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Health and Disability

Characteristics of perceived electromagnetic hypersensitivity in the general population

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Health problems evoked in the presence of electrical equipment is a concern, calling for better understanding for characteristics of electromagnetic hypersensitivity (EHS) in the general population. The present study investigated demographics, lifestyle factors, frequency and duration, coping strategies, proportion meeting clinical criteria for intolerance attributed to electromagnetic fields (EMF) and comorbidity. Using data from a large-scale population-based questionnaire study, we investigated persons with self-reported (n = 91) EHS in comparison to referents (n = 3,250). Middle age, female sex and poor perceived health was found to be associated with EHS. More than 50% in the EHS group reported having EMF-related symptoms more often than once a week, and the mean number of years experiencing EHS was 10.5. More than half of the EHS group reported that their symptoms started after a high-dose or long-term EMF exposure, that they actively tried to avoid EMF sources and that they mostly could affect the EMF environment. A minority of the EHS group had sought medical attention, been diagnosed by a physician or received treatment. Exhaustion syndrome, anxiety disorder, back/joint/muscle disorder, depression, functional somatic syndrome and migraine were comorbid with EHS. The results provide ground for future study of these characteristic features being risk factors for development of EHS and or consequences of EHS.

Key words: Electromagnetic hypersensitivity, functional somatic syndrome, environmental intolerance, prevalence, lifestyle factors, coping strategies.

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INTRODUCTION

The notion that symptoms can have their origin in radiating devices goes back at least to the 1950s (Genius & Lipp, 2011). It is well documented that exposure to strong electromagnetic fields (EMFs) indeed can result in health effects. However, strong exposure is controlled by regulations and guidelines (International Commission on Non-Ionizing Radiation Protection, 1998), and there is no indication of persons with EMF-related symptoms developing their symptoms from EMF exposure per se (Baliatsas, Van Kamp, Lebret & Rubin, 2012; Hillert, Åkerstedt, Lowden *et al*., 2008; Rubin, Nieto-Hernandez & Wessely, 2010;). For these reasons, the term perceived electromagnetic hypersensitivity (EHS) is commonly used to refer to symptoms attributed to electrical equipment (Baliatsas *et al*., 2012). High comorbidity in EHS with various other types of environmental intolerances (Nordin, Neely, Olsson & Sandström, 2014; Palmquist, Claeson, Neely, Stenberg & Nordin, 2014) and strong association with psychological factors (Bergdahl, 1995; Johansson, Nordin, Heiden & Sandström, 2010; Kjellkvist, Palmquist & Nordin, 2016), suggest that attention should be directed towards individual factors. Indeed, there is evidence for a nocebo effect in triggering acute health effects (Baliatsas *et al*., 2012; Rubin *et al*., 2010; Witthöft & Rubin, 2013). Nevertheless, health problems evoked in the presence of electrical equipment is a concern.

Persons with EHS often report facial skin symptoms, cognitive problems such as memory loss, neurological symptoms such as dizziness, and general symptoms such as fatigue (Hagström, Auranen & Ekman, 2013; Seitz *et al*., 2005). Symptoms are frequently attributed to mobile phones, computer monitors or electrical equipment in general. Between 1.5 and 5.0% in population-based studies report symptoms attributed to EMFs (Hillert, Berglind, Arnetz & Bellander, 2002; Levallois, Neutra, Lee & Hristova, 2002; Schreier, Huss & Roosli, 2006). This range in prevalence rate may partly be due to differences in the researcher's conceptual framework (Baliatsas *et al*., 2012).

Studies on demographics as potential risk factors for EHS symptoms show a higher prevalence in women, in persons with low income and born outside a Nordic country (Swedish study), and in ethnicities other than Caucasian, Afro-American and Hispanic (American study), whereas education and marital status have not been found to be associated with EHS (Baliastas *et al*., 2014; Carlsson, Karlson, Ørbaek, Osterberg & Ostergren, 2005; Hillert *et al*., 2002; Levallois *et al*., 2002; Schreier *et al*., 2006; Stenberg, 2004). Carlsson *et al*. (2005) reported higher prevalence rates in participants in working age, whereas Hillert *et al*. (2002) found no significant age difference in prevalence, and Baliastas *et al*. (2014) reported higher age in EHS than in a referent group. There appears to be no documentation of associations between EHS and lifestyle factors such as smoking and physical exercise. Furthermore, there is a lack of information about EHS in the general population regarding how often the EMF-related symptoms are evoked, for how long time the afflicted person has had the hypersensitivity, and how they believe it started.

