be wise to pay greater attention to this subdivision**.**

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

Idiopathic Environmental Intolerance attributed to electromagnetic fields (IEI-EMF; formerly 'electromagetic hypersensitivity') is a medically unexplained illness in which subjective symptoms are reported following exposure to electrical devices. In an earlier systematic review, we reported data from 31 blind provocation studies which had exposed IEI-EMF volunteers to active or sham electromagnetic fields and assessed whether volunteers could detect these fields or whether they reported worse symptoms when exposed to them. In this article, we report an update to that review. An extensive literature search identified 15 new experiments. Including studies reported in our earlier review, 46 blind or double-blind provocation studies in all, involving 1175 IEI-EMF volunteers, have tested whether exposure to electromagnetic fields is responsible for triggering symptoms in IEI-EMF. No robust evidence could be found to support this theory. However, the studies included in the review did support the role of the nocebo effect in triggering acute symptoms in IEI-EMF sufferers. Despite the conviction of IEI-EMF sufferers that their symptoms are triggered by exposure to electromagnetic fields, repeated experiments have been unable to replicate this phenomenon under controlled conditions. A narrow focus by clinicians or policy makers on bioelectromagnetic mechanisms is therefore, unlikely to help IEI-EMF patients in the long-term.

**Rubin GJ, Hillert L, Nieto-Hernandez R, van Rongen E, Oftedal G. Do people with idiopathic environmental intolerance attributed to electromagnetic fields display physiological effects when exposed to electromagnetic fields? A systematic review of provocation studies. Bioelectromagnetics. 32(8):593-609, 2011.**

Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) is a controversial illness in which people report symptoms that they believe are triggered by exposure to EMF. Double-blind experiments have found no association between the presence

of EMF and self-reported outcomes in people with IEI-EMF. No systematic review has assessed whether EMF exposure triggers physiological or cognitive changes in this group. Using a systematic literature search, we identified 29 single or double-blind experiments in which participants with IEI-EMF were exposed to different EMF levels and in which objectively measured outcomes were assessed. Five studies identified significant effects of exposure such as reduced heart rate and blood pressure, altered pupillary light reflex, reduced visual attention and perception, improved spatial memory, movement away from an EMF source during sleep and altered EEG during sleep. In most cases, these were isolated results that other studies failed to replicate. For the sleep EEG findings, the results reflected similar changes in the IEI-EMF participants and a non-IEI-EMF control group. At present, there is no reliable evidence to suggest that people with IEI-EMF experience unusual physiological reactions as a result of exposure to EMF. This supports suggestions that EMF is not the main cause of their ill health.

**Sage C. The implications of non-linear biological oscillations on human electrophysiology for electrohypersensitivity (EHS) and multiple chemical sensitivity (MCS). Rev Environ Health. 2015 Sep 12.**

