Electromagnetic Hypersensitivity

Proceedings
International Workshop on EMF Hypersensitivity
Prague, Czech Republic
October 25-27, 2004

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FOREWORD

A WHO workshop on Electromagnetic Hypersensitivity was held in Prague on October 25-27, 2004. This meeting was arranged in collaboration with the National Reference Laboratory for Non-Ionizing Radiation, Ministry of Health, Czech Republic and was co-sponsored by the European Commission Coordinated Action EMF-NET and the Action COST 281 (Potential Health Implications from Mobile Communication Systems) within the European Framework for Cooperation in the Field of Scientific and Technical Research.

Sensitivity to EMF has been given the general name "Electromagnetic Hypersensitivity" or EHS. It comprises nervous system symptoms like headache, fatigue, stress, sleep disturbances, skin symptoms like prickling, burning sensations and rashes, pain and ache in muscles and many other health problems. Whatever its cause, EHS is a real and sometimes a disabling problem for the affected persons. Their EMF exposure is generally several orders of magnitude under the limits of internationally accepted standards. The aim of the conference was to review the current state of knowledge and opinions of the conference participants and propose ways forward on this issue.

The meeting was conducted by the WHO International EMF Project as part of the scientific review process to determine biological and health effects from exposure to EMF. The purpose of these workshops is to bring together expert scientists so that established health effects and gaps in knowledge requiring further research can be identified.

EHS has been a particularly contentious issue for a number of years. There have been over 30 studies to determine if EHS symptoms are related to EMF exposure. The workshop and the papers in this proceedings provide up-to-date information on this issue. The editors thank all speakers to the workshop for their contribution to this proceeding.

The Editors

January 2006

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INTERNATIONAL EMF PROJECT

Workshop on Electrical Hypersensitivity
Prague, Czech Republic
Monday 25 October & Tuesday 26 October 2004

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17.00 Close of meeting

WORKSHOP SUMMARY

WORKSHOP SUMMARY

Background

As societies industrialize and the technological revolution continues, there has been an unprecedented increase in the number and diversity of electromagnetic field (EMF) sources. These sources include high voltage power lines, radars, video display units associated with computers and TVs, radio and television broadcasting stations, mobile phones and their base stations, microwave ovens as well as security, anti-theft devices, automated highway toll systems and fluorescent lights. While these sources have made our life richer, safer and easier they have been accompanied by concerns about possible health risks due to their EMF emissions.

For some time a number of individuals have reported a variety of health problems that they relate to their exposure to EMF. The EMF levels to which these individuals are exposed are generally well below recommended exposure limits and are certainly far below those known to produce any adverse effects.

The reported sensitivity reactions include a wide range of non-specific symptoms, which afflicted individuals attribute to exposure to EMF. The symptoms most commonly reported include dermatological symptoms (redness, tingling, and burning sensations) as well as neurasthenic and vegetative symptoms (fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitation, and digestive disturbances). Some individuals are so severely affected that they cease work and change their entire lifestyle, while others report mild symptoms and react by avoiding the fields as best they can.

The reported symptoms are not part of a recognized syndrome and have been generally termed as "electrical hypersensitivity" or "electromagnetic hypersensitivity" (EHS). However, the term EHS is ill-defined and is frequently used in two different contexts:

- as a medical condition based on the afflicted person's interpretation of the cause of their ill health, but irrespective of any established causal relationship;
- to describe the ability of certain individuals to perceive or react to EMF at significantly lower levels than most people.

Workshop objectives and scope

To address the issue of potential electromagnetic hypersensitivity, the World Health Organization (WHO) convened a Workshop on "Electrical hypersensitivity" in Prague in October 2004. This meeting was co-sponsored by the European Commission Coordinated Action EMF-NET, the European Cooperation in the Field of Scientific and Technical Research (COST 281), and the Ministry of Health of the Czech Republic. The meeting comprised a 2-day international meeting, open to all persons who wished to contribute and/or attend (see Rapporteur report page 7, for further details). This was followed by a 1-day working group meeting, which included the speakers, the WHO secretariat and other interested parties (see Working Group report page 15, for further details). The working group meeting included break-out sessions on the following topics: (i) Characterization, diagnosis and treatment, (ii) Research needs, and (iii) Policy options.

The purpose of the Workshop was to conduct a thorough review of the scientific evidence to determine if there is a relationship between EMF exposure and the symptoms reported by EHS individuals and what further research is necessary to fill any gaps in knowledge about the condition and its management. In addition, the Workshop reviewed what had and could be done to assist EHS individuals.

Conclusions from the workshop

EHS is characterized by a variety of non-specific symptoms that differ from individual to individual. The symptoms are certainly real and can vary widely in their severity. For some individuals the symptoms can change their lifestyle.

The term "Idiopathic Environmental Intolerance (IEI) with attribution to EMF" was proposed by the working group to replace EHS since the latter implies that a causal relationship has been established between the reported symptoms and EMF. The term IEI originated from a workshop convened by the International Program on Chemical Safety (IPCS) of the World Health Organization (WHO) in 1996 in Berlin. IEI is a descriptor without any implication of chemical etiology, immunological sensitivity or EMF susceptibility. Rather it has been described as:

- an acquired disorder with multiple recurrent symptoms,
- associated with diverse environmental factors tolerated by the majority of people,
- not explained by any known medical, psychiatric or psychological disorder.

IEI incorporates a number of disorders sharing similar non-specific medically unexplained symptoms that adversely affect people and cause disruptions in their occupational, social, and personal functioning.

The majority of studies indicate that IEI individuals cannot detect EMF exposure any more accurately than non-IEI individuals. By and large well controlled and conducted double-blind studies have shown that symptoms do not seem to be correlated with EMF exposure.

There are also some indications that these symptoms may be due to pre-existing psychiatric conditions as well as stress reactions as a result of worrying about believed EMF health effects, rather than the EMF exposure itself. It was added that IEI should not be used as a medical diagnosis since there is presently no scientific basis to link IEI symptoms to EMF exposure.

Recommendations for medical evaluation

Whatever its cause, IEI can be disabling for the affected individual. Treatment should focus on the health symptoms and the clinical picture by performing:

- a medical evaluation to identify and treat any specific conditions that may be responsible for the symptoms,
- an assessment of the workplace and home for factors that might contribute to the presented symptoms. These could include indoor air pollution, excessive noise, poor lighting (flickering light) or ergonomic factors. A reduction of stress and other improvements in the work situation might be appropriate. EMF might be assessed to ensure that levels of exposure meet existing standards and recommendations.
- a psychological evaluation to identify alternative psychiatric/ psychological conditions that may be responsible for the symptoms.

Some studies suggest that certain physiological responses of IEI individuals tend to be outside the normal range. In particular, the findings of hyper reactivity in the central nervous system and misbalance in the autonomic nervous system need to be followed up in clinical investigations and the results for the individuals taken as input for possible treatment.

Under the umbrella of WHO's EMF project, internationally qualified physicians should develop a "best practice" protocol for managing IEI individuals and provide this information to national health authorities for implementation at the local level.

Research recommendations

Because EMF has not been established as a causative factor for symptoms of IEI individuals, the focus of research should be on characterizing their physiological responses.

Normally there are two types of human studies conducted to determine the toxicity of an agent. First, epidemiological studies can be used to inform on the occurrence of a disease. However, for IEI, epidemiological studies are not considered helpful because the definition of an IEI individual is still lacking and so it is not possible to design a useful study. Second, provocation studies on human volunteers can usually inform on issues such as causality and other aspects of the symptoms. To date provocation studies with double blind exposure sessions have failed to verify a causal relationship between electric, magnetic or electromagnetic fields and symptoms. If provocation studies are to be considered, they should be properly designed and include ethics committee approval.

Advice to national authorities

National authorities should not ignore the plight of IEI individuals as it affects some 2-3% of populations in a number of countries. Governments need to provide general physicians with appropriate advice based on information provided by qualified experts. To that end, it was recommended that WHO issue a fact sheet that contains information on the symptoms of IEI individuals, indicating that, at present, these symptoms cannot be attributed to EMF, warn against commercial products to shield against EMF and provide advice on how best to manage IEI.

Governments should also note that IEI patients have real symptoms, but that there is no scientific evidence of causal link with EMF exposure, and therefore no grounds to use IEI as a diagnostic classification. Further there is no indication that lowering internationally accepted limits would reduce the prevalence of symptoms attributed to EMF. More generally, governments should anticipate problems with new technologies, develop adequate general risk communication strategies, provide balanced information and promote dialogue on related issues.

RAPPORTEUR'S REPORT

RAPPORTEUR'S REPORT

Kjell Hansson Mild
National Institute for Working Life
Umeå, Sweden

The WHO workshop on "Electrical hypersensitivity" in Prague, Oct 25-26, 2004, was well-attended with over 150 participants from 25 countries. There were a total of 18 invited talks, and for the free communications over 40 abstracts were submitted, of which 14 were presented in short oral presentations and 15 as posters. This report briefly summarizes the talks given by the invited speakers and the key points of discussion. Speakers slide presentations can be found on the meeting website.

After the opening of the meeting with an address from the Ministry of Health in the Czech Republic, read by Professor Ludek Pekárek, the WHO EMF Project's coordinator **Mike Repacholi** welcomed the participants to the meeting. He stressed that the objectives of this meeting were to identify what is known about electrical hypersensitivity, to review the scientific data on EHS and its possible connection to EMF, to discuss what further studies are needed to fill gaps in knowledge, and to determine what can be done to assist EHS suffers.

The first presentation at the meeting was a tutorial by Dr **Berndt Stenberg** of the Northern University Hospital in Umeå, Sweden. Dr Stenberg is an occupational dermatologist who has been working since 1985 with patients seeking medical care for skin symptoms associated with visual display terminals (VDT) work. He has seen over 350 patients and gave an overview of the historical development of EHS and his experience on prognosis for different patient groups.

Dr Stenberg quoted a definition of EHS which originated in an EU-sponsored report (Bergqvist et al. 1997) as: “a phenomenon where individuals experience adverse health effects while using or being in the vicinity of devices emanating electric, magnetic or electromagnetic fields (EMFs)”. This definition was subsequently mentioned by many of the speakers during the meeting.

Dr Stenberg stressed the importance of making a distinction between two groups of patients: those who experience facial skin symptoms in connection with work near a VDT, and those who, besides skin symptoms, also had general nervous system response when exposed to EMF from different electrical appliances, here called EHS. The first group has typically sensory sensation as stinging, itching, burning erythema, eczema, rosacea, while most of the EHS group has these symptoms, as well as fatigue, headaches, sleeplessness, dizziness, cardiac and cognitive symptoms.

The prognosis for the first group is generally good, they improve over time and most can still work. The EHS group with more general symptom have much in common with other environmental illnesses such as dental filling problems and Multiple Chemical Sensitivity (MCS). This group consists of slightly older individuals, with lower income, mainly women, many with different ethnic backgrounds. There are also factors in this group, such as atopic illness, different self-image, different coping strategies, proneness to anxiety, having been through more traumatic life events than most people. The prognosis for this group is not as favourable as the other, and they do not generally recover as well as the first group. Dr Stenberg underlined the need for early and consistent management of both groups because of the nature and extent of the problem.

Dr **Herman Staudenmayer**, Denver, USA, presented a tutorial on Idiopathic Environmental Intolerance (IEI), and reflected on how toxicogenic and psychogenic theories could be applied to the EHS issue. At a WHO meeting in 1996 in Berlin IEI was defined as:

- An acquired disorder with multiple recurrent symptoms.
- Associated with diverse environmental factors tolerated by the majority of people.
- Not explained by any know psychiatric or psychological disorder.

He applied the Bradford Hill criteria of causality to EHS and added "reversibility" to the criteria. In none of these criteria did he find a connection to the toxicology theory, but rather to the psychogenic theory.

During discussion Dr Staudenmayer argued that the name EHS should be changed to IEI. This was supported by a number of people, making the point that the term EHS is misleading both in implying a causal relationship to EMF and because the term "hyper" has no medical support. Dr Staudenmayer suggested the use of IEI but with an addition of "EMF attributed" in analogy with the MCS issue.

Dr **Patrick Levallois**, Quebec, Canada, gave an overview of studies investigating the prevalence of EHS in the general population. The prevalence was found to vary between countries and was dependent on what definition of EHS was used and how the questions were phrased; underscoring differences in cultural background. He estimated that 1-3 % of the general population report a wide range of complaints that they attribute to EMF.

The prevalence reported was higher for some subgroups (low income, ethnic minorities, and sometimes women). He stated that the link with the so-called «multiple chemical sensitivity» needs to be clarified.

Dr **Kjell Hansson Mild**, National Institute for Working Life, Umeå, Sweden, gave an overview of the different EMF sources that are encountered in everyday life. He argued that EMF cover a wide range of frequencies, encompassing fields from static up to hundreds of GHz. Thus it is more informative to quote the frequency range of the field exposure. He also made it clear that no study had shown that EHS people lived in an unusual EMF environment.

Professor **Jan Bures**, Prague, presented a quantitative characterization of the neural network of the human brain. He indicated that "at any moment about 1 % of the neurons were active and generated each one second period 10^9 action potentials which exposed the brain to a deluge of randomly distributed pico- and microampere currents. This inherent electrical noise with amplitude in the range of 10-100 microvolts and field intensities of about 1 V/m but does not interfere with the highest cognitive and executive functions of our brain."

Dr **Eugene Lyskov**, Umeå, Sweden, reported on a set of neurophysiological studies on EHS patients. The group with skin rashes all complained about problems with VDT, fluorescents lights and TV. All these sources had flickering light, which was thus used to test the patients. It was found these patients had a higher critical flicker frequency (CFF) than normal, their visual evoked potential (VEP) was significantly higher than in controls, but their electroretinogram was normal. In follow-up studies with EHS patients, similar findings were recorded: patients had increased CFF, increased VEP, increased heart rate, decreased heart rate variability (HRV) and increased electrodermal (EDA) reaction to sound stimuli. When a provocation with 60 Hz, 10 µT magnetic field was conducted, no effect was seen in any of the physiological parameters, and they were the same for both the EHS group and controls. In a study with a 24 h ECG recording in a group of 20 EHS patients, a night time decrease in the ratio of the low frequency/high frequency components of the heart rate variability indicated an autonomic imbalance and lack of normal circadian rhythms in these patients.

In the subsequent discussion it was noted that the increased EDA could be a psychogenic response. It was also mentioned that these findings of a hyper reactivity in the central nervous system and in an imbalance in the autonomic nervous system were known as *vasoregulatory asthenia* or *neurocirculatory asthenia*. In the 50's and 60's many patients complained of the same symptoms as we now have in the EHS groups, but today no one is coming to the clinical physiology departments with these symptoms. Is EHS just another name for *neurocirculatory asthenia?*

Leitgeb reported results from a survey he conducted among physicians. About 96 % of participating physicians believed that EMF can cause illness. He also reported on his own studies on electric current perception and sleep problems. Measured perception threshold among a large group of subjects was found to be generally lower than previously found. The level where 0.5 % of the population could perceive the current was almost ten times lower than previously found. Overall there is a large spread in the values of perception threshold, some 2 orders of magnitude.

He also found that exposure to ELF magnetic fields before testing the perception threshold led to a temporary lowering of the threshold. This is a new finding that needs to be followed up in other laboratories.

Dr **Bruce Hocking**, Australia, a specialist in occupational medicine, has been working with patients claiming EHS for many years. He described his experience by giving examples to illustrate the diversity of cases. He also discussed the great difficulties in doing provocation studies since there are so many unknowns such as of the characteristics of EMF to use, exposure time, washout time, and blinding conditions. There is no “gold standard” for EMF sensitivity testing. He urged that peripheral nerve mechanisms as well as CNS mechanisms should be considered when studying EMF sensitivity.

Dr **Robin Cox**, UK, an occupational physician, presented an overview on human EMF studies in the UK. However, only two of the studies were directly related to the topic EHS and these two involved physiological investigations of people perceiving sensitivity to EMF. The researchers have in general found it difficult to recruit cases because of the patients' reluctance to subject themselves to EMF exposures that might produce unpleasant symptoms.

One of the studies was from King's College, London (Professor Wessely) and was a double blind provocation study with handheld mobile phone. The outcome studied was self-reported symptoms and levels of neuroendocrine hormones. The plan was to test 60 cases and 60 controls, and so far only 33 people have been tested, and therefore no results could be presented.

The other study conducted at the University College London hospital (Professor L. Luxon) was on the effect of mobile phone stimulation on labyrinthine function. So far the study included 51 subjects (25 cases and 26 controls) 18-55 years of age, however, 11 had declined to participate. The cases were not considering themselves generally EHS but experienced symptom with the use of a mobile phone. The majority described the headache they got in connection with the use of the phone as different from anything else they had experienced. The analysis of the study is still ongoing.

Dr **Lena Hillert** from the Karolinska Institutet, Stockholm, Sweden, discussed her experience with cognitive behavioural therapy (CBT) for EHS patients. Her EHS group is very heterogeneous in both complaints and reported triggering factors. The patients diagnosed themselves as EHS patients.

Since provocation studies have failed to provide support for a causal relationship between exposure to EMF and complaints, psychophysiological reactions (possibly in combination with environmental stresses) have been proposed as an alternative explanation. Therefore psychological methods, such as CBT were introduced. CBT is based on the way people structure their experiences (based on core beliefs and basic assumptions), which influence the way in which they think, feel, and behave. This method *"teaches patients to identify, evaluate, and respond to dysfunctional thoughts and beliefs".*

This may be one way to control or reduce complaints. CBT has been shown to improve the well being of patients with asthma and cancer pain. This therapy is tailored to each participant and requires teamwork between the patient and the therapist.

So far three studies have been completed in Sweden with CBT. The average age of the patients was 42 years. The results varied, but the conclusion was that CBT may be of benefit for some patients reporting EHS but not for all.

Dr **Emilie van Deventer**, WHO, Geneva, discussed the various responses to the EHS issue being undertaken by governments. In a survey sent to over 50 Departments of Health in different countries only 13 answered, and most reported no activity for EHS. The WHO has EHS as one priority area in the research agenda and has encouraged its member states to fund research to identify if there is a relationship between EMF and EHS.

Dr **Jill Meara** Deputy Director of the NRPB, UK, was invited to discuss possible policy options for dealing with EHS individuals. One of the overarching issues was that EHS lacks a clear definition. Also there is a lack of understanding of what is included in the use of the word EMF, low or high frequency, electric or magnetic fields, chronic or intermittent exposure, etc. Looking at the overall evidence it is clear that there is no support or need for an intense electrical sanitation of the home and workplaces of EHS patients. A lowering of exposure levels of EMF in general could be proposed as a precautionary approach, especially for afflicted persons, but this was not seen as a remedy for a person's symptoms. As for treatment, since EHS has symptoms similar to other environmental illnesses, clinicians would normally adopt largely psychologically based managements strategies.

POSTERS

Some of the poster presenters were given an opportunity to give a short oral summary of their posters.

Dr **Yoshikaza Ygawa** from the Graduate School of Medicine, The University of Tokyo, presented a research plan for a study on susceptibility to non-thermal levels of RF from base stations and handheld phones among subjects with and without complaints. Exposure to CW and intermittent RF exposure as well as noise exposure will be used. The parameters include a neuropsychiatric interview, Big Five Personality Test, and physiological functions such as peripheral circulation and skin temperature. In 2004 a pilot study will be completed, the base station study is scheduled for 2005 and the hand held phone study for 2006.

Dr **Martin Röösli**, Switzerland, presented results from a Swiss survey on concerns and health complaints attributed to EMF. It was found that half of the Swiss population was concerned about health effects from EMF exposure. The proportion of EHS individuals was estimated to be 5 %, but they do not attribute symptoms primarily to base station exposure but to power lines and handhold phones, TV and computers mainly.

Dr **Elaine Fox**, University of Essex, UK, is one of the contractors in the UK MTHR programme. She is leading a two-phase study on EHS. The first phase is the development of an EHS questionnaire, and the second is a provocation study with 132 cases and controls, and exposing to GSM 900, and 1800, and 3G signals. The questionnaire has been sent out to 20 000 people randomly selected in East Anglia, and 3 600 responded (18 %). Of these, 399 (11%) reported some sensitivity to EMF. Analysis of the result is ongoing and phase 2 is about to begin.

Professor **Osmo Hänninen**, Kuopio, Finland, has tried to develop a method for studying physiological responses in EHS patients. By using recordings of circulatory parameters controlled by the autonomic nervous system the results so far suggest that it may be possible to use this in the evaluation of subjects reporting EHS. He has been testing subjects with a handhold phone near the head and measured heart rate and blood pressure. Included in the provocation study was also a physical task in the form of 20 successive stand ups. The EHS patients´ reactions deviated from the controls to the mobile phone signal and further studies on this are needed.

WORKING GROUP REPORT

WORKING GROUP REPORT

On October 27, 2004, a working group meeting was held, which included the speakers, the WHO secretariat and other interested parties. The working group meeting included break-out sessions on the following topics: (1) Characterization, diagnosis and treatment, (2) Research needs, and (3) Policy options. The reports from each of these groups is provided below.

(1) Report on CHARACTERIZATION, DIAGNOSIS and TREATMENT

Rapporteur: Lena Hillert, Department of Public Health Sciences, Karolinska Institute, Sweden

Participants:
Jan Bureš, The Academy of Sciences of the Czech Republic
Eduard David, Universität Witten-Herdecke, Germany
Gerd Friedrich, Forschungsgemeinschaft Funk e.V., Germany
Bruce Hocking, Medical Specialist, Australia
Sheila Johnston, Neuroscience Consultant, United Kingdom
Patrick Levallois, Institut national de santé publique du Québec, Canada
Torbjörn Lindblom, FEB - The Swedish Association for the ElectroSensitive, Sweden
Luděk Pekárek, The National Reference Laboratory for Non-Ionizing Radiation, Czech Republic
Martin Röösli, Department of Social and Preventive Medicine, University of Bern, Switzerland
Berndt Stenberg, Department of Dermatology, University Hospital Umeå, Sweden
Arne Wennberg, National Institute of Working Life, Sweden
Oldřich Vinař, Charles University Prague, Czech Republic

BACKGROUND

There are individuals that report a wide range of symptoms that they attribute to electromagnetic fields or being close to electrical equipment[1]. To date, experimental and epidemiological studies have failed to provide clear support for a causal relationship between electromagnetic fields and complaints. The reported symptoms are generally non-specific and no consistent set of symptoms has been identified.

NAME AND WORKING DEFINITION

Name

The term *Idiopathic environmental intolerance (Electromagnetic field attributed symptoms)***,** or IEI-EMF**,** is proposed to replace terms that imply an established causal relationship between symptoms and electromagnetic fields (e.g. electromagnetic hypersensitivity, electrosensitivity and hypersensitivity to electricity). Should a causal relationship to EMF or any other explanation be established in the future, the name of this condition may be changed according to this new knowledge. The specification "EMF attributed symptoms" is motivated by the need to distinguish the group of individuals who attribute their symptoms to EMF from individuals who attribute their ill health to other environmental agents, e.g. odorous chemicals. In the remainder of the text, it will be referred to as IEI.

Working definition

Symptoms that are experienced in proximity to, or during the use of, electrical equipment, and that result in varying degrees of discomfort or ill health in the individual and that an individual attributes to activation of electrical equipment.

CHARACTERIZATION

In the absence of any diagnostic criteria, further characterization of IEI is necessary. Several factors may be included in standardized protocols and questionnaires to characterize IEI individuals, as further detailed below.

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[1] The term "electrical equipment" in this report includes any equipment which emits electric, magnetic or electromagnetic fields 0-300 GHz, e.g. power lines, electric motors, hair dryers, mobile phones and base stations etc. EMF is used as an abbreviation for these fields.

i. Symptoms

Scores of most typical symptoms or indices of these symptoms (e.g. skin symptoms and neurovegetative symptoms, 'headaches' with mobile phones).

Note that IEI is not to be used as a diagnostic classification. In the absence of any identified disease, diagnosis should be based on the most pronounced symptoms (e.g. headache), according to ICD-10 (International Classification of Diseases; for diseases and/or symptoms) or DSM-IV (Diagnostic and Statistical Manual 4th edition; for psychiatric disorders)

ii. Self Reported Triggering or Aggravating Sources

Include information on the EMF sources that are considered by the patient to be the cause of their ailment, for example:

1. Electrical environment in general
2. Specified electrical equipment or sources of EMF (e.g. VDU environment, mobile phones, power lines, other specific electrical equipment)

iii. Exposure (assessment)

Assess EMF exposure to determine if the person's exposure is below existing EMF limits.

iv. Temporal aspects

Symptoms vary/do not vary within 1 hour (or alternatively 24 hours) upon change in presumed exposure	Yes/No
Symptoms increase with longer duration of exposure	Yes/No
Perceived exposure – response relationship	Yes/No

v. Behavior

Avoidance behavior	Yes/No
Sick leave (If yes: Number of days)	Yes/No

vi. Clinical findings

Pathological findings in medical work-up, e.g. in blood chemistry, skin tests or in investigations of reactions in the autonomic nervous system (ANS) Yes/No

In case of provocation tests (see discussion in next section), indication of a relationship between exposure (specify!) and complaints Yes/No

Subgroups

Typical subgroups may be described based on the variables above in order to focus on these specific groups in experimental or epidemiological studies. These groups may include, for example:

A. A group of persons, without a reasonable alternative diagnosis, with predominantly skin symptoms that present themselves within one hour of work with VDUs, all persons still working part or full time.

B. A group of persons, without a reasonable alternative diagnosis, with predominantly neurovegetative symptoms that present themselves within 24 hours of exposure to mobile phone base stations or other EMF source e.g. power lines (as reported by the persons themselves), working or on sick leave, all of which have taken measures to reduce their exposure to EMF in their homes or places of work.

C. A group of persons, without a reasonable alternative diagnosis, with predominantly unpleasant feelings on the scalp (which the patient distinguishes from ordinary headaches) and sometimes feeling of slowness of thought, which the afflicted persons associate with use of mobile phones.

MANAGEMENT AND TREATMENT

The patient's medical history needs to be carefully taken to assess the plausibility of symptoms in relation to EMF exposures (dose-response) and possible alternative diagnoses. Physical examination should be carefully done to assess signs (e.g. skin changes) or alternative diagnoses.

IEI patients suffer from real health problems, but there is no known biological marker or any diagnostic test for IEI. Different contributing factors have been indicated in scientific studies. The primary focus of the medical work-up is to exclude or identify any medical diagnosis or psychological condition that calls for specific handling or treatment (see Figure 1). Psychosocial factors that may influence the patient's well-being should also be considered.

Several studies on IEI patients have indicated that this group of patients has an imbalance in their autonomic nervous system. Deviating reactions have been shown for different environmental stimuli (but not EMF) as well as indications of increased sympathetic activation. Standardized tests for investigation of individual patients may be developed. It is presently not known whether these findings may be predisposing factors or an effect of long suffering from ill health.

Information on what is known about health effects from exposure to EMF and medically unexplained symptoms in general are important parts in the medical consultation. The prognosis of IEI seems to be good in many patients, especially in those reported early and in predominantly skin symptoms. The use of hands-free mobile phone kits have been reported to resolve the problem with complaints during mobile phone calls. If symptoms do persist in spite of medical work-up and interventions, it is usually necessary to refrain from pursuing a causal factor and focus on reducing symptoms and disability. The choice of treatment should be based on a broad evaluation of the patient's symptoms and situation and taking the patients motivation for different interventions into account. Regardless of the initial cause of ill health, the patient may be in need of continued support from the medical doctor or a psychologist due to co-existing psychological conditions or secondary effects of suffering from ill health of unknown origin where no standard cure is to be offered.

General recommendations to the physician for the medical consultation and follow-up include:

- allowing enough time and/or repeated visits
- establishing a trustful relationship and agreeing on a shared ambition, i.e. the patient's improvement
- ensuring follow-up of the patient
- applying a non-judgmental and supportive approach, but informing the patient of your professional opinion
- in case of persisting symptoms, focusing on reducing disability rather than searching for a specific causal factor.

Measuring and reducing the exposure to electric and/or magnetic fields

Patients who suffer from ill health and attribute it to electric or magnetic fields frequently ask for measurements of fields and actions to reduce the exposure to EMF. Measuring fields are not generally recommended since there is no known causal relationship between electric or magnetic fields and symptoms unless the EMF fields are likely to exceed recommended exposure limits. However, measurement in workplaces may be important to assess compliance with exposure standards. For further discussion on advantages and disadvantages of actions aimed at EMF, please see the chapter “Handling of individuals claiming “electromagnetic hypersensitivity” in *Possible health implication of subjective symptoms and electromagnetic fields; A report prepared by a European group of experts for the European Commission, DG V*. [Bergqvist U et al. Stockholm, Sweden; 1997: National Institute for Working Life. (1997:19)] http://ebib.arbetslivsinstitutet.se/ah/1997/ah1997_19.pdf .

Provocation tests

Provocation studies with double blind exposure sessions have failed to verify a causal relationship between electric, magnetic or electromagnetic fields and complaints. The option to conduct individually designed provocation tests on a single patient needs careful consideration by the physician and the patient, including discussions on how different outcomes of the tests might be interpreted.

Should individually designed provocation tests be considered, it should be noted that the design needs to be carefully considered, e.g. regarding the exposure field intensity and modulations, blinded randomization of exposures, number of tests etc. If the patient states that he/she will not change his/her belief regarding the cause of ill health, regardless of the outcome in any provocation tests, a provocation test will not serve any purpose.