Appropriate coping strategies for dealing with life-hassles on an everyday basis are important also in ill-heath conditions. The most referred types of coping strategies are problem-focused (analyzing, reducing and eliminating stressors) and emotion-focused (acknowledging, understanding and expressing the emotion; Lazarus & Folkman, 1984). In chemical intolerance the problem-focused strategy of avoiding the exposure associated with the symptoms has been shown to be the most common

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strategy in severe cases of chemical intolerance, whereas the strategy of seeking medical attention was used to a considerably less extent (Nordin *et al*., 2010). However, there is a lack of documentation as to what extent strategies of these kinds are used in EHS.

A systematic review shows that the by far most commonly used criterion for EMF-related health problems in population-based observational studies is the individual reporting adverse health effects attributed to EMFs (Baliatsas *et al*., 2012). Although this criterion, per se, is useful, a potential problem is that it is commonly used to represent the term idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF), which includes several other criteria. Thus, definition criteria for IEI, proposed by the IPCS/WHO (1996) include: (i) acquired disorder with multiple recurrent symptoms; (ii) associated with diverse environmental factors tolerated by the majority of people; and (iii) not explained by any known medical or psychiatric/psychologic disorder. For IEI-EMF, specifically, the environmental factors should include electrical devices. Consequently, it would be valuable to know how large proportion of those in the general population who attribute adverse health effects to EMFs, who also meet criteria for IEI-EMF, but also who have been given a diagnosis of IEI-EMF by a physician.

High levels of anxiety, depression, burnout, muscular tension and somatization has been found in EHS (Johansson *et al*., 2010). These findings evoke the question as to whether diagnoses of anxiety disorder, depression and exhaustion syndrome, back/joint/muscle disorder, functional somatic syndromes (FSSs) and migraine are more common than normal in EHS.

The objective of the current study was to obtain better understanding for EHS in the general population by addressing: (i) the role of demographic and lifestyle factors; (ii) frequency and duration; (iii) coping strategies; (iv) proportion meeting criteria for IEI-EMF; and (v) comorbidity (diagnoses of psychiatric conditions, back/joint/muscle disorder, FSSs and migraine). This was conducted by comparing persons in the general population with and without EHS by means of data from a large-scale population-based questionnaire study, the Västerbotten Environmental Health Study.

METHODS

Population and samples

Data were derived from the Västerbotten Environmental Health Study, which is a longitudinal large-scale questionnaire-based survey that started in 2010 with focus on various environmental hypersensitivities. See Palmquist *et al*. (2014) for age and sex distributions for the sample as well as further description of the survey. A random sample of 8,520 participants (18–79 years), stratified for age and sex, were invited, of which 3,406 (40.0%) agreed to participate. Ninety-one individuals responded affirmatively to the question "Are you getting symptoms from certain switched-on electrical devices that you believe most other people are not getting symptoms from?" constituting an EHS group. Sixty-five participants did not respond to the question, and the remaining 3,250 participants who responded negatively to the question about symptoms from switched-on electrical devices constituted a reference group. Mean age (SD) for the EHS group and the referents were 49.7 (14.3) and 51.0 (16.9) years, respectively. In the EHS group, 33.3% reported excellent or very good general health, 30.0% reported good general health, and 36.7% reported poor or somewhat good general health. Corresponding percentages for the referents were 40.7, 34.4 and 24.9%, showing significantly poorer perceived general health in the EHS group ($\chi^2(2) = 6.48$, $p < 0.05$).

