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The prevalence of symptoms attributed to electromagnetic field exposure: a cross-sectional representative survey in Switzerland

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Summary

Objectives: To investigate health risk perception as well as to assess the prevalence of self-reported symptoms attributed to electromagnetic fields (EMF) and other environmental exposures in the general population of Switzerland.

Methods: Between May and June 2004, telephone interviews of a representative sample of the Swiss population ($n = 2048$, >14 years old) about: 1) health symptoms attributed to five environmental factors (one of which was EMF), 2) health risk perception related to 12 environmental risk factors (five of which were different EMF sources).

Results: We found a prevalence of 5% (95% CI 4–6%) for electromagnetic hypersensitivity (EHS) in our study sample. The most common health complaints among EHS individuals were sleep disorders (43%) and headaches (34%), which were mostly attributed to power lines and mobile phone handsets. In addition, 53 percent (95% CI 51–55%) were worried about adverse health effects from EMF, without attributing their own health symptoms to them.

Conclusions: The large proportion of the population who is concerned or attributes own symptoms to EMF may cause societal conflicts given the ubiquity of EMF in our everyday life.

Keywords: Electromagnetic fields – Electromagnetic hypersensitivity – Sleep disorders – Cross-sectional representative survey – Risk perception.

Potential health risks from electromagnetic fields (EMF) are a matter of public and scientific controversy. Repeatedly, cases of adverse health effects attributed to EMF have been

reported in the literature. The phenomenon of subjective adverse health effects attributed to EMFs is often referred to as electromagnetic hypersensitivity (EHS). The symptoms most commonly associated with EHS are non-specific health complaints such as concentration difficulties, nervousness, distress, headache and sleep disorders (David et al. 2002; Hietanen et al. 2002; Raczek et al. 2000). Symptoms have been attributed to extremely low frequency sources such as power lines or electrical devices, although over the last 10 years high frequency sources from mobile communication technologies have come increasingly into public focus. A descriptive study of EHS individuals in Switzerland found that the complainants mostly attributed their symptoms to mobile phone base stations followed by mobile phones, cordless phones and power lines (Rössli et al. 2004). Objective diagnostic criteria classifying these subjects as hypersensitive have not yet been established (Frick et al. 2005). Three conditions have to be fulfilled for an EHS self diagnosis: i) suffering from a health problem, ii) perceiving oneself as exposed to the suspected source, and iii) perceiving EMF as a health risk (Fig. 1). At present it is unknown whether there is a direct link (pathway of biological causation, points I to IV in our model in Fig. 1) between EMF exposure and impaired well-being (Seitz et al., 2005). In population-based surveys the prevalence of EHS has been reported to be 1.5% in Sweden (Hillert et al. 2002) and 3.2% in California (Levallois et al. 2002). In Germany, the prevalence of EHS was estimated at 6% in 2001 (Schroeder, 2002) and 8% in 2003 (Infas, 2003). However, it is not known how often and to what degree EMF is subjectively perceived as a health risk and hence what the prevalence of EHS in the general population of Switzerland is.

The aims of this cross-sectional survey were to obtain the prevalence of EHS in the Swiss population and to investigate the health risk perception regarding EMF exposure according to Figure 1.