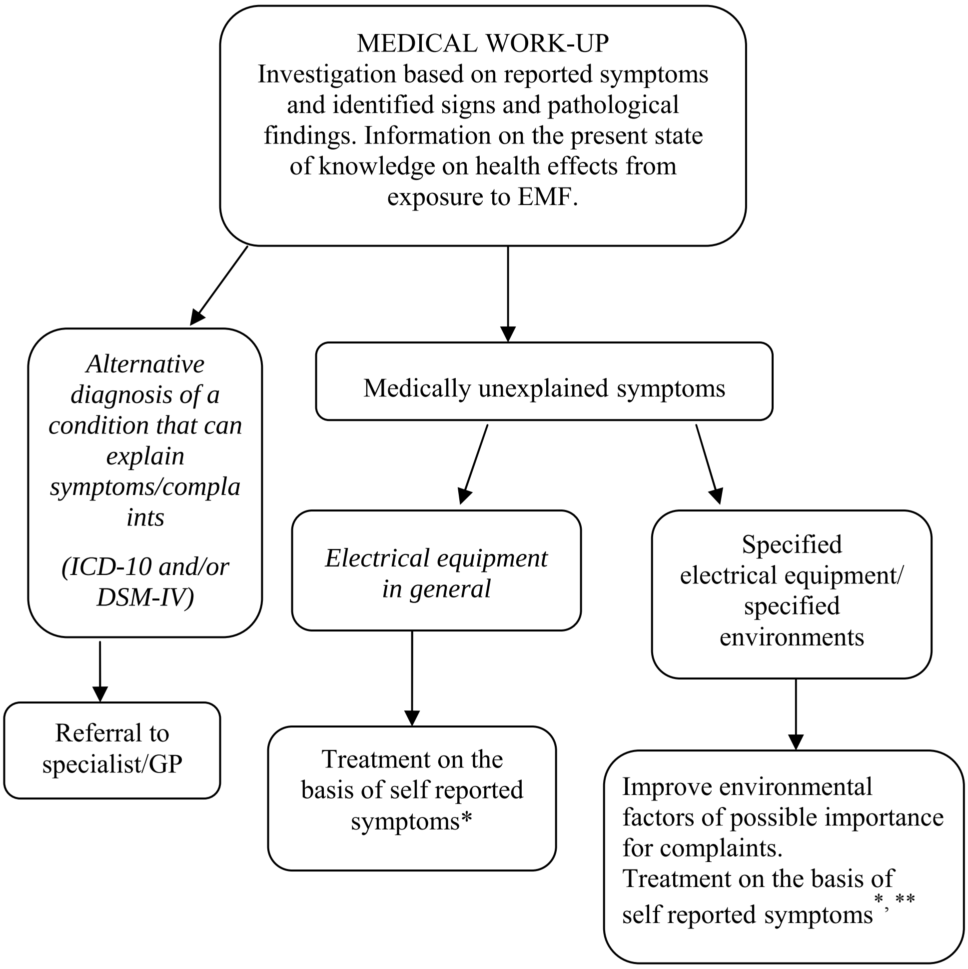

Figure 1 Flow chart of investigation and intervention of IEI patients.

*The choice of treatment may be based on reported success of different treatments for similar symptoms of other conditions and may include stress reduction strategies and cognitive behavioral therapy.

**Different options that the afflicted person may choose to consider may be discussed (e.g. use of hands-free mobile phone kit, reduction of working time with a VDU), but the decision to take these actions is left to the patient.

(ii) Report on research needs

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** Dr Johansson has reservations with the contents of this report*

The working group (WG) noted that electrical hypersensitivity (EHS) has gained relevance that goes beyond the number of individual cases but influences the risk perception of a much wider percentage of the general population.

The WG was aware that the term "electrical hypersensitivity" is only one among others such as "electromagnetic hypersensitivity" and "sensitivity to electricity". It concluded that these terms are misleading and should be replaced by IEI (idiopathic environmental intolerance) which would fit better in the commonly used terminology for similar health-associated environmental factors.

The working group concluded that specific diagnostic IEI facilities would be helpful and that there was a need for further research in this field. Research needs in the following ranges were identified:

DIFFERENTIATION OF IEI

IEI cases with EMF attributed symptoms needs to be differentiated from other IEI cases:

a) there should be a search for a symptom cluster: Present studies were very valuable in determining groups of self-declared EHS cases. There is a need not to restrict the attempt to self-declared EHS cases but to study the group of IEI on a broader scale, e.g. by hypothesis-based studies of symptom groups according to the frequency of occurrence or symptom-trigger by specific sources.

b) there is a need to define IEI inclusion/exclusion criteria, e.g. definitions based on baseline tests for characterizing the status of the autonomic nervous system and the psychological/ psychiatric status.

PROVOCATION STUDIES

Provocation studies are considered to be the most powerful way of studying/ proving a causal relationship. For proper design, apart from ethical considerations, the following aspects need to be considered:

- differentiation between potential electromagnetic versus psychological/ psychophysiological impact by adequate tests
- double-blind placebo-controlled crossover design
- inclusion of an appropriate psychiatric control group exhibiting similar symptoms (e.g. anxiety, affective disorders, somatoform reactions, etc.)
- inclusion of a positive control factor, e.g. other environmental stressors like sound, flickering light or mental stress
- accounting for potentially different individual reaction onset/recovery time constants
- characterization of provocation conditions, including the duration of exposure and the duration of washout times
- measurement of the EMF background level (which should be well below the provocation level)
- consideration of person's belief/ experience when choosing provocation factors (e.g. fields, exposure time)

- use of well documented and validated questionnaires and test procedures with preference given to yes/no questions (such as the Minnesota MMPI-2 test protocol or the SCL-90R- symptom checklist)
- neuropsychological testing before and after exposure
- consideration of appropriate signal characteristics, e.g. frequency, modulation and intensity

There is a need to harmonize protocols and establish multinational/ international cooperation.

EPIDEMIOLOGICAL STUDIES

For the time being, epidemiological studies are not considered helpful. The reasons for this are the following:

- the definition of "cases" is still lacking
- possible device-specific reactions could be missed because of the different devices encountered in daily life
- exposure level might not necessarily be a selection criterion for exposure groups

(iii) Report on policy options, communications with IEI individuals and recommendations to national authorities

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INFORMATION FOR GENERAL PUBLIC

WHO to develop a general fact sheet that includes the following points:

- range of symptoms of IEI
- no attribution of causality to EMF
- do not include prevalence of EHS but rather prevalence of the different symptoms (and longstanding history of these) in general population

- do warn against commercial products to shield against EMF
- discourage measurements in homes
- exclude underlying somatic disease by usual physical examination
- no proof of any correlation between these symptoms and later diseases
- reminder of basic physics (NIR vs. IR, etc)
- recovery is certainly possible without taking drastic measures
- stress due to introduction of new technologies
- need for coping strategies

INFORMATION FOR PHYSICIANS

- Information regarding ill-defined symptoms and undifferentiated illness should be included in post-graduate training
- Experts should develop an international protocol for physicians that includes current diagnosis and treatment information
- National governments should develop tailored information for medical practitioners

ADVICE TO GOVERNMENTS

Governments need to put the issue of IEI into their general risk communication strategies.

They also need to address the following issues:

- Patients have real symptoms, some of which are attributed to EMF, but there is no scientific evidence of causal link, therefore no grounds to use IEI as a diagnostic classification for handicap status. But symptoms could be used as a classification.
- No indication that lowering the limits would reduce the prevalence of symptoms attributed to EMF
- Discourage measurements in homes
- Develop appropriate interaction with self-help groups

- Anticipate problems with new technologies, and provide balanced information, promote dialogue. Note different attitude taken for new pharmaceuticals, both before introduction and post-marketing surveillance. Study the possible role of complaints registers.

TUTORIALS

Characterizing Electrical Hypersensitivity

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BACKGROUND

Facial skin symptoms related to visual display terminal (VDT) work, were reported in Great Britain and Norway in the late 1970s (Pearce 1984, Lindén & Rolfsen 1981, Rycroft & Calnan 1984, Tjonn 1984, Nielsen 1982). Since the first Swedish cases were reported in 1986 (Stenberg 1987), this issue has become of major concern to local health services and a topic of considerable controversy in Sweden (Berg et al. 1990). There are also cases reported from the US (Feldman & Eaglstein 1985, Fisher 1986) and Japan (Matsunaga et al. 1988).

In the past two decades, a group of patients with perceived electrical hypersensitivity (EH) has been described. These patients normally report facial skin symptoms but also, general symptoms, such as fatigue, neurological symptoms including dizziness, and cognitive disturbances, such as memory loss. Patients with EH attribute their symptoms to VDT work and other forms of exposure to electric sources. Such cases are reported mainly from European countries and North America (Bergqvist et al. 1997).

Since the mid-1990s, many people have experienced symptoms while using mobile phones (Hocking 1998, Sandström et al. 2001). These persons have been characterized only with respect to their demography and symptoms.

DEFINITION AND TERMINOLOGY

It has been suggested that patients with electrical hypersensitivity should be divided into two subgroups, one group with “VDT-related skin symptoms” (VSS) or “dermatological syndrome” and one with electrical hypersensitivity (EH), or “general syndrome” presenting a more complex picture of symptoms and attribution. Both phenomena are sometimes referred to as “environmental illnesses”, (Bergqvist et al. 1997, Levallois 2002a). VSS patients normally attribute their symptoms to work with VDTs and exposure to fluorescent tubes and TV screens. EH patients perceive their symptoms, when exposed to electrical sources ranging from watch batteries and cell phones to power lines. A suggested definition of the complex is as follows: “electromagnetic hypersensitivity is a phenomenon where individuals experience adverse health effects while using or being in the vicinity of devices emanating electric, magnetic or electromagnetic fields (EMFs)" (Bergqvist et al. 1997). This definition opens for a divergent use of the term electric hypersensitivity. In a report to the European Commission (Bergqvist et al. 1997) it was obvious that there are some differences between countries with respect to symptoms and attributions among EH cases. In many studies the subjects involved are not described in detail to allow for comparing the findings. In the following VSS will be separated from EH when data permit such a distinction. When this distinction is not made, EH might stand for a mixed group of VSS and EH according to the definition above.

DEMOGRAPHIC FACTORS

In population studies from the US, (Levallois et al. 2002b) and Sweden (Hillert et al. 2002), persons with perceived EH are slightly older, have a lower income and a different ethnic background than the general population. There is a tendency to higher prevalence among women. VSS is much more prevalent among women in Swedish population studies (Stenberg et al. 1993, Eriksson & Stenberg 2004). In a clinical report based on hospital records of VSS and EH, females are more over-represented than in population studies (Stenberg et al. 2002). Young age and female gender were both related to a higher prevalence of symptoms in Scandinavian mobile phone users (Sandström et al. 2001).

PERSONAL FACTORS

Atopic illnesses and symptoms attributed to amalgam dental fillings, are reported to be prevalent among EH subjects in a Swedish population study (Hillert et al. 2002). Self-reported chemical sensitivity is associated with EH in a US population study (Levallois et al 2002b). These findings are well in line with clinical reports, except for atopic illnesses that are not always over-represented in VSS/EH patients (Stenberg et al. 2002).

Mental stress is a well-established risk factor for reporting VSS and EH. Many clinical studies have tried to find personality and psychological/physiological factors, that might lead to a proneness to react to stressful situations with somatic symptoms. Results given, are not concordant between studies. Further, it is not clear whether personality or psychological/physiological findings represent a state that precedes VSS/HE, or whether they develop in parallel.

Psychological factors were studied in 10 EH patients and in 10 VSS patients, and compared with a sex- and age-matched control group. Personality, psychological functioning, and quality of life were determined by using the Karolinska Scales of

Personality (KSP), an additional Personality Scale (PS), a Psychological Functioning Scale (PFS), and a quality of Life Scale (QLS). The result showed that the VSS patients scored significantly higher only in the KSP Somatic Anxiety and Muscular Tension scales, and the EH patients scored significantly lower in the KSP Socialization scale and significantly higher in the Somatic Anxiety, Muscular Tension, and Psychasthenia scales. In addition, only the EH group differed significantly on the PS, PFS, and QLS. The EH patients differed significantly in such psychological aspects as being more fatigued, having more difficulty in concentrating, taking the initiative, getting on with people and experiencing inactivity and visiting other people rarely. The conclusion was that patients with symptoms presumed to be caused by electricity and visual display units differed from each other psychologically and, therefore, should be handled clinically in different ways (Bergdahl 1995).

This conclusion was supported by recent results from studying coping and self-image in Swedish patients that were referred to hospital clinics. Inventories used were; Coping Resources Inventory (CRI) and Structural Analysis of Social Behavior (SASB). In short, both VSS and EH patients scored high on the CRI spiritual/philosophical scale and high on the SASB spontaneous, positive and negative clusters, but low on the controlled cluster. A deviant self-image was found especially in female EH patients. This group of patients also had the worst social and medical prognosis. It was concluded that, in the clinic, a trustful alliance should be established with the patient in order for a more realistic view to be achieved of the capacity (Bergdahl et al. 2004). To summarize, VSS patients by large seem to differ from the general population regarding proneness to anxiety, while EH patients differ with respect to self-image, coping resources or proneness to anxiety.

In has been shown that a mixed group of patients, (VSS and EH persons), have a dysbalance of the autonomic nervous system regulation with a tendency to hypersympathotonia, as measured by heart rate and electrodermal activity, and a hyperreactivity to different external stimuli, as measured by brain evoked potentials and sympathetic skin responses to visual and audio stimulation (Sandström et al. 1997, Lyskov et al. 2001).

A study of heart rate variability (HRV) in a similar group of patients, found that these persons had a disturbed pattern of circadian rhythms of HRV indicating parasympathetic withdrawal during night. The authors concluded that this could lead to a diminished recovery during the night, and thereby maybe a greater irritability during daytime (Sandström et al. 2003). A similar phenomenon has been observed in patients with fibromyalgia, (Martinez-Lavin et al. 1998).

SYMPTOMS AND SIGNS

Typical skin symptoms reported by VSS subjects are sensory sensations (stinging, itching, burning) and signs such as erythema, eczema and rosacea of facial skin (Pearce 1984, Lindén & Rolfsen 1981, Rycroft & Calnan 1984, Tjonn 1984, Nielsen 1982, Stenberg 1987, Berg et al. 1990, Feldman & Eaglstein 1985, Fisher 1986, Matsunaga et al. 1988). The sensory sensations are often described by patients as a feeling of sunburn.

A study of 201 patients using VDTs and perceiving skin problems noted that the sensory sensations were generally more severe, than those in ordinary cases of rosacea. The clinical diagnoses were common facial dermatoses. No specific VDT-related diagnoses were seen (Berg 1988). Routine histopathology did not deviate from what is normally seen in patients with the same diagnoses not exposed to VDTs (Berg et al. 1990).

Other findings have however been reported. When comparing VSS patients with normal healthy controls, differences were found for the biological markers calcitonin gene-related peptide (CGRP), somatostatin (SOM), vasoactive intestinal peptide (VIP), peptide histidine isoleucine amide (PHI), neuropeptide tyrosine (NPY), protein S-100 (S-100), neuron-specific enolase (NSE), protein gene products (PGP), 9.5 and phenyl-ethanolamine N-methyltransferase (PNMT) (Johansson et al. 1996).

The same authors examined two VSS patients before and after an open provocation study to an ordinary TV set. Before exposure, high to very high numbers of somatostatin-immunoreactive dendritic cells, as well as histamine-positive mast cells, were found in skin biopsies from the neck. After exposure the number of mast cells was unchanged while the dendritic cells had seemingly disappeared, (Johansson et al. 1994).

Most EH subjects have similar skin symptoms and signs as VSS patients. However, what normally worries them more, are symptoms such as fatigue, headache, sleep disturbances, dizziness, cardiovascular symptoms and cognitive disturbances such as difficulties concentrating and memory loss, (Bergqvist et al. 1997).

Stress-sensitive hormones have been studied in a mixed group of patients. The distribution of VSS/EH patients was not given. They were followed during a regular workday and during a day of leisure. In the initial report, workers with symptoms had higher levels of thyroxin and prolactin compared with employees without symptoms. Symptomatic patients also reported more occupational mental strain. Based on the results a model was proposed in which physiological signals act as unconditioned stimuli and the VDU environment as the conditioned stimuli, (Berg et al. 1992). Analyses of adrenocorticotropic hormone (ACTH) and melatonin in the same patients were separately published later on. Melatonin levels decreased significantly during

VDU work, whereas ACTH levels increased. Mental strain during work was significantly associated with levels of ACTH but not melatonin. Specific factors contributing to changes in melatonin were not found (Arnetz & Berg 1996).

Alternations in cholinesterase activity as an explanation for fatigue in EH persons has been studied. The results did not support this hypothesis, (Hillert et al. 2001).

A symptom specifically reported from cell phone users is warmth behind or on the ear. It was first described in 1998 as a burning feeling or a dull ache mainly occurring in the temporal, occipital or auricular areas. The symptoms often began minutes after beginning a call. Among forty respondents to a telephone interview, 75% of cases were associated with the use of digital mobile phones (Hocking 1998). Neurological changes in the C-fiber nerves of the affected area of dull pain was found and published as a case report (Hocking & Westerman 2002).

In a correspondence, other symptoms such as dizziness, disorientation, nausea, headache, suggesting stimulation of the vestibular apparatus, were reported, Cox & Luxon, (2000). In response to mobile phone user complaints in Norway and Sweden, a population study compared symptoms among Nordic Mobile Phone (NMT) and Global System of Mobile Communication (GSM) users. The prevalence of symptoms was the same in users of both systems but there was a dose-response association and a significant association between calling time/number of calls and the prevalence of warmth behind/around or on the ear, headaches and fatigue, (Sandström et al. 2001).

PROGNOSIS

The natural history of VSS and EH is hard to establish as most patients have been subject to a number of actions, medical treatments as well as changes in the environment. Studies have shown that VSS patients have a favorable prognosis (Stenberg et al. 2002, Berg 1988). They seem to improve over time and most of them can still be at work, many of them can even take up VDT work to some extent. Similar findings have been reported in a population study, (Eriksson et al. 1997). Subjects with isolated skin symptoms had been improved at 5-year follow-up, while persons reporting both skin and general symptoms did not improve at a similar rate.

A follow-up study of EH patients, referred to hospital clinics, showed that particularly women, have extensive medical problems and a considerable number of them stop working. They do not heal over time in the way VSS patients do, (Stenberg et al 2002). There are no published studies of prognosis in persons perceiving symptoms when using mobile phones.

CONCLUSIONS

VSS and EH are mostly reported from industrialized countries with a high technical standard. Women seem to be over-represented, and especially EH subjects may have personality and psychological/physiological traits, making them more prone to react to mental and physiological stress. There is an association between EH and other idiopathic environmental illnesses. A distinction between VSS and EH may be gainful because they have different prognosis. Both groups do, however, need early and consistent management, patients with EH because of the nature and extent of their problems, and VSS patients to prevent further progress. Subjects reporting symptoms when using mobile phones should be further studied. Like VDT users, they seem to have specific sensory sensations, but also general symptoms and cognitive disturbances, which are similar to those reported by persons perceiving electrical hypersensitivity.

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Idiopathic Environmental Intolerance (IEI): A Causation Analysis

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BACKGROUND

My assigned topic for this workshop on electromagnetic fields was the history of "environmental illness." I have structured the history using Sir Austin Bradford Hill's nine criteria of causation (Strength, Consistency, Specificity, Temporality, Biological Gradient, Biological Plausibility, Coherence, Experimental Intervention, and Analogy) with the addition of a tenth criteria (reversibility). Each of these criteria is presented below with a brief statement of the findings for the toxicogenic theory and the psychogenic theory. Because of space limitations, references are not included and the reader is referred to the original reviews by Staudenmayer, Binkley, Leznoff, and Phillips (2003).[2,3] This analysis applies to the alleged ill health effects of low level exposure to electromagnetic fields, although a thorough review of the literature is beyond the scope of this analysis.

IDIOPATHIC ENVIRONMENTAL INTOLERANCE (IEI)

Idiopathic Environmental Intolerance (IEI) is a descriptor, not a definition, originating from a 1996 Berlin workshop convened by the International Program on Chemical Safety (IPCS) of the World Health Organization (WHO) and agencies of the German government.[1] The designation IEI should displace the term multiple chemical sensitivity (MCS), as well as other labels such as environmental illness and chemical intolerance because they suggests unproven causation and physiological mechanisms. IEI is a descriptor without any implication of environmental etiology, immunological sensitivity, or susceptibility. IEI may be further modified by the type of environmental agent in question such as IEI (chemicals), IEI (foods), or, as applies for this workshop on electromagnetic fields, IEI (EMF). IEI is described as:

- An acquired disorder with multiple recurrent symptoms
- Associated with diverse environmental factors tolerated by the majority of people
- Not explained by any known medical or psychiatric or psychological disorder.[1]

IEI incorporates a number of disorders sharing similar nonspecific medically unexplained multiorgan system symptoms that are attributed to environmental factors believed to be harmful. It is universally accepted that IEI patients are in distress and are suffering, with disruptions in their occupational, social, and personal functioning. The fundamental issue is whether the effects attributed to environmental exposures are explained by a toxicogenic theory or a psychogenic theory.

THE TOXICOGENIC THEORY

The toxicogenic theory of IEI presupposes that susceptibility or intolerance to low-levels of any environmental agent accounts for somatic or psychological multisystem symptoms, either through toxicodynamic pathways, or by sensitizing neural pathways.

THE PSYCHOGENIC THEORY

The psychogenic theory presupposes that IEI is a culturally learned phenomenon, a belief characterized by an overvalued idea of toxic harm explained by psychological, psychosocial, and psychophysiological processes (Table 1). An overvalued idea is analogous to a psychosomatic 'meme', an idea that works like an infectious agent in functional somatic syndromes, spreading and enduring in the individual and infecting others. A functional somatic syndrome is not a disease but a description of multisystem symptoms with associated low threshold of pain or discomfort, without corroborating medical signs or pathophysiology. A psychosomatic 'meme' mimics disease and projects distress onto factors external to the self.

Table 1. Factors in the Psychogenic Theory of IEI

Premorbid psychiatric disorders
Comorbid psychiatric disorders
Personality traits associated with personality disorders
Personality traits associated with somatization
Psychological defense mechanisms: denial, repression, projection
Motivation (malingering, primary gain, secondary gain)
Childhood abuse and emotional trauma
Genetic predisposition to psychiatric illness, particularly panic disorder
Psychophysiology of anxiety and panic attack
Psychophysiology of stress responses
Amplification of bodily sensations to symptoms
Bias to equate symptoms with disease
Vigilance for environmental triggers, perceived or real
Cognitive processing styles: hypochondriasis, catastrophic consequences
Acquired beliefs about toxic harm and attribution to environmental agents
Suggestibility
Physician suggestion associated with iatrogenic reinforcement of belief
Mass psychogenic illness processes associated with sick building syndrome
Reinforcement by media, support groups and the Internet
Illness behavior and the sick role
Functional disability and poor coping skills
Seeking disability compensation, litigation

CAUSATION ANALYSIS

Bradford Hill proposed his criteria (Table 2) to be applied to demonstrate a causal interpretation of an association that was demonstrated in epidemiology studies, and generally accepted in the scientific community, the association between chronic smoking and lung cancer.[4] Strict adherence to Hill's methodology would preclude its application to a causal analysis of IEI, because no epidemiological studies exist that have shown the nexus between exposure and IEI. However, such exclusion is not acceptable in the current social, cultural, and political contexts in which IEI is labeled "controversial."

Table 2. Bradford Hill's Criteria of Causation

1.	Strength: increased prevalence of symptoms/disease in the exposed population
2.	Consistency: reliable association between exposure and symptoms and replication of empirical findings
3.	Specificity: the association is limited to people with specific exposures with specific symptoms in specific physiological systems
4.	Temporality: the cause precedes the effect
5.	Biological Gradient: the dose-duration-response curve
6.	Plausibility: the association is biologically plausible and consistent with scientific knowledge
7.	Coherence: the causal interpretation does not conflict with generally known facts of the natural history and biology of the disease
8.	Experimental Intervention: some preventive action or intervention prevents the association
9.	Analogy: to well-characterized disease

The rationale for extending the application of Hill's criteria to IEI, is supported by a recent monograph[5] released by the US Agency for Toxic Substances and Disease Registry (ATSDR) entitled, "A Quick Guide to Evaluating Environmental Exposures", outlining a logical process for the evaluation of adults with potential environmental exposures. In this guide, the ATSDR recommended reviewing "...Past and chronic health problems" and "Mental health history" as part of a comprehensive evaluation. The ATSDR guidelines also recommended that the information gathered during the evaluation be subjected to a causation analysis following Bradford Hill's criteria, used to establish a nexus between an exposure and an effect that would apply on a population basis.

STRENGTH OF ASSOCIATION

The strength of an association is defined in terms of the prevalence of symptoms and disease in the exposed population. Hausteiner and colleagues have recorded the number of multisystem symptoms as high as 252 in a clinic sample of 295 IEI patients in Germany, the largest study sample reported to date. Many of the general malaise symptoms associated with IEI are common in the general population. Some of the more common IEI complaints are also symptoms of depression found in the general population (impaired attention and memory, fatigue, insomnia or hypersomnia, low energy, anhedonia defined as the lack of capacity for enjoyment, and loss of libido) and anxiety, (restlessness or feeling keyed up, irritability, difficulty concentrating, mind going blank, muscle tension, and sleep disturbance). Symptoms associated with acute reactions to self-identified environmental triggers represent symptoms of hyperventilation including shortness of breath in the presence of normal pulmonary function, lightheadedness, impaired mentation, depersonalization, confusion with incoordination, paresthesias, headache, trembling, sweating, and abdominal distress. In the general population, individuals with more medically unexplained multiorgan system symptoms, tend to have more psychiatric morbidity.

In evaluating patients' symptoms, somatic diseases alone or in combination with psychiatric or toxicological factors must be considered. It is not uncommon for IEI patients to have other somatic conditions or alternative diagnoses that explain certain symptoms. However, they do not account for all of the patients' complaints and IEI persists, even when such conditions are addressed medically.

Since the low-level environmental exposures associated with IEI are commonly found in everyone's daily living environment, the exposed population is indistinguishable from the general population. Everyone is exposed.

Proponents of the toxicogenic theory define prevalence in terms of self-reported chemical intolerance or by a "diagnosis" from a physician. A survey conducted by the California State Health Department asking general questions about unusual sensitivity to chemicals showed 6.3 % of 4,046 respondents had a doctor diagnosed "multiple chemical sensitivity," 15.9% reported being allergic or unusually sensitive to everyday chemicals, 11.9% described sensitivity to more than one type of chemical, and 0.6% reported a restrictive health. These investigators suggested that the 0.6% who reported a perception of unusual sensitivity to chemicals, a physician's diagnosis of chemical sensitivity, and a health problem that restricts their daily activities, might be the closest to those described as IEI patients in medical clinic settings.

Surveys such as these, may be helpful in estimating the percentage of the population that holds certain beliefs, but they typically overestimate the prevalence of objective disease even in those instances where such a disease is established and generally accepted. This is illustrated in three population studies showing a remarkable discrepancy between perceived intolerance to food or food additives and placebo controlled challenges. In the UK, food intolerance was perceived by 20.4% of the respondents, but confirmed prevalence was less than 2.0%. A UK study of food additives found an even greater discrepancy between perception (7.4%) and prevalence (less than 0.25%). In a Dutch study perceived food intolerance was 12.4% with less than 3% confirmed.

Epidemiological prevalence estimates of IEI have been hampered by lack of an accepted definition of IEI and specific symptoms in the absence of objective medical findings. There is a paradoxical finding that there is no evidence of increased incidence of IEI in individuals with documented chemical exposures such as farmers, heavy industry or chemical industry workers.

IEI patients are heterogeneous in their diagnoses of clinical psychiatric syndromes, which are coded on Axis I of the five axis coding scheme recommended by DSM-IV, and personality disorders, which are coded on Axis II. Nevertheless, somatoform disorders are the most common and are typically comorbid with other psychiatric diagnoses.

Clusters of nonspecific medically unexplained symptoms have been referred to in the literature by many different labels, including somatization, symptom-based conditions, and functional somatic syndromes, among many others. Multisystem symptoms associated with psychiatric disorders are characteristic of somatization. Somatization is a process by which individuals inappropriately focus on physical symptoms and seek medical attention, while psychosocial problems are denied. Somatizing patients no doubt experience distress, although the mechanisms underlying symptoms are associated with psychiatric disorders or are a manifestation of stress-responses or cognitive styles. Somatization in IEI is characterized by multiple medically unexplained symptoms, vigilance for exposures and bodily sensations, amplification of common bodily sensations experienced by the general population into symptoms, the hypochondriacal attitude of equating symptoms with disease, and seeking medical diagnoses and treatment to support the belief of toxicologically-induced organic disease.

The role of somatization and associated psychopathology has a lengthy history, which culminated in the 19th century diagnosis of neurasthenia. Neurasthenia is retained as a diagnosis in the World Health Organizations' International Classification of Diseases (ICD-10), defined as a neurotic disorder characterized by fatigue, irritability, headache, depression, insomnia, difficulty in concentration, and lack of capacity for enjoyment (anhedonia). DSM-IV does not have a diagnostic code for neurasthenia, but refers to it as an undifferentiated somatoform disorder. It has been suggested that neurasthenia is the unifying construct among numerous functional somatic syndromes that evolved in the 20th century including IEI. Individuals with functional somatic syndromes typically have comorbid psychiatric clinical syndromes such as depression, anxiety, and somatoform disorders including conversion disorder.

The ICD-10 diagnosis of neurasthenia, as well as the DSM-IV diagnosis of undifferentiated somatoform disorder, describe IEI patients in terms of symptoms without medical signs or pathophysiology with impairment above and beyond that expected by the symptoms. However, neither of these diagnoses addresses the belief of attribution unique to IEI. An additional new somatoform diagnosis seems warranted called "overvalued idea" to encompass IEI as well as other functional somatic syndromes in which cause is attributed to actual or perceived environmental exposures.

CONSISTENCY

The consistency criterion requires replication of findings. Provocation challenges in a controlled environment provided by an exposure chamber allow for objective open and blinded observation of the reliability of reactions to self-reported environmental triggers. According to the IPCS/WHO recommendations, if IEI did exist, it would be demonstrated only if verified by results of controlled provocation challenges:

> "Human research is urgently needed to determine the nature (e.g., psychogenic, toxicogenic) of IEI since the outcome will influence public policy and clinical practice for IEI prevention and treatment, respectively. The key question is whether subjects with IEI are able to discriminate in double-blind, placebo-controlled challenge studies between reported environmental (e.g., chemical) triggers and placebos. Ability to discriminate suggests a toxicologic (i.e., chemical receptor) mechanism. Inability to discriminate would suggest a psychogenic (e.g., conditioned or learned) mechanism."[1]

A comprehensive review of the literature by the UK Health and Safety Executive failed to find a single provocation challenge study to support the toxicogenic theory of IEI. When provocation studies with foods, clinical ecology provocation/desensitization methods, household or industrial chemical agents, fragrances, and electromagnetic fields are conducted under methodologically sound double-blind, placebo-controlled conditions, symptom responses do not correlate with exposure. The implication is obvious; the perceived reactions are cognitively mediated.

SPECIFICITY

The association is limited to people who have had specific exposures with specific reactions in specific physiological systems. It is a fundamental axiom of toxicology that individual chemicals elicit predictable effects limited to specific organ systems. Adverse effects from chemical exposure tend to have well-defined dose-related "toxic syndromes." In toxicology, the agent determines specificity. However, in the toxicogenic theory of IEI, the individual determines specificity. Proponents of the toxicogenic theory postulate that most IEI patients have individually stereotypic syndromes. But these are manifestly non-specific in that the idiosyncratic susceptibilities, idiosyncratic thresholds of responsiveness, and idiosyncratic symptoms are protean not only from one individual to another, but also from one exposure event to another for the same individual. The toxicogenic theory makes no specific predictions about what outcomes are expected. Any outcome is consistent with the theory.