The 'informational content' of Earth's electromagnetic signaling is like a set of operating instructions for human life. These environmental cues are dynamic and involve exquisitely low inputs (intensities) of critical frequencies with which all life on Earth evolved. Circadian and other temporal biological rhythms depend on these fluctuating electromagnetic inputs to direct gene expression, cell communication and metabolism, neural development, brainwave activity, neural synchrony, a diversity of immune functions, sleep and wake cycles, behavior and cognition. Oscillation is also a universal phenomenon, and biological systems of the heart, brain and gut are dependent on the cooperative actions of cells that function according to principles of non-linear, coupled biological oscillations for their synchrony. They are dependent on exquisitely timed cues from the environment at vanishingly small levels. Altered 'informational content' of environmental cues can swamp natural electromagnetic cues and result in dysregulation of normal biological rhythms that direct growth, development, metabolism and repair mechanisms. Pulsed electromagnetic fields (PEMF) and radiofrequency radiation (RFR) can have the devastating biological effects of disrupting homeostasis and desynchronizing normal biological rhythms that maintain health. Non-linear, weak field biological oscillations govern body electrophysiology, organize cell and tissue functions and maintain organ systems. Artificial bioelectrical interference can give false information (disruptive signaling) sufficient to affect critical pacemaker cells (of the heart, gut and brain) and desynchronize functions of these important cells that orchestrate function and maintain health. Chronic physiological stress undermines homeostasis whether it is chemically induced or electromagnetically induced (or both exposures are simultaneous contributors). This can eventually break down adaptive biological responses critical to health maintenance; and resilience can be compromised. Electrohypersensitivity can be caused by successive assaults on human bioelectrochemical dynamics from exogenous electromagnetic fields (EMF) and RFR or a single acute exposure. Once sensitized, further exposures are widely reported to cause reactivity to lower and lower intensities of EMF/RFR, at which point thousand-fold lower levels can cause adverse health impacts to the electrosensitive person. Electrohypersensitivity (EHS) can be a precursor to, or linked with, multiple chemical sensitivity (MCS) based on reports of individuals who first develop one condition, then rapidly develop the other. Similarity of chemical biomarkers is seen in both conditions [histamines, markers of oxidative stress, auto-antibodies, heat shock protein (HSP), melatonin markers and leakage of the blood-brain barrier]. Low intensity pulsed microwave activation of voltage-gated calcium channels (VGCCs) is postulated as a mechanism of action for non-thermal health effects.

**Sandström M, Lyskov E, Berglund A, Medvedev S, Mild KH. Neurophysiological effects of flickering light in patients with perceived electrical hypersensitivity. J Occup Environ Med. 39(1):15-22, 1997.**

An increasing number of people in Sweden are claiming that they are hypersensitive to electricity. These patients suffer from skin as well as neurological symptoms when they are near computer monitors, fluorescent tubes, or other electrical appliances. Provocation studies with electromagnetic fields emitted from these appliances have, with only one exception, all been negative, indicating that there are other factors in the office environment that can effect the autonomic and/or central nervous system, resulting in the symptoms reported. Flickering light is one such factor and was therefore chosen as the exposure parameter in this study. Ten patients complaining of electrical hypersensitivity and the same number of healthy voluntary control subjects were exposed to amplitude-modulated light. The sensitivity of the brain to this type of visual stimulation was tested by means of objective electrophysiological methods such as electroretinography and visual evoked potential. A higher amplitude of brain cortical responses at all frequencies of stimulation was found when comparing patients with the control subjects, whereas no differences in retinal responses were revealed.

**Sandström M, Lyskov E, Hörnsten R, Hansson Mild K, Wiklund U, Rask P, Klucharev V, Stenberg B, Bjerle P. Holter ECG monitoring in patients with perceived electrical hypersensitivity. Int J Psychophysiol. 49(3):227-235, 2003.**

Earlier studies have indicated that patients claiming to be sensitive to electromagnetic fields, so-called electrical hypersensitivity (EHS), have a dysbalance of the autonomic nervous system (ANS) regulation. This paper focuses on a possible dysbalance in the ANS among EHS patients by the use of long-term monitoring of electrocardiogram (ECG) in both a patient and a matched control group. At the same time, the environmental power frequency magnetic field was recorded for both groups in order to see if there was any difference in exposure between the groups. ECG, heart rate (HR) and heart rate variability (HRV) as well as the magnetic field exposure were monitored for 24 h. Fourteen patients with perceived EHS symptoms were selected from the University Hospital, Umeå, Sweden. Symptoms indicating autonomic nervous dysregulation were not part of the inclusion criteria of the patient group. Age and sex matched healthy subjects were used as controls. No differences were found between the groups regarding magnetic field exposure or the mean HR for 24 h. The HRV analyses showed that the high-frequency (HF) component did not have the expected increase with sleep onset and during nighttime in the EHS group. When separating the sleeping and awake time even less differences between the two conditions in the EHS patients, both for the low-frequency and HF components in the HRV spectrum, were seen. EHS patients had a disturbed pattern of circadian rhythms of HRV and showed a relatively 'flat' representation of hourly-recorded spectral power of the HF component of HRV.