The 11-item Electromagnetic Field Sensitivity Scale (EMFSS-11; Nordin *et al*., 2013) was used to quantify degree of affective reactions to and behavioral disruptions by electrical devices believed to emit EMFs. Based on the scores for the EHS group (mean $\pm$ SD = 30.1 $\pm$ 10.6) and referents (17.2 $\pm$ 7.9) and on normative data (Nordin *et al*., 2013), degree of affective reactions/behavioral disruptions correspond, in average, to the 93th and 48th percentile, respectively, of the general population.

Questionnaire

The participants responded to questions about demographic and lifestyle factors, frequency and duration, onset and coping strategies, criteria for IEI-EMF, and comorbidity. The survey questions about demographics and lifestyle factors were: "Your age," "Sex," "Present marital status," "Highest educational level," "Do you smoke regularly?," and "How often do you exercise?." The question about diagnosed illness was "Have you been diagnosed by a physician for these conditions? Mark all conditions that apply to you." Symptom frequency attributed to EMFs was investigated with the question "how often do you in general have these symptoms?" (response alternatives: Daily/Once or a few times a week/Once or a few times a month), and duration with the question "For how long time have you had electromagnetic hypersensitivity?" Regarding onset and coping strategies, the following questions were used: "Did the electromagnetic hypersensitivity start with intense or long-term exposure to electromagnetic fields?" "Do you actively try to avoid electromagnetic fields?" "Can you, in most cases, affect the environment that causes the symptoms (e.g. by shutting of electives devices)?" "Have you sought medical care for your electromagnetic hypersensitivity?" and "Have you received any form of treatment for your electromagnetic hypersensitivity?"

Meeting criteria for IEI-EMF was considered to be present if fulfilling the following criteria: (i) acquired disorder (reporting having had the EHS for fewer years than their age); (ii) multiple recurrent symptoms (more than two reported symptoms from among symptoms in the Environmental Hypersensitivity Symptom Inventory; Nordin *et al*., 2013); and (iii) associated with diverse environmental factors tolerated by the majority of people (responding affirmatively to the question "Are you getting symptoms from certain switched-on electrical devices that you believe most other people are not getting symptoms from?").

Having been given a diagnosis by a physician of IEI-EMF, anxiety disorder (generalized anxiety disorder or panic disorder), depression, exhaustion syndrome, back/joint/muscle disorder, FSS (fibromyalgia or chronic fatigue syndrome) and migraine was assessed with the question "Have you been diagnosed with this condition by a physician?"

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Procedure

The questionnaire was sent to the participants with the instruction to return it via mail with prepaid postage. Those who did not respond to the first invitation received up to two reminders. All participants responded to the questionnaire during the period March–April, 2010. The study was conducted in accordance with the Helsinki Declaration and approved by the Umeå Regional Ethics Board (Dnr 09-171M). All participants gave their informed consent to participate.

Statistical analysis

All analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY). The EHS group was compared with the referents on demographics and life-style variables with chi-square analysis. Post-hoc analysis was conducted to investigate whether observed frequencies deviated significantly between groups. Specifically, adjusted standardized residuals were used to calculate χ^2-values and corresponding p-values for each cell (Beasley & Schumacker, 1995). The original alpha level of 0.05 was adjusted for Type I error rate using Bonferroni correction. With six cell values being tested, $alpha_{adj}$ = 0.0083. Logistic regression analyses were conducted to obtain crude (unadjusted) and adjusted (for age and sex which differed between the groups) odds ratios (ORs) for studying comorbidity in EHS with the various diagnoses. The α-level was set at 0.05.

RESULTS

Results for demographics and life-style are given in Table 1. An association was found between age strata and EHS, such that EHS was significantly overrepresented among those aged 40–59 year (p = 0.0070). No other observed frequencies differed between groups. EHS was also significantly more common in women than in men, but there were no significant associations between EHS and marital status, education, smoking or physical exercise.