A psychogenic theory consideration is whether there are certain psychiatric conditions to which the more common symptoms are specific. Provocation challenge studies with panicogenic agents and self-reported triggers in IEI patients have demonstrated specific symptoms resulting from hyperventilation and hypocarbia during anxiety and panic attacks. IEI patients, like patients with panic disorder, have panic attacks when exposed to panicogenic agents in single-blind studies of intravenous sodium lactate and inhalation challenge of CO_2 . This suggests that many IEI patients have either a neurobiological condition similar to panic disorder, or a central nervous system mediated fear mechanism that involves the prefrontal cortex, the hippocampus, and the amygdala that is activated in anticipation of exposure.

TEMPORALITY

The exposure precedes the effect. The toxicogenic theory postulates two phases to IEI, onset and chronicity. It is hypothesized that onset of IEI symptoms is caused by acute exposure or cumulative exposures. Originally, the effects were hypothesized to create a state of "sensitization" mediated by immune mechanisms. Subsequently, proponents of the toxicogenic theory relabeled the phenomenon as "toxic induced loss of tolerance" and "chemical intolerance" and hypothesized non-immune mechanisms, focusing on the central nervous system. All of these mechanistic hypotheses are unsubstantiated.

Proponents of the toxicogenic theory contend that exposure may be established by patient history alone, which can lead to the faulty reasoning of *post hoc ergo propter hoc* (after the fact, therefore because of the fact). The first error in reasoning is that symptoms are proof of sufficient dose to cause toxicity and injury. The second error in reasoning is that even if there was an exposure, which may or may not be identified by measurement studies, it was the probable cause of exposure symptoms. The toxicogenic theory does not allow exclusion criteria. Genetic predispositions to psychiatric disorder, psychiatric morbidity, psychological distress, emotional trauma, or childhood abuse and neglect premorbid to the onset of IEI are hypothesized to be predispositions that lower the resistance to the onset of toxicologically induced IEI.

With chronicity of effects, it is hypothesized that there is a progressive "spreading" of the intolerance to other non-specific multiple environmental agents usually accompanied by additional multisystem symptoms. The time course for "spreading" to occur is non-specific, ranging from days to weeks, to months to years, seemingly unrelated to identifiable toxic exposures. The effects of spreading reflect a belief reinforced iatrogenically by “environmental physicians” the strength of which appears to be correlated with the time spent in the hands of alternative medicine practitioners.

The toxicogenic theory relies on patient history without objective toxicological evidence of toxic exposure and without objective medical evidence of injury. Temporality cannot logically be applied to the toxicogenic theory because symptoms are synonymous with exposure. The postulate that premorbid psychological traits predispose susceptible individuals to acquire chemical intolerance, actually lends more credence to the psychogenic theory than the toxicogenic theory. This conclusion is strengthened by the usual lack of evidence for an acute toxic exposure prior to the onset of symptoms, which has been demonstrated in cases of sick building syndrome for which there is no plausible rationale for chronic effects.

There is ample evidence for psychiatric and psychological morbidity prior to the onset of IEI, as well as comorbidity after onset, in support of a psychogenic etiology of IEI. Genetic predisposition to a psychiatric disorder, psychiatric morbidity, or psychological distress interact with psychosocial factors such as childhood abuse and neglect, adult emotional trauma, and personality traits associated with personality disorders. The long-term sequelae of childhood sexual, physical, and psychological abuse as well as neglect and emotional deprivation can have profound effects on mood and affect, cognitive processing, dissociation, beliefs and attitudes, personality development, social functioning, distress, stress-response psychophysiology, and certain medical disorders and health-risk behavior. These factors may also be associated with somatization premorbid to the onset of IEI. The psychogenic theory presupposes that these factors are predisposing risk factors to somatization and associated anxiety and somatoform disorders and their manifestation as a variety of functional somatic syndromes including IEI.

Studies of genetics found that there was an increased prevalence of the panic disorder-associated cholecystokinin B receptor allele 7 in IEI patients. These findings provide preliminary evidence that IEI and panic disorder share a common neurogenetic basis, which would predate the anxiety producing effects of having acquired IEI.

BIOLOGICAL GRADIENT

The biological gradient criterion refers to dose-response, where the effects of exposure correlate with dose. Low-level dose has been defined both relatively and absolutely. A dose tolerated by most of the population is a normative definition. There are also specific quantified guidelines for industrial exposure set by regulatory and advisory agencies. The toxicogenic theory has no definition of low-dose exposure and the dose defined as low-level may be as little as one molecule.

While toxicologists note that IEI does not follow the classic laws of dose-response, proponents of the toxicogenic theory counter this position with faulty rationalizations as to why exposures could have different effects, including no effect, at different times, often within minutes. One flawed solution suggested is a scientific paradigm shift to supplant scientific toxicology. The replacement paradigm would have as its foundation patient's appraisal of exposure based on perceived symptoms and attribution of cause based on belief of toxic exposure. The validity of this paradigm is based on the faulty presupposition that patient perceptions are reliable, which was shown to be false under double-blind, placebo-controlled provocation challenges, thus eroding the foundation of this proposed paradigm.

It may be difficult to conceptualize and quantify dose-response for distress and the emotional trauma associated with abuse and neglect. However, the clinical literature suggests a correlation between amount and severity of emotional trauma and medical morbidity, mortality, medical use, distress, self-ratings of low mental health, and psychopathology.

BIOLOGICAL PLAUSIBILITY

This criterion requires that the association be biologically plausible and consistent with scientific knowledge. Proponents of the toxicogenic theory argue that neither biological evidence to identify the pathophysiology nor an understanding of the etiology of IEI are necessary to have a clinical diagnosis. There are many examples in medicine in which syndromes existed with specific signs and symptoms brought on by a cause that was not initially identified. However, IEI symptoms and environmental triggers are so protean that not only do they fail to meet the criterion of specificity reviewed above, but it would also be difficult to identify the characteristics that make it a syndrome. That every environmental agent known to mankind, as well as those yet to be discovered or created, would share a common pathophysiology and a common biological mechanism that induces protean multisystem symptoms with debilitating effects but without objective signs is implausible.

While arguing that the identification of a mechanism to explain IEI is not necessary, proponents of the toxicogenic theory nonetheless have speculated one biological process after another to explain chemical intolerance. Seemingly plausible mechanistic hypotheses of the toxicogenic theory are unsupported by evidence. Their rationale does not follow recognized toxicological, immunologic, allergic, neurological, biochemical, or physical laws.

The neurobiological mechanisms underlying psychiatric disorders such as depression and anxiety disorders, distress and stress responses, and the adult sequelae of childhood abuse, are all relevant to the criterion of biological plausibility as it applies to the psychogenic theory. However, these factors also apply to other criteria in this causation analysis where much of the discussion is presented.

The fundamental presupposition of the psychogenic theory is that IEI is a belief disorder characterized by an overvalued idea of environmental hazards and their debilitating effects. Therefore, the emphasis of our assessment of biological plausibility is to illustrate mechanisms and processes of perception and learning that mediate the neurobiology and physiology of multisystem symptoms associated with IEI.

Learned sensitivity is a process by which individuals develop symptoms from actual or perceived exposure to low-level doses of environmental exposures they believe are toxic. A basic learning mechanism that is relevant to IEI is classical Pavlovian conditioning. It has been suggested to apply to both acute and chronic documented exposures. Learning based on belief of exposure without actual exposure is also within the realm of learned sensitivity, explained by cognitive mechanisms that create ideas and beliefs. The neural encoding of Pavlovian classical conditioning is different from that of associative learning. Cognitively mediated learning can better explain the non-specific generalizations of triggering stimuli, because it is not limited to specific generalization gradients that characterize Pavlovian conditioning.

Among the sequelae of abuse and emotional trauma is mood dysregulation with associated chronic autonomic nervous system arousal resulting in attentional processing difficulties, as measured by reaction time studies and general cognitive dysfunction. Dysregulation of the stress system to chronic, physiologic, and biochemical basal levels of hyperarousal or hypoarousal has been suggested as a theory for the etiology of certain stress disorders, psychopathology, and problems of living. Prolonged physiological arousal and homeostatic instability can disrupt psychophysiological processes leading to higher resting heart rates, hypertension, and increased conditioned physiological and emotional startle responses and disrupted attention.

COHERENCE

The coherence criterion specifies that the causal interpretation does not conflict with generally known facts of the natural history and biology of the disease. Proponents of the toxicogenic theory suggest that IEI either causes somatic syndromes or mimics the associated psychiatric symptoms because it has the same pathophysiology and neurobiological mechanisms. There is no biology and no specific natural history specific to the toxicogenic theory of IEI. By definition, symptoms occur in the absence of objective medical findings. These arguments reveal a presupposition of the toxicogenic theory that a toxicogenic explanation of symptoms can never be ruled out, and that a psychiatric explanation can never be diagnosed as the underlying pathology.

The psychogenic theory posits that the neurobiology of stress and emotional trauma and accompanying stress-responses can account for the multisystem complaints of IEI. Stress is defined as the sum of the biological reactions to adverse stressors, physical, mental or emotional, internal or external, that tend to disturb homeostasis. Psychophysiological stress responses are compensating reactions to maintain or regain homeostasis. Should these coping reactions be inadequate, they may lead to somatic and psychological symptoms mediated by physiological systems including alterations of various neurohormones and neurotransmitters (e.g., catecholamines, glucocorticoids, serotonin, and dopamine). Individual differences in stress-responses, psychological defenses, and coping skills have a complex etiology involving interactions among many factors including inherited disposition and temperament, child rearing and nurturing, attachment, development of affect regulation, and traumatic experiences.

The subjective cognitive complaints described by proponents of the toxicogenic theory as "brain fog" in a heterogeneous sample of IEI patients may be explained by processes other than toxicity. These include biases in perception and reporting following exposures, distraction by preoccupation and attentional vigilance for offending agents or bodily sensations, amplification of symptoms, catastrophic thinking, depression, anxiety and phobia, and hypocarbia induced by acute or chronic hyperventilation.

EXPERIMENTAL INTERVENTION

The criterion of experimental intervention specifies that some preventive action or intervention prevents the association. Proponents of the toxicogenic theory rely on unsubstantiated diagnostic and treatment methods, which have even been characterized as deceptive practices. A number of these methods employed for both diagnosis and treatment such as provocation and neutralization tests administered by routes of inhalation, sublingual absorption, or intracutaneous injection have been shown to be no more accurate than placebo under double-blind, placebo-controlled provocation challenge studies. Additional treatments including elimination diets, mega doses of vitamins and supplements, and sauna depuration, have been deemed unsubstantiated and potentially harmful. Avoidance of environmental exposures by isolation in "safe houses" has never been proven effective, and can have harmful effects on IEI patients by removing them from feedback from the real world and providing a distraction from their underlying psychological problems.

Preliminary clinical evidence suggests that some IEI patients improve when their psychiatric disorders are addressed, and that there is reversibility of triggered responses, despite the continued exposure to agents formerly considered by the patient to be toxic. Treatment is comprised of medications and psychotherapies including relaxation/stress management, behavioral desensitization to phobic stimuli, cognitive-behavioral problem solving therapy, and cognitive insight oriented psychotherapy. Cognitive-behavioral therapies incorporating methods of systematic desensitization have demonstrated limited success when applied to IEI patients. Most IEI patients believe that psychological factors do not explain their symptoms. When beliefs are held with such firm conviction that they are closed to alternative explanations and all experiences are attributed to environmental intolerance, life is organized around the illness and the prognosis for change is poor. As in other functional somatic syndromes, risk factors for poor outcome in treatment include a closed belief of non-psychological causation, resistance to accepting the therapeutic rationale, poor motivation to treatment adherence, and primary gain and secondary gain for maintaining the sick role. Overcoming primary gain may require extensive cognitive restructuring in psychotherapy, in which underlying fears and dynamics are addressed. This type of therapy integrates psychodynamic, neurophysiological, and cognitive-behavioral theoretical formulations and clinical approaches, and emphasizes the importance of early childhood experiences of trauma and emotional deprivation. This approach has been successful in the treatment of anxiety and panic disorder as well as IEI.

ANALOGY

The criterion of analogy queries whether there is an analogy to a well-characterized disease or disorder. Proponents of the toxicogenic theory contend that IEI is not analogous to any known toxic syndrome. Therefore, it is uncontested that the criterion of analogy does not apply to the toxicogenic theory.

Psychiatric comorbidity, victimization, stress-physiology, psychological disturbance, psychological defenses associated with somatization, and the various psychosocial and cognitive biasing factors are commonly reported in other functional somatic syndromes.

REVERSIBILITY

Reversibility is not one of Hill's criteria, and does not apply when Hill’s criteria are employed in a causation analysis of epidemiology studies that demonstrate an association that is generally accepted. However, because the ATSDR guidelines[5] suggest extending Hill’s criteria to infer causation in individual incidents of potential exposure, my colleagues and I have added it to the assessment of IEI causation. The criterion of reversibility posits that there is improvement in health status with removal from exposure.

The vast majority of persons will not have persistent clinical findings following a chemical exposure of sufficient dose to cause a clinical effect. In the absence of a permanent alteration in tissue morphology or function, the clinical findings will resolve. This simply reflects the human body’s capacity for recovery from toxic insults. Reversibility, either through healing or resumption of normal physiologic activity is usually expected.

Upon removal from an initial exposure, real or perceived, IEI patients may improve but subsequently become symptomatic on exposure to ambient doses of multiple real or perceived environmental triggers. In the extreme, the patient becomes an invalid. This is inconsistent with the criteria of reversibility.

Beliefs can spread in the knowledge system in the individual or act as a contagious psychosomatic ‘meme’ in the community to infect those at risk to acquire a functional somatic syndrome. Mass psychogenic illness epidemics may fade away when the exposure facts become known, as would be expected when anxieties are ameliorated by reliable information. However, in the context of irrational thought associated with IEI, selected individuals may develop chronic complaints that become progressively worse.

CONCLUSION

The results of this causation analysis indicate that the toxicogenic theory fails all of the Bradford Hill criteria and the additional criterion of reversibility. There is no evidence to support the fundamental postulate that IEI has a toxic etiology. The claimed unique hypersensitivity of patients has not been demonstrated. Patient appraisals of exposure are unreliable. The hypothesized biological processes and mechanisms are implausible. The research program of the toxicogenic theory is degenerative in the sense that it has generated no evidence to support it and has failed to explain the evidence in support of the opposing psychogenic theory.

These conclusions are consistent with the prevailing opinion in the medical/scientific community. Among the professional organizations that have presented position papers concluding that the theories and methodologies advocated by proponents of the toxicogenic theory are unproven and unsubstantiated are the American Academy of Allergy Asthma and Immunology, the American College of Occupational and Environmental Medicine, the American Medical Association, the American College of Physicians, the Royal College of Physicians, the International Society of Regulatory Toxicology and Pharmacology, the International Program on Chemical Safety/World Health Organization, and the American Academy of Clinical Toxicology, the largest organization in the world devoted to toxicology.

In contrast, the psychogenic theory meets all of the Hill criteria and the added criterion of reversibility directly or indirectly. The psychogenic theory is characterized by a progressive research program including double-blind, placebo-controlled provocation challenge studies. A neurobiological diathesis similar to anxiety, specifically panic disorder, is a neurobiological plausible mechanism to explain triggered reactions to ambient doses of environmental agents, real or perceived. In addition, there is a cognitively mediated fear response mechanism characterized by vigilance for perceived exposures and bodily sensations that are subsequently amplified in the process of learned sensitivity. While several psychiatric diagnoses apply, as expected in a heterogeneous population, somatoform disorders are most prevalent.

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EHS AND THE ELECTROMAGNETIC ENVIRONMENT

Prevalence of «Electrical Hypersensitivity» in Populations of Different Countries

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ABSTRACT

In several countries, many subjects are suffering of symptoms that they associate to the exposure to extremely low frequency electric and magnetic fields (EMF). This has been described in the literature as «Electrical Hypersensibility». This paper reviews the principal studies reporting the frequency of self-reported acute symptoms, potentially related to short term exposure to EMF in various populations. While the first reports deal with occupational exposure to video display terminals, there have been few reports of the frequency of such symptoms in the general population. The two main studies were carried out in Sweden and California. With different methodologies, they reported that a few percent (1 to 3%) of the general population, report to be hypersensitive or very allergic to the exposure to EMF from diverse sources (electrical devices, high power lines, etc). In those two studies, the symptoms of subjects were self-reported and no verification of the relationship to EMF was done.

Self-reported symptoms potentially associated with EMF exposure, seem quite common in the general population of several industrialized countries. There is a need to characterize it better and study its real causes.

For several years, «Electrical Hypersensitivity» (EHS) has been presented in the medical literature as a possible new illness, related to a kind of intolerance to the exposure to electric and magnetic fields (EMF). Due to the potential importance of this problem, in term of frequency and severity, the European Commission (EU) has decided to study it as a priority, Bergqvist and Vogel, (1997) and several initiatives have been carried out to clarify the importance of its burden.

DEFINITION

Despite a number of papers on this issue, there is no clear definition of this potential health problem, Levallois, (2002a). It is mainly self-reported and no diagnostic criterion has been proposed by the medical community to define this entity. In fact, clinical portraits of EHS reported in medical journals are quite diverse and unspecific, going from subjective dermatological symptoms (itching, burning, stinging, etc) to a more general portrait with various functional symptoms including dizziness, fatigue, headache, difficulties concentrating, memory problems, anxiety, sleeping disorders and depression, Berqvist and Vogel, (1997); Levallois, (2002a). The common feature of this self-reported disorder seems its acute occurrence or exacerbation when the subject is near different EMF emitting sources which might be a computer, a power line, an electrical device, a cellular phone, or other source. The definition proposed by a European Commission (EC) working group could be used, at least temporarily, to describe this potential health problem: «EHS is a phenomenon where individuals experience adverse health effects while using or being in the vicinity of devices emanating electric, magnetic or electromagnetic fields», Bergqvist and Vogel, (1997).

EPIDEMIOLOGIC SURVEYS

Many case reports have been published on EHS, but very few epidemiological studies have been reported on populations. The first epidemiological studies carried out in workplaces in Nordic European countries, compared video display terminal (VDT) operators, to non VDT operators. Higher symptoms rates were usually reported among operators including eye discomfort, musculoskeletal disorders, and skin disorders Knave, (1985). In particular, non-specific facial skin symptoms were reported in Sweden twice as frequently on VDT operators, compared to non-operators: 35 % versus 19% (Berg et al. 1990). Reports of general symptoms possibly attributable to EHS were mainly case reports, with a few series of cases self-reporting general symptoms, (Knave et al. 1992); Bergdahl, (1995).

THE EUROPEAN COMMISSION SURVEY

Faced with the lack of data on the incidence or prevalence of EHS in the general community, the European Commission sponsored a survey of European Centers for Occupational Medicine (COM) and self-aid groups (SAG) to try to quantify the frequency and the severity of this health phenomenon in the general population. From this survey, carried out in 1996, the European working group concluded that the frequency of cases seems to differ quite notably between countries. Estimation of prevalence was found to be from «less than a few per million, (estimated from COM form UK, Italy and France), to a few tenths of a percent (estimated from SAG in Denmark, Ireland and Sweden)» Bergqvist and Vogel, (1997).

The estimation of prevalence of severe cases ,as of an order of magnitude, lower than those frequencies. While these estimations were quite speculative, it gives an idea of the importance of the problem among European countries. One of the most interesting findings of this survey was that the clinical complaints vary quite a lot between countries. In particular, skin symptoms were more frequently reported in the Nordic countries while «nervous system» symptoms seem to be more frequently reported in Austria, Denmark and Germany. With a few exceptions (as in Germany), symptoms were reported more frequently in workplaces but the alleged sources of EMF vary greatly by country, Bergqvist and Vogel, (1997).

POPULATION STUDIES

Two prevalence studies in the general population were published in the recent years. (Hillert et al. 2002) conducted a postal questionnaire survey in 1997 among 10,670 Swedish adults. One and half percent of respondents (1.5%; 95% CI: 1.2-1.8) reported to be «hypersensitive or very allergic» to electrical or magnetic fields. Prevalence was higher among female, elders, higher educated subjects but also in low income and people having lived outside Nordic countries. Symptoms the most reported were: fatigue, heaviness in the head, headache, facial skin problems and eye irritation. Degree of severity and sources of EMF alleged to be responsible for the symptoms were not evaluated.

(Levallois et al. 2002b) evaluated by telephone interview 2,072 adults in California in 1998. Three percent of the respondents (3.2%; 95% CI: 2.8-3.7) reported to be «allergic or very sensitive to being near electrical appliances, computers or power lines». Prevalence was higher in Hispanic and Asian subjects. It was also higher in low income and low educated people. Prevalence of self-reported EHS leading «to job change or remaining unemployed» was estimated to be 0.5% (95%CI:0.4-0.6). Interestingly, people alleging that a source of EMF («either distribution or power lines or hair dryer») could cause a health problem, reported twice as frequently to being allergic to EMF. History of asthma and hay fever, was reported to be an important risk factor for self-reported EHS in the Swedish study, but not in the California study. However, in the two studies, subjects frequently reporting EHS, reported other «environmental illnesses»: 53 % of the Swedish EHS subjects reported «amalgam intolerance» and 60% of the Californian EHS subjects reported being «allergic or unusually sensitive to everyday chemical». Despite this, the California study reported some difference in the characteristics of people reporting EHS, and those reporting only multiple chemical sensitivity (MCS). In particular, women, white and wealthy people were more frequently found in the group reporting only MCS, (Levallois et al. 2002b).

These two studies from quite different countries (Sweden and USA) using slightly different methodologies (mail or telephone questionnaire, with questions referring to EMF or specific sources of EMF), gave a similar picture regarding the frequency of this health problem. Prevalence of self-reported EHS was estimated to be a small percentage (1.5 and 3 %), which is much higher that the previous estimation done by the EC working group. The California study confirms that an important percentage of those people afflicted, alleged that they have changed their job or remained unemployed because of this self-perceived EHS; confirming that this health problem might be severe, and not only in European countries. The two studies quite surprisingly also found that EHS was reported more frequently in some groups (low income, ethnic minorities). Yet, these two studies did not validate the EHS self-reported by subjects, nor inquire about trigger sources of the symptoms.

HYPERSENSITIVITY TO EMF

There is still controversy on the possibility that exposure to EMF is causally associated with this self-reported «Electrical Hypersensitivity». Its definition is unclear, and to date no experimental study has linked it to well define exposure to EMF. Also, the fact that people report complaints with various exposures to electrical devices, unrelated to intensity of EMF exposure, is troublesome. After a complete review of the available literature, I conclude recently that « globally, the largest amount of the evidence pleads against a role of EMF in the reported symptoms», Levallois,(2002a). Until now, no link to EMF exposure has been demonstrated in controlled trials but most of these studies concerned people with dermatological problems and were limited to Sweden and Norway, Levallois, (2002a). On the other side, there is some evidence of an important psychological component associated with it, in particular for people reporting general symptoms, Bergdahl, (1995).

There is also a need to consider more broadly this notion of hypersensitivy to EMF. In a study on melatonin excretion of women living near high power lines, we found that aged and overweight women seem more susceptible to EMF exposure (Levallois et al. 2001). While the causal link could not be proved, it raised the question of vulnerability to EMF exposure in some sub-groups of the general population. More recently, Leitgeb and Schröttner (2003) reported that women are more sensitive that men to the perception induced current and that there is a wide variability of this perception among the general population. As a matter of fact, these authors found that, in both genders, about 2 % of the population could be considered «very electrosensible», Leitgeb and Schröttner, (2003).

CONCLUSION

Self-reported EHS seems quite common in general populations. This is based mainly on a survey of European occupational medicine clinics and self-aid groups, and two recent surveys carried out in Sweden and California. The challenge now is to study this health problem more specifically to be able to characterize it better, and offer some effective treatment to patients. There is in particular a need to describe better its clinical characteristics. Recent studies which compared complaints among EHS and non EHS subjects (Hillert et al. 1999) or the general population (Röösli et al. 2004) are headed in the right direction.

Developing a case definition for such a symptom-based condition is not a simple task but it is a necessity to improve the quality of epidemiologic studies, Hyams, (1998). The possible relationship with other symptom-based conditions as MCS should also be studied more deeply. Finally, there is a need to study the real causal factors of this health problem, and consider more broadly this notion of hypersensitivity in order to evaluate if some subjects are really more susceptible to adverse health effects of EMF.

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Electromagnetic Environment in Electrical Hypersensitives Homes and Workplaces

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INTRODUCTION

In our homes and workplaces we are all on daily basis exposed to electromagnetic fields (EMF) from natural as well as man-made sources, and with frequencies ranging from low ELF to microwaves. The EMF emissions from man-made sources exceed those from natural fields, sometimes by many orders of magnitude and are detectable everywhere in the world. The field strength we encounter for the large majority of people, is low to very low, and it is only in some specific occupations high field strength above or near the ICNIRP guidelines can be found. Examples of such occupations are found in the electro steel industry, work with induction heaters, electrical welding using high currents, RF sealers, glue dryers and radio/TV broadcast tower work. Also in hospitals some high fields can be encounter, for instance near the MR imaging machine, or near surgical diathermy equipment.

This paper will give a very brief overview of the EM fields we encounter in our environment, both for the general public and for those experiencing electrical hypersensitivity (EHS).

NATURAL SOURCES

The existence of the earth's magnetic field has been known since ancient times. The total field intensity diminishes from the poles, with a high at the South magnetic pole of 67 µT, and a low of about 30 µT near the equator. However, the geomagnetic field is not constant but continuously subject to more or less strong fluctuations. There are diurnal variations, which may be more pronounced during the day and in summer than at night, and in winter, (see further for instance Köning et al. 1981). There are also short-term variations associated with ionospheric processes. When the solar wind brings in protons and electrons towards Earth, phenomena like the Northern Lights, and rapid fluctuations in the geomagnetic field intensity. The variation can be rather large; the magnitude of the changes can sometimes be up to 1 µT in a time scale of several minutes. The variation can also be very different in two fairly widely separated places due to the atmospherics conditions.

Electromagnetic processes associated with lightning discharges are termed *atmospherics* or "*sferics*" for short. They consist mostly of waves in the ELF and VLF ranges (see further König et al. 1981). Each second about 100 lightning discharges occur globally, and in the USA one cloud-to-ground flash occurs about every second, averaged over the year (Home page of Global Atmospherics, Inc). The VLF signals travel efficiently in the waveguide formed by the Earth and the ionosphere, and can be detected many thousands of kilometers from the initiating stroke.

MAN-MADE SOURCES

ELF electric and magnetic field in homes and workplaces

High voltage power lines: The electric and magnetic fields from high voltage power lines have been in the debate about EM fields for a long time. In the early days of bioelectromagnetics research, the electric field was the most important part, and measurements of field strengths were performed in many places. The field strength depends on the voltage of the line but also on the distance between the phases and the height of the tower. The strongest field can be found were the lines are closest to the ground, and this usually occurs midway between two towers. Here field strengths up to a few kV/m can be found. The field strength inside buildings close to the line, is usually low and rather dominated by other sources since the walls have a shielding effect for the electric field.

The magnetic field from the line depends on the load carried by the line. For a 400 kV line with a full load of 1200 A, a flux density in excess of 0.2 μT can be found up to 100 m from the line. The magnetic field inside house, is about the same as outside, since the building have very low shielding effect on the magnetic field.

Electrical appliances: Measurements of magnetic fields from a sample of various appliances show that the fields have a rapid falloff with distance from the device, (Kaune et al. 2002). Very close the values may exceed international guidelines, but at a distance of 0.5-1 m the fields are seldom higher than tenths of μT. In general, it can be said that the more power the equipment uses, the higher the magnetic field.

Vistnes (2001) gave some examples of flux densities near appliances, and of special interest may be a clock radio, which due to bad electrical design may give rise to exposure of the order of 100 μT close to the equipment. Since people are likely to place such a clock radio very close to the pillow in their bedroom, the head may experienced quite a large magnetic field exposure exceeding the normal levels in the house. See also

Behrens et al. (2004) for recent study of household appliances and the lifetime accumulated ELF-EMF exposure.

Near sewing machines increased magnetic fields can be found, and depending on the type of machine used the values differ. The mean average value logged during some working hours is of the order of several tenths of µT (Kelsh et al. 2003).

EXPOSURE IN HOMES

Several studies have explored the exposure to ELF electric and magnetic fields in homes in different countries. Deadman et al. (1999) investigated the exposure of children in Canada. A logging device was used and recorded the fields during 2 consecutive 24-hour periods. For the 382 children up to the age of 15 they found an arithmetic mean (AM) of the magnetic field of 0.121 µT with a range 0.01 – 0.8 µT. The corresponding values for the electric field were AM 14 V/m, range 0.82 – 65 V/m.

A comparative study of 50 Hz electric and magnetic fields in houses and offices in Sweden and Norway has been carried out by Hansson Mild et al. (1996). The local distribution systems in houses were different in the two countries. Overall mean levels determined in houses were as follows: E fields 54 V/m (SD = 37) and 77 V/m (SD = 58) in Sweden and Norway respectively; B fields 40 nT (SD = 37) and 13 nT (SD = 17) respectively. The difference in the magnetic field levels is considered to reflect larger ground currents in Swedish houses. In offices the fields varied substantially. E fields were of the order of 40 V/m and 15 V/m in Sweden and Norway, while the B fields varied from some nT to over 1 µT in both countries. Some reasons for the high office levels were safety ground errors and in-house magnetic field sources.

Women exposure in USA was measured by Mccurdy et al. (2001) by use of personal magnetic field exposure meters that were worn by the women during a working day or a day at home. The geometric mean of the time-weighted average for the working day was 0.14 µT with a range of 0.022 – 3.6 µT, and for the homemakers the corresponding values was 0.11 µT, range 0.022 – 0.40 µT.

In the meta analysis by Ahlbom et al. (2002) on childhood cancer and residential magnetic fields, it was stated that 99.2% of the population resided in homes with $B \leq 0.4$ µT.