**Schreier N, Huss A, Röösli M. The prevalence of symptoms attributed to electromagnetic field exposure: a cross-sectional representative survey in Switzerland. Soz Praventivmed. 51(4):202-209, 2006.**

OBJECTIVES: To investigate health risk perception as well as to assess the prevalence of self-reported symptoms attributed to electromagnetic fields (EMF) and other environmental exposures in the general population of Switzerland. METHODS: Between May and June 2004, telephone interviews of a representative sample of the Swiss population (n=2048, >14 years old) about: (1) health symptoms attributed to five environmental factors (one of which was

EMF), (2) health risk perception related to 12 environmental risk factors (five of which were different EMF sources). RESULTS: We found a prevalence of 5% (95% CI 4-6%) for electromagnetic hypersensitivity (EHS) in our study sample. The most common health complaints among EHS individuals were sleep disorders (43%) and headaches (34%), which were mostly attributed to power lines and mobile phone handsets. In addition, 53 percent (95% CI 51-55%) were worried about adverse health effects from EMF, without attributing their own health symptoms to them. CONCLUSIONS: The large proportion of the population who is concerned or attributes own symptoms to EMF may cause societal conflicts given the ubiquity of EMF in our everyday life.

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**Schröttner J, Leitgeb N, Hillert L. Investigation of electric current perception thresholds of different EHS groups. Bioelectromagnetics. 28(3):208-213, 2007.**

An increasing number of persons with health symptoms of unclear origin take refuge in the hypothesis that they suffer from electromagnetic hypersensitivity (EHS). So far EHS is not an accepted diagnosis and there is no validated test to verify the proposed relationship between electromagnetic fields and symptoms. Groups reporting EHS are very heterogeneous but share a belief that they have an increased sensitivity to electromagnetic fields. It was studied to which extent a quantitative indicator for electrosensitivity, the electric current perception threshold, and its variability coefficient, depend on the recruitment strategy for self-declared hypersensitive persons. Individual electrosensitivity was investigated by provocation of the lower arms to directly coupled 50 Hz electric currents. Self-declared EHS persons were selected from members of a self aid group, from responders to a newspaper call, and from persons actively asking for investigations in their search for help. It turned out that quantitative electrosensitivity was quite different among the three groups. It is interesting that the members of the EHS self aid group exhibit a considerable overlap with general population sample. Pooled together it could be shown that hypersensitive persons as a group differ significantly from the general population sample, however with a pronounced overlap with the normal range. It can be concluded that EHS groups are very inhomogeneous and contain numerous persons with no increased ability to perceive low frequency electric or magnetic fields. This investigation shows the importance of the study design, in particular of the recruitment strategies of EHS persons for the final outcome.

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

BACKGROUND: An increasing number of persons suffer from non-specific health symptoms such as headache, sleep disturbances, difficulties in concentrating and more. In lack of a medical explanation, more and more persons take refuge to the assumption that they were electromagnetic hypersensitive (EHS) and electromagnetic pollution causes their problems. The discussion whether electromagnetic fields (EMF) could cause such adverse health effects is still ongoing. METHODS: Based on the Austrian inhabitants a statistical cross-sample of the general population with regard to age, gender and federal state had been investigated to assess the actual situation and potential temporal changes in comparison with a former study of 1994. In a telephone survey a total number of 526 persons were included. RESULTS: This study showed an actual EHS prevalence of 3.5% compared with 2% estimated in 1994. About 70% of the sample believed that electromagnetic pollution could be a risk factor for health. More than 30% declared to at least some degree to be concerned about their well-being near mobile phone base stations or power lines. However, only 10% were actively looking for specific information. Media triggered EHS hypothesis in 24% of the cases. CONCLUSION: The results show that concerns about EMF did not decrease with time in spite of scientific studies and health risk assessments concluding that a causal relationship of EMF below recommended reference levels and non-specific health symptoms would be implausible.