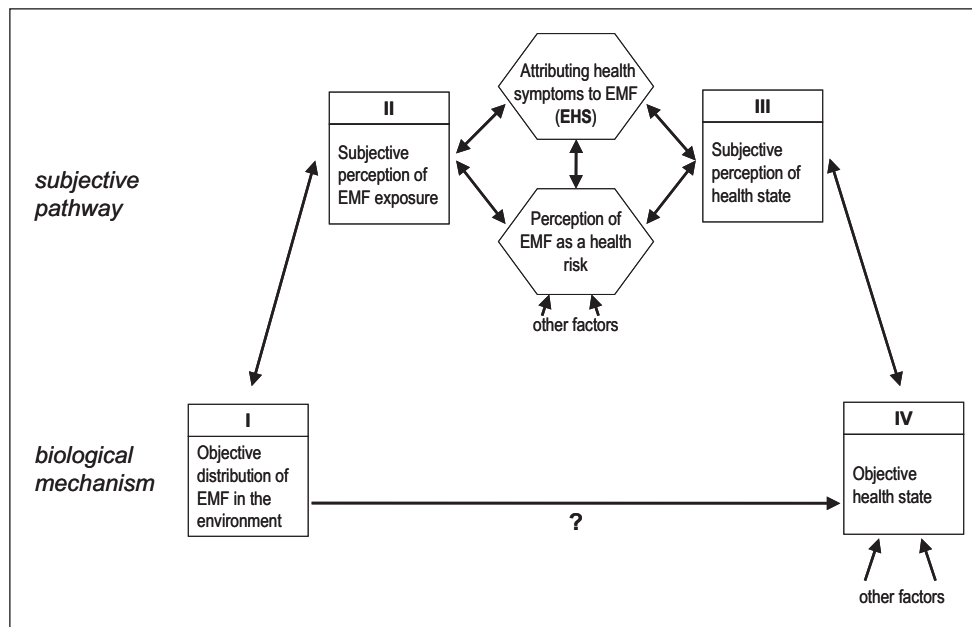


Figure 1 Electromagnetic hypersensitivity (EHS) model: Associations between objective and perceived (subjective) exposure and health. For an EHS self-diagnosis all three conditions have to be fulfilled: suffering from health problems, perceiving oneself as exposed and perceiving electromagnetic fields (EMF) as a health risk.

Methods

This study was based on computer assisted telephone interviews (CATI) carried out between May and July 2004. A random sample was drawn from the telephone directory and we wrote to them to say that we would phone them for an interview about environment and health. Once a household was reached, all persons living in the household ≥ 14 years of age were enumerated and, if more than one was eligible, the last-birthday-method was used to select randomly the participant (two stage random sampling).

A questionnaire was developed which allowed to divide the sample into three groups: “EHS persons”, “EMF concerned” and “EMF unconcerned” individuals. All three groups were asked about their exposure to EMF sources, which included mobile phones, cordless phones, mobile phone base stations and power lines. Additionally, they were asked if they took measures against EMF and the type of measures taken.

EHS individuals

With respect to five environmental exposures of which one was about EMF sources, we asked the participants whether they attributed own health symptoms to them. Non-EMF factors included weather, distress, air pollution and noise; EMF sources were “electro-smog such as from mobile phones, mobile phone base stations, power lines, cordless phones or other electrical devices”. To avoid order bias, the order of the five items was randomly changed in each interview. Persons were classified as “EHS individuals” if they reported adverse health effects from an EMF source at the time of the interview or anytime in the past. These individuals were questioned

about which of their health symptoms they suspected to have been caused by specific sources of EMF. The question was openly asked with a prepared list for the interviewer to avoid suggestion bias. Temporal occurrence of the symptoms was inquired about as well as questions about what measures were taken to treat the symptoms, which experts were consulted or what individual actions were taken.

EMF concerned and EMF unconcerned individuals

All persons were questioned about the extent of their health concerns (not at all, a little bit, quite a bit, extremely) with respect to twelve environmental risk factors, of which five were EMF sources (order randomly changed in each interview). Non-EMF risk factors were air pollution, UV radiation, genetically modified foods, road traffic accidents, distress, food additives and traffic noise. The five inquired EMF sources were mobile phone base stations, power lines, mobile phones, cordless phones and electrical devices. Persons who had “quite a bit” or “extremely” concerns about at least one of the EMF sources, but did not report adverse health effects that they attributed to them, were classified as “EMF concerned”. Persons reporting neither symptoms nor general concerns about health risks from EMF were classified as “EMF unconcerned”.