Most modern electrical appliances are equipped with a switched power supply; an electronic circuit replaces i.e. the transformer. This leads that the current is no longer a pure sinusoidal 50/60 Hz signal but contains harmonics. The current used by a low-energy fluorescent lamp is illustrated in Figure 1, where also the Fourier analyses is shown indicating all the harmonics. Since the three-phase systems used for electrical distribution are dimensioned for sinusoidal fields, the harmonic content can create problems. Today we have large stray currents in water pipes, ventilation systems, reinforcement, etc, and the current flowing is also containing these harmonics. In Figure 1 we give an example of a measurement of a current flowing in a cable in a large office building. The corresponding magnetic field in the building thus also has these harmonic components

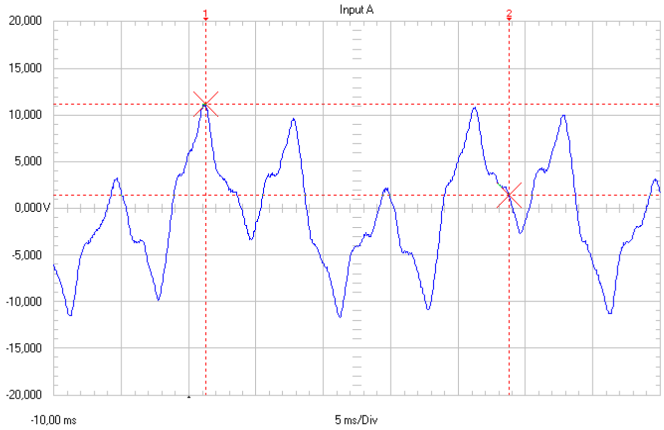

Figure 1 *Stray current wave shape in delivery cable in an office building. The peak to peak current is of the order 20 A.*

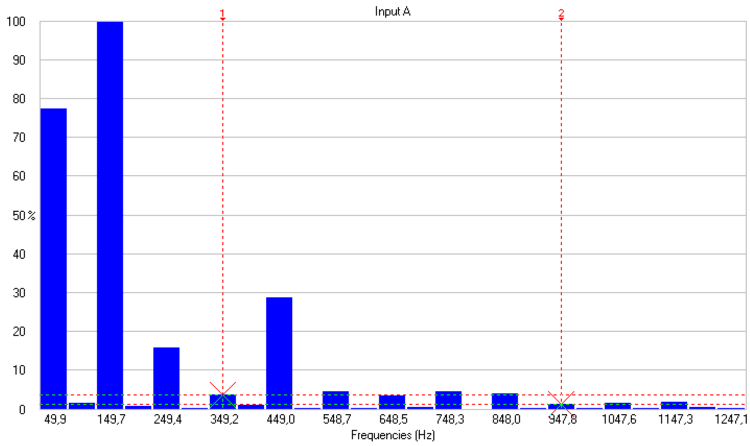

Figure 2 *The Fourier spectrum of the wave shape in Fig 1. Note the high 150 Hz component.*

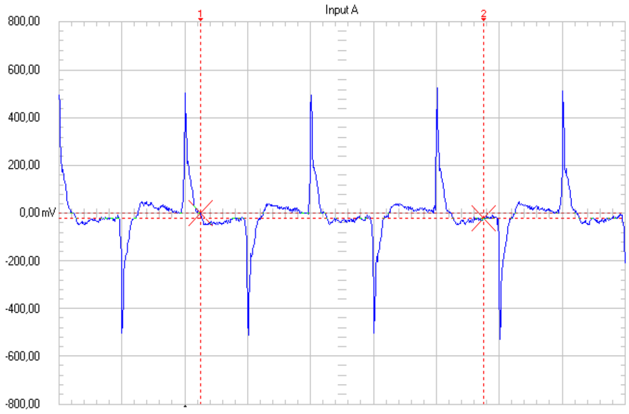

Figure 3 *Wave shape of the current to a low energy fluorescent lamp. The time scale is 10 ms per div.*

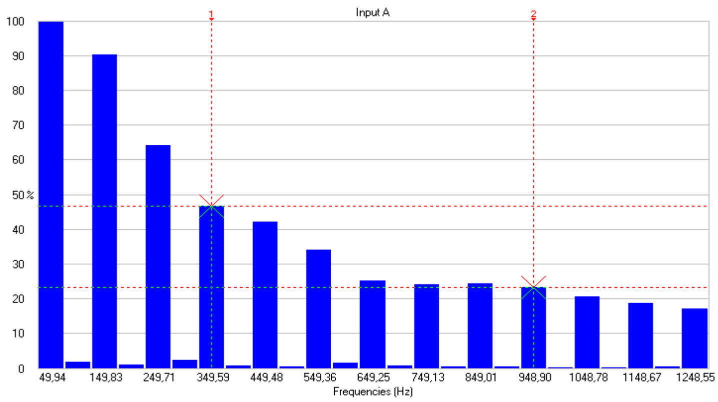

Figure 4 *The Fourier spectrum of the wave shape in Fig 1. Note the high 150 Hz component.*

ELECTRONIC ARTICLE SURVEILLANCE

Several libraries and stores are nowadays equipped with electronic article surveillance systems, which generate EM fields ranging from low ELF up to radio frequencies. Sometimes, employees are spending long times close to parts of these systems, and they might therefore be exposed to strong EM fields, well in excess of the reference levels (RL) in the ICNIRP guidelines. Kjellsson et al. (2002) made measurements on two different systems, one used in a shop and one in a library. The coils at the exit in the library was working on 920 Hz, and the flux density at the center of the coils was of the order of 10 µT, to be compared with the RL for general public of 6.25 µT. When the books are returned to the library, the electronic tag in the book has to be activated before the book is put back into the library. The system used for deactivating operates at 50 Hz and, at close range, the flux densities was of the order of some mT, thus, again above the reference level for occupational exposure of 500 µT. In the store the signal was composed of both 17 Hz and 6.25 kHz. The flux densities at the lower frequency were of the order of 200-300 µT, and at the higher frequency the values were well in excess of 100 µT. The reference levels at 6.25 kHz for general public is 6.25 µT, so the RL are clearly exceeded and more in depth analysis is needed to see if still the basic restrictions are not violated. See also Harris et al. (2000), for a technical description.

Both at the shop and in the library there are situations and places where the general public as well as the employees are exposed to magnetic fields that exceed the RL given by ICNIRP. Logging the exposure during a work shift at the shop also showed that the cashiers are exposed to magnetic fields generated by the transmitter signal of the detection gates, which was often activated by customers during the studied work shift. Similar results and conclusions have been made in a previous study by Eskelinen et al. (2001).

ELECTRIC FIELDS FROM VDTS

There are five different types of fields present in the vicinity of the cathode ray tube (CRT) based VDT: an electrostatic field, ELF electric and magnetic fields with the refresh rate frequency, VLF electric and magnetic field with line frequency. Measurement show that the equivalent electrostatic surface potential on the screen can reach up to 20 kV for some VDTs, and the ELF electric field in front of the VDT at a distance of 0.5 m range from some up to tens of volts per meter but most of the time it is not distinguishable from the office background 50/60 Hz electric field. The ELF magnetic field can reach a few tenths of a µT, and close to the tube the values are up to some µT. The VLF electric fields range from some up to tens of volts per meter and the corresponding magnetic field is of the order of a few tenths of a µT at 0.5 m in front of the VDT and the VLF B-field time derivative ranges from some up to a few hundreds of mT/s.

ELECTROSTATIC FIELDS

Electrostatic potential is created on the screen of the CRT due to the positive voltage applied on the inner surface of the screen. The moisture in the air will affect the conductivity of the glass surface, and hence change the field strength. If the relative humidity exceeds 50 %, the electrostatic field from many tubes is often entirely eliminated.

ALTERNATING ELECTRIC AND MAGNETIC FIELDS

The electron beam in a CRT moves across the screen in a series of horizontal lines that start at the top and moves downward, much like a typewriter fills a page. In a VDT or TV, the electron beam scans each line in about 10-50 µs, and during the electronic "carriage return", which takes a few µs, the beam repositions to the beginning of the next line, and, thus, it operates at frequencies 17 – 100 kHz.

The time required for the beam to scan horizontal in the range lines from the top to the bottom of the screen is about 16 ms. The beam requires less than 1 ms to return to the top of the screen. The refresh rate is usually 60 – 100 Hz.

Three different processes can be identified giving rise to alternating fields:

1. Fields arising from the mains supply voltage and connections to the mains. The predominant frequency of these fields is 50/60 Hz. If the power unit is a switched power supply, fields in the 20-100 kHz range can also be caused.

2. The vertical control of the electron beam in a CRT together with the refresh rate of the screen, can give rise to alternating fields in the 50 Hz – 2 kHz range.

3. The horizontal deflection voltage, or scanning of individual lines on the screen, can give rise to alternating fields in the frequency range of 2 – 400 kHz.

Table 2. *The environmental electric and magnetic fields in the offices as well as the electromagnetic fields associated with the VDT at 150 workplaces. From, (Sandström et al. 1993).*

	Geo.Mv	Q_1	Md	Q_3	Max	n
In room						
B-field (μT)	0.07	0.03	0.07	0.15	1.0	150
E-field (V/m)	18	10	20	30	100	148
VDT-related electric field						
Equiv surface pot. (kV)	2.5	*	*	5	25	142
ELF						
E_{rms} (V/m)	20	12	20	35	330	147
VLF						
E_{rms} (V/m)	1.6	0.45	1.5	3.2	15	144
VDT-related magnetic fie						
ELF						
$\lvert B_{rms}\rvert$ (μT)	0.21	0.15	0.21	0.30	1.2	149
VLF						
$\lvert B_{rms}\rvert$ (nT)	23	7	26	55	142	148
$(dB/dt)_p$ (mT/s)	25	*	16	32	101	148

Results are given as geometric mean (Geo.Mv), first and third quartiles (Q_1;Q_3), and median values (Md). The maximum value found (Max) and the number of measured workplaces (n) is also given. All VDT related alternating field measurements are taken at 50 cm distance in front the screen.

**Indicates values below the detection limit of the instrument. From, (Sandström et al. 1993).

EM FIELDS AT RADIO FREQUENCIES (0.3-300 MHZ)

FM radio and TV transmission

Exposures to RF fields have been occurring for as long as we have had radio and TV broadcasting. Since the antenna towers are usually quite high and the emissions are directed for reaching a long distance, exposure levels near the towers are minimal. The input power is often highest for UHF TV broadcasting. The TV signal consists of an amplitude-modulated video signal and a frequency-modulated audio signal. In Sweden for instance 30 kW of power is used for the video signal and about 5 kW for the audio. With the antenna gain this gives an effective radiated power (ERP) of 1000 kW. The electrical field strength ranges from a few volts/meter in the near zone (1 km) to a few hundreds of a V/m at 50 km.

Short wave transmission

High power short wave transmitters are used for international broadcasts. Often the power supplied to the antenna system can be several hundreds of kilowatts. The antenna systems used are most often-movable log-periodic or steerable curtain type antennas.

Measurements of field strengths from such transmitters have been recently presented by Altpeter et al. (1998) in connection with their study on health effects on people living near a station. The magnetic field values ranged from tens of mA/m for those at a distance of 500 m from the antenna to some tenths of a mA/m for those at a distance of a few km. In a study of leukemia and residence near a high power short wave transmitter in Italy, Michelozzi et al. (1999) reported spot measurements of the electric field in some of the closest houses to be between 3 and 20 V/m. (Under far field conditions 3 V/m corresponds to a magnetic field of 8 mA/m and 20 V/m to 53 mA/m.) For a review of measured field strengths see also Mantiply et al. (1997).

Mobile phone base stations

Current mobile telephone systems operate at frequencies between 800 and 2100 MHz. With the rapid increase of use of mobile phones the number of base stations has also increased. The phones operate by communicating with a nearby base station, which is a low-powered radio transmitter, typically mounted on a tower or the roof of a building that relays calls between the user and the telephone system. The antenna system used for base stations are often either omnidirectional (“whip”) antennas, which radiate in all directions in the horizontal plane, or directional (“panel”) antennas, which radiate energy primarily from their front surfaces. Most commonly employed is a sectorized arrangement with three sets of directional transmitting and receiving antennas oriented 120 degrees apart.

The antennas have a high gain giving a narrow beam in the vertical direction but quite wide in the horizontal direction. In the main beam of the antenna (i.e. directly in front of and at a distance of several meters or more) the intensity of the beam (i.e. the power density) decreases as the inverse square of the distance from it. The RF exposure a person receives from a base station thus depends both on the distance from the antenna, and on the angle below the direction of the main beam. At ground level, the signal is relatively weak near the base of an antenna tower (since the main beam is passing directly overhead). It characteristically increases with distance from the tower, to reach a maximum at a distance of between 10 and 100 meters from the base of the tower, and then decreases at still greater distances. Panel antennas only radiate significant amounts of energy in the forward direction. Thus, for panel antennas mounted facing outwards on building parapets, the exposure is very low to people on the rooftop, or in rooms below the antenna. See further the recently released report by the UK House of Commons Committee on Science and Technology Report 22 Sept 1999.

In rural areas, where there is a lower user density, base stations are typically two kilometers apart. In towns and cities where there are more users, the cells are smaller and transmitter base stations can be as little as a few hundred meters apart. The actual levels of transmitted power vary widely between urban and rural areas. In the urban areas there are small cells and the output powers are relatively low, whereas longer reaching distance is wanted in rural areas so that the output power tends to be greater. The large increase in number of base stations within the cities will make the cells smaller and thereby also permit a reduction of output power from the surrounding base stations. Therefore, the levels of public exposure to RF energy from any system will not increase in proportion to the number of its base stations in an area.

Measurements of field strength from base stations have recently reported by Thuroczy et al. (1999) and Hamnerius and Uddmar (1999). They found levels encountered within about 20 m from the antenna in the range of a few to some tens of V/m. However, at distances where most people would be exposed, the field strength is down to tens of mV/m within cities and in rural area values as low as a few mV/m can be measured.

EMF IN HOMES AND WORKPLACES OF EHS PEOPLE

Very few studies have been devoted to measurements of EMF in home and workplaces of people experiencing EHS. One of the first studies of this was on people with skin symptoms in connection with VDT work. Sandström et al (1995) made a case referent study of 75 cases and controls where the EMF in the rooms and from the VDT was measured. It was found that more cases than referents were found in the highest exposure categories for two of the measured parameters. For the background electric field in the room the relative risk in terms of odds ratio (OR) was 3.0 (95%CI 1.2 – 7.2) for the high exposed group (> 31 V/m) compared to the lowest group (<10 V/m). Also for the magnetic field in the ELF range from the VDT an increased OR of 2.7 was found (95%CI 1.0 – 6.9), and here the high group was from > 0.30 µT vs. < 0.145 µT. It is possible that a high electric field background in a room is an indication of a certain type of job, in small rooms with lots of electrical equipments.

Sandström et al. (2003) monitored the ECG in an EHS patient group and a control group. The 24 h mean and median values of the magnetic field recordings for the patient group was 0.10 and 0.05 μT, respectively, and for the control group the corresponding values were 0.11 and 0.06 μT. The mean values of the broadband field and the intermittency were also analyzed during sleeping time and when awake and no significant differences in magnetic field values were found between the groups.

Radiofrequency fields have been studied by Altpeter et al. (1995) in connection with health effects from a shortwave transmitter. He found a higher frequency of disorders of a neurovegetative nature among residents up to about 1000 m from the transmitter, and the 24 h average magnetic field from measurements in the bedroom in this zone averaged to 2.5 mA/m, which was slightly higher than in the zones further away from the transmitter.

A few studies have also been done of people living near base stations. Santini et al. (2002) performed a study in France and, (Navarro et al. 2003) did a study in Spain. None of the studies have reported how subjects were selected for participation in the studies, and participation rates cannot be estimated. Participants have answered questions about various symptoms such as headaches, concentration difficulties, memory loss, fatigue, sleeping problem, etc. They were asked to estimate the distance to the nearest base station but it has also been shown that distance is a poor surrogate for RF exposure from base stations, Schuz and Mann (2000). In the Spanish study, measurements of the exposure in the homes were made, but did neither report how subjects were selected for measurements nor the proportion of subjects agreeing to have measurements taken in their homes. Both the French and the Spanish study report an increased prevalence of symptoms close to base stations, but the design limitations make it impossible to assess whether these findings are a results of bias or real effects.

Hutter et al. (2002) studied effects on health and wellbeing in Austria in connection with base stations. They found a significant relation to measured power density and cardiovascular symptoms and perceptual speed. However, the study was an explorative one and no far reaching conclusions can be drawn. All the measured values very far below recommended levels (max value found 1.4 mW/m^2, 95 percentile 0.57 mW/m^2).

PROVOCATION STUDIES

It is also of interest to look at the provocation that has been done where EHS people have been exposed to EMF. Rubin et al. (2005) recently reviewed these. An extensive systematic search of databases identified relevant blind or double-blind provocation studies. The results of relevant studies were tabulated and meta-analyses were used to compare the proportions of 'hypersensitive' and control participants able to discriminate active from sham EMF exposures. In total 31 experiments testing 725 'electromagnetic ally hypersensitive' participants were identified. Twenty-four of these studies found no evidence to support the existence of a bio-physical hypersensitivity, while seven reported some supporting evidence. For two of these seven, the same research groups subsequently tried and failed to replicate their findings. In three more, the positive results appear to be statistical artifacts. The final two studies gave mutually incompatible results. Thus, the meta-analyses found no evidence of an improved ability to detect EMF in 'hypersensitive' participants.

The so called TNO study examined the effects of RF signals from mobile phone base stations on cognitive functions (Zwamborn et al. 2003). Cognitive functions (reaction time, memory comparison, dual-tasking, visual selective and filtering irrelevant information) were measured during exposure. to a 1 V/m field at 900 MHz and 1800 MHz (GSM signal), or 2100 MHz (UMTS signal). Each session took 45 min including exposure, questionnaire, and break. The questionnaire estimated degree of well being from 23 assessed symptoms. Both the EHS group and the healthy volunteers reported a somewhat lower degree of well being during UMTS exposure compared to no exposure, whereas no effects were seen for periods of GSM 900 or 1800 exposures in either of the groups. Additional studies are needed before any conclusions can be drawn. Such replication studies are ongoing in Switzerland, UK and Denmark.

DISCUSSION

At present there are no firm indications that the EMF encountered by EHS people are different in amplitude or frequency content than what is normally found in our everyday environment. However, very few studies have been conducted but none of the provocation studies have been able to give a strong support for a connection between the EMF and the symptoms. Until we know what the interaction mechanism might be and then also know what properties of the electromagnetic field that might be of interest, further studies in this area should concentrate more of the neurophysiological findings reported on in other papers in this proceeding, (Lyskov et al. 2005).

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PHYSIOLOGICAL STUDIES

Electrical hypersensitivity and tissues generating electric current -mental construction and biological reality

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INTRODUCTION

Unlike environmental diseases due to presence of toxic or absence of vitally important substances in food, water or air, electrical and magnetic forces are indispensable for life at levels considerably exceeding the limits considered as harmful by the EHS concept. One of the underlying misunderstandings is the assumption that EMFs are novel forces introduced by technical development of industrial countries and that living creatures are not prepared to live with them. However, already the first unicellular organisms starting the evolution of life on our planet were marvelous examples of electrical engineering. Their lipid cell membrane is only 5nm thick but separates an electrical potential of 0.1 V, which corresponds to the electrical field of 10^{-1}V/5x10^{-9}m = 2x10^{7} V/m. Electrical phenomena have played an essential role in development of animals and particularly of their brains, the function of which is impossible without electrical signals mediating transmission of information between individual neurons and neural networks, and implementing the highest cognitive functions. Up to 10^{11} neurons of the human brain generate a large amount of electrical activity, which in its diversity, intensity and ubiquity exceeds what most alleged sources can produce.

BACKGROUND

Neuron is a special cell endowed with the property of excitability, serving the purpose of intercellular communication (Kandel et al. 1999). Its main part, the cell body 10 to 100 µm in diameter, is surrounded by 5 nm thick lipid membrane, which separates the intracellular fluid inside from the extracellular fluid outside. The membrane is in addition equipped with ionic channels, pore like openings in the hydrophobic wall, which allow gated movement of soluble molecules across the barrier. The intracellular fluid contains as the main cation K^+, whereas the main extracellular cation is Na^+. Difference between the ionic composition of these two compartments accounts for the membrane potential measured between an intracellular and an extracellular electrode. Under resting conditions the membrane potential is -0.07 to -0.1 V (intracellular electrode negative) but activation of the voltage dependent sodium channels may change the MP to +0.04 to +0.06 V (intracellular electrode positive). An intracellular electrode records this so called action potential as a transition from -0.085 to +0.05 V, which is immediately compensated by increased conductance of potassium channels, gradual closure of sodium channels and return of the membrane potential to the resting level. The change is completed in less than 1 ms. Its full amplitude is recorded with intracellular electrode. The extracellular electrode at close distance (less than 10 μm) from the cell surface records the largest spike with the amplitude of 100 μV to 1mV which drops at 100 μm from the active cell to less than 10 μV. The corresponding electrical field is 10^{-4} V / 10^{-4} m = 1 V / m and is rather stationary around the excited cell. In neurons with long axons the action potential propagates far from the point where it is initiated to other neurons or effectors (muscle cells). The propagation velocity is up to 100 m/s and is marked by the traveling wave of action potential. It is obvious that the activity of this multitude of neurons (about 30 milliards in the hemispheres of the human brain) is enormous and may easily lead to disruption caused by regulation failures. This happens when all neurons are simultaneously active, e.g. during an epileptic seizure. Each action potential raises the concentration of K^+ in extracellular space which reaches after 5 to 10 s the level of 10 mequ/l and blocks further action potential generation. Such depression of activity is usually prevented by the activation of inhibitory neurons.

The requirement that electrical phenomena generated in the brain tissue by external sources, should not exceed the inherent level of EMF noise of biological origin seems reasonable and is generally strictly followed by hygienic regulations for the use of electrical appliances. But this is not always respected in some medical treatments, when higher stimulation intensity is deliberately used to restore a failing vital function. Thus cardiac flutter blocking blood circulation can be stopped by high intensity electrical pulse applied to the chest, which elicits cardiac arrest usually followed by recovery of normal heart beat. A less dramatic example is the cardiac pacemaker, implanted stimulator which cures patients with atrio-ventricular blockade by replacing the irregular discharge of the cardiac sinus node by electrical stimuli activating the heart contractions at regular intervals.

The same applies to stimulation of various brain centers, which may elicit in animals pleasant feelings, motivating them to press a switch administering a short (0.1 s) electric stimulus (about 40 μA) to the hypothalamic pleasure centers (Olds and Milner, 1954). High preference of this artificial activity against other motivated behaviors e.g. (feeding, drinking) shows that the nature of the stimulus does not interfere with its further processing and does not prevent the animal to use the cognitive functions required for access to the rewarding stimulation. Similar desirable effects of brain stimulation were recently demonstrated in Parkinson patients, whose tremor, rigidity, muscle weakness and difficult walking are clearly alleviated by self-administered series of pulses applied through implanted electrodes to their thalamic nuclei (Hashimoto et al., 2003)

Electrical stimulation requires application of higher voltages and currents produced by technical devices, but biological forms of effective stimulators were introduced by the evolutionary process millions years ago. Several classes of electric fish have developed so called electric organs, in which hundreds to thousands cells are connected in series to a column in which the 0.1 V emf of individual cells may lead to the discharge amplitude of 100 V to 700 V, and by parallel connection of such columns to currents of up to 10 A (Grundfest, 1960). While the strongly electric fish (the electric eel, Electrophorus electricus), use their discharge for stunning the prey or for predator defense, the weakly electric fish use it for electrolocation. In Gnathonemus Petersii the electric organ discharges low rate of 10 V pulses from the tail. Current flows through the electroreceptors on the anterior surface of the body, innervated by the lateral line nerves, which monitor the density of current flow through the surrounding water in the rostro-caudal direction. Any asymmetry of this density shows that the conductivity of the water was influenced by presence of some objects with high or low resistance in the vicinity of the fish. Electro-sensitivity is also used by some non-electric fish like sharks, for detection of electric current in the environment, e.g. for finding live prey buried under a layer of sand. Sharks can detect electrocardiogram of such fish, remove the covering sand and eat the prey. The development of electrolocation demonstrates, that evolution has tried a variety of available methods to improve the animal's capacity to locate prey, or avoid obstacles in the environment in which the animal lives, but which cannot be detected with effective use of vision or touch. Limited contact with aquatic environment did not lead to development of an analog of the lateral line system in humans. But the most important lesson we get from electric fishes, is that they were not deterred by the mysterious force and used it ingeniously to their advantage. It is obvious that they do not obey the simplistic recommendations of environmentalists, prohibiting the use of high voltage and current which would make evolution a very safe but rather ineffective process.

We often hear in the heated discussions about the risk of mobile phones, that normative legislature should be highly restrictive, and eliminate all possibly dangerous effects of new technologies. This is the second misunderstanding: biomedicine should not only eliminate dangerous EMF influences on the brain, but to use them effectively in diagnostic and therapeutic applications. The present norms are several times lower than the electrical fields existing in our body, but this does not mean that they cannot be ignored, if this will be the only way to save human lives. The evolution has convincingly demonstrated that living organisms can tolerate excessive values of voltage, and current when this will give them obvious benefits. It is very difficult to determine some absolute norms of electrical fields applicable to living organisms. The values are different in various parts of the body, during subsequent phases of activity, in the context of actual situations. This is probably the reason why it is so difficult to establish any reliable relationships, between the prevalence of the annoying symptoms and EMF in the EHS patients. As pointed out by Goethe et al. (1995) switching off the putative source of the noxious influence in the environment of the patient has only a limited, and sometimes even adverse therapeutic effect. This shows that the computer or VDU is not a real source of the patient's complaints, but only an abstract symbol of the psychogenic influences acting on the subject. The fact that the annoying symptoms are independent on the activity of the equipment, indicates that they are due to continued presence of important psychosocial stressors and to serious misconceptions about the cause of the prevailing symptoms which is often ascribed to some elusive environmental component. Thus unabated symptoms after the suspicious equipment is switched off increase the patient's fear and intensify his stress. The physician must not question the patient's complaints but concentrate on efficient symptom-reducing therapy of the most annoying difficulties. The rapidly growing number of mobile phone users exceeding one billion in the world, and the increasing number of studies reporting an absence of disruptive effects of mobile phones on cognitive functions of experimental animals (Sienkiewicz et al., 2000) suggest that this episode of somatization syndrome will be soon over.

CONCLUSION

EHS was from the beginning one of the rightful concerns of WHO that had carefully followed the development of this epidemic. The present state of affairs indicates that EHS belongs to the family of somatization diseases, the patients of which believe that their complaints are caused by exposure to EMF components of their external environment, which are, however, not perceived by the majority of the population sharing the same conditions. WHO should continue its care for the victims of EHS and similar psychogenic epidemics, but to classify it as an environmental somatization disease, not caused by the EMF influence. I am sure that such realistic approach, will make it possible to find more effective prophylactic and therapeutic measures directed not towards elimination of the presumed disease inducing physical forces, but against the psychogenic elements of the disease, affecting directly the patients. I hope that the task force will include more psychologists, psychiatrists and social experts, and that it will propose practical steps helping the patients to overcome their anxiety and to find safer conditions of work and life.

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Sensor reactivity and autonomous regulation in persons with perceived electrical hypersensitivity

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INTRODUCTION

We have during several years studied people with perceived electrical hypersensitivity (EHS), both in epidemiological studies and in neurophysiological examinations. These investigations were carried out at the National Institute for Working Life, Umeå, Sweden, in collaboration with the Department of Dermatology and Department of Environmental Medicine, University Hospital in Northern Sweden, Umeå, and supported by grants from the Swedish Council for Working Life and Social Research (FAS) and Trygg Hansa, Stockholm, Sweden. In this paper we will summarize the results of the neurophysiological examinations.

The problem to find a causal connection between the originate of symptoms and electromagnetic fields in provocation tests, have lead us in to new line of thought. How do people with EHS respond to other physical factors in our environment? What are their physiological and neurophysiologic baseline status?

Since amplitude modulated light emitted from the video display units (VDU) was considered as a possible cause of EHS symptoms, the aim of our first study (Sandström et al. 1997) was to make an objective physiological assessment of individual sensitivity to this factor. It is known that brain and retina reactions to flickers, can be recorded far above critical fusion frequency. Therefore, amplitude of electroretinogram (ERG) and visual evoked potentials (VEP) during photo stimulation at frequencies below and above CFF was chosen as markers of the sensitivity. Additionally, heart rate was recorded to control possible activation due to photo stimulation session. We tested 10 people with perceived EHS and an equal number of age and sex matched healthy controls. The results showed significantly increased amplitude of the VEP at all tested frequencies in the patient group in comparison with a healthy control group, whereas no difference in ERG were revealed. Increased mean heart rate in rest (baseline) period was also found when comparing the patient group with the control group.

These preliminary findings indicated an increased sensitivity to flickering light, and possible engagement of the autonomous nervous system in the patients. That motivated further investigations of the baseline neurophysiological characteristics of the central and autonomous regulation, and their reactivity to different functional tests in EHS. Therefore in our second study (Lyskov et al. 2001a), the arsenal of physiological methods, and tests as well as the number of patients was extended.

STUDIES

Twenty patients with prevalence of skin (tingling, redness) and neurasthenic (fatigue, tiredness, headache) symptoms were recruited from the University hospital, age and sex matched with twenty control subjects without health complaints. They were examined in a one day laboratory session, that included recording of electroencephalogram, steady-state visual potentials in response to stroboscope stimulation at frequencies 30-70 Hz, ECG, blood pressure, and electrodermal activity. Subjective measure of sensitivity to flickering light - critical fusion frequency was recorded in response to manually controlled matrix of the red light emitting diodes. Vision acuity and contrast sensitivity were also assessed. After acclimatization in the experimental chamber physiological processes were recorded in baseline conditions and in response to several functional tests: deep breathing test, orthostatic test, audiostimulation. The total duration of the test battery was 25 minutes, with at least 5 minutes pauses between functional tests.

Differences between EHS subjects and control were found in several experimental outcomes. The patients had a higher mean value of critical fusion frequency, modest but significantly increased amplitude of the fundamental harmonics of the steady-state VEP in occipital derivations in patients in comparison with control subjects. The overall difference, was detected with all autonomous variables used in the experiments. In rest conditions mean values of heart rate was higher and heart rate variability lower in EHS persons in comparison with control. Decreased 30:15 ratio in response to orthostatic test was detected on the level of statistical trend. Sympathetic skin response to audio clicks showed increased amplitude, decreased latency and relative asymmetry of responses in patients in comparison with control. The results of this neurophysiological study showed that patients with a perceived electrical hypersensitivity, had a tendency towards increased sympathetic activity during baseline relaxation period, hyper responsiveness to sensor stimulation such as flickering light and audio stimulation, and their physiological profile showed imbalance of autonomic regulation with a trend towards hypersympathotone and increased arousal. In the discussion (Lyskov et al. 2001a) we pointed out that such clinico-physiological pattern has many things in common with a syndrome previously described as neurocirculatory asthenia, (Linderholm, 1992), which was particularly characterized by sympathotonic ECG changes in rest conditions, accentuated during orthostatic test and physical exercises; low physical work capacity; variety of vegetative and neurasthenic symptoms with no signs of organic heart, lung or other somatic diseases. The syndrome was also characterized by vulnerability to variety of environmental factors, (high or low temperature, rapid changes of atmosphere pressure), especially in conditions of psychological strain and stress, (Vein, 2002; Kits van Waveren, 1994).