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

Literature published between 2000 to 2004 concerning electromagnetic fields (EMF) of mobile communication and electromagnetic hypersensitivity (EHS) or unspecific symptoms of ill health, respectively, is reviewed. Basically, literature from established databases was systematically searched for. For each study, the design and quality were evaluated by means of a criteria list in order to judge evidence for causality of exposures on effects. Finally, 13 studies of sufficient quality were considered for this review. In only one provocation study, individuals with self-reported electromagnetic hypersensitivity were exposed to EMF. Their perception of field status was no better than would have been expected by chance. Results of five randomised cross-over studies on impaired well-being due to mobile phone exposure were contradictory. Even though these studies would allow more reliable exposure assessment, they are limited due to short exposure period and the small study size. No firm conclusion could be drawn from a few observational epidemiological studies finding a positive association between exposure and unspecific symptoms of ill health due to methodological limitations. Causality of exposure and effect was not derivable from these cross-sectional studies as field status and health complaints were assessed at the same time. In addition, exposure assessment has not been validated. In conclusion, based on the limited studies available, there is no valid evidence for an association between impaired well-being and exposure to mobile phone radiation presently. However, the limited quantity and quality of research in this area do not allow to exclude long-term health effects definitely.

**Silny J. Electrical hypersensitivity in humans--fact or fiction? Zentralbl Hyg Umweltmed. 202(2-4):219-233,1999.**

The phenomenon of the so-called electrical hypersensitivity in the weak electromagnetic fields of everyday life, potentially causing different health symptoms, is reviewed under consideration of current results from in-vivo and in-vitro investigations as well as of statistical data. Electrical hypersensitivity cannot be explained by means of the known and validated influence mechanisms of electromagnetic fields in humans, as their thresholds are at least 50 times higher for harmless effects, and more than 1000 times higher for adverse effects than the strengths of the environmental fields. Present statistical data reveal clear inconsistencies in many respects. The prevalence varies by a factor 1000 although the reporting countries have comparable field and exposure situations. Neither the apparently random combination of symptoms on the side of the suffering patients nor the problematic attribution of the symptoms to certain electromagnetic field situations do support the hypothesis of a electrical hypersensitivity. On the other hand, the statistical data must be considered unsubstantiated because of the small number of cases and the procedures of survey. Consequently, there is a need for additional, systematic investigations of this group of patients under participation of different medical and biomedical disciplines.

**Sobiczewska E, Szmigielski S. [Electromagnetic fields hypersensitivity]. Med Pr. 60(3):235-241, 2009. [Article in Polish]**

The development of industry, particularly of new technologies in communication systems, gives rise to the number and diversity of electromagnetic field (EMF) sources in the environment. These sources, including power-frequent, radiofrequent and microwaves, make human life richer, safer and easier. But at the same time, there is growing concern about possible health risks connected with EMF exposure. An increasing number of persons have recently reported on a variety of health problems induced, in their opinion, by exposure to EMF. It is important to note that EMF levels to which these individuals are exposed are generally well below the recommended exposure limits and are certainly far below those known to produce any adverse effects. These persons call themselves "electromagnetic hypersensitivity individuals" And complain about experiencing various types of non-specific symptoms, including dermatological, neurological and vegetative. In the present paper, the problem of electromagnetic hypersensitivity phenomenon is discussed based on the recently published literature.