Data analysis

Data were analysed using the module “Analyses of Survey data” of the program STATA 8.2 (StataCorp, College Station, Texas, USA). The representative prevalence for the Swiss population was estimated by direct adjustments, with weights for age and gender derived from the 2003 popula-

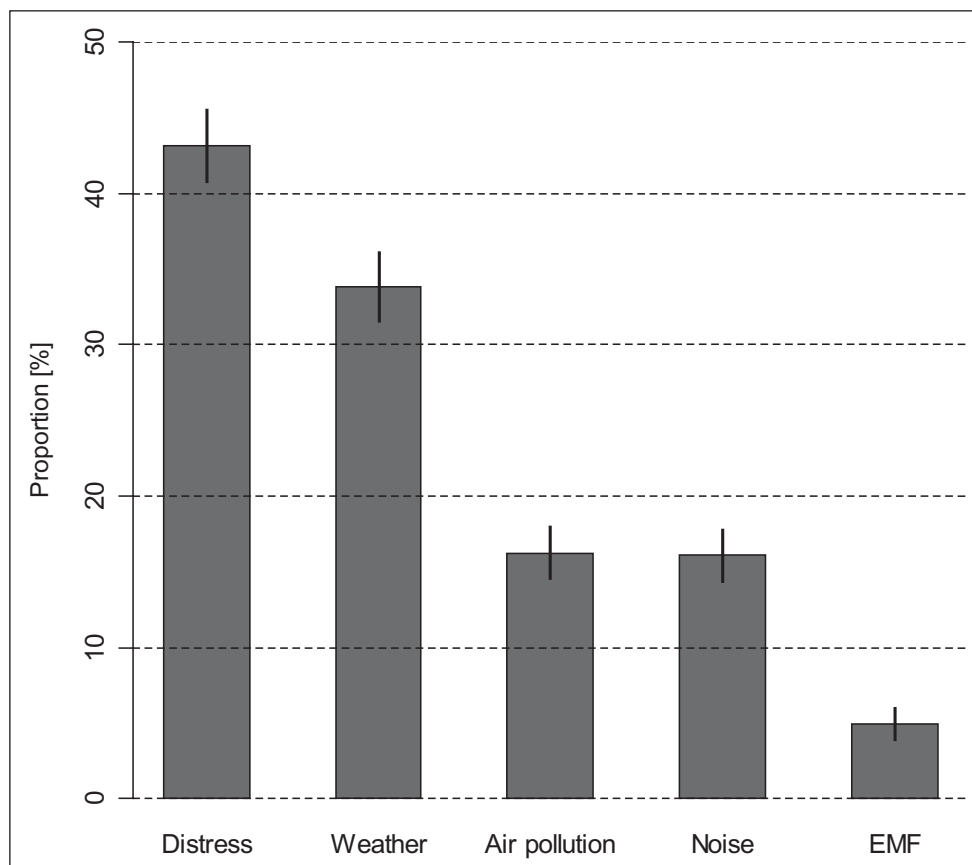


Figure 2 Proportion of individuals with adverse health effects attributed to multiple environmental risk factors at present or in the past (Switzerland, 2004, $n = 2048$). Vertical lines indicate 95% confidence intervals.

tion estimate of the Swiss Federal Statistical Office (ESPOP 2003). Confidence intervals were calculated using the Wilson score method based on quadratic equations (Newcombe, 1998). Comparisons of proportions between the three groups EHS individuals, EMF concerned and EMF unconcerned were done with chi-square analysis and logistic regression. Prevalence odds ratios with 95% confidence intervals were adjusted for age sex, educational level and marriage status using logistic regression for survey data.

Results

We interviewed 2048 individuals older than 14 years of age for this study. The upper boundary of the response rate (proportion of eligible households contacted that had completed an interview) was 64.2%. The response rate was 55.1%, assuming that a proportion of households that could not be reached represented potentially eligible households.