We further speculated that persons with such prerequisites could be potentially more sensitive to “EHS related” environmental factors, such as flickering light emitted from VDUs and magnetic field exposure. These factors would probably play a role of a “last drop” – weak, additional stressor in basically stressful environment, that could trigger pathological responsiveness and development of symptoms.

We tested this hypothesis in specially designed provocation study (Lyskov et al. 2001b). Specificity of our sham-controlled provocation study was phase synchronization of a 60 Hz sinusoidal signal with 10 μT rms flux density, (whole body exposure to a vertically oriented magnetic field), synchronized with the 60 Hz refresh rate of the VDT, which was viewed by participants during real and sham exposure, provided combined “resonance” exposure of MF and amplitude modulated light in real exposure conditions and only light exposure during sham conditions.

The participants were exposed in relaxed conditions and during the mental task. Each exposure session lasted 40 min, and was divided into four 10 min epochs; two relaxed phases and two phases of cognitive task (mathematical calculations). Each participant was investigated on two separate days. The participants were informed that sham and field exposure would be presented randomly on one day. In order to reduce possible stressful effects associated with entrance to a new laboratory environment and expectations of experimental field exposure, the data from the first day session were discarded and in order to exclude unnecessary MF exposure, they were exposed only during the second experimental session.

Physiological set-up was practically identical to that of the previous study (Lyskov et al. 2001a) except that VEPs were recorded as a steady-state response to flickering video display unit with a refresh frequency of 60 Hz. The participants were viewing the white screen with a centrally located fixation point at a distance of 70 cm.

Twenty EHS subjects and an age and sex matched control group participated in these examinations. The participants were informed about methods and general design of the investigation. They agreed to be exposed to magnetic field, and they knew that they could interrupt the experiment at any time.

Examinations showed that subjects in both groups were not able to judge on which day they were exposed to magnetic fields. Some participants, mainly from the patients group, noted certain sensations, which they subjectively associated with MF exposure. However, this was observed in eight cases after the first “acclimatization” session when no exposure was given. After the second session, during which magnetic field exposure actually occurred, subjective feelings were reported only in two cases. The results of the physiological investigations showed differences between patients and controls for baseline (pre-exposure) values of CFF, skin sympathetic response, diastolic pressure and heart rate (Lyskov et al. 2001b).

During the cognitive task increased heart rate and spontaneous electrodermal activity were observed in the patient group in comparison with the controls. These effects did not depend on exposure conditions. Thus, baseline difference and reactions to cognitive task, confirmed our previous findings, indicating subtle disbalance of autonomous regulation and increased sensor reactivity in EHS patients in comparisons with control persons. On the other hand the results rejected the hypotheses that these processes might be further affected by MF exposure. No field related changes in EEG, heart rate variability and all other physiological parameters were found.

In order to better characterize the balance of the autonomous regulation in patients with perceived EHS and to test its possible relations with exposure to MF, we also carried out simultaneous monitoring of ECG and magnetic fields. For this study, (Sandström et al. 2003) patients were again recruited from the register at the University Hospital in Northern Sweden, Umeå. As inclusion criteria, subjects should perceive exposure to VDT, fluorescent tube light, TV set or other electrical sources as induced symptoms within 24 hours from exposure. The subjects should also either have VDT-related skin symptoms in whom facial skin symptoms dominated, or/and suffer from perceived hypersensitivity to electricity for whom neurasthenic symptoms dominated and were aggravated by non-light emitting sources. Fourteen patients matched all criteria and participated in the study together with equal number of control subjects (age and sex matched).

Continuous, ambulatory ECG was recorded over a 24-h period, using standard equipment (Tracker 2, Reynolds Medical Ltd. UK). The dynamics of the heart rate variability (HRV), was assessed in time and frequency domains. The monitoring of ELF MF exposure was done by an EMDEX II instrument (Enertech Inc. USA). The instrument measures the magnetic field in frequency range 40-800 Hz.

The results of the HRV analysis did not show any overall group difference in the time or frequency domains. However, on an hour-by-hour basis slightly lowered heart rate in the patient group was noted for the late evening-early night hours. Moreover, the high frequency component, reflecting the activity of the parasympathetic branch, did not show the normally expected increase during nighttime in the patient group. The low frequency component of the HRV, representing the activity in the sympathetic and parasympathetic branches, showed no difference between groups. However, when comparing the log-transformed ratio low to high frequency, reflecting balance between the two branches of the ANS significant difference between groups was also found (Sandström et al. 2003).

These data indicated that patients with received EHS have a disturbed pattern of circadian rhythms of HRV. In healthy subjects, the autonomic activity shows a circadian rhythm with dominating sympathetic tone during the day, and considerable increase in parasympathetic tone during the night, that was clearly seen in our control subjects. In contrast the patients showed relatively flat representation of hourly-recorded spectral power of the high frequency component, indicating significant parasympathetic withdrawal during night hours in comparison with a normal circadian variation. It is worth mentioning, that similar trends towards night time parasympathetic inefficiency was found in subjects suffering from Gulf War syndrome (Haley et al. 2004) and fibromyalgia (Martinez Lavin et al. 1998), pathological conditions which, same as EHS, are often discussed in context of stress related forms of environmental intolerance.

Possible interactions with the ‘internal clock’ and circadian fluctuations of hormones and other basic physiological parameters that affect HRV (e.g. breathing patterns and respiratory capacity), need to be further investigated to clarify mechanisms of dysautonomia in these patients. The findings in our studies should also be followed up by a thorough clinical investigation of the autonomic system functions.

Analysis of the recorded magnetic field, showed that mean values did not differ between patients and controls; the EHS patients had even lower values during 24-h measurements, compared to the control group. Furthermore, the observed values did not differ from what normally is present in our homes.

In summary, we found no experimental evidences that MF exposure would influence on these processes in patients or control subjects. However, the results of the experiments indicated modest but distinctive signs of autonomous imbalance with a trend to sympathetic over activity and deviated circadian rhythmic in patients with EHS. Sensory responsiveness were observed in form of increased evoked potentials to flickering light and facilitated skin sympathetic responses to audio stimulation. Sensory amplification and labiality of the autonomous nervous system, could be considered as a sort of physiological predisposition to stress vulnerability, increased sensitivity and lower tolerance to physical environmental factors. These studies must be followed up later on.

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Electrohypersensitivity: Observations in the Human Skin of a Physical Impairment

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An ever increasing number of studies have clearly shown various biological effects at the cellular and molecular level of electromagnetic fields. This including powerfrequent and radiofrequent ones, as well as microwaves. Such electromagnetic fields are present in your everyday life, at the workplace, in your home, at school, and at places of leisure.

More than 25 years ago, a new category of persons was described in the literature, namely those who claim to suffer from subjective and objective skin- and mucosa-related symptoms, such as itch, smarting, pain, heat sensation, redness, papules, pustles, etc. This after exposure to visual display terminals (VDTs), fluorescent strip light tubes, mobile phones, DECT telephones, TETRA systems, as well as other electromagnetic devices. Frequently, symptoms from internal organ systems, such as the heart and the central nervous system, are also encountered. In Sweden, these persons are officially fully recognized as a group with a physical impairment called electrohypersensitivity (EHS).

Persons claiming such adverse skin reactions after having been exposed to computer screens or mobile phones, very well could be reacting in a highly specific way and with a completely correct avoidance reaction, especially if the provocative agent was radiation and/or chemical emissions - just as you would do if you had been exposed to e.g. sun rays, X-rays, radioactivity or chemical odours. The working hypothesis, thus, early became that they react in a cellularly correct way to the electromagnetic radiation, maybe in concert with chemical emissions such as plastic components, flame retardants, etc. something later focused upon by professor Denis L. Henshaw and his collaborators at the Bristol University, (cf. Fews et al. 1999a,b) [This is also covered in great depth in Gunni Nordström's latest book "The Invisible Disease - The Dangers of Environmental Illnesses caused by Electromagnetic Fields and Chemical Emissions" (Nordström, 2004).]

Very soon, however, from different clinical colleagues, and in parallel to the above, a large number of other 'explanations' became fashionable, e.g. that the persons claiming EHS only were imagining this, or they were suffering from post-menopausal psychological aberrations, or they were old, or having a short school education, or were the victims of classical Pavlovian conditioning or a journalist-driven mass media psychosis.

Strangely enough, most of the, (often self-made), 'experts' who proposed these explanations, had themselves never met anyone claiming EHS and these 'experts' had never done any investigations of the proposed explanatory models.

The aim of our own studies has been to investigate possible alterations, in the cellular and neuronal systems of these persons' skin. As controls, age- and sex-matched persons, without any subjective or clinical symptoms or dermatological history, have served. Immunohistochemistry using antisera to the previously characterized marker substances of interest has been utilized. Among many discoveries, the following may be mentioned:

We have investigated the presence of intraepidermal nerve fibers in normal human skin from healthy volunteers using the new marker PGP 9.5, (Wang et al. 1990); (Hilliges et al. 1995); (Johansson et al. 1999). The intraepidermal nerve fibers are found as close as 20-40 µm from the surface, which makes it highly possible that weak electromagnetic fields may affect them.

In facial skin samples of electrohypersensitive persons, the most common finding is a profound increase of mast cells. Nowadays we do not only use histamine, but also other mast cell markers such as chymase and tryptase, but the pattern is still the same as reported previously for other electrohypersensitive persons, (Johansson and Liu, 1995). From these studies, it is clear that the number of mast cells in the upper dermis, is increased in the EHS group. A different pattern of mast cell distribution also occurred in the EHS group, namely, the normally empty zone between the dermo-epidermal junction and mid-to-upper dermis disappeared in the EHS group, and instead, this zone had a high density of mast cell infiltration.

These cells also seemed to have a tendency to migrate towards the epidermis (=epidermiotrophism) and many of them emptied their granular content (=degranulation) in the dermal papillary layer. Continually, more degranulated mast cells could be seen in the dermal reticular layer in the EHS group, especially in those cases which had the mast cell epidermiotrophism phenomenon described above. Finally, in the EHS group, the cytoplasmic granules were more densely distributed and more strongly stained than in the control group, and generally, the size of the infiltrating mast cells was found to be larger in the EHS group as well. It should be noted, that increases of similar nature later on were demonstrated in an experimental situation employing normal healthy volunteers in front of visual display units, including ordinary house-hold television sets, (Johansson et al. 2001).

In one of the early papers, (Johansson et al. 1994), we made a sensational finding when we exposed two electrically sensitive individuals to a TV monitor. When we looked at their skin under a microscope, we found something that surprised us. In this article, we used an open-field provocation, in front of an ordinary TV set, of persons regarding themselves as suffering from skin problems due to work at video display terminals. Employing immunohistochemistry, in combination with a wide range of antisera directed towards cellular and neurochemical markers, we were able to show a high-to-very high number of somatostatin-immunoreactive dendritic cells, as well as histamine-positive mast cells in skin biopsies from the anterior neck, taken before the start of the provocation. At the end of the provocation the number of mast cells was unchanged, however, the somatostatin-positive cells had seemingly disappeared. The reason for this latter finding is discussed in terms of loss of immunoreactivity, migration, increase of breakdown, etc. The high number of mast cells present, may explain the clinical symptoms of itch, pain, edema and erythema.

We have compared facial skin from electrohypersensitive persons with corresponding material from normal healthy volunteers, (Johansson et al. 1996). 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). It has to be pointed out that we cannot, based upon those results, draw any definitive conclusions about the cause of the changes observed. Blind or double-blind provocations in a controlled environment, (Johansson et al. 2001) are necessary to elucidate the underlying causes for the changes reported in this particular investigation.

I, along with my collaborator, dr. Shabnam Gangi, in two recently published papers of theoretical nature, Gangi and Johansson, (1997, 2000), have put forward a model for how mast cells and substances secreted from them, (e.g. histamine, heparin and serotonin), could explain sensitivity to electromagnetic fields.

The model bounces off from known facts in the fields of UV- and ionizing irradiation-related damages, and use all the new papers dealing with alterations seen after e.g. power-frequent or microwave electromagnetic fields to propose a simple summarizing model for how we can understand the phenomenon of EHS.

In the first paper, in the journal *Experimental Dermatology*, Gangi and Johansson, (1997), we describe the fact that 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 and the heart, when being close to electric equipment. A major group of these persons are the users of video display terminals, who claim to have subjective and objective skin- and mucosa-related symptoms, such as pain, itch, heat sensation, erythema, papules, and pustules. The central nervous system-derived 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 electrohypersensitive persons similar to those observed in the skin damaged due to ultraviolet light or ionizing radiation. In electrohypersensitive persons, 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 EHS group 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 electrohypersensitive persons, 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 electrohypersensitive persons, as regards the clinical manifestations, as well as alterations in the cell populations, and in skin damaged by ultraviolet light or ionizing radiation.

In the second publication, Gangi and Johansson, (2000), from the journal *Medical Hypotheses*, the relationship between exposure to electromagnetic fields and human health is even more in focus. This is mainly because of the rapidly increasing use of such electromagnetic fields within our modern society. Exposure to electromagnetic fields has been linked to different cancer forms, e.g. leukemia, brain tumors, neurological diseases, such as Alzheimer's disease, asthma and allergy, and to the phenomenon of EHS/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. These people suffer from subjective and objective skin and mucosa-related symptoms, such as itch, heat sensation, pain, erythema, papules and pustules (cf. above). In severe cases, people can not, for instance, use video display terminals or artificial light at all, or be close to mobile telephones. Mast cells, 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 electromagnetic fields affect the mast cell, and also the dendritic cell, population and may degranulate these cells. The release of inflammatory substances, such as histamine, from mast cells 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 persons suffering from EHS/screen dermatitis. Mast cells are also present in the heart tissue and their localization is of particular relevance to their function. Data from studies made on interactions of electromagnetic fields with the cardiac function have demonstrated that highly interesting changes are present in the heart after exposure to electromagnetic fields. Some electrically sensitive have symptoms similar to heart attacks after exposure to electromagnetic fields. One could speculate that the cardiac mast cells are responsible for these changes due to degranulation after exposure to electromagnetic fields. However, it is still not known how, and through which mechanisms, all these different cells are affected by electromagnetic fields. In this article, Gangi and Johansson (2000), we present a theoretical model, based upon the above observations of electromagnetic fields and their cellular effects, to explain the proclaimed sensitivity to electric and/or magnetic fields in humans.

In summary, it is evident from our preliminary data that various biological alterations are present in the electrohypersensitive persons, claiming to suffer from exposure of electromagnetic fields. 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 to be further analyzed.

What about making the society fully accessible for the persons with EHS? In a recent study, (Sromová et al. 2001), electrically sanitized premises (called the "ELRUM") in Skellefteå (in the northern part of Sweden), were used to study possible ways of rehabilitating electrosensitive persons. In summary, the results of our study of persons hypersensitive to electricity, clearly points to that intensive electrical environments cause their ailments, and that a reduction of electromagnetic fields in the living and workplace environment seems to be highly positive as a mean for rehabilitation. Other factors, such as exhaust fumes, certain chemicals, moulds, etc., probably also contribute to the symptoms. Our study, thus, can therefore lead to future recommendations regarding necessary adaptations, in the form of electrical (and chemical) sanitation, of a person's work and home environment.

As we have pointed out in earlier documentation, a majority of the guests at the ELRUM premises has been sick-listed for long periods of time (several years). The rehabilitation process can therefore, in its turn, be expected to take a long time and be demanding. This process can be initiated at such a rehabilitation centre as the ELRUM, but must be continued at home, assuming that the person receives full support from all parties involved, (social insurance office, employer, doctor, etc.) Finding constructive solutions with regard to the person's work situation requires creativity, patience and perseverance on the part of all. When following up our recommendations, we see that it is very difficult to get economic help for carrying out an electrical sanitation of the home environment. Only on exceptional occasions municipalities provide funds for making necessary adaptations at home, and it is almost as difficult to get economic resources for adapting work environments. There are, however, companies that make an effort to carry out an electrical sanitation of their workplaces and adapt work assignments in order to retain staff.

The majority of the persons who took part in this project at the ELRUM rehabilitation centre, at the one-year follow-up, says that is has led to a positive change in their situation. The reason why some have answered "no", seems more to be a reflection of their personal disappointment that the recommendations we gave them have not been carried out back home.

Finally, it must be mentioned that quite recently, by the end of 2004, The Irish Doctors' Environmental Association (IDEA) has announced that "they have identified a sub-group of the population who are particularly sensitive to exposure to different types of electromagnetic radiation. The safe levels currently advised for exposure to this non-ionizing radiation are based solely on its thermal effects. However, it is clear that this radiation also has non-thermal effects, which need to be taken into consideration when setting these safe levels. The electrosensitivity experienced by some people results in a variety of distressing symptoms, which must also be taken into account when setting safe levels for exposure to non-ionizing radiation and when planning the siting of masts and transmitters." (The Irish Doctors' Environmental Association (IDEA), 2004).

Furthermore, the IDEA also points out the following:

1. An increasing number of people in Ireland are complaining of symptoms which, while they may vary in nature, intensity and duration, can be demonstrated to be clearly related to exposure to electro-magnetic radiation (EMR).

2. International studies on animals over the last 30 years have shown the potentially harmful effects of exposure to electro-magnetic radiation. In observational studies, animals have shown consistent distress when exposed to EMR. Experiments on

tissue cultures and rats have shown an increase in malignancies when exposed to mobile telephone radiation.

3. Studies on mobile telephone users have shown significant levels of discomfort in certain individuals following extensive use or even, in some cases, following regular short-term use.

4. The current safe levels for exposure to microwave radiation were determined based solely on the thermal effects of this radiation. There is now a large body of evidence that clearly shows that this is not appropriate, as many of the effects of this type of radiation are not related to these thermal effects." (The Irish Doctors' Environmental Association (IDEA), 2004).

Finally, The Irish Doctors' Environmental Association "believes that the Irish Government should urgently review the information currently available internationally on the topic of the thermal and non-thermal effects of exposure to electro-magnetic radiation with a view to immediately initiating appropriate research into the adverse health effects of exposure to all forms of non-ionizing radiation in this country, and into the forms of treatment available elsewhere. Before the results of this research are available, an epidemiological database should be initiated of individuals suffering from symptoms thought to be related to exposure to non-ionizing radiation. Those claiming to be suffering from the effects of exposure to electro-magnetic radiation should have their claims investigated in a sensitive and thorough way, and appropriate treatment provided by the State. The strictest possible safety regulations should be established for the installation of masts and transmitters, and for the acceptable levels of potential exposure of individuals to electro-magnetic radiation, in line with the standards observed in New Zealand." (The Irish Doctors' Environmental Association (IDEA), 2004).

With all these data in mind, it is surprising that mankind over-and-over again, dares to initiate the kind of full-scale human biological experiments that we are all, right now, witnessing. For the microwave-based, wireless telecom-type society, that is now rapidly introduced all over the world, the basic scientific issue is not primarily about the exact siting of base stations, it is about whether it is alright to irradiate the whole population with microwaves, and likewise. This is, of course, a full-scale human experiment, with you and I and everyone else in it, regardless of if we own a mobile telephone, a DECT-telephone, etc., or not.

At the same time, it is worrying that so many observations are made, all over the world, connecting health problems with the erection of telecom base station systems - hopefully, all these observations will disappear as a mental haze, only leaving a 100%

security behind, but that means that quite a number of such observations, as well as very many scientific studies, all will have to be wrong!

One of the latter is a recent paper, by me and my coworker Örjan Hallberg, demonstrating that 1997 was a very curious year in Sweden in that a large number of health-related measures suddenly started to indicate a fast degradation in the health of the Swedish population. Several health characteristics and diseases seem to correlate with the Swedish introduction of the GSM 1800 MHz system both in time and place, (Hallberg and Johansson, 2004).

Finally, a new paper, just published a few days ago, shows acute effects of pulsed microwaves. Nerve cell damage was seen after 30 minutes (!) of 6 W/kg microwave exposure consisting of 1.25 GHz radiation delivered as 5.9 microsecond pulses with a repetition frequency of 10 Hz. The authors concluded that the microwave exposure used changed neuronal ultrastructure, in ways that depended on microwave SAR and neuron metabolic status, (Seaman and Phelix, 2005). It should be noted, that the area chosen for study, the rat dorso-lateral caudate-putamen, is of great importance for movement disorders, such as Parkinson disease and others. Naturally, the results could thus have an enormous impact on the health of children, since they could be much more vulnerable to early nerve cell damage.

Could all of this be pure speculation? Well, to people who suggest that EHS is purely imagined or psychological, I want to ask them to explain all the peer-review-published results around effects of, often very weak, electromagnetic fields on molecules, cells, tissues, organs and various non-human experimental animals, i.e. situations which cannot at all be understood in terms of imagination or psychology. If failing this task, I would then ask them to return to the first statement regarding humans, and to scrutinize and re-evaluate it. People at that moment suddenly lack scientifically sound arguments, and most of them also confess this.

I am, and have always been, very annoyed to see that it is still alright for 'experts' to claim, for instance, "that the best way to treat EHS persons is to completely ignore them through silence". Enigmatically though, these 'experts' do not have to face any personal consequences...!?

Nothing happens to them, their position is not questioned, their competence as physicians is not questioned, their suitability as representatives for the medical profession is not questioned. Nothing! What kind of society is that?

I am also very disturbed by the fact that even if the electrosensitive persons were victims of an illusion, where in the health and law system does it say that you can treat them so badly as several have done, and still do? When I attended the medical school I was taught the very opposite: You should always address fellow men and women, young and old, with kindness, a will to learn and help, support them, meet them and their concerns in a most respectful way, and so on. Where did that disappear? It seems as our world-famous health insurance policy contains very big gaps through which EHS people, as well as other new diagnoses, fell, and still fall, head down!

There must be an end to the harassments of persons with impairments. This is not only unfair and inhuman, it is also against the laws regarding discrimination and impairment in our society. Medical pogroms will never solve anything, only the respectful search for knowledge will! I hope that such scientific endeavors immediately will commence, based only on an unbiased search for the truth. But then, there must be a true willingness from the society to sponsor such projects - and such a support is today, more or less, completely lacking...

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PROVOCATION AND EPIDEMIOLOGICAL STUDIES

Project NEMESIS: Double Blind Study on effects of 50 Hz EMF on sleep quality, physiological parameters and field perception in people suffering from electrical hypersensitivity

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ABSTRACT

The Electrical Hypersensitivity Syndrome (EHS), is a very complex problem with a variety of non-specific symptoms. The difficulty in finding a correlation between electric and magnetic fields and effects in humans stands in contrast to the number of case reports. In many cases sleep disturbances are reported. In order to investigate an effect of 50 Hz EMF on subjective sleep quality and objective physiological parameters in people with EHS, a double-blind study was performed. In a second stage it was tested in a double-blind provocation experiment, whether subjects suffering from EHS and healthy controls are able to detect weak 50 Hz electric and magnetic fields.

There was an effect on subjective sleep parameters, well being in the morning, movement patterns during sleep as well as a statistically significant number of subjects with the ability for direct field perception. Overall, there were more reactions measured than could be explained by chance results alone. The full report is available in German at: http://e-collection.ethbib.ethz.ch/cgi-bin/show.pl?type=diss&nr=13903 (Müller, 2000)

STRUCTURE OF PROJECT NEMESIS

Project NEMESIS (short for "Nicht-ionisierende Elektrische und Magnetische Felder und Elektrosensibilität in der Schweiz" or "Non-Ionizing Electric and Magnetic Fields and Electrical Hypersensitivity in Switzerland", started in April 1996, and was concluded in October 2000. The Project consisted of various parts aimed at shedding light on the nature of the many case reports from people claiming to suffer from ill-effects by electric and magnetic fields (EMF) in the 50 Hz range.

Project NEMESIS was approved by the ethics committee of the ETH Zurich. After advertising the planned study through a workshop and nation wide media coverage of the same, many people got interested in the study and applied as subjects. Everybody interested in taking part in the experiment (n>250) was issued a questionnaire, where he/she answered general questions on field sources and wrote a short summary about their problems attributed to EMF. The questionnaires returned formed the basis for the selection of the subject group for the field study and the laboratory experiment. The questionnaires themselves were analyzed as well.

With a first rough selection of about 100 volunteers, more elaborate interviews were conducted. With these interviews, a separate study on risk perception in people suffering from EHS was performed, (Müller 1998; Müller, Krueger, Schierz, 1999).

In a second interview phase, a more precise selection of 70 subjects was asked to join in a study, in order to be able to compare the subjects group with the general population. The FPI-R (Freiburger Persönlichkeitsinventar), the SOMS (Screening for somatoformic disorders) and a questionnaire for "Magical Ideation" were used. The subjects group did not show any significant deviation from the general population.

The main part of Project NEMESIS was the field experiment, where 54 subjects were tested during 20 to 26 days each in a double-blind cross-over study (Müller, Krueger, Schierz, 2000). The experiment took place in the bedrooms of the subjects, and involved a randomly switched electric and magnetic field provocation in their beds (see "Methods").

The second double-blind experiment was conducted in the laboratory at the ETH Zurich (Müller, Krueger, Schierz, 2002). The aim was to test the ability of subjects to detect a weak electric and/or magnetic field.

Figure1 shows the four main parts of Project NEMESIS:

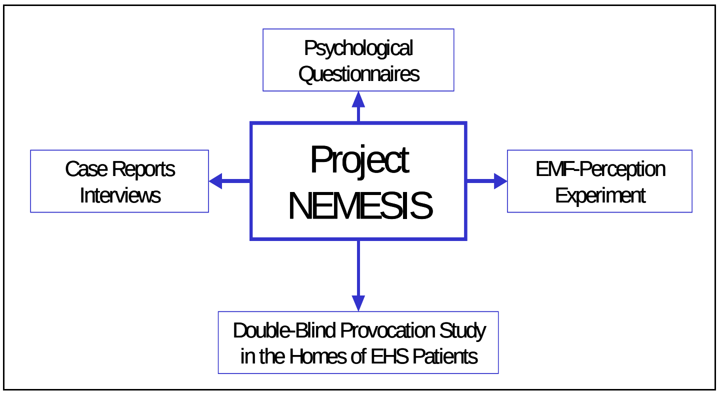

Figure 1 *Structure of Project NEMESIS with its four main parts. The collecting and analysis of case reports and questionnaires was performed between 1997 and 1998. The Provocation studies in the field and in the laboratory took place between 1997 and 1999.*

HYPOTHESES

Part I: Field Experiment

Exposure to 50 Hz EMF of 80-160 V/m and 2-6 µT respectively during 4 hours in the night affects *sleep quality*, *physiological parameters* and *behavior* in people suffering from EHS.

Part II: Laboratory Experiment

There are subjects who are able to perceive a 50 Hz EMF of 100 V/m and 4 µT (discern between "field on" and "field off")

SUBJECTS

Part I: Field Experiment

The subjects were selected from a group of self declared patients suffering from Electrical Hypersensitivity Syndrome (EHS) with their symptoms attributed to 50 Hz EMF sources. The selection was based on the following criteria:

- subjects had successful EMF-mitigation done in their homes (EMF reduced in their home environment either through professional help or by removing EMF sources)

- they had to be free of symptoms attributed to EMFs at the time of the experiment or at least feel themselves in good shape in order to take part

In total 54 subjects (m=21; f=33) were selected within an age range of 17-76y (mean=47.3y). In a double-blind cross-over study design, there is no need for a placebo or control group because each subject acts as his/her own control.

Part II: Laboratory Experiment

For the laboratory experiment, two groups were recruited: The first group consisted of 49 subjects (m=19; f=30) with EHS attributed to 50 Hz EMF sources. Most of these subjects did also take part in the field study (part I). The second group of 14 subjects (m=12; f=2) were recruited from volunteers familiar with the phenomenon but not suffering from EHS.

The selection criteria was that they had to be free of symptoms attributed to EMFs at the time of the experiment or at least feel themselves in good shape in order to take part.

The selection of two groups was not aimed at looking at case control issues. The study design again was a double blind cross-over design with no need for a sham exposed group. The goal of having two groups within the same experiment was to find out, whether a group claiming to be hypersensitive is also more likely to detect weak EMF, than a group of subject who does not claim to suffer from any ill effects from EMF.

METHODS

Part I: Field Experiment

A double-blind cross-over study was conducted in the bedrooms of subjects suffering from EHS. The testing of subjects in their home environment renders practical results and allows including realistic confounding factors of an EMF effect.

a) Subjective sleep parameters were measured using a diary containing questions on sleep quality and emotional states (pleasure and arousal)

b) Objective sleep parameters such as movements, heart rate and breathing frequency were measured making use of indirect actigraphy (Dormograph)

c) A battery powered field generator induced a 50 Hz electric and magnetic field (80-160 V/m, 2-6 μT). The provocation field was switched according to a double-blind schedule.

The input and output parameters measured and taken into account during the field study are summarized in Figure 2 below. For the measurement of the physiological parameters, the so-called "Dormograph" (Seismosomnography SSG) was developed at the Institute for Hygiene and Applied Physiology of the ETH Zurich (Brink, Müller, Schierz, 2005). The Dormograph allowed measuring the physiological parameters without touching the subjects. Considering the subjects' sensitivity, the battery-powered apparatus itself did not produce any EMF outside the metal container of the Dormograph.