Table 1. *Descriptive statistics of participants with perceived electromagnetic hypersensitivity (EHS) and referents*

	EHS (n = 91)	Referents (n = 3,250)	Chi^2	P-values
Age strata (years); n (%)			7.62	p = 0.022
18–39	22 (24.2)	897 (27.6)		
40–59	44 (48.4)	1,126 (34.6)		
60–79	25 (27.4)	1,227 (37.8)		
Women, n (%)	65 (71.4)	1,791 (55.1)	9.55	p = 0 .002
Married/co-habitant, n (%)	69 (75.8)	2,388 (73.5)	0.49	p = 0.785
	(Missing, n = 1)	(Missing, n = 23)		
Education, n (%)	(Missing, n = 1)	(Missing, n = 39)	1.98	p = 0.372
Compulsory school	16 (17.6)	762 (23.4)		
Senior high school	31 (34.1)	1,096 (33.7)		
College/University	43 (47.3)	1,353 (41.6)		
Smoking, n (%)	3 (3.3)	284 (8.7)	3.23	p = 0.072
	(Missing, n = 2)	(Missing, n = 23)		
Physical exercise, n (%)	(Missing, n = 1)	(Missing, n = 42)	1.00	p = 0.802
Once a month or less	11 (12.1)	410 (12.6)		
2–4 times/month	20 (22.0)	642 (19.8)		
2–3 times/week	30 (33.0)	1,218 (37.5)		
More than 3 times/week	29 (31.9)	938 (28.9)		

Regarding frequency of experiencing EMF-related symptoms in the EHS group, 18.3% reported having symptoms daily, 34.1% reported once or a few times a week, and 47.6% reported once or a few times a month. The mean (SD) number of years experiencing EHS was 10.5 (8.2).

Prevalence rates regarding onset of EHS, coping-related behavior and a physician-based IEI-EMF diagnosis are shown in Fig. 1. Somewhat more than half of the sample reported that the problems had started after a high-dose or long-term EMF exposure and that they actively try to avoid EMF sources, and a vast majority reported that they mostly are able to affect the EMF environment. A minority of the EHS group had sought medical attention, been diagnosed by a physician or received treatment for their condition, and about tree out of four (n = 68) met criteria for IEI-EMF. Furthermore, among those who had sought medical attention (n = 23), about one third (n = 8) had been given a physician-based diagnosis, and about two thirds (n = 15) met criteria for IEI-EMF.

Percentage of participants who also had a certain physician-based diagnosis is shown in Fig. 2. The percentages are modest in size, ranging from 5.5 to 25.3%. The figures also give ORs for comorbidity in the EHS group with the various diagnoses when crude (unadjusted) and adjusted for age and sex. All ORs are significantly larger than unity for all diagnoses when both crude and adjusted, ranging from 2.15 to 4.79 when adjusted.

DISCUSSION

The present study is one of few from which population-based data on EHS have been reported (for an overview, see Baliatsas *et al*. 2012). It investigated EHS in the general population by addressing the role of demographic and lifestyle factors, frequency and duration, coping strategies, proportion meeting criteria for IEI-EMF and comorbidity with a number of diagnoses. The EHS group can be considered as rather severely affected emotionally and behaviorally by their environmental intolerance since the severity corresponded, in average, to the 93th percentile of the general population according to the EMFSS-11. As one would expect, the EHS group perceived their general health as significantly poorer than did the referents.

The results show higher prevalence rates of EHS in women than in men, which was also reported by Carlsson *et al*. (2005) and Baliatsas *et al*. (2012), and a strong such tendency by Hillert *et al*. (2002). A weaker tendency of higher prevalence rates of EHS in women is reported by Tseng *et al*. (2011) in a Taiwanese population-based study. A higher prevalence rate was found also in the middle-aged compared to the young and old adults. Congruent with this, Carlsson *et al*. (2005) reported higher prevalence rates in working age compared to old age, and Tseng *et al*. (2011) reported higher prevalence rates among those aged 35–49 year. The association between EHS and psychosocial stress is rather well documented (e.g., Carlsson *et al*., 2005; Johansson *et al*., 2010; Österberg *et al*., 2007), and higher level of stress is generally found in working age compared to old age, and in