**Swanbeck G, Bleeker T. Skin problems from visual display units. Provocation of skin symptoms under experimental conditions. Acta Derm Venereol. 69(1):46-51, 1989.**

Thirty patients having skin problems experienced being caused by work with visual display units (VDU) were tested double-blind with two VDUs. One VDU had strong electrostatic and electromagnetic fields and the other VDU had an identical appearance but the electrostatic field and electromagnetic fields were practically eliminated. Approximately 80% of the patients reacted with stinging or itching in the face during the 3 hours working period with 25% relative humidity in the room. No difference between the VDUs was found with regard to provoking these symptoms. At 60% relative humidity 13 patients of 19 experienced stinging or itching in the face. Those 13 that reacted were asked to come another time and were informed that the VDU was not turned on and that all electric fields that were present came from the cable to the VDU. A green cloth was put over the VDUs. This time 11 of the 13 patients reacted with stinging and itching in spite of the fact that the VDU was turned off. The present study does not indicate that electric and electromagnetic fields are of major importance in provoking subjective skin symptoms in patients experiencing skin problems when working with VDUs.

**Tseng MC, Lin YP, Hu FC, Cheng TJ. Risks Perception of Electromagnetic Fields in Taiwan: The Influence of Psychopathology and the Degree of Sensitivity to Electromagnetic Fields. Risk Anal. 2013 Mar 28. doi: 10.1111/risa.12041. [Epub ahead of print]**

Little is known about the perceived health risks of electromagnetic fields (EMFs) and factors associated with risk perception in non-Western countries. Psychological conditions and risk perception have been postulated as factors that facilitate the attribution of health complaints to environmental factors. This study investigated people's perceived risks of EMFs and other environmental sources, as well as the relationships between risk perception, psychopathology, and the degree of self-reported sensitivity to EMFs. A total of 1,251 adults selected from a nationwide telephone interviewing system database responded to a telephone survey about the relationships between environmental sources and human health. The interview included questions assessing participants' psychiatric conditions and the presence and degree of sensitivity to EMFs. One hundred and seventy participants were self-identified as having sensitivity to EMFs, and 141 met the criteria for psychiatric conditions without EMF sensitivity. More than half of the survey respondents considered power lines and mobile phone base stations to affect people's health to a big extent. Higher sensitivity to EMFs, psychopathology, being female, being married, more years of education, and having a catastrophic illness had positive associations with perceived risks of EMF-related environmental sources as well as for all environmental sources combined. We observed no moderating effect of psychopathology on the association between degree of sensitivity to EMF and risk perception. Thus, psychopathology had influence on general people's risk perception without having influence on the relationship between people's degree of sensitivity to EMF and risk perception. The plausible explanations are discussed in the text.

**Tuengler A, von Klitzing L. Hypothesis on how to measure electromagnetic hypersensitivity. Electromagn Biol Med. 32(3):281-290, 2013.**

Electromagnetic hypersensitivity (EHS) is an ill-defined term to describe the fact that people who experience health symptoms in the vicinity of electromagnetic fields (EMFs) regard them as causal for their complaints. Up to now most scientists assume a psychological cause for the suffering of electromagnetic hypersensitive individuals. This paper addresses reasons why most provocation studies could not find any association between EMF exposure and EHS and presents a hypothesis on diagnosis and differentiation of this condition. Simultaneous recordings of heart rate variability, microcirculation and electric skin potentials are used for classification of EHS. Thus, it could be possible to distinguish "genuine" electromagnetic hypersensitive individuals from those who suffer from other conditions.

**Wallace D, Eltiti S, Ridgewell A, Garner K, Russo R, Sepulveda F, Walker S, Quinlan T, Dudley S, Maung S, Deeble R, Fox E. Do TETRA (Airwave) base station signals have a short-term impact on health and well-being? A randomized double-blind provocation study. Environ Health Perspect. 118(6):735-741, 2012.**