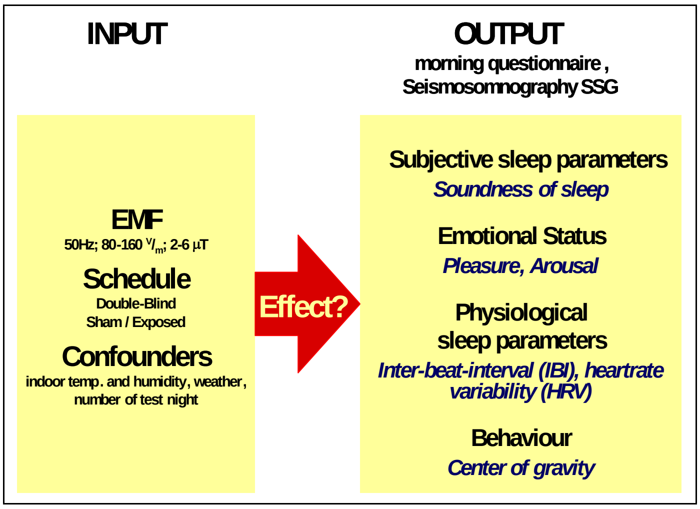

Figure 2 *Input and output parameters for the field study in the homes of 54 subjects with self reported EHS.*

The set up in the homes of the subjects is shown in Figure 3 below. The Dormograph was placed under the bed, containing the small computer with the double-blind schedule and flash memory device for storing the data collected over a period of 4 to 6 days. The field generator placed near the upper end of the bed, was controlled by the computer as well. On top of the field generator sensors for temperature, humidity, sound and light were mounted in order to record those confounding factors during the testing phase. Under the mattress, a magnetic field coil (plus a dummy coil, see Figure 4) and a conductive sheet for the electric field were placed. The field generating devices could neither be heard, nor felt nor smelled. The field strength/magnetic induction were distributed heterogeneously over the area of the bed and reached values around 100 V/m and 4 µT respectively.

The subjects had to fill in questionnaires in the morning just after waking up and in the evening just before going to bed. The questionnaires were the only task the subjects had to do during the four weeks of testing.

The magnetic field coil was placed asymmetrically under the subjects' mattresses, to find out whether subjects tend to move unconsciously towards or away from the area of maximum field intensity during nights with field provocation. To prevent subjects from finding out where the field coil was positioned, a dummy coil was placed next to the real one. The Dormograph measured the center of gravity of the subjects from which the behavioral effect of the field provocation was derived.

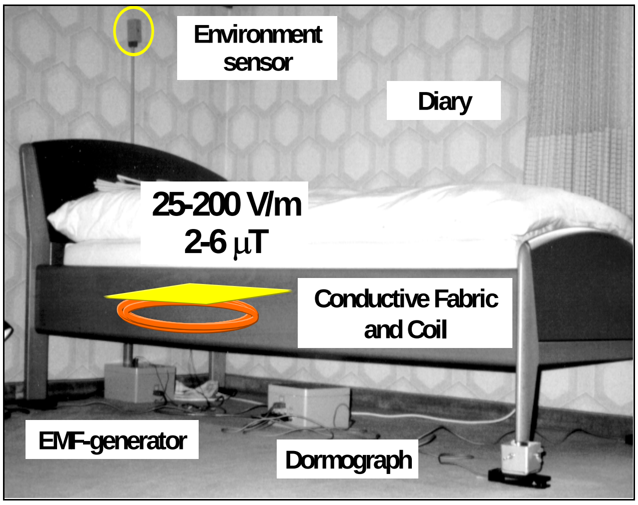

Figure 3 *Set up in the homes of subjects taking part in the field study.*

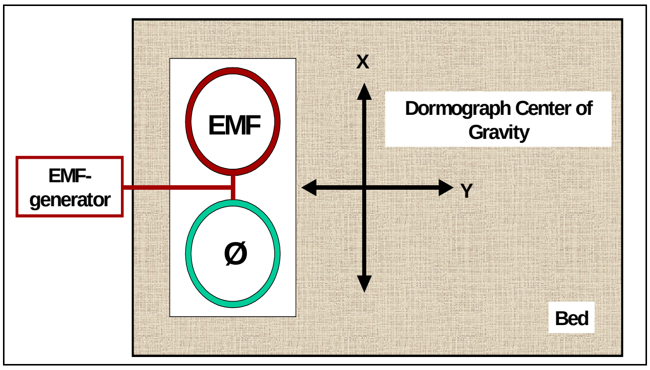

Figure 4 *Placement of the magnetic field coil under the subjects' mattresses: The field coil and a dummy coil were positioned asymmetrically under the subjects' neck/shoulder area. This in order to check for behavioral effects on the subjects during the nights with field provocation, compared to those without provocation.*

Part II: Laboratory Experiment

To see whether a weak electric and magnetic field had an effect on direct field detection, 63 subjects were invited to take part in a laboratory experiment at the ETH Zurich.

a) 49 subjects with EHS and 14 without EHS took part in the experiment.

b) The subjects had to rate the field condition as either "on" or "off". The exposure schedule counted 10 sham and 10 exposed 2-minute blocks. The exposure was switched in randomized sequence and the sequence was programmed by a third party outside the test team. The 50 Hz electric field strength and magnetic flux density measured between 80 and 150 V/m and 3 to 6 µT respectively.

c) Double blind cross-over study design.

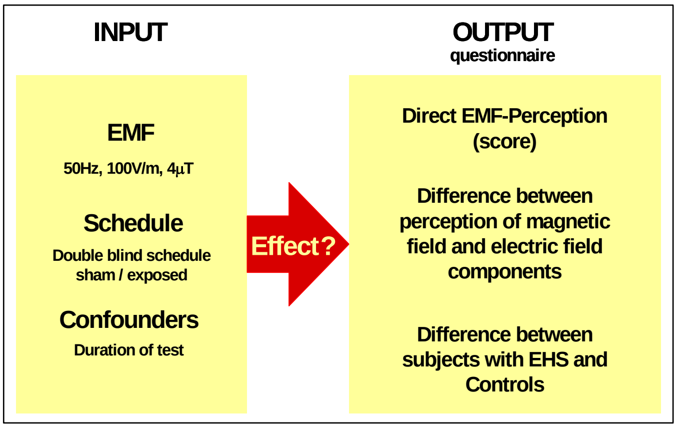

Figure 5 *Input and output parameters for the laboratory experiment.*

Just before the field provocation experiment, the subjects had to answer questions about their well-being and subjective levels of sensitivity to electromagnetic fields (self-rated sensitivity to EMF). Immediately after the experiment, before discussing the individual results, a second questionnaire had to be filled in with the same questions as before, plus additional questions about the number and types of symptoms experienced during the experimental session and the perceived intensity of the provocation field.

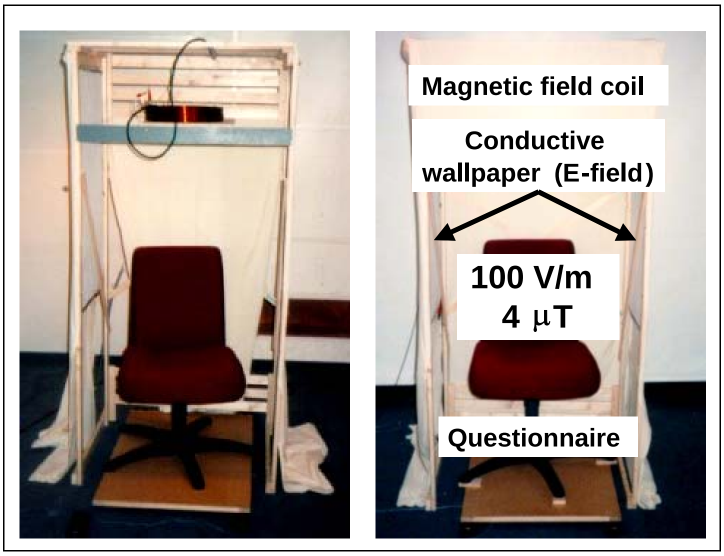

Figure 6 *Exposure cubicle: Two 60 x 140 cm sheets of conductive wallpaper were attached on the left and right of a wooden frame. The magnetic field coil with 30 cm diameter was installed in a compartment above the subject's head. The conductive wallpaper and coil were connected to a field generator device and wrapped with non-conductive linen to hide the field generating equipment. An adjustable chair was used to control the subject's position relative to the electric and magnetic field.*

RESULTS

Part I: Field Experiment

A robust linear regression method was used to test the hypothesis of a link between sleep quality and field exposure on/off. The robust linear regression produced a p-value for each of the three a priori parameters (sleep quality, pleasure, arousal). These three p-values were averaged and the distribution of the averaged p-values was tested (Wilcoxon: one-sided, median=0.5) for a deviation from the uniform distribution assumed for no effect. There was a significant overall effect of the EMF-provocation on subjective parameters in the morning: p=0.042. The EMF-provocation affected the emotional scores pleasure and arousal in the morning ($p_{Pleasure}$=0.011; $p_{Arousal}$=0.046), the sleep quality score was not affected. Further inspection of the results revealed a trend towards a positive correlation between the EMF-provocation and well-being in the morning. Table 1 summarizes the results from the field study.

Table 1 *Results from the statistical analysis of the parameters measured during 20 to 26 nights (field study).*

Parameter (a priori hypotheses)	p-Value	Remarks
Soundness of sleep and well-being in the morning	0.042	Soundness of sleep and well-being in the morning were affected significantly. There was a positive correlation between "field provocation on" and soundness of sleep.
Self reported sleep quality	0.535	Self rated sleep quality was not affected measurably.
Field perception (rating field situation in retrospect in the morning for the night)	0.018	Subjects were able (collectively) to detect the nights with field provocation with statistically significant result, although nights with provocation were rated as "field off".
Well-being during the day	0.191	There was no measurable effect on the well-being during the day evoked by the field provocation during the previous night.
Random movements and breathing frequency	0.226	The number of movements and the breathing frequency was not measurably affected by the EMF provocation.
Heart rate, heart parameters (inter-beat-interval, hear rate variability)	0.433	There was no detectable change in heart rate or other heart parameters measured with the provocation field turned on.
Behavioral effects	0.007	There were more subjects who showed significant behavioral effects by moving away from the area of the highest field intensities than could be explained by chance.

Heart parameters and breathing frequency as well as the number of movements during the night were not changed by the EMF provocation. There was a significant behavioral effect: Six out of 35 subjects slept on a different side of the mattress on nights with field provocation than on nights without. Figure 7 shows the averaged values for the position of the center of gravity (relative) during the whole testing phase of the three subjects who showed the most significant behavioral effects.

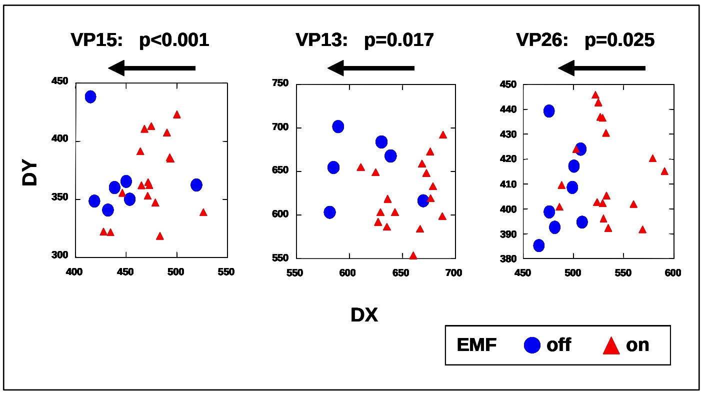

Figure 7 *Averaged values (relative) for the position of the center of gravity during the whole testing phase of the three subjects who showed the most significant behavioral effects. The triangles show nights where the field provocation was turned on. There was a significant movement away from the area with the strongest field exposure. The arrow indicates the position of the magnetic field coil which in these three cases is on the left hand side of the mattress.*

Part II: Laboratory Experiment

Two-sided probabilities were assumed, since it is sufficient to detect the differences between the EMF-situations without having to identify "on" and "off" phases correctly. The analysis of the pilot study's questionnaires further revealed, that the duration of the test session is an important confounding factor. Weariness leads to either more yes or no answers judging the EMF situation. The EMF effect including weariness as confounding factor was analyzed for each subject with linear regression. When performing 63 independent statistical tests, three significant results with $p<0.05$ are expected to occur by chance. The probabilities for a certain number of significant and independent p-values can be derived from the binomial distribution. Therefore, the null-hypothesis that there are not more statistically significant individual results ($pEMF<0.05$) than expected to occur by chance was tested by counting the number of significant results and calculating the probability from the binomial distribution.

Seven out of 63 subjects reached a statistically significant result which points to the existence of a small subgroup of "Electrosensitive" (= subjects who are able to detect a weak electric and magnetic field at the intensities used for the field provocation in Project NEMESIS) within the whole study group ($p=0.037$). There was no measurable difference between the subjects with self reported EHS and those without in terms of success rate in the field perception experiment as well as the number and types of symptoms encountered during the test. Furthermore, 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. Table 2 lists all results from the laboratory experiment.

Table 2 *Results from the statistical analysis of the laboratory experiment.*

Parameter (a priori hypotheses)	p-Value	Remarks
Direct field perception (true/false)	0.037	There were more subjects with statistically significant result showing some sort of *"Electrosensitivity" than could be expected by a chance result (corrected for multiple testing).
Differences between field components (true/false quota compared between test runs with magnetic field vs. tests with electric fields)	0.92	There was no significant difference between detecting a magnetic or electric field.
Ability to detect EMF in subjects with EHS and subjects without EHS	0.697	The hit rate in the group of subjectively hypersensitive subjects and those who were not hypersensitive did not differ significantly.

* "Electrosensitivity" is defined as the ability to detect a weak electric and magnetic field at the intensities used for the field provocation in Project NEMESIS

The analysis of the questionnaires from the laboratory experiment yielded interesting insights into the Hypersensitivity Syndrome. From the subjects who considered themselves to be hypersensitive (to various degrees) before undergoing the EMF perception test in the lab, many were convinced to be able to perceive the EMF and that they would react to the field provocation showing symptoms. The level of self rated sensitivity to EMF is depicted in Figure 8. After the test, the self rated level of sensitivity towards EMF showed a different distribution (see Figure 9): The overall self rated sensitivity to EMF was lower after the experience than before.

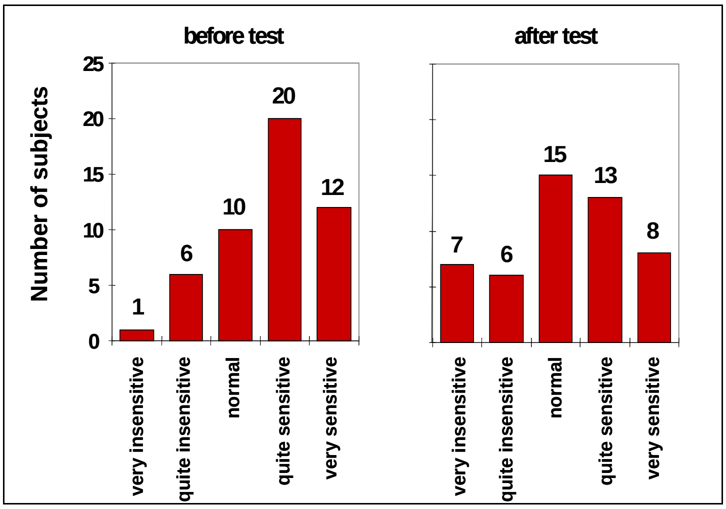

Figure 8 *lf rated sensitivity to EMF just before and after the provocation test in the lab: Before taking the test, the subjects from the EHS-group were rather convinced to either feel the provocation field or to show the "usual" reactions or symptoms (see graph to the left). The rating shifted towards the less sensitive side just after the experience (see graph to the right).*

These observations show, that for some subjects - those who have not reached the "point of no return", Harlacher, Schahn, (1997) in respect of their conviction to be hypersensitive to EMF – there is the possibility to unlearn the "hypersensitivity". For those cases where EMF is not the cause for the Idiopathic Environmental Illness (IEI), being able to experience a field provocation experiment can be very helpful in shifting the focus away from EMF to the real cause(s) of the symptoms they are suffering from.

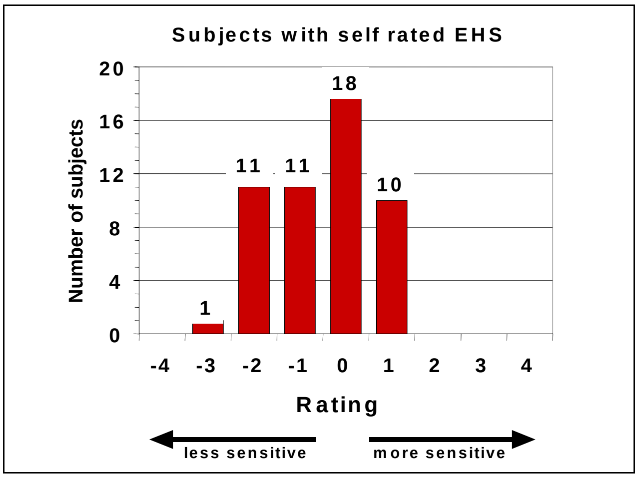

Figure 9 *Shifting of self rated sensitivity to EMF in the group of subjects who rated themselves as being hypersensitive to EMF: The score shifted significantly to the "less sensitive" side after experiencing the provocation test. This shift is an indicator that EHS can be unlearnt by "experiencing" EMF exposure which do not induce symptoms or direct field perception. The abscissa shows the shift of score points: 0=no change in self-rating.*

DISCUSSION

The results from the subjective parameters suggest, that subjective sleep parameters are affected by weak 50 Hz electric and magnetic fields in some people. The results presented in this paper point to an association between EMF exposure and subjective parameters in the morning. A purely psychosomatic reaction or a placebo effect can be dismissed. Further studies on psycho-physiological aspects of EMF perception and on changes in subjective sleep parameters through EMF have to be carried out.

In the laboratory experiment, the hypothesis on Electrosensitivity (association between field situation and effects reported by subjects) was confirmed. 49 subjectively hypersensitive subjects and a second group of 14 people not claiming to be hypersensitive but who are aware of the EHS issue showed, that several subjects perceive weak 50 Hz EMF of 200 V/m and 6 µT. However, the Electrosensitivity does not seem to be connected to the perceived degree of EHS. And, the ability to detect an EMF does not a priori mean that EMF cause health effects.

The synthesis of the complete results from Project NEMESIS makes clear that Hypersensitivity to Electricity cannot be reduced to a simple causal relationship between electric and magnetic fields and the biological effects observed. The character of the reaction under electric and magnetic field exposure depends upon the point in time of the provocation and the current condition of the subjects exposed. Table 3 summarizes the overall conclusions of Project NEMESIS.

Table 3 *Conclusions from Project NEMESIS.*

1	There is a strong indication of objective (measurable) Electrosensitivity, the ability to consciously perceive weak electric and magnetic fields at field strengths used in the provocation studies.
2	Electrosensitivity seems not to be a phenomenon which is individually stable over time.
3	Subjective Hypersensitivity to Electricity ≠ objective Electrosensitivity: It is impossible to conclude an objective sensitivity on the basis of a subjective hypersensitivity syndrome.
4	The group of subjects who took part in the Project NEMESIS did not show any psychological characteristics different from the general population.
5	The reactions to the provocation field were not always negative. Soundness of sleep and well-being in the morning did improve after nights with field exposure.
6	Electrical Hypersensitivity Syndrome can be – in some cases – unlearnt. In some subjects, being able to experience being exposed without producing symptoms resulted in a lower score in their self reported hypersensitivity in the aftermath.

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Provocation Studies in Electromagnetically Hypersensitive Persons

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INTRODUCTION

In the last two decades the existence of electromagnetic hypersensitivity is increasingly discussed in literature, mass media and environmental policy in the context of health hazards. Electromagnetic hypersensitivity (EMH) also plays a major role in some countries in standard-setting committees and for authorities.

Although numerous scientific studies were performed in the past fifteen years, no conclusive and substantial evidence supports the view of electromagnetically hypersensitive persons (EMH persons). Furthermore, it is not yet known whether the phenomenon of EMH could be an independent disease entity or a kind of Multiple-Environmental-Sensitivity-Syndrome as we know it from Multiple-Chemical-Sensitivity-Syndrome. As a neutral starting position, we defined EMH persons as those, who subjectively ascribe symptoms of vegetative dystonia to the presence of electromagnetic fields. EMH persons were also named patients as compared to healthy volunteers.

AIM

Based on the assumption, that a prerequisite for EMH should be an input into the nervous system, we formulated three main questions in order to understand the nature of EMH:

1. Is there a difference among different people in sensitiveness against electromagnetic fields and could there be a correlation between common somato or other sensory sensitiveness and EMH?
2. Is there a special pattern of symptoms which can define EMH as a typical disease in a clinical sense?
3. What is the background for self-reported EMH in respect of the environmental situation of the patients, or their psychological structure, or the influence of media like television, printed matter or oral communication?

In order to investigate these topics we used our contacts to those who asked for help concerning their problems with electromagnetic fields. During the last 15 years more than one thousand persons addressed our institution in order to find technical, psychological and medical help for their problems

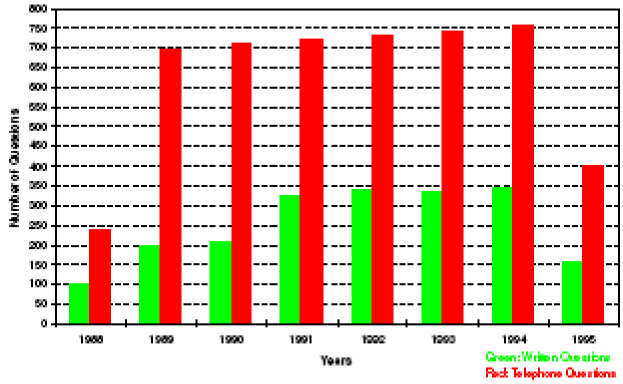

Figure 1 *Displays the number of questions addressed to the Electropathological Research Center during the years 1988 until 1995 separated in oral and telephone contacts.*

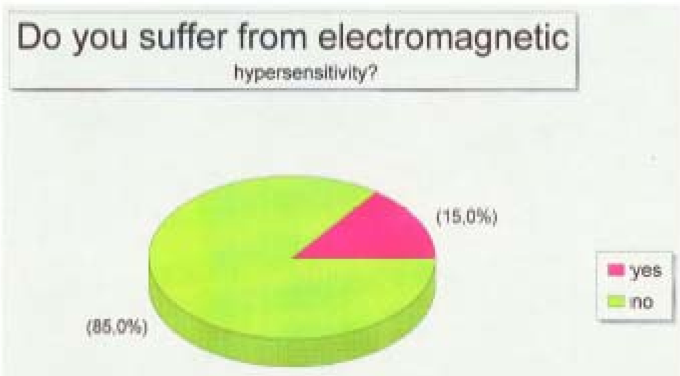

Figure 2 *15% of persons contacting our Electropathological Research Section by letter or by telephone are convinced to suffer from electromagnetic hypersensitivity.*

In addition to the answers to their questions we investigated the reason of their contacts, their social situation and if possible their medical anamnesis and asked them to take part in an experiment with exposure to electromagnetic fields.

Those who reported to be electromagnetically hypersensitive were separated from the other group but had to undergo the same procedure as the other group:

Method: A special Witten Test for EMH was used in the study.

Figure 3 *Test environment for provocation experiments. In actual test situation, no electric lamp was provided in the room and the magnetic coil was mounted on other side of the wall (not accessible to volunteer).*

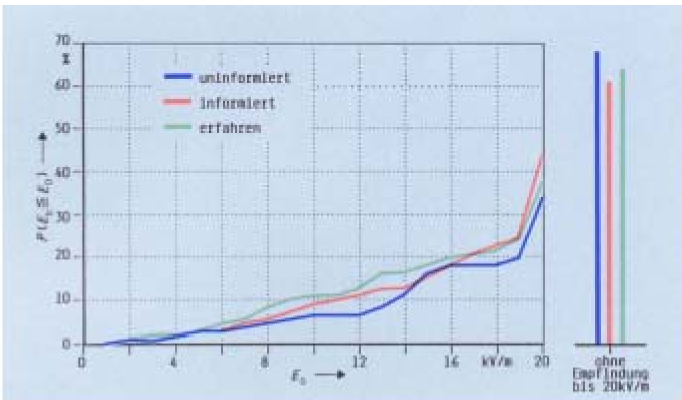

Figure 4 *Demonstrates the correlation between 50 Hz electric field exposure at intensities from 1 – 20 kV/m and the number of correct field detection (blue line: uninformed about experimental course, red: informed, green: experienced volunteers. (Haubrich et al. 1989)*

Even with field strengths of 5 kV/m, (the limits in Germany´s 26. Ordinance of the Immission Control Act), about 3 % of persons recognized the presence of fields. The result documents that there are different sensitivities concerning electrical fields, depending on the informational state of the persons.

A thorough patient history was obtained with special detail in areas such as occupation, chemical or physical exposure to stressors, telephone and appliance use and exposure, patient and/or family history of depression, schizophrenia or neurosis.

A systematic neurological and internal medicine examination also was made. If an organic cause for health problems was identified, patients were excluded from the study. A questionnaire was used to generate a pool of information about each EMF-hypersensitive patient. Patients included in the study were found to have neither hypochondria nor to meet any criteria of psychiatric diagnoses. Patients and controls underwent a screening especially developed for substantiating the hypothesis of EMF-hypersensitivity by testing their capacity to detect a well-defined field situation: subjects were exposed to a series of field situations in which they were exposed to 50 Hz magnetic flux densities of 10 µT, generated by a coil or to a control situation (sham, field off). The magnetic field was activated or not activated (sham) for 2 minutes. Hereafter patients were informed that fields were "shut off" for another 3 minutes (2 min + 3 min = 1 cycle). After that, they were again confronted with the possibility that fields might be activated in the following cycle. The succession of sham or verum cycles was determined on a stochastic basis by computer program (intermittent exposure). The probability of magnetic fields being switched on was 50 %. The 5-minute-cycles were repeated 10 times in one experiment with two experiments for each person on the same day.

Confronted with the possibility that fields were activated, subjects were invited to give their opinion on whether or not fields had been switched on. On the basis of the information obtained, hit frequency scores could be deduced for each person. This procedure was carried out twice. Before the first set of exposures (real experiment), participants were "trained" to the test procedures by applying a field on/field off situation three times and telling participants simultaneously the correct status "field on" or "field off".

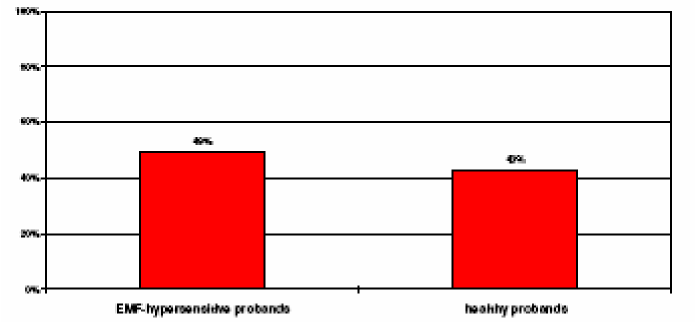

Figure 5 *Shows average hit frequencies of EMF-hypersensitive (n=24) and healthy probands (n=24). The results demonstrate no significant difference between electromagnetically hypersensitive persons and control persons.*

This investigation was accompanied by an anamnesis and clinical examinations, a questionnaire concerning symptoms (Witten/Herdecke University Questionnaire Concerning EMF-Hypersensitivity), and another one Hypochondria-Hystery-Inventary (HHI by Prof. Dr. Fritz Süllwold) focussing on hypochondriac tendencies. In between the experiments, a blood sample was taken at different daytimes by antecubital venipuncture. Radioimmunoassay kits (IBL, Hamburg) were used to determine plasma melatonin levels.

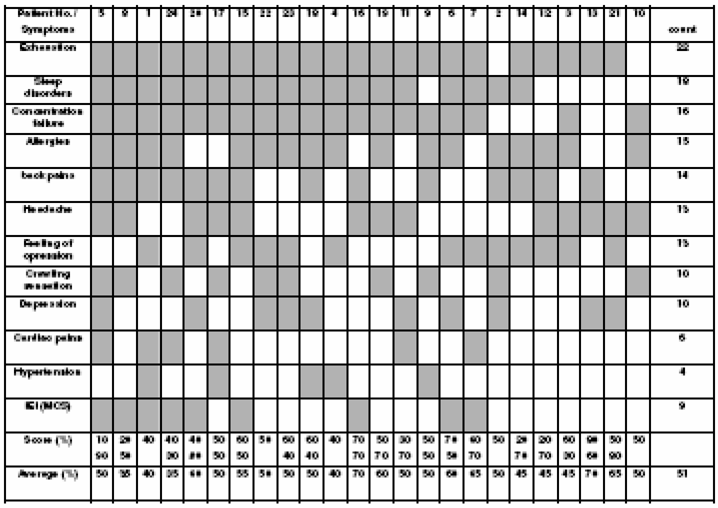

Figure 6 *Shows an attempt to correlate abundance of single symptoms (box marked grey if present) and field perception in individual EMH persons. The persons are listed according to a decreasing number of symptoms from left to right while the abundance of discrete symptoms decreases from the top to the bottom. For each participant the individual field perception (hit ratio or single experiment score and average score) is given at the bottom.*

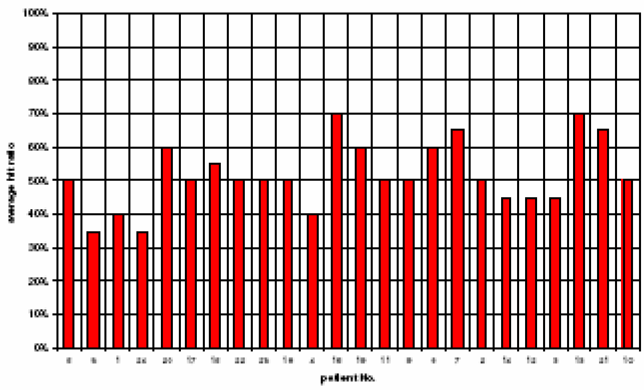

Figure 7 D*isplays a plot between hit ratio in percent and number of patients in the sequence of decreasing number of symptoms. No correlation between symptom number and hit ratio shows up.*

In order to find out if a discrete psychological component has an impact on field perception in the present study design, we conducted an experiment summarized in figs. 8 and 9:

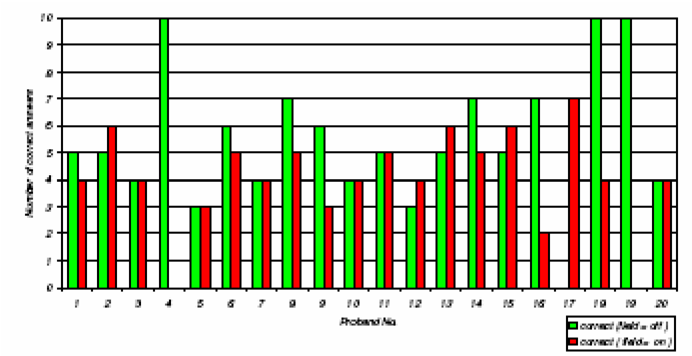

Figure 8 *Correlation between field status and correct answers (10 answers at maximum) for healthy volunteers.*

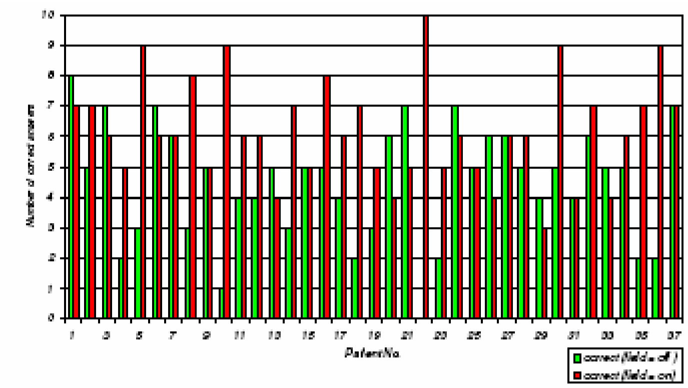

Figure 9 *Correlation between field status and correct answers (10 answers at maximum) for EMH persons.*

In Figures 8 and 9, one recognizes that the correct number of answers for the situation "field on" is more elevated in the electromagnetically hypersensitive group than in the control group. It can be concluded that expectations play a certain role in the selfassessment of field influence.