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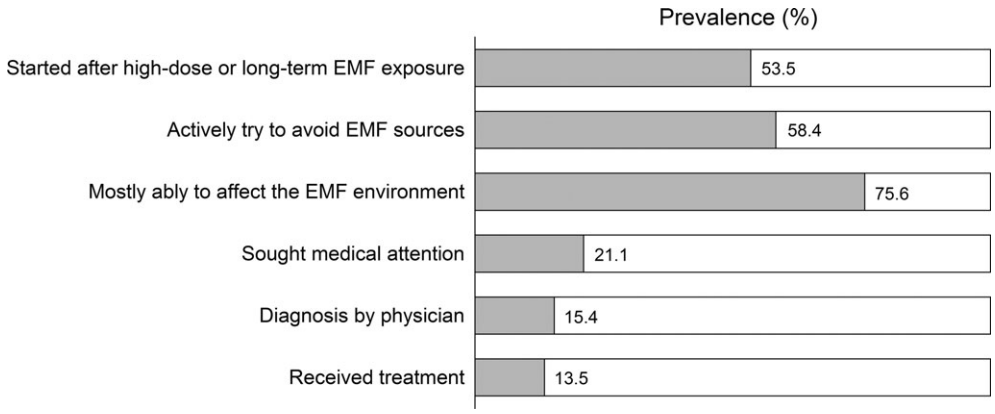


Fig. 1. Prevalence of experience and behaviour related to EMF in the EHS group.

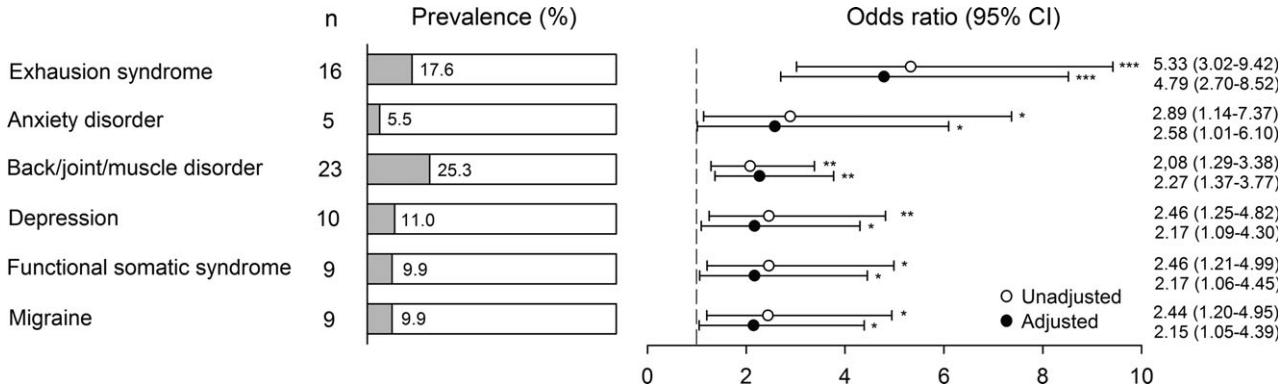


Fig. 2. Percentage of participants with EHS who reported a certain diagnosis as well as odds ratios (ORs), confidence intervals (CIs), and p-values for comorbidity with a certain diagnosis when unadjusted (crude) and adjusted for age and sex.

women compared to men (Nordin & Nordin, 2013). Thus, the sex and age-related differences in EHS prevalence may to some extent be referred to level of psychosocial stress. The absence of an association with education and marital status is in accordance with prior findings (Hillert *et al*., 2002). Furthermore, this study showed no association with smoking or physical exercise.

About half of the EHS group reported EMF-related symptoms on a daily or weekly basis, and that the group in general, on average, had lived with the condition for about ten years. This implies that every other person in the general population with EHS quite frequently attribute symptoms to EMF exposure, and that symptom attribution of this kind tends to last for a long period of time.

In line with findings on chemical intolerance (Nordin, Andersson & Nordin, 2010), the present results suggest that avoidance of environmental sources to which symptoms are attributed are commonly avoided also in EHS. Thus, a majority of the participants with EHS reported using an avoiding strategy, but also that they often were able to affect their EMF environment. Future studies may address the questions of how the EMF environment is affected.

A slight majority in the EHS group reported that their intolerance started after high-dose or long-term EMF exposure. Although the present study did not investigate causality in EHS, this result evokes speculation of causality, for which a nocebo effect (a negative expectation causing exposure to have a more negative effect than it otherwise would) may be of particular relevance (Baliatsas *et al*., 2012; Rubin *et al*., 2010; Witthöft & Rubin, 2013).