BACKGROUND: "Airwave" is the new communication system currently being rolled out across the United Kingdom for the police and emergency services,based on the Terrestrial Trunked Radio Telecommunications System (TETRA). Some police officers have complained about skin rashes, nausea, headaches, and depression as a consequence of using their Airwave handsets. In addition, a small subgroup in the population self-report being sensitive to electromagnetic fields (EMFs) in general. OBJECTIVES: We conducted a randomized double-blind provocation

study to establish whether short-term exposure to a TETRA base station signal has an impact on the health and well-being of individuals with self-reported "electrosensitivity" and of participants who served as controls. METHODS: Fifty-one individuals with self-reported electrosensitivity and 132 age- and sex-matched controls participated in an open provocation test; 48 sensitive and 132 control participants went on to complete double-blind tests in a fully screened semianechoic chamber. Heart rate, skin conductance, and blood pressure readings provided objective indices of short-term physiological response. Visual analog scales and symptom scales provided subjective indices of well-being. RESULTS: We found no differences on any measure between TETRA and sham (no signal) under double-blind conditions for either controls or electrosensitive participants, and neither group could detect the presence of a TETRA signal at rates greater than chance (50%). When conditions were not double blind, however, the self-reported electrosensitive individuals did report feeling worse and experienced more severe symptoms during TETRA compared with sham.CONCLUSIONS: Our findings suggest that the adverse symptoms experienced by electrosensitive individuals are due to the belief of harm from TETRA base stations rather than to the low-level EMF exposure itself.

**Wallace D, Eltiti S, Ridgewell A, Garner K, Russo R, Sepulveda F, Walker S, Quinlan T, Dudley S, Maung S, Deeble R, Fox E. Cognitive and physiological responses in humans exposed to a TETRA base station signal in relation to perceived electromagnetic hypersensitivity. Bioelectromagnetics. 33(1):23-39, 2012.**

Terrestrial Trunked Radio (TETRA) technology ("Airwave") has led to public concern because of its potential interference with electrical activity in the brain. The present study is the first to examine whether acute exposure to a TETRA base station signal has an impact on cognitive functioning and physiological responses. Participants were exposed to a 420 MHz TETRA signal at a power flux density of 10 mW/m(2) as well as sham (no signal) under double-blind conditions. Fifty-one people who reported a perceived sensitivity to electromagnetic fields as well as 132 controls participated in a double-blind provocation study. Forty-eight sensitive and 132 control participants completed all three sessions. Measures of short-term memory, working memory, and attention were administered while physiological responses (blood volume pulse, heart rate, skin conductance) were monitored. After applying exclusion criteria based on task performance for each aforementioned cognitive measure, data were analyzed for 36, 43, and 48 sensitive participants for these respective tasks and, likewise, 107,125, and 129 controls. We observed no differences in cognitive performance between sham and TETRA exposure in either group; physiological response also did not differ between the exposure conditions. These findings are similar to previous double-blind studies with other mobile phone signals (900-2100 MHz), which could not establish any clear evidence that mobile phone signals affect health or cognitive function.

**Wang J, Su H1, Xie W, Yu S. Mobile Phone Use and The Risk of Headache: A Systematic Review and Meta-analysis of Cross-sectional Studies. Sci Rep. 2017 Oct 3;7(1):12595. doi: 10.1038/s41598-017-12802-9.**

Headache is increasingly being reported as a detrimental effect of mobile phone (MP) use. However, studies aimed to investigate the association between MP use and headache yielded conflicting results. To assess the consistency of the data on the topic, we performed a systematic review and meta-analysis of the available cross-sectional studies. Published literature from PubMed and other databases were retrieved and screened, and 7 cross-sectional studies were finally included in this meta-analysis. The pooled odds ratio (OR) and 95% confidence interval (CI) were calculated. We found that the risk of headache was increased by 38% in MP user compared with non-MP user (OR, 1.38; 95% CI, 1.18-1.61, $p < 0.001$). Among

MP users, the risk of headache was also increased in those who had longer daily call duration (2-15 min vs. <2 min: OR, 1.62; 95% CI, 1.34-1.98, p < 0.001; >15 min vs. <2 min: OR, 2.50; 95% CI, 1.76-3.54, p < 0.001) and higher daily call frequency (2-4 calls vs. <2 calls: OR, 1.37; 95% CI, 1.07-1.76, p < 0.001; >4 calls vs. <2 calls: OR, 2.52; 95% CI, 1.78-3.58, p < 0.001). Our data indicate that MP use is significantly associated with headache, further epidemiologic and experimental studies are required to affirm and understand this association.