RESULTS

The results showed an interesting tendency. More than 50 self-reported electromagnetically hypersensitive persons were compared with the group of the healthy control persons. There was no regular psychological abnormity especially in respect of hypochondriac tendencies although some hypersensitive persons showed an inclination to schizoid behavior. There was no specific pattern of medical symptoms to be detected either. The rating of the field situation by EMH during exposure in weak fields did not differ from healthy controls but regarding the correct rating of field-situation during field on there was a marked difference between the two groups which can be explained by expectations of the respective person.

CONCLUSION

With given low intensity fields (50 Hz, 10 µT) the detection of exposure was not different for healthy volunteers compared to self-reported electromagnetic hypersensitive persons. There was also no specific symptom pattern or abundance. In summary our results do not suggest EMH to be comprehensible as a clinical disease, but to be a special situation clouded by social, behavioural and expectational contributions.

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UPCOMING RESEARCH

Studies of electrical hypersensitivity in the UK

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ABSTRACT

An outline is given of five provocation studies of electrical hypersensitivity (EHS) that are presently underway in the UK. The studies investigate some of the symptoms (nausea, headaches, dizziness, fatigue, warmth etc), that have been reported as a result of exposure from radiofrequency fields (RF). Four are concerned with RF exposure from handsets (two from GSM 900 and two from TETRA) and the fifth with RF exposure from GSM or UMTS base stations. They are part of a UK portfolio of ten provocation studies, the other five being concerned with the effects of mobile phones on cognitive and physiological functions.

BACKGROUND

Electrical hypersensitivity (EHS) is a real and often disabling problem for those affected. The symptoms that have been reported by some people as a result of exposure from radiofrequency fields (RF) include nausea, headaches, dizziness, fatigue, warmth, memory loss and loss of concentration. The EHS syndrome is presently ill-defined and not understood and more research is needed. Only two provocation studies on volunteers reporting symptoms, "EHS volunteers", have been published to date. One of these looked at handsets, both analogue and GSM, but found no association between exposure and the occurrence of various symptoms, (Hietanen et al, 2002). The other looked at exposure from base stations, (GSM 900 and 1800 and UMTS) and found some association with exposure from UMTS base stations, (Zwamborn et al, 2003).

Five further provocation studies of EHS are presently underway in the UK. Four are concerned with RF exposure from handsets (two from GSM 900 and two from TETRA). The fifth is concerned with RF exposure from GSM or UMTS base stations and it is hoped to extend this to include TETRA base stations. They are part of a UK portfolio of ten provocation studies, the other five being concerned with the effects of mobile phones on cognitive function (2), blood pressure, electrical activity of the brain or their distractive effects on driving although in this last study, the volunteer is not subjected to RF exposure. Eight of these studies are supported through the Mobile

Telecommunications and Health Research Programme (MTHR) (www.mthr.org.uk), and two were commissioned directly by government as part of the Health and Safety programme, relating to the use of TETRA handsets by police officers (http://www.policereform.gov.uk/implementation/tetra/index.html).

The two exposure systems (GSM 900 and TETRA) used for all the handset studies were commissioned by MTHR. They provide exposure under double-blind conditions of either pulsed fields, continuous wave fields (CW) or sham and care was taken to ensure that the blinding was not compromised by differences in the surface temperature or acoustic noise. The systems resemble "typical" handsets and their exposures produce SARs of around 1.6 Wkg^{-1}.

STUDIES

Study 1

The first of the EHS phone studies, which is being carried out by Prof Linda Luxon and colleagues (National Hospital for Neurology and Neurosurgery), recognizes that many of the symptoms reported by people with EHS are similar to those resulting from stimulation of the vestibular labyrinth in the inner ear. The studies are being carried out on EHS volunteers and 20 who do not report symptoms, "non-EHS volunteers". In each session the volunteer is exposed for 30 minutes, either to pulsed fields from the GSM 900 system or to sham and then to the reverse. In each case, the volunteer is asked whether or not they think the phone is emitting. Hearing and balance are assessed using otoacoustic emission and video-oculography before and after each session to determine whether the exposure caused stimulation of the inner ear. The project started in November 2002. The experiments have been completed but the data are still being analyzed.

Study 2

The second study is being carried out by Prof Simon Wessely and colleagues (King's College, London), and is looking both at the occurrence of symptoms, and also whether certain hormone levels can be changed by exposure from GSM phones. It involves 60 EHS and 60 non-EHS volunteers and questionnaires are used to determine their phone usage, symptoms, if any, and health. In addition, assessments are made of psychological predictors of symptom reporting. In each session, the volunteer receives either a 50 minute exposure from the GSM 900 phone, or a CW signal, or a sham. After each session, the volunteer is asked to describe any symptoms, and whether or not they thought the phone was emitting. Blood samples are used to determine hormone concentrations. Heart rate and critical flicker fusion threshold are measured before each session. The project started in April 2003 and is due to finish in March 2006.

Study 3

The third study is also beingcarried out by Prof Wessely and colleagues, and involves 60 EHS and 60 non-EHS volunteers who will all be serving police officers. The protocol is similar to that of the GSM study but is studying effects from TETRA signals. The other main difference is that the study focuses on symptom reporting and no blood samples are taken. The project started in July 2005.

Study 4

The fourth study, which is by Dr Adrian Burgess and colleagues (Imperial College, London), forms part of a large health monitoring study of police officers who are using TETRA handsets. It involves 50 EHS and 100 non-EHS volunteers, consisting of equal numbers of high and low users of TETRA. After initial assessments are made by questionnaire, the volunteers participate in 10 four-minute auditory discrimination tasks followed immediately by a self-rating of level of alertness. Using the double-blind system, they are exposed to TETRA signals for half of the four-minute slots and sham the other half. EEG, ECG and behavioral responses are monitored throughout. The project started in March 2005.

The base-station study is being carried out by Professor Elaine Fox and colleagues (University of Essex), and involves 132 EHS and 132 non-EHS volunteers. The selection of the EHS volunteers uses a questionnaire developed in a pilot study. This is believed to be the first psychometric instrument specifically targeted at EHS, and should provide information about the profile of people who report EHS. They are exposed to simulated base station radiation in a screened room to ensure that they receive negligible exposure from other sources. Their exposure is preceded by a waiting period in another screened room. The exposure is either 10 mWm^{-2} GSM (5 mWm^{-2} at 900 MHz plus 5 mWm^{-2} at 1800 MHz), 10 mWm^{-2} UMTS or sham. The first part of the session is an open provocation study followed by brief tests of attention and memory. The volunteers are invited to report any symptoms in each case and physiological data are taken during the exposure. This is followed by 3 blind exposures from either GSM, UMTS or sham signals and under both high and low mental load. The volunteer is asked to guess the exposure status in each case. The project started on Jan 2004 and is due to finish in June 2006.

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Ongoing and Planned EHS Research

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INTRODUCTION

In the past years, the percentage of the general population suffering from non-specific health symptoms, including sleep disturbance has grown. An increasing number of affected people associate their symptoms with the exposure to electromagnetic fields, ELF as well as RF, claiming themselves to be electromagnetic hypersensitive. Reference to electromagnetic hypersensitivity is usually made when political pressure is made, and public petitions are submitted to lower existing exposure limits and restrict the use of new technologies such as mobile telecommunication.

Although the individual's suffering is undisputed, the proof of a causal relation of ambient electromagnetic fields is still pending. However it is commonly agreed that affected persons need help. Besides this, even unreal causes until clarification might have very real individual, social and financial consequences. Therefore, scientific research on electromagnetic hypersensitivity has been already recommended by several independent groups, such as the UK Independent Expert Group on Mobile Phones (IEGMP), the German Commission on Radiation Protection (SSK) and, more recently, the European Coordination Action in the Field of Effects of Electromagnetic Fields (EMF-NET).

RESEARCH

Although WHO's EMF database already includes 85 citations of scientific studies on electromagnetic hypersensitivity since 1993, the questions whether there is a causal link between weak EMF exposure and non-specific health symptoms and whether electromagnetic hypersensitivity does exist, is still open. However, taken as a whole, the body of results in the meanwhile, changed the issue in terms of differentiation between increased ability to perceive electricity and EMF (hypersensitivity) on the one hand and the increased vulnerability to develop health- relevant somatic reactions (hypersensibility) on the other hand. Furthermore, it is not yet decided whether increased sensitivity to perceive electricity could be a result rather than a cause of vulnerable changes of the autonomous nervous system.

Although it has not been included in the 6th European Framework Research Program, presently, this issue has gained increased attention. There are many research activities ongoing and planned. This is done on a national level mainly, but not exclusively, in European countries. The activities can be grouped as follows:

ASSESSMENT OF THE PREVALENCE OF EHS

Estimates on the prevalence of EHS cases, have already been made several times. Leitgeb (1995) concluded from electrosensitivity measurements that EHS should be less than 2%. (Bergqvist et al. 1997) found a European south to north EHS increase associated with a change of attributed sources in terms of outdoor sources in the south and indoor sources in Scandinavian countries. The following estimated EHS percentages were 2%, (Ericsson et al. 2000), 1,5%, (Hillert et. al.) both for Sweden and 3,2% (Levallois et al. 2002) for California.

Public awareness of EHS is considerably influenced by beliefs of opinion leaders. In a demoscopic study, (Leitgeb et al. 2005) made a national inquiry among general physicians in Austria. The results show that it is not rare for general practitioners are faced with questions about possible adverse health impact of environmental electromagnetic fields. Two thirds of the physicians (68%) are asked about this by their patients, among them 49% occasionally and 2% even frequently while 32% are never asked (Fig. 1).

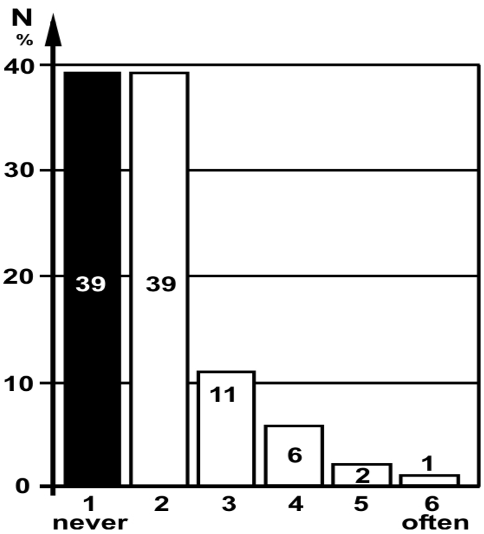

Figure 1 *Percentages of general physicians contacted by patients with health concerns about environmental electromagnetic fields*

An overwhelming percentage of 95% agrees to some degree, or even completely, that environmental electromagnetic fields can cause illness. This, among other results, show that beliefs and convictions of the overwhelming majority of the general practitioners are in clear contradiction to WHO's position. This may be partly explained by the fact that the majority (53%) of physicians consider the available information on EMF and health insufficient, only 2% are content with it.

It is unique that there is such a widespread contradiction between individual physician's opinions and established national and international health risk assessment on electromagnetic fields. This clearly indicates the need for adequate actions by physician's associations, as well as by responsible authorities.

SYMPTOM STUDIES

There are several EHS symptom studies ongoing.

- Following the initial attempt made by an European study in 1996 collections of EMF- attributed symptoms are on the way in Germany ("Mainzer Watchdog"), Australia (ARPANSA EMR health complaints register) and Austria.

- EHS-associated biological indicators are going to be investigated with and without potential cofactors like allergies and other hypersensitivities in Germany and Japan,

- The provocation study of EHS and non-EHS group, presented by TNO which resulted in a higher score of influences on the well being of EHS following UMTS exposure and non significant changes associated with GSM exposure and some impact on cognition is going to be replicated in Switzerland.

- EMF-perception or scoring and EMF- provoked biological (hyper-) reactions, are studied in Austria, Finland, Germany, Japan, Korea, the Netherlands, Sweden and Switzerland.

EPIDEMIOLOGICAL AND/OR FIELD STUDIES

Present studies are mainly concentrating on mobile telecommunication fields.

- EMF-associated sleep disturbances are investigated in two different kinds of field studies. On the one hand, in Switzerland and Great Britain provocation studies are planned to study the potential impact of RF- electromagnetic fields. On the other hand, the impact of the protection from environmental fields is investigated. In Germany it is planned to selectively switch off mobile phone base stations.

- In an ongoing sleep study in Austria (Leitgeb et. al. 2004) the protection from environmental fields is realized by mounting a mobile RF shield around the bed (Fig. 2).

Figure 2 *Mobile EF shield around the bed and proband with somnomedical data acquisition means.*

First Austrian results show that people, although selected just by their complaints, show increased electrosensitivity compared with normal (Fig. 3). Furthermore, there is an indication that increased electrosensitivity in the evening might be associated with impaired sleep quality. Figure 3 shows the sleep quality in dependence on the electric current perception threshold (electrosensitivity) measured in the evening. It can be seen that sleep quality becomes worse with increasing electrosensitivity (decreasing electric current perception threshold).

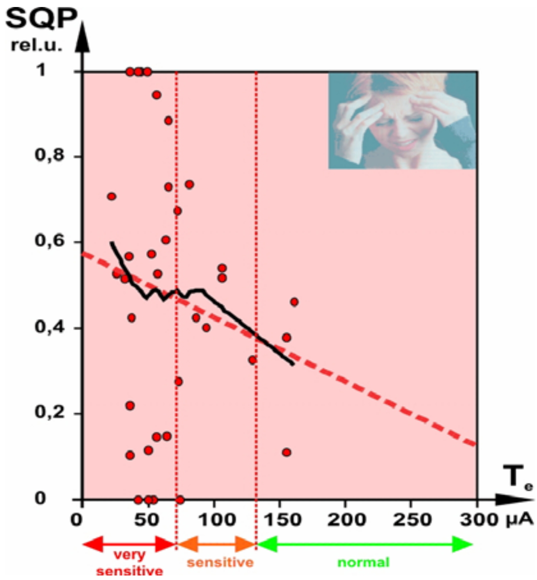

Figure 3 *Variation of the sleep quality parameter SQP (0: good sleep, 1: bad sleep) with respect to the electric current perception threshold T_e for individuals suffering from severe sleep disturbance*

- Besides this, studies whether or not non-specific health symptoms may be associated with mobile telecommunication base stations are in preparation in Germany and Switzerland (feasibility study) and under discussion in some other countries.

CONCLUSION

The ongoing and planned research activities follow the recommendations made in WHO's research agenda 2003, where the need was identified for research of electromagnetic hypersensitivity and to separate facts from fiction. Although, current studies of people claiming EMF hypersensitivity did not confirm the causal link between self- associated EHS with environmental EMF, the results show that the question still remains unsolved and further research is needed.

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CLINICAL STUDIES/TREATMENT

A physician's approach to EMF sensitive patients

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ABSTRACT

The paper discusses one physicians approach to patients who present with complaints attributed to low levels of exposure to electromagnetic fields (EMF). Selected case studies are presented to illustrate the diversity of patients, seen with a view to refining the diagnosis of the condition and improving the management of these patients. It is suggested the differential diagnosis needs to consider a spectrum of illness, ranging from localized sensitivity to fields through more generalized symptoms, to phobic states and psychiatric disorder, each with an appropriate management. The importance of history taking to assess the pattern of symptoms in relation to the exposure to EMF and to exclude other medical disorders is noted. Various aspects of provocation testing are discussed including type of tests, exposure and washout times, and type 1&2 errors in statistical analysis. Because the sensitivity and specificity of provocation tests is unknown the results of such tests should be interpreted in conjunction with the total clinical picture. Finally it is suggested the term "Electromagnetic Hyper-sensitivity" is meaningless and the term "EMF Sensitivity" or similar would be preferable.

INTRODUCTION

"EMF Hypersensitivity" is a poorly defined condition. It is said to include various symptoms, such as fatigue, headaches, skin rashes and insomnia which occur in association with exposure to low levels of electromagnetic fields (EMF/RF/ELF) (Stenberg in these Proceedings) It appears to have its origins in a contentious syndrome called "microwave sickness" which was originally described during the 1960s in Russian technicians, and has been recently described in western radio-frequency radiation workers. The syndrome involves the nervous system and includes fatigue, headaches, dysaesthesia and various autonomic effects (Hocking 2001). In 1991 Rea et al described electromagnetic field sensitivity in American patients who also had diverse symptoms including neurological (tingling, fatigue, headache), musculoskeletal, cardiovascular and dermal symptoms (Rea et al. 1991).

This paper discusses one physician's approach to patients who present with complaints attributed to low levels of exposure to electromagnetic fields. Selected case studies are presented to illustrate the diversity of patients seen with a view to refining the diagnosis of the condition and improving the management of these patients. Management of patients who have been overexposed to high levels of EMF has been discussed elsewhere (Hocking 2001).

CASE STUDIES

Case 1

Hocking (1998) reported a case series of 40 persons who complained of symptoms associated with use of mobile phones. A burning sensation or dull ache, (quite distinct from an ordinary headache), was felt ipsilateral to the side of use of the phone. It occurred minutes after use and lasted minutes or hours. Some cases also reported visual symptoms or not thinking clearly, ("like being hung over"). The mechanism was speculated to be neurological.

Hocking and Westerman (2002) studied a 34 year old journalist who complained of similar symptoms associated with use of a digital mobile phone. She agreed to a provocation study with her phone. Current perception threshold testing before and after exposure, showed marked changes in the C-fiber nerves of the affected area compared to the opposite side. She was advised the phone was causing her symptoms and to try use of a hands free kit which was important to her work. Equally importantly she was reassured that she was not 'imaging' symptoms or having onset of a mental illness or developing a brain tumor. The case is supportive of a neurological basis for some cases of dysaesthesia associated with mobile phone use.

Case 2

A 30 year old man presented requesting testing, "to see if I am electrosensitive because all my friends think I am mad". Previously he was a mobile phone salesman. In 1993, when using analogue phones he felt warmth on the side of the head and developed a hot ear. In 1995, associated with demonstrating digital mobile phones, he developed increasing symptoms of headache and earache on the ipsilateral side of his head. In 1997 he ceased sales work and moved to a house as a result of which he lived close to powerlines (with exposures of upto ~8mG in his house). He developed diffuse symptoms including palpitations and breathlessness, lines in his vision in both eyes and floaters and colored lights when he closed his eyes, tightness in the throat, and dizziness. Around 2001, associated with use of digital mobile phones his symptoms became more intense. He felt dull pain at the top of his head and bilateral throbbing of the temples, saw lines in his vision in both eyes and floaters, and colored lights when he closed his eyes. He also felt bilateral earaches, noticed tingling of the nose and upper lip, felt upper abdominal and groin pains, itchiness on the body, and had low energy levels.

Because of his concerns about sensitivity to EMF in April 2003 he moved from Sydney to a semi-rural area to minimize his exposures to EMF. The electricity supply on the new housing estate was underground and the house was fitted with demand switches on the circuits so there was minimization of fields in the house (up to 0.3mG as measured by the patient). He ceased use of mobile phones and the house was some km from any mobile phone tower. He ate a vegetarian diet and took regular exercise. He began to feel better. There is no past history of head injury or epilepsy, and no other health condition such as an anxiety-state was present. The family relationships were good.

He was first seen in December 2003. A single blind test was conducted to assess if he recognized when a specially designed mobile phone was “on or off” as judged by onset of his symptoms. He was correct for 10/12 tests which was statistically significant. He was advised he was probably sensitive to digital mobile phone fields. He continued to live in a semi-rural area and continued to improve. Eight months later (Aug 2004) he returned for double-blind testing of recognition of mobile phone fields (20 tests/d over 2 days, with less washout time between tests than previously). Prior to testing, he commented that he felt well and may be less sensitive to fields. On day 1 of testing, he was not able to detect whether the phone was on or off (approx. 50% accuracy). He said he felt poorly overnight with recurrence of his symptoms, which he attributed to the test exposures. He was more accurate on day 2 (approx. 70%). A Current Perception Threshold test, showed no differences between sides of the head after sham and real mobile phone exposure. This was not surprising in view of the lack of localized symptoms (unlike Case 1).

He has serendipitously had an n=1 trial of exposure to, and exclusion from, EMF. He has an overall pattern of worsening when exposed to digital mobile phone fields. This is shown by his symptoms originally developing when exposed to mobile phones in Sydney and a positive provocation test in Dec 2003, then on repeat testing in Aug 2004 he worsened after being exposed to 10 (on) challenges on Day 1 saying he felt poorly overnight and had increased sensitivity (accuracy) to the fields on Day 2. Conversely he had improvement when avoiding mobile phones and minimizing 50Hz fields in his home, particularly between his first challenge (Dec 2003) and 8 months later (Aug 2004) when he said he felt better and on Day 1 of testing did not show sensitivity (accuracy) to the fields. The overall clinical picture is consistent with EMF sensitivity even though the second round of provocation test data, (after he had improved), is equivocal. The case indicates that in selected cases a change of life style to EMF avoidance may be beneficial.

The mechanism of his sensitivity to EMF is not known. Also it is not clear if his likely sensitivity is to the RF carrier wave &/or ELF from power lines (50Hz) and mobile phone generated (8 and 217Hz) fields. He was not tested with 50Hz fields.

Case 3

A 32 year old electronics complained of a persistent cramp like feeling on the scalp above his right ear for the previous 3-4 years. It worsened when near a mobile phone in use including polling, but not an ordinary handset. The pain became piercing after several minutes exposure, and then became a dull ache and lasted for 1-2 hours. If exposure was prolonged he felt nausea, palpitations and chest constriction. His doctor had diagnosed tension headaches.

He was well until Oct 1995 when he was testing mobile phones. He made some 30-40 test calls /d. In the period 1995-97 he had onset of his symptoms, and in 1997-8 he had severe symptoms and time off work. He felt sensitive around a metal crown to a tooth; this was removed and he improved. He was extensively investigated, and no neurological abnormality was found. From 1998 onward he improved. He attributed this to reducing his exposure to mobile phones and 3 phase electricity at home. For example, the stove and hot water services were replaced by gas.

He was tested 10 times for sensitivity to RFR using a double blind study of exposure to GSM (polling) from a mobile phone. The phone was held near his head in a harness and driven at maximum output. Exposures lasted 30 minutes in morning and afternoon, allowing a washout period of 2-3 hours. His sensations were recorded on an agreed 10 point scale every 5 minutes, and 5 minutes after cessation, when he was also asked if the phone had been on or off. He accurately judged the field to be on in 7/10 tests which is not statistically significant (binomial test, 11.7 %). His flicker test EEG showed some increased responsiveness in the right occipital area.

He was advised he was not hypersensitive to RFR at present on the basis of the test to exposures and somatic symptoms. He lies at the upper limit of normal for detection of flicker suggesting his nervous system is innately sensitive to some stimuli but not abnormally so. I advised he should consider rebuilding his life and work, now that he knew he was not hypersensitive to these fields. The working diagnosis remains tension-vascular headaches probably associated with job and relationship stresses and a mis-attribution of symptoms to concomitant exposures to EMF (phobia). With hindsight there was probably a role for a behavioral therapist to help rebuild his career and relationships.

Case 4

A 22 year old male complained of pain over the back of his head, and difficulty in concentrating which he attributed to EMF. He also felt distant to events, for example floating above his bed or outside a room looking in. He had the onset of his symptoms when studying at an overseas religious college, when he noticed facial symptoms from a mobile phone, and later from a computer and power lines. On returning to Australia he was initially able to use phones and other electronic devices without ill effects, but months later his symptoms occurred when using them. His mother described him as an intense young man who wanted to right the wrongs of the world.

He had an inconsistent exposure pattern as shown by his initial symptoms occurring only when overseas but not when first exposed to the same equipment in Australia although he did later. He also had evidence of psychotic symptoms, as shown by his out of body experiences. He was advised it was unlikely he had sensitivity to EMF causing his symptoms. He was reluctant to accept this diagnosis. His physician was contacted and advised that he was unlikely to be sensitive to EMF, and his delusional state warranted psychiatric assessment regarding psychotic illness.

DISCUSSION

The spectrum of EMF sensitivity.

The table summarizes some of the aspects of diagnosis and treatment of patients with EMF sensitivity as illustrated by the previous case studies. The table shows a spectrum of illness ranging from localized sensitivity to fields through more generalized symptoms, to phobic states and psychiatric disorder. The concept of a spectrum of EMF sensitivity has implications not only in the clinic but also for research and epidemiology since case definition is also critical in these areas. However several aspects of diagnosis and treatment are problematic and warrant discussion.

Table Diagnosis & Treatment of EMF sensitivity

Type	Symptoms	Provocation Test	Treatment
1.	Localized symptoms after low level exposure(s)	+ (peripheral nerve)	Selected field minimization
2.	Generalized symptoms after low level exposure(s)	+ (CNS)	General field avoidance
3.	Generalized symptoms associated with EMF/equipment (phobia).	-	Reassure; De-condition (Cognitive Behaviour Techniques)
4.	Generalized symptoms attributed to EMF/equipment, with delusional/psychotic features.	(-)	Refer for psychiatric assessment

After exposure to low level of EMF some patients, such as Cases 1&2, have symptoms which are distressing, disrupt daily living and work, have a consistent history and findings on provocation testing. These patients need to managed appropriately regarding attenuation of their exposures to EMF, for example by use of a "hands-free" mobile phone kit, or even major life-style changes in *carefully selected cases*. Reassurance regarding fears of cancer or mental illness are important benefits to the patient from accurate diagnosis. The usefulness of 'support' groups for these patients is unclear.

Some patients, such as Cases 3&4, have distressing symptoms associated with low level EMF exposures or proximity to electrical/electronic equipment, but on clinical and/or laboratory grounds, the symptoms cannot be attributed to EMF. These patients need to be diagnosed, their fears of EMF managed, and other diagnoses considered and treated. Some cases perceive a strong association between their symptoms and using or being near equipment (such as computers) that may emit fields. Their symptoms are analogous to a Pavlovian conditioned reflex or an acquired phobia to the equipment, as described by Berg et al. (1992). They studied 47 workers, 19 of whom complained of skin symptoms when working with visual display units (VDU), which was attributed to hypersensitivity to electricity. They found affected workers showed greater stress hormone changes and other responses in relation to their work, and this could cause increased dermal blood flow. The authors suggest the stressful VDU environment acted as a conditioned stimulus to cause physiological and thence the dermal changes. Once the conditioned response has been learned, the psychophysiological responses are elicited purely by exposure to the VDU environment, but are incorrectly attributed to alleged EMF from the VDU. A similar learned or conditioned mechanism has been described by van den Burgh et al (1999) in some patients with the related condition of "multiple chemical sensitivity". This mechanism is possibly important in management, since patients who consider themselves sensitive to EMF may have made extensive life-style changes and simple reassurance may not suffice. Referral to a cognitive behavior therapist to help 'decondition' them as well as assist in readjusting to work and relationships, including embarrassment at their 'false' belief, may be appropriate (see Hillert in these Proceedings). However, in the event of patients showing delusional or related symptoms, urgent referral for psychiatric assessment is required. Ruling out EMF sensitivity is an important role for the specialist physician, although it may be counter-productive to do a provocation test in some patients lest it entrenches the sick-role.

The deliberate falsification of symptoms for secondary gain (malingering) is also a possibility, although such a case has not yet been seen by myself.

History taking is the key to diagnosis. It is critical to listen to the patient to ascertain the pattern of their symptoms and the relationship to EMF exposures. A good general knowledge of medicine is required since symptoms may occur in diverse parts of the body, depending on the exposure and raise a range of differential diagnoses. Also an understanding of the way ELF or RF fields may interact with the body and the way equipment emits fields is important. However, most physicians have very limited knowledge of this, which lessens their diagnostic capacity. For example, a patient may complain of symptoms after a neighbor has had a microwave 'dish' erected facing the patients house, but it is more likely that the 'dish' is only for receiving pay-TV than for transmitting. Unless a doctor understands the difference an erroneous diagnosis may be made. Careful clinical examination is necessary to look for subtle signs, such as altered sensation to cotton wool, and to exclude alternative pathology. Patients sometimes enquire of a blood or other test regarding EMF in their body but no such tests are validated. The main help in diagnosis is provocation testing.

PROVOCATION TESTING

The importance of provocation testing is shown by the report from Rea et al. (1991), who studied 100 patients presenting with EMF sensitivity to their environmental clinic. Rea assessed the patients using a sweep of frequencies from 0.1 Hz to 5 MHz, with nT exposures to their torso and head for 3 min, using active and blank challenges. Of the 100 patients tested 34 had no reaction to the active challenges, and 50 reacted to several blanks, leaving only 16 (16%) for detailed study. Of the 21 frequencies used in exposure, most responded to about 11. More detailed studies were then done on these 16 using several measures of pupil reaction and other physiological changes. Positive findings were claimed in the 179/336 (53%) of active challenges. However, the detailed results are not tabulated, and since multiple testing was involved it is possible the results occurred by chance. Responses to the blank exposures occurred 6/60 (10%) of challenges. Perhaps the major finding from the whole study, was that the large majority of patients (84%), who considered themselves to be EMF sensitive, were found not to be so on provocation testing.