About one out of five in the EHS group reported having sought medical attention for their condition. This is a small proportion considering that this group was rather severely affected emotionally and behaviorally by their condition and since three out of four met clinical criteria for IEI-EMF. A possible explanation is that they may not expect to be given help for their condition. Indeed, only about one out of seven reported having received treatment. To what extent the received treatment was provided by alternative health care is not known. Notably, Schreier and associates (2006) reported that 13% of individuals with EHS had consulted their general practitioner, and that 32% had received alternative health care. Together these findings indicate limited access to treatment and/or limited belief in these patients of a successful outcome of treatment. The fact that three out of four met clinical criteria for IEI-EMF implies that EHS and IEI-EMF are very similar conditions, but also that IEI-EMF with its criteria is stricter than EHS. Furthermore, far from all, about two out of three, of those who had sought medical attention met criteria for IEI-EMF, and only about one out of three had been given a physician-based diagnosis. The latter small proportion may partly be explained by a possible time lag between seeking medical attention and responding to the present questionnaire. Note that the small cell counts calls for caution.

The EHS group showed comorbidity with all studied diagnoses, thus exhaustion syndrome, anxiety disorder

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(generalized anxiety disorder or panic disorder), back/joint/muscle disorder, depression, functional somatic syndrome (fibromyalgia or chronic fatigue syndrome) and migraine, with about two to almost five-fold increased risk when adjusted for age and sex. Whereas the ORs differed significantly from unity, the prevalence rates in the EHS group were not high in absolute terms (5.5–11.0%), with the exceptions of back/joint/muscle disorder (25.3%) and exhaustion syndrome (17.6%). These findings of comorbidity with diagnoses of exhaustion syndrome, anxiety disorder, back/joint/muscle disorder and depression supplement prior findings of high levels of burnout, anxiety, muscular tension and depression, respectively, in EHS (Johansson *et al*., 2010). The results encourage future investigation of possible underlying mechanisms in EHS. This includes nocebo effect and classical conditioning regarding the comorbidity with anxiety disorder, depression and exhaustion syndrome (Van den Bergh *et al*., 1997), central sensitization regarding FSSs, migraine, anxiety disorder, depression and exhaustion syndrome (Yunus, 2007), and somatosensory amplification and symptom attribution regarding anxiety disorder and depression (Barsky, Goodson, Lane & Cleary, 1988; Kessler, Lloyd, Lewis & Gray, 1999). Notably, Kato and Johansson (2012) reported much higher proportions of various self-reported symptoms ranging from 54.7% for anxiety to above 85.3% for fatigue/tiredness in a Japanese sample of EHS persons. These higher proportions may be explained by symptoms being self-reported in contrast to diagnosed by a physician. Somewhat surprisingly, Baliatsas *et al*. (2014) reported no increased comorbidity with anxiety and depression disorders despite inclusion criteria similar to ours.

Whereas the present study has certain strengths, such as being population-based and having a large sample size, it also has limitations. One limitation is the fact that only 40% of the randomly selected individuals participated, which compromises the representativeness due to increased risk of selection bias. Another limitation is that only self-reported data of physician diagnosis are available, and we lack information of the year of the given diagnoses.

To conclude, despite limitations of the study, the present results suggest that being woman and middle-aged are risk factors for EHS, that every other person with EHS quite frequently attribute symptoms to EMF exposure, and that EHS is typically a long-lasting condition. Regarding coping, the findings suggest that a majority of individuals with EHS experience that the hypersensitivity started after high-dose or long-term EMF exposure, that they actively try to avoid EMF sources, and that they mostly are able to affect their EMF environment. In contrast, a small minority report having sought medical attention, having been diagnosed with IEI-EMF and having received treatment for their hypersensitivity. However, a majority met criteria for IEI-EMF. Finally, comorbidity in EHS was found with exhaustion syndrome, anxiety disorder, back/joint/muscle disorder, depression, functional somatic syndrome and migraine.

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