Of those interviewed, 66.8% (95% Confidence Interval 64.6–69.1%) reported symptoms attributed to at least one of the listed environmental risk factors (Fig. 2). The occurrence of adverse health effects attributed to EMFs was low compared to the other environmental risk factors. Of all respondents

2.7% (95% CI 2.0–3.5%) reported current adverse health effects attributed to EMFs, and 2.2% (95% CI 1.6–2.9%) reported having had such effects in the past, giving an overall total of 5.0% of our study population who had or still experienced EHS. On average 1.3 symptoms per person were reported, which were mainly non-specific. Sleep disorders and headaches were ranked highest, followed by concentration difficulties and nervousness (Table 1). Most of the EHS individuals attributed their symptoms to one or several EMF sources, in particular power lines and mobile phones (see Table 2). “Constant” or “daily” symptoms was reported from 38.8% (95% CI 28.4–49.1%) of the EHS individuals. Most of the EHS individuals (61.5%, 95% CI 51.2–71.8%) had had some kind of treatment, such as complementary medicine (32.1%, 95% CI 22.4–41.8%) or had consulted their general practitioner (13.4%, 95% CI 6.7–20.1%). Individuals with a past history of symptoms attributable to EMFs gave “turned off the source” as the answer to measures taken three times as often (33.8%, 95% CI 22.3–47.6%) as the ones who still had symptoms (11.1%, 95% CI 5.3–21.8%). Otherwise there were no differences in taken measures between the EHS individuals reporting adverse health effects in the past and those having them at present.

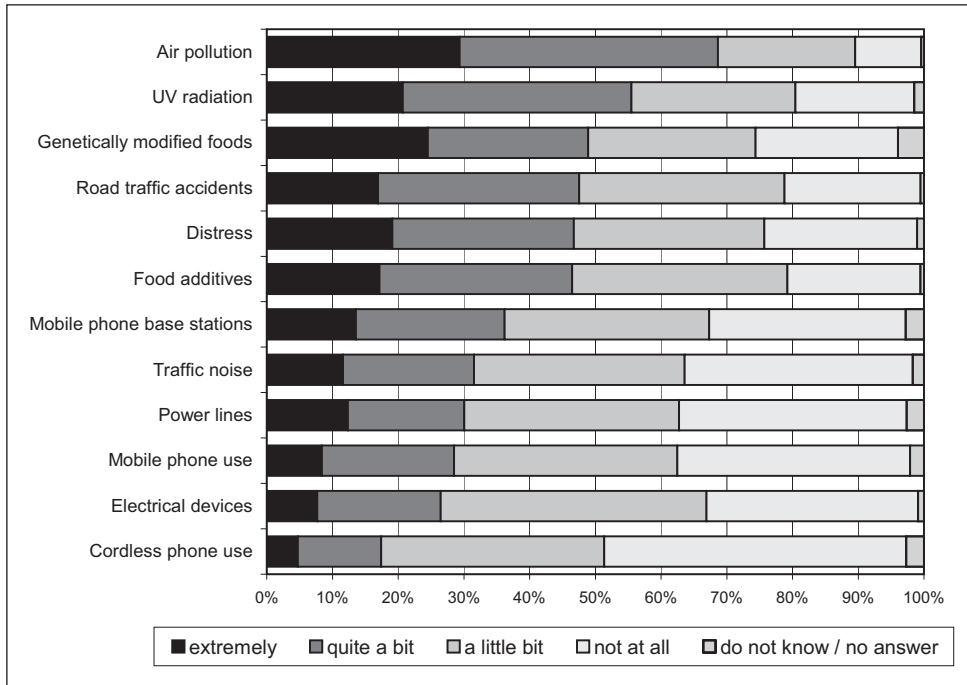


Figure 3 Perceived risk of different environmental exposure on the basis of the question: “Do you have concerns about your health due to the following influences?” (Switzerland, 2004, n = 2048)

Table 1 Type and frequency of reported symptoms attributed to EMFs by 107 EHS individuals (multiple nomination possible). The demographic description of this group can be found in Table 3.