Provocation tests are potentially important to help diagnosis in selected patients and internationally recognized protocols would be helpful. However several aspects of provocation tests warrant careful consideration including the following:

- ***Type of test.*** The type of test needs to be chosen appropriate to the complaint, e.g. simple field perception, symptom scale reporting, EEG changes, current perception threshold, etc. (NB: Current perception threshold testing should only be undertaken by practitioners experienced with the technique and interpretation of the results). No electrophysiological change has been proven to be a definitive marker of EMF sensitivity, and so negative studies cannot be taken as definitive evidence that a patient is not sensitive. The number of electro-physiological end-points measured in a test, need to be carefully considered. Given there is no specific marker of EMF sensitivity differing end-points may be valid, and arbitrary exclusion of some may disadvantage particular patients, but if numerous end-points are used then a few are likely to be 'positive' by chance causing a false positive result.
- ***Duration of test exposure.*** The duration of exposure in a test needs to be adjusted to the person, rather than an arbitrary time imposed. For example, Case 1 had to read for about 9 min to onset of her symptoms, which would have been overlooked if a time limit of say, 5 min was imposed on the test. Croft et al. (2002), have shown the importance of adequate exposure time in the induction of EEG changes after mobile phone exposure; exposures for 20 min bought about consistent changes, compared

to the standard protocol of ~5 min. An open trial of time to onset of symptoms may be helpful to establish this parameter at the outset of testing.

- ***Washout times***. The time allowed between tests is important to allow recovery ('washout time'). Otherwise, there may be a carry-over effect from a real exposure into a sham exposure giving a false result. There is a trade-off between the time available to conduct the number of tests required for statistical power and the need for an adequate wash-out time between tests. There is little guidance on this key issue, which is possibly the greatest problem in designing accurate provocation tests.
- ***Statistical power***. The durations of exposure and the washout times have practical implications for the number of tests that can be conducted in a reasonable time say, over a day or a week. The number of tests should be sufficient to avoid both Type 1 (false positive) & Type 2 (false negative) errors. But the number of tests needed for these statistical purposes, must balance the need for a high level of statistical confidence, with the need to treat the patient with consideration from the harm imposed by multiple tests. For example, it is possible that if Case 3 had more than the 10 provocation tests a statistically significant result may have been achieved, whereas Case 2, who was recovering, felt poorly after the first day of testing. Related to this is the problem of the statistical level, which is to be set for a result to be termed "significant". Given there is no 'gold standard' for diagnosis should significance be set at $p = 0.01$ or 0.05 or 0.1, because too stringent or too lax a value, may lead to respectively under- or over-diagnosis in patients?
- ***Ethics.*** The ethics of provocation tests needs consideration. They may induce unpleasant symptoms, as in Case 2 – yet there is a subtle implication that if a patient refuses a test they are a fraud.
- ***Availability***. Provocation tests require special facilities and experienced staff for their proper conduct. For example, test rooms must be shielded against a wide spectrum of EMF, or mobile phones which are designed to emit silently at full power may be needed. These requirements often are not readily available, which limits the application of diagnostic criteria requiring these tests.

Provocation tests need to balance standardization of a protocol with personalizing the test to the patient's specific symptoms. Because there is no gold standard for diagnosis the sensitivity and specificity of provocation tests is unknown and therefore the results of tests should be interpreted in conjunction with the total clinical picture (see Case 2).

GENERAL COMMENTS REGARDING EMF SENSITIVITY

Based on the above Cases (1-4) and other clinical experience, some more general observations are made regarding EMF sensitivity:

- Noting the spectrum of EMF sensitivity shown in the Table, the case definition of "sensitivity to EMF" needs to be refined so only agreed cases are entered into research or epidemiological studies. Inclusion and exclusion criteria are critical in the design of future studies. Patients should be carefully assessed by an experienced physician, and relevant laboratory studies used to confirm a diagnosis of sensitivity in suitable cases. Relying on symptom complexes or self-reported cases is not likely to be useful. If patients with uncertain diagnoses are entered into studies, then inconclusive results are to be expected.
- Peripheral nerve mechanisms as well as central nervous system should be considered when studying EMF sensitivity. Case 1 shows that low level exposures to RF can affect peripheral nerves, and other cases of dysaesthesia have been described after RF exposure, Hocking and Westerman (2003). Wilén et al. (2003) have shown a dose-response for similar cranial symptoms in mobile phone users. Leitgeb and Schrottner (2003) have shown that electromagnetic field sensitive persons as a group, differ significantly from the general population with regard to peripheral electric current perception thresholds. Peripheral nerves are more exposed than the brain, since many are subcutaneous. They could be affected by exposure to EMF, and so, contribute to the totality of symptoms experienced by some patients such as tingling, itchiness and fatigue (Case 2). Peripheral and central mechanisms of effects of EMF are not mutually exclusive. Also studies of peripheral nerves may give insights into the effects of EMF on the neurons of the central nervous system.
- The term Electromagnetic "HYPER"-Sensitivity (EHS) is medically meaningless and should be replaced by terms such as "EMF sensitive" or "EMF susceptible" or "symptoms at low level EMF exposures". The term "Hyper Sensitivity" is likely to create skepticism within the medical profession to such patients. Sensitivity is a well recognized term implying a reaction to an exposure well outside the normal range, often due to an immune (e.g. asthma and pollens) or genetic (e.g. phenylketonuria and milk) mechanism. However, the addition of the term "Hyper" adds nothing meaningful to the diagnosis and simply invites mockery for an unjustified exaggeration. A change in terminology is recommended.

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Cognitive behavioral therapy for patients who report electrical hypersensitivity

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BACKGROUND

The group of persons who report electrical hypersensitivity (EHS) is very heterogeneous when it comes to complaints and triggering factors. The afflicted persons' suffering is real, but there is no known biological marker for the condition. Afflicted persons share the same conviction: *complaints are triggered or aggravated in the vicinity of activated electrical equipment*. EHS is not used as a diagnosis; instead, symptom-based diagnoses are applied and complemented with additional information, e.g. the person interprets his or her ill health as EHS. But we need a working definition, for example, to define target groups in scientific studies of this condition.

In a workshop on EHS in Sweden 2000, invited experts agreed on this working definition (Bergqvist et al., 2000): *Symptoms that (1) are experienced in proximity to, or during use of, electrical equipment and that (2) result in varying degrees of discomfort or ill health in the individual and that (3) the afflicted individual attributes to activation of electrical equipment.*

Because of the heterogeneity of the group, which meets the criteria in this working definition, additional characterization is motivated, (Hillert et al., 1999). This may include information on the most pronounced symptoms, reported triggering factors, and if symptoms are triggered distinctly at perceived exposure from specified sources of electromagnetic fields, or if symptoms are more chronic (and possibly attributed to the common existence of electromagnetic fields in the general environment). Another important aspect is if complaints made individuals change their behavior, for example, by avoiding triggering factors or being unable to work.

Symptoms in the skin are common and often among the first complaints to be reported, but no specific symptom profile could be identified. In a survey in Stockholm County in 1997, the prevalence of all symptoms included in the questionnaire was higher in the group of responders who also reported EHS (Hillert et al., 2002). Symptom indices may be used for characterization of study groups (Hillert et al., 1999).

Afflicted individuals report that electrical equipment in their everyday lives trigger symptoms. In Sweden, the most common group of complainers used to be persons who experienced temporary skin symptoms in relation to work with video display units (VDUs). A relationship between electric and magnetic fields (or activated VDUs) and complaints was tested in several scientific studies, i.e. in epidemiological and in provocation studies (for review, see Bergqvist and Vogel, 1997, Bergqvist et al., 2000). But these studies failed to provide support for a causal relationship between exposures to electromagnetic fields and complaints. Later studies attempted to include possible contributing factors, such as stress (Lonne-Rahm et al., 2000) or environmental factors in general, by using the actual electrical equipment that the participant claims to react to in his or her real life environment at work or at home (Flodin et al., 2000). The participants could not detect the presence of the fields and exposure was not associated with more symptoms in these studies. Recent studies on mobile phones and radiofrequency fields also failed to provide support for a role in the reported triggering factors (Hietanen et al., 2002; Zwamborn et al., 2003). In the Dutch TNO study, exposure to UMTS-like fields were associated with more symptoms in the EHS group and in the control group, but no effect was observed with regard to exposures (900 and 1800 MHz) that the EHS group had reported as triggering their ill health (Zwamborn et al., 2003). Taken together, these results indicate that electric or magnetic fields are neither a sufficient nor a necessary cause for complaints reported as EHS. Support for the fields being a contributing factor, is diminishing with the increasing number of studies that fail to provide support for this hypothesis. Psychophysiological reactions, possibly in combination with some environmental stressors, have been proposed as an alternative explanation.

The influence of stress on symptoms reported as EHS was discussed. Work-related factors, such as lack of support from co-workers (Eriksson et al., 1997a), heavy workloads and inadequate support (Stenberg et al., 1995) were associated with VDU-related skin symptoms. Berg and co-authors suggested the term *techno-stress* (Berg et al., 1992). They observed a larger increase in stress-related hormones during VDU work in the group that reported skin symptoms. There is no strong indication of an association between specific personality or personal trait and EHS (Hillert et al., 1998; Hillert et al., 1999). But one study observed higher scores in the *Karolinska Scales of Personality* (KSP) for somatic anxiety, muscular tension and psychasthenia and, lower scores for socialization in the EHS group – compared to controls (Bergdahl, 1995).

Intervention programs

The rationale for the management and interventions programs in Sweden (e.g. *Guidelines from the Swedish National Board of Health and Welfare* [Socialstyrelsen, 1998]), is that several different contributing factors have been indicated in studies on EHS, while electromagnetic fields (EMF) have not been proven to be a causal factor. Based on current knowledge, we can not exclude the possibility that conditioned stimuli may trigger symptoms in some cases. And avoidance of EMFs and/or VDUs is unnecessary for improvement in all cases (Eriksson et al., 1997b). Different treatments and actions were reported to be beneficial (Hillert, 2001). There are no well-designed studies on *EMF clean ups*, that is, interventions aimed at reducing exposure to EMF.

Intervention programs emphasize that a broad investigation should be obligatory in all new cases of ill health reported as EHS. The investigation should include a medical work-up and an evaluation of psychosocial and environmental factors of potential importance. Often, well-known diseases are identified (Hillert, 2001). Prevalence of disease greatly depends on the group being studied, e.g. early cases in company-based occupational health services differ from cases with more severe complaints, that are referred to occupational medicine centers. Psychiatric diagnoses are rare, but psychological conditions of possible importance are frequently identified.

In the case of medically unexplained symptoms interpreted by the afflicted persons as EHS, no standard treatment is available. Any identified sub-optimal condition should be the target of prompt intervention and a plan of action should be decided on and later evaluated. The choice of further actions should be based on a broad individual evaluation, which accounts for the patient's own motivation. After the initial investigations, it is important to start focusing on reducing symptoms and disability – instead of pursuing discussions on what the cause of symptoms might be. Treatments that are proven to be beneficial in other chronic conditions may be tried, for example, cognitive behavioral therapy. Cognitive behavioral therapy has been shown to be beneficial in, for example, chronic fatigue syndrome (Sharpe et al., 1996), burning mouth syndrome (Bergdahl et al., 1995), and cancer pain (Thomas and Weiss, 2000). Cognitive behavioral therapy may be introduced as one way to reduce symptoms and improve health, and the patients need not commit themselves to accepting alternative explanations for EHS.

COGNITIVE BEHAVIORAL THERAPY

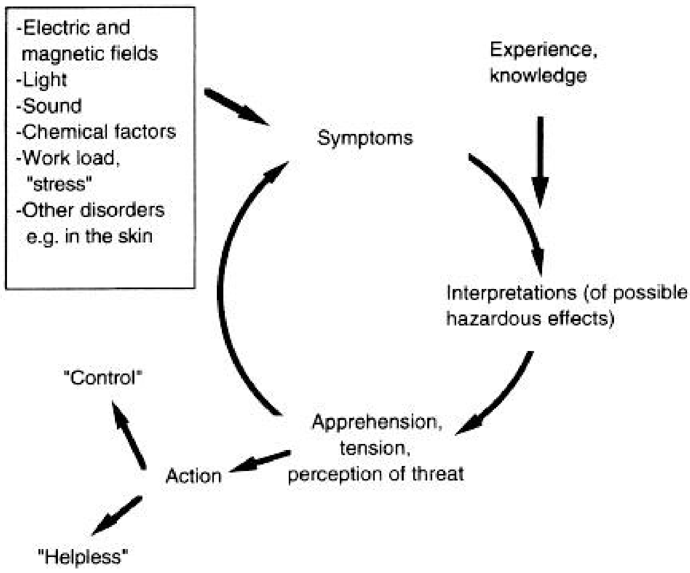
Cognitive behavioral therapy may focus primarily on controlling or reducing complaints, or more directly on questioning and testing beliefs in causal factors and explanatory models. It is an active, directive, structured form of short-term therapy. The underlying theory, is that the way in which people structure their experiences will influence how they think, feel, and behave. This structuring is governed by *core beliefs* and basic assumptions, that is, beliefs that we regard as absolute truths and don't question – *just the way things are*. Cognitive therapies put primacy on changing dysfunctional cognitions presumed to underlie psychological disorders. Cognitive behavioral therapy combines this with behavioral therapy goals, that is, altering behavior.

The therapy is goal-oriented and problem-focused. It is characterized by *team work* between therapist and patient, and emphasizes collaboration and active participation. The patient and therapist set the goals together. The patient will learn to identify, evaluate, and respond to dysfunctional thoughts and beliefs that may have a negative influence on his or her well-being. This influence may emerge from automatic thoughts that the patient is hardly aware of, but may leave the patient with unwanted feelings and moods. Focus of the therapy varies from patient to patient – depending on identified needs and short- and long-term goals. A variety of techniques, including relaxation techniques, may be used.

The sessions are structured. They may start with a brief update on what has happened since the last session, and then the agenda for the present session is set. In the first sessions, theoretical models, for example, on how psychological factors may influence symptoms, may be presented. One example is shown here: a model in the form of a vicious circle which illustrates how somatic symptoms could interact with the person's interpretation of symptoms (Figure 1). Risk of confirmation bias is pointed out, i.e. the person is more apt to identify and accept observations that confirm his or her already existing beliefs. A feeling of helplessness and loss of control may force the person to avoid certain situations, which may lead to more stress and enhancement of symptoms.

Homework between sessions is assigned, for example, to test beliefs or identify automatic thoughts. Reactions and interpretations are discussed in the following session. At the end of each session, the patient and the therapist summarize and evaluate the session.

Figure 1 *The "vicious circle" model for describing how psychological factors affect or induce symptoms (from Andersson et al., 1996. Reproduced with the permission of Lippincott Williams & Wilkins.)*



Intervention studies

Cognitive behavioral therapy in patients who report EHS was evaluated in three intervention studies. All three studies are from Sweden: two are published in scientific journals, and one is published in a Ph.D. thesis from the University of Lund. The therapies offered were short-term cognitive behavioral therapies. The mean numbers of sessions were similar in all three studies; a mean of 7.4 sessions, range 4 to 10 (Andersson et al., 1996), a mean of 6.5 sessions, range 3 to 12 (Hillert el al., 1998) and a mean of 8 sessions, range 3 to 16 (Harlacher, 1998) Sessions were offered weekly or sometimes with somewhat longer intervals. Models on how psychological factors may influence complaints were included in all three treatment studies of EHS patients. Alternative explanations to electromagnetic fields were discussed and tested, but it is obvious from the reported studies that the focus of the therapy varied from patient to patient. The individual patient's short- and long-term goals and identified needs guided the choice of specific approach. In some cases, stress-control methods were used.

Andersson and Harlacher used a waiting-list control-group design. In the study by Hillert and co-workers, the patients were informed, after consenting to participate in the study, about which group they had been assigned to, treatment, or control group. All patients in the control group were offered therapy after completion of the study.

The inclusion criteria in the study by Andersson and co-workers, required that the patients should all have distinct subjective reactions in the skin within 30 minutes of perceived exposure and limitations on their lives because of these symptoms. Subjects recruited to the study by Hillert and co-workers, were to report symptoms triggered by electrical equipment. Harlacher recruited patients who had been given an unofficial syndrome label at the dermatology clinic: *EHS* or *VDU-related complaints*. Patients with somatic or psychiatric disorders, which could explain symptoms attributed to electrical equipment or that were in need of other treatments, were excluded in all studies.

The study groups were rather similar, with fairly mild complaints and no extensive avoidance behavior. In the study by Hillert and co-workers, an additional inclusion criterion was that the participants should have been working for at least one week during the last three months. The rational for this criterion was to ensure, that all participants had a present place of work in case of successful rehabilitation. As it turned out, all participants but one were actually working in the early study.

Table 1 shows baseline assessments in the three studies. The mean age was just above 40 in all studies, and there were more women than men in all three study groups. Harlacher mainly describes a group of 80 patients, from which 26 patients that were included in the evaluation of the therapy (including 13 subjects who initially constituted the waiting list group) were recruited. Andersson and co-worker compared 9 patients in the treatment group to 8 in the waiting-list control group. One patient in the control group did not participate in the provocation test after treatment. In the study by Hillert and co-workers, 10 patients were in the therapy group and 12 patients were in the control group. In all three studies, several patients were not included because of lack of motivation, practical problems that made it difficult to participate, and reluctance to expose themselves to an *electrical* environment, where treatment sessions took place. All patients in the three studies had had their complaints for more than 6 months, in most cases for several years.

Table 1 *Baseline assessments of subjects in the three intervention studies on cognitive behavioral therapy.*

Study	Andersson et al.	Hillert et al.	Harlacher
Recruitment	Patients (Dermatology clinic and Occupational medicine center)	Patients (Occupational medicine center)	Patients (Dermatology clinic)
Number of subjects (Men/women)	17 (5/12)	22 (6/16)	26
Age, years; mean (range)	42 (26-53)	40 (26-58)	44
Duration of illness, years	>0.5	<1-6	<2->4
Skin symptoms, number of patients or index	17 (subjective skin reactions within 30 min when exposed)	1.9*	26
Neurovegetative symptoms, number of patients or index	?	1.2**	26
Triggering factors: Sources of light	17	22	26
Other factors	?	14	26
Avoidance behavior	17	20	26
On sick leave/ disability pension	2	1 (for less than 3 months)	?
Working (part or full time)	15	21	?

(?=no information available/not analyzed)
**Skin index (range 0-3): mean rating of heat or burning sensation, tingling and redness.*
***Neurovegetative index (range 0-3): mean rating of difficulties concentrating, fatigue and headache.*

Two of the studies (Andersson et al., 1996) and (Hillert et al., 1998) included biological measures (e.g. thyroxin, prolactin, cortisol, dehydroepiandrosterone, cholesterol, and fructosamine). In the study by Andersson and co-workers, double-blind provocation tests were performed at the assessments before and after treatment (mean interval 22 weeks), and the participants rated their symptoms and did a self-evaluation of limitations in life caused by EHS. In the study by Hillert and co-workers, outcome parameters were assessed before treatment, after six months (post-treatment), and after an additional 6-month follow-up period. Besides biological measures, the assessments included self-reported symptoms, perceived degree of discomfort from reported symptom-triggering factors, avoidance behavior, and a question on perceived EHS (always, sometimes, and never). In the study by Harlacher, the mean time between the first and second assessments was 144 days. Assessments included scoring of symptoms and symptom-related aspects (e.g. influence on daily life). Based on these scores, criteria for classifying a patient as improved or "cured" were defined.

Psychological inventories were administered in two of the studies, for example, the Symptom Checklist-90 (SCL-90), Toronto Alexithymia Scale (TAS-20), Attributional Style Questionnaire (ASQ), Sense of Coherence (SOC), (Hillert et al., 1998), Gordon Personality Inventory (GPI), Coping Resources Inventory (CRI), and Zung's Self-rating Depression Scale, (Harlacher, 1998).

Two studies reported improvement after therapy. In the assessment after treatment, Andersson and co-workers noted that the treatment group rated their symptoms to be less intense (before the provocation sessions), and rated the disability caused by EHS to be lower – compared to the assessment before the treatment period. But the change in complaints in relation to the provocations did not differ between the treatment group and the control group. In the study by Harlacher, a significant reduction in complaints was shown after therapy, compared to the waiting-list controls. Half of the patients were classified as improved or "cured" after treatment.

Hillert and co-workers did not observe significant difference between the treatment group and the control group in complaints or in self-rated discomfort from triggering factors. A reduction in complaints over the one-year study period was noted in both groups. Three persons in the treatment group did not report EHS at the six-month follow-up, while all patients in the control group still reported EHS.

No significant difference was reported between the treatment groups and control groups in the biological measurements with one exception (serum cholesterol before the provocation tests in the study by Andersson and co-workers).

Hillert and co-workers did not observe time-dependent differences between the groups in the psychological inventories. The scoring was within the normal range, according to the evaluation guidelines – except for the somatization factor in the first assessment. This scoring on this factor was increased for both groups, compared to a Swedish norm. Harlacher reports that characteristics of the EHS patients appear to "resemble much more those of a normal population than of a psychopathological one". No major treatment effect was observed.

DISCUSSION

Results in the three published studies on cognitive behavioral therapy in patients who reported EHS show similar results, although statistically significant improvement was only observed in two of the studies. There is an agreement between the studies in the tendency to larger improvement in symptom reduction, and distress from the perceived EHS in the therapy groups.

Evaluations of interventions in conditions of medically unexplained symptoms face several difficulties. Normally, the main assessments are based on subjective ratings of symptoms and distress because no signs or deviations in objective measurements have been linked to the condition. A reduction in complaints over time is frequently observed regardless of intervention. It is not unusual that several measures, apart from the intervention applied in the study, are undertaken during the study period. It is possible that individual differences in outcome may be lost in group studies.

Follow-up studies reported improvement after several different interventions in patients who reported EHS (Hillert, 2001). In a company-based occupational service, where patients received different individually designed interventions, 90% showed improvement after two years, (Lidén et al., 1996). Patients who were referred to specialists, for example, occupational medicine centers, have been reported to show an improvement in about half of the cases, after a follow-up time of 4 months to 2 years (Gustavsson and Ekenvall, 1992; Hillert et al., 1993). In a treatment study of a group of EHS patients, who were similar to those in the study groups that received cognitive behavioral therapy, Arnetz and co-workers did not observe significant effects from acupuncture. But again, the treated, as well as the control group, reported significantly fewer symptoms at six-month follow ups (Arnetz et al., 1995). Individual differences that seem to exist among persons who report EHS, may be one reason why no intervention has been more clearly proven superior to others.

Deviating physiological reactions in persons who report EHS have been indicated in several studies – possibly signs of an imbalance in the autonomic nervous system (Lyskov et al., 2001a; Lyskov et al., 2001b; Sandström et al., 2003). This may be an additional argument for trying cognitive behavioral therapy, which, for example, has been reported to decrease cardiovascular and neuroendocrine reaction to stress, (Facchinetti et al., 2004). But the effect of cognitive behavioral therapy on reactions in the autonomic nervous system has not been investigated in EHS patients.

Based on the present state of knowledge, choice of intervention in EHS should be based on a broad evaluation of the patient, including a thorough medical work up, evaluation of psychosocial and environmental factors, and accounting for the patient's own motivation for different actions. Cognitive behavioral therapy may have beneficial effects in some patients who report EHS. Taken together, the effect of cognitive behavioral therapy in the studies discussed here and in studies on other groups of patients with medically unexplained symptoms or treatment-resistant, symptoms is a strong argument for considering this treatment in patients who report EHS.

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POLICY OPTIONS

Possible policy options

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BACKGROUND

The Radiation Protection Division of the Health Protection Agency (HPA-RPD) of the United Kingdom is responsible for advising government on the public and occupational exposure guidelines for electromagnetic fields (EMFs).

A number of people believe they suffer from electric hypersensitivity. By this, they understand that they suffer symptoms from exposure to a range of electromagnetic fields encountered in everyday life. Many also believe that there are serious long-term risks associated with such exposures.

These people feel that, a) their condition should be recognized and b) that steps should be taken to decrease their exposure to EMFs through the national exposure guidelines. HPA-RPD decided to commission a public health review of electrical hypersensitivity (ES) in order to more fully inform its advice. The review was conducted by Neil Irvine, Consultant in Pubic Health, Health Protection Agency, Northern Ireland was at a draft stage of preparation at the time of the conference and has now been published.

AIM

The project is a public health needs assessment of electrical sensitivity.

The aims of the project are:

- to describe and define electrical sensitivity using sources such as the scientific literature, grey literature (Internet and support groups) and personal anecdote
- to examine its overlap with other conditions such as multiple chemical sensitivity
- to review the information on course, prognosis and effective treatments
- to explore whether there is a role for HPA-RPD in terms of prevention, management, public information, reflecting electrical sensitivity in exposure guidelines and continuing to be explicit about what harms the guidelines do or do not protect people from, why and how.
- to produce a report of the work that can be published on the HPA-RPD website and/or in other scientific literature

ADVANTAGES OF TAKING A PUBLIC HEALTH APPROACH

- It's how all other diseases are tackled
- Systematic approach can be used using validated assessment tools
- Can easily consider the wider societal aspects and account for similarities with other conditions
- Considers the condition in relation to the health of the population as a whole
- Includes sufferer's perspective
- Incorporates methods of defining benefits as well as harms of technologies, treatments etc.
- Incorporates consideration of the 3 levels of preventing ill health[2]
- Includes an understanding of ways to evaluate measures taken to improve health

QUESTIONS CONSIDERED IN THE LITERATURE REVIEW

- What symptoms do subjects experience? How severe are they? Are they different or similar for different perceived exposures?
- What types of exposure are believed to trigger these symptoms? What is the time course for triggering? How consistent is the triggering?
- Was there a precipitating exposure event that caused the problem?
- How do subjects determine they are sensitive to EMFs?
- How has the reported sensitivity affected a person's daily activities, their social roles and their self-image?
- Do people who report electrical hypersensitivity (ES) have similarities (demographic, co-morbid conditions, psychological characteristics)?
- Do reports of ES vary in different populations (people with different diseases, different cultural experiences, victims of technological disasters)?
- Are there laboratory correlates with some discernible group who reports ES?
- Are there any treatments that are known to work

[2] Primary prevention is eliminating exposure to the harmful agent, e.g. helping young people not to start smoking. Secondary prevention is minimizing harm of exposure e.g. smoking cessation campaigns. Tertiary prevention is minimizing the effects of the harm that has been caused e.g. coronary rehabilitation programmes following a myocardial infarct caused by smoking

POSSIBLE POLICY OPTIONS

Definition of electrical hypersensitivity

- As a stand alone condition or
- As part of a spectrum of related conditions

Either of these can be:

- On the basis of the symptoms and/or signs
- On the basis of the exposures thought to cause symptoms (an aetiological process)
- On the basis of biomedical investigations (a pathophysiological process)

An adequate definition should include consideration of natural history and prognosis

Prevention and treatment options

- All proposed interventions should be based on evidence that they do more good than harm. There is no problem in combining all three approaches. Once agreed they would benefit from wide publicity.
- Primary Prevention… decreasing exposure to electromagnetic radiation in the whole population.
- Advice and product labeling to ensure that the public can gauge exposures.
    - Regulatory activity that comprises enforcing existing regulations and ensuring the quality of testing as well as setting new guidelines.
    - Secondary Prevention... decreasing exposure to electromagnetic radiation in susceptible individuals. This could include practical measures to avoid or decrease exposures in susceptible individuals.
- Tertiary Prevention... treatment of affected individuals. This could include physical agents as well as pharmacological, behavioral and psychological approaches.

Now that the report has been published it is a little awkward to report “draft findings”. Suggest replace with the published findings.

The report has now been published and is available at: http://www.hpa.org.uk/radiation/publications/hpa_rpd_reports/2005/hpa_rpd_010.htm

Summary of findings

This review considers electrical sensitivity (ES) in terms of the subjective attribution of symptoms to electric and magnetic fields and radiations (EMFs), at levels below those shown to cause adverse health effects. The use of the term ES in this review does not imply the acceptance of a causal relationship between symptoms and attributed exposure, however.

The starting point for this review is recognition, by the Radiation Protection Division of the Health Protection Agency (HPA RPD), of the need to consider ES in terms other than its aetiology, as this position alone is failing to meet the needs of those who consider themselves affected by ES.

The review was commissioned to identify and appraise the literature in order to describe and define ES, review the information on its course, prognosis and treatments, and examine its overlap with other conditions such as multiple chemical sensitivity. Specifically excluded from the review were attributed health effects in terms of specific disease processes, and examination of the ongoing debate around the aetiology of ES.

Electrical sensitivity symptoms can be broadly grouped into facial skin symptoms attributed to exposure to visual display units (VDUs) and more general, non-specific symptoms across a range of body systems. Neurological symptoms such as headache and fatigue predominate in this latter group. There may be progression from skin-only symptoms to more generalised symptoms, although this may be relevant only to Sweden.

Facial skin symptoms and their attribution to VDUs are largely a phenomenon of the Nordic countries, and Sweden in particular. In other countries, ES sufferers tend to describe general symptoms attributable to a wide range of EMF sources. With the exception of facial skin symptoms and VDUs, there is no consistent symptom type and attributed source association. Some subjects are only symptomatic to specific sources; others claim sensitivity to a range of sources.

There is no typical time period from exposure to onset of symptoms.

Electrical sensitivity can have severe consequences for the social functioning of those affected. Experience from Sweden is that subjects with general symptoms have a worse prognosis than those with skin-only symptoms.

There is no consistent scientific evidence of sensitive or specific pathophysiological markers.

There is geographical variation in terms of symptomatology, the attributed source of exposure and the estimated prevalence of ES.

There is only limited evidence to guide the management of affected individuals. The majority of conventional medical effort to date has been directed at psychological therapy, such as cognitive behavioural therapy. Evaluation of this approach has been limited to date, but shows some potential for success.

There is considerable overlap between ES and other conditions known as symptom-based conditions, functional somatic syndromes or idiopathic environmental intolerances.

From what little description of the UK experience exists in the published literature and from some case reports on support group websites, the general symptom group appears to predominate in the UK. However, no useful estimate of prevalence in the UK was found.

Recommendations for future research include carrying out studies to describe and understand ES and estimate its prevalence within the UK; engaging with therapists currently treating sufferers in order to source evaluations not identified by this review, and to identify treatment areas where such evaluation might be feasible; and conducting robust trials of cognitive behavioural therapy (CBT).

FUTURE RESEARCH

- An acceptance that EMF has a causal role in ES, would have widespread implications for future policy on prevention and management.
- It has been suggested that despite a gap in understanding of the aetiology of a condition, descriptive studies can add much to the policy making process. However, the review found it impossible to construct even a symptom-based case definition of ES. This has major implications for the future study of ES using a conventional epidemiological approach, and in particular makes any findings population-specific.
- There is currently very little UK-based literature from any source. Useful information could be gained from the type of questionnaire survey performed by Roosli et al in Switzerland; perhaps directed at ES sufferers identified through support group networks. This type of survey might also usefully include the UK-based therapists employed in the treatment of people with this phenomenon.

However, in the absence of validated effective treatments, the value of case-finding may be questioned.

REFERENCES

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