**Wilén J, Sandström M, Hansson Mild K. Subjective symptoms among mobile phone users--a consequence of absorption of radiofrequency fields? Bioelectromagnetics. 24(3):152-159, 2003.**

In a previous epidemiological study, where we studied the prevalence of subjective symptoms among mobile phone (MP) users, we found as an interesting side finding that the prevalence of many of the subjective symptoms increased with increasing calling time and number of calls per day. In this extrapolative study, we have selected 2402 people from the epidemiological study who used any of the four most common GSM MP. We used the information about the prevalence of symptoms, calling time per day, and number of calls per day and combined it with measurements of the Specific Absorption Rate (SAR). We defined three volumes in the head and measured the maximum SAR averaged over a cube of 1 g tissue (SAR(1g)) in each volume. Two new exposure parameters Specific Absorption per Day (SAD) and Specific Absorption per Call (SAC) have been devised and are obtained as combinations of SAR, calling time per day, and number of calls per day, respectively. The results indicates that SAR values >0.5 W/kg may be an important factor for the prevalence of some of the symptoms, especially in combination with long calling times per day.

**Wilen J, Johansson A, Kalezic N, Lyskov E, Sandstrom M. Psychophysiological tests and provocation of subjects with mobile phone related symptoms. Bioelectromagnetics. 27(3):204-214, 2006.**

The aim of the present study was to investigate the effect of exposure to a mobile phone-like radiofrequency (RF) electromagnetic field on persons experiencing subjective symptoms when using mobile phones (MP). Twenty subjects with MP-related symptoms were recruited and matched with 20 controls without MP-related symptoms. Each subject participated in two experimental sessions, one with true exposure and one with sham exposure, in random order. In the true exposure condition, the test subjects were exposed for 30 min to an RF field generating a maximum SAR(1g) in the head of 1 W/kg through an indoor base station antenna attached to a 900 MHz GSM MP. The following physiological and cognitive parameters were measured during the experiment: heart rate and heart rate variability (HRV), respiration, local blood flow, electrodermal activity, critical flicker fusion threshold (CFFT), short-term memory, and reaction time. No significant differences related to RF exposure conditions were detected. Also no differences in baseline data were found between subject groups, except for the reaction time, which was significantly longer among the cases than among the controls the first time the test was performed. This difference disappeared when the test was repeated. However, the cases differed significantly from the controls with respect to HRV as measured in the frequency domain. The cases displayed a shift in low/high frequency ratio towards a sympathetic dominance in the autonomous nervous system during the CFFT and memory tests, regardless of exposure condition. This might be interpreted as a sign of differences in the autonomous nervous system regulation between persons with MP related subjective symptoms and persons with no such symptoms.

**Wilén J, Wiklund U, Hörnsten R, Sandström M. Changes in heart rate variability among RF plastic sealer operators. Bioelectromagnetics. 28(1):76-79, 2007.**

In a previous study, we showed that operators of radiofrequency (RF) plastic sealers, RF operators (n = 35) had a lower heart rate during nighttime compared to a control group (n = 37). We have analyzed the heart rate variability (HRV) on the same group of people to better understand the possible underlying rhythm disturbances. We found a significantly increased total HRV and very low frequency (VLF) power during nighttime among the RF operators compared to a control group. Together with our previous finding of a significantly lower heart rate during nighttime among the RF operators compared to the controls, this finding indicates a relative increase in parasympathetic cardiac modulation in RF operators. This could in turn be due to an adaptation of the thermoregulatory system and the cardiac autonomic modulation to a long-term low-level thermal exposure in the RF operators.

**Ziskin MC; Committee on Man and Radiation. Electromagnetic hypersensitivity--a COMAR Technical Information Statement. June 27, 2002. IEEE Eng Med Biol Mag. 21(5):173-175, 2002. (no abstract available)**