	Proportion (95% CI)
Sleep disorders	42.7 (33.7–52.2)
Headache	33.8 (25.5–43.2)
Concentration difficulties	10.4 (5.9–17.6)
Nervousness	8.6 (4.6–15.4)
Rheumatism/Muscle pain	5.6 (2.6–11.7)
Respiratory problems	5.0 (2.2–10.9)
Dizziness	4.8 (2.1–10.6)
Other ^a	35.9 (27.4–45.3)

^a other non-specific symptoms such as ear pain, aggressiveness or depression, etc.

Table 2 EMF sources most commonly suspected as being linked to symptoms among 107 EHS individuals.

	Proportion [%] (95% CI)
No specific source	20.0 (13.5–28.5)
At least one specific source ^a	80.0 (71.4–86.5)
Power lines	28.0 (20.4–37.2)
Mobile phones	24.8 (17.6–33.7)
TV and computers	20.8 (14.2–29.5)
Broadcast transmitters	15.0 (9.5–23.0)
Other devices	14.8 (9.3–22.8)
Mobile phone base stations	12.9 (7.9–20.6)
Cordless phones	2.1 (0.6–6.9)
Microwave oven	2.1 (0.6–6.9)
Do not know	0.9 (0.2–5.1)

^a multiple nomination possible

In addition to the 5% of EHS individuals, we found that 52.9% (95% CI 50.5–55.2%) of the study population were concerned about at least one EMF source being a health risk (“EMF concerned”) as compared to 42.2% (95% CI 39.8–44.5%) of the population who were “EMF unconcerned”. Compared to other environmental risk factors, EMF sources were ranked in the second half of the ranking (Fig. 3). For example 69% (95% CI 66.4–70.9%) stated to have “extreme” or “quite a bit” worries that air pollution could be a risk for their health. EHS individuals reported that they lived “close” to a mobile phone station or to power lines (Table 3) more often than non-EHS individuals. The use of mobile phones was similar among all three groups. However, EHS individuals

were about 30 times more likely to state “no usage” explicitly due to health reasons compared to the unconcerned group. Women and persons between the ages of 35 and 65 years were generally more concerned about health effects of EMF exposure and were more often in the EHS group. There were more low educated persons in the group of the EMF unconcerned.

Discussion

This study found a prevalence of 5% of EHS in the population of Switzerland. By extrapolating the prevalence to total persons living in Switzerland older than 14 years of age, it

		EHS individuals	EMF concerned	EMF unconcerned
N = 2048		107	1083	858
Socio-demographic characteristics				
Age (years) 14–34	% (95 % CI)	28.1 (20.5–37.3)	28.0 (25.4–30.7)	35.2 (32.1–38.5)
35–64	% (95 % CI)	59.4 (49.9–68.2)	54.7 (51.7–57.6)	44.1 (40.8–47.4)
65+	% (95 % CI)	12.5 (7.5–20.1)	17.3 (15.2–19.7)	20.7 (18.1–23.5)
Sex Females	% (95 % CI)	54.5 (45.1–63.6)	55.2 (52.2–58.1)	47.2 (43.9–50.5)
Males	% (95 % CI)	45.5 (36.4–54.9)	44.8 (41.9–47.8)	52.8 (49.5–56.1)
Education Low	% (95 % CI)	12.2 (7.3–19.7)	14.5 (12.0–17.0)	18.2 (15.1–21.3)
Middle	% (95 % CI)	60.5 (51.0–69.2)	55.4 (52.1–58.7)	52.6 (48.9–56.3)
High	% (95 % CI)	27.3 (19.8–36.4)	30.0 (27.1–32.9)	29.1 (26.0–32.2)
Exposure				
Use of own mobile phone	% (95 % CI)	81.1 (73.3–88.9)	79.0 (76.4–81.6)	80.3 (77.4–83.2)
	OR (95 % CI)	0.87 (0.51–1.49)	0.85 (0.65–1.11)	1
Did not use mobile phones for health reasons	% (95 % CI)	6.2 (1.1–11.4)	2.4 (1.5–3.4)	0.2 (0.09–0.6)
	OR (95 % CI)	29.2 (5.3–161.9)	9.9 (2.3–42.5)	1
Use of cordless phone	% (95 % CI)	79.1 (71.3–86.9)	74.4 (71.6–77.2)	74.4 (71.2–77.6)
	OR (95 % CI)	1.26 (0.77–2.05)	0.95 (0.75–1.21)	1
Reported to live close ^a to a mobile phone base station	% (95 % CI)	26.1 (16.6–35.6)	21.1 (18.4–23.7)	18.5 (15.5–21.4)
	OR (95 % CI)	1.62 (0.95–2.75)	1.17 (0.91–1.51)	1
Never paid attention to mobile phone base stations	% (95 % CI)	5.2 (1.4–9)	8.1 (6.3–9.9)	9.2 (7.2–11.3)
	OR (95 % CI)	0.50 (0.22–1.13)	0.85 (0.59–1.21)	1
Reported to live close ^a to a power line	% (95 % CI)	13.0 (5.6–20.4)	11.6 (9.5–13.7)	8.4 (6.4–10.5)
	OR (95 % CI)	1.64 (0.80–3.35)	1.42 (1.01–2.01)	1
Reported to live close ^a to a train power line	% (95 % CI)	34.3 (24–44.6)	30.6 (27.6–33.6)	32.3 (28.9–35.8)
	OR (95 % CI)	1.07 (0.66–1.74)	0.93 (0.75–1.16)	1

^a close: not specified, if asked then <500 m

Table 3 Comparison of socio-demographic factors and reported exposure to EMF sources between the three groups (Switzerland, 2004, n = 2048). Frequency in percent with 95 % confidence interval [% (95 % CI)] as well as prevalence odds ratios (OR) with 95 % confidence interval. (OR were adjusted for age sex, educational level and marriage status.)

can be estimated that about 300 000 persons report to suffer from EHS. Symptoms attributed to EMFs were mainly of non-specific nature. Most prevalent complaints among EHS individuals were sleep disorders (43 %) and headache (34 %), which were mostly attributed to power lines and mobile phone handsets. Mobile phone base stations as source of the symptoms were less often reported than expected given the ongoing public discussion.

It is meanwhile reasonable to ask if a random sample of the population from the telephone directory, as used in this study, gives a representative cross section of the population. The possibility exists that individuals not registered in the directory are mainly persons with mobile phones and those without fixed-line phones. Such persons could differ from the rest of the population regarding their health risk perception about EMF. The latest Swiss data (LINK Institut, 2000)

showed that 8.5 % of the population had no fixed-line phone and relied on a mobile phone only. Most of them (85 %) were nevertheless registered in the telephone directory, which leads to the conclusion that there is no bias to be expected from this side.

Comparing EHS prevalences from different studies is problematic due to the fact that there are no objective criteria for assessing EHS. There are a few population-based studies on concerns and adverse health effects attributed to EMFs, each of which were concentrated on different aspects. Some focused on certain sources like mobile phone base stations or video display units, others were more general and considered a wide range of sources, like in the study at hand. In some studies the type of the health effect was taking centre stage, in others the concern about EMFs being a health risks was more important. A representative survey in Stockholm came

to the conclusion that 1.5 percent of the population reported EHS (Hillert et al. 2002). A survey in California yielded a proportion of 3.2% (95% CI: 2.8%–3.7%) (Levallois et al. 2002). The German Federal Office for Radiation Protection (BfS) commissioned two representative surveys on concerns and adverse health effects attributed to EMFs, one in Autumn 2001 and one in the year 2003 (Infas 2003; Schroeder 2002). In the first survey, 6% reported adverse health effects from EMFs, in 2003, the proportion increased to 8%. A comparable proportion had been estimated in an Austrian study with an experimental approach (Leitgeb & Schröttner 2003). In another telephone survey carried out in Switzerland, about 1.5 percent of the individuals stated that they experienced adverse health effects which they attributed to EMFs (Peters 2004). This estimate is lower than our findings and may have been due to the fact that they used an open question approach without naming specific sources. Our findings of 5 percent with EHS are consistent with these other international studies that report a range between 1.5–8% for EHS in their study populations. Of note is that the suspected sources for self-reported health symptoms were mostly power lines and not mobile phone base stations, as suggested by ongoing public discussion. In contrast, “concerns” were more often expressed regarding mobile phone base stations and power lines as compared to mobile phone handsets, electrical devices and cordless phones. This reflects the well known fact that involuntary exposure is less well accepted than voluntary exposure. Similar results were found in a Swiss (Siegrist et al. 2005) and Austrian (Hutter et al. 2004) survey on public risk perception concerning mobile phone base station and mobile phones as well as in a survey on cancer risk perception in Spain (Garcia et al. 2005).

Causal relationships between EMFs and adverse health effects cannot be inferred from cross-sectional studies such as this one and this was not the objective of this study. EHS is a self-diagnosis based on one’s subjective perception of EMF as a health risk as well as perception of own EMF health and exposure state (Fig. 1). A person living far away from any mobile phone base station would hardly attribute their symptoms to a base station. Therefore, although the EHS group reported that they were exposed to outdoor sources more often than the rest of the population, this should not be interpreted as a causal association. EHS individuals were 50% less likely to state that they had never paid attention to mobile phone base stations in their neighbourhood compared to unconcerned individuals. This indicates that EHS individuals pay more attention to potential EMF sources in their neighbourhood and that, as a result their self-reported exposure, was expected to be elevated.

In principle, the presence of a mobile phone base station in a neighbourhood could be objectively determined using

geo-coded data. With this information one could test the association between perceived and true proximity to the source. However, because distance to base stations has not been found to be correlated with exposure levels (Neubauer et al. 2005; Radon et al. 2006), we did not think that the effort would be worthwhile in order to investigate the biologically relevant association I–IV (Fig. 1). It would be more promising to measure levels of EMF at participants’ homes. However, this was not feasible within this study and the interpretation of the data would be problematic unless data were available for all boxes shown in Figure 1.

In the absence of complete data, the exact nature of the reported association between symptoms and EMF could not be solved. In principle, there are two possibilities: either a biological mechanism or a purely subjective pathway. According to our model (Fig. 1) a biological mechanism would represent the direct pathway from I to IV (omitting II and III). Examples for a subjective pathway would be a nocebo effect or selective perception. Nocebo effects are the opposite of placebo effects and refer to the development of adverse health effects out of concerns about it (Fig. 1: perceiving both EMF as a health risk and oneself as exposed). Selective perception refers to the possibility that one suffers from health problems (box III in Fig. 1) and in the process of searching for a cause one assumes to be exposed to a “hazardous” EMF source. Whereas the existence of subjective pathways is beyond controversy, there is scientific uncertainty whether exposure levels to which the general population is typically exposed can cause adverse health effects through a biological mechanism. A systematic review of blind and double-blind provocation studies comparing the perception of EMFs of EHS and Non-EHS individuals did not find evidence that EMF below standard limits can be perceived in a blind setting (Rubin et al. 2005). The authors stated that it was difficult to prove that EMF exposure could trigger these symptoms and came to the conclusion that EHS was probably unrelated to the presence of EMF. On the other hand, case studies carried out in Basel (Huss et al. 2005), using EHS individuals, found a plausible relationship between EMF exposure and EHS in about a third of the cases.

This survey showed that EMF is a public health issue in Switzerland. Extrapolating the observed prevalence to the whole Swiss population older than 14 years results in about 300 000 individuals, who attribute adverse health effects to EMF. In addition, the majority of the Swiss population perceives EMF as a possible health risk. Concerns may lead to a nocebo effect and thus result in additional burden of disease. One way to address this problem are well conducted studies which allow to clarify the association between EMF exposure and health.

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Zusammenfassung

Prävalenz von Symptomen, die der Einwirkung von elektromagnetischen Feldern zugeschrieben werden: eine repräsentative Querschnittsstudie in der Schweiz

Fragestellung: Das Ziel der vorliegenden Studie ist es, Sorgen der Schweizer Bevölkerung um die eigene Gesundheit, sowie gesundheitliche Beschwerden im Zusammenhang mit elektromagnetischen Feldern (EMF) zu erfassen und mit anderen Umwelteinflüssen zu vergleichen.

Methoden: Im Mai und Juni 2004 wurde in einer repräsentativen Bevölkerungsstichprobe (n = 2048 Personen, Alter: >14 Jahre) mittels standardisierten telefonischen Interviews erhoben, ob eigene Gesundheitsbeschwerden der Wirkung von EMF oder vier weiteren Umwelteinflüsse zugeschrieben wurden. Zusätzlich wurden für 12 verschiedene Umwelteinflüsse (davon fünf EMF-Quellen) nach der Gesundheitsrisikoeinschätzung gefragt.

Resultate: Die Prävalenz der elektromagnetischen Hypersensibilität (EHS) in der Schweizer Bevölkerung lag bei 5 % (95 % CI 4–6 %). Die am häufigsten EMF zugeschriebenen Symptome waren Schlafstörungen (43 %) und Kopfschmerzen (34 %), welche am meisten Hochspannungsleitungen und Mobiltelefonen attribuiert wurden. Zusätzliche 53 Prozent (95 % CI 51–55 %) machten sich Sorgen um ihre Gesundheit aufgrund von EMF, ohne aber gesundheitlich darunter zu leiden.

Schlussfolgerungen: Der grosse Anteil von Personen in der Schweiz, die sich besorgt äussern oder eigene gesundheitliche Beschwerden der Wirkung von EMF zuschreiben, birgt ein grosses soziales Konfliktpotential hinsichtlich der ubiquitären Verbreitung von EMF in unserem Alltag

Résumé

Prévalence de symptômes attribués à une exposition aux champs magnétiques en Suisse

Objectifs: Evaluer la perception des risques pour la santé et déterminer la prévalence des symptômes subjectivement attribués aux champs électromagnétiques (CEM) dans la population générale en Suisse.

Méthode: Entre mai et juin 2004, des entretiens téléphoniques ont été menés auprès d'un échantillon représentatif de 2048 personnes de plus de 14 ans en Suisse sur: 1) la présence de symptômes attribués à cinq facteurs environnementaux différents, parmi lesquels les CEM; 2) sur la perception des risques pour la santé liés à 12 facteurs environnementaux, dont 5 étaient sources de CEM.

Résultats: La prévalence d'hypersensibilité aux CEM (EHS) dans la population suisse est de 5 % (95 % CI 4–6 %). Les symptômes généralement mentionnés sont les troubles du sommeil (43 %) et les céphalées (34 %) qui ont été surtout attribués aux lignes à haute tension et aux téléphones mobiles. 53 % des personnes interviewées (95 % CI 51–55 %) se disent préoccupées par les risques des CEM pour la santé sans toutefois y attribuer leurs propres symptômes.

Conclusions: Vu l'omniprésence des CEM dans notre vie quotidienne, la proportion importante de la population préoccupée ou qui attribue des symptômes aux CEM peut être source de conflits sociaux.

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