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The Prevalence of People with Restricted Access to Work in Manmade Electromagnetic Environments

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Abstract

Some surveys have identified people who have restricted access to work in environments with man-made electromagnetic exposures. This study attempts to determine their prevalence, an aspect not previously investigated in its own right. It is based on analyses of the two different types of surveys of people with Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF), or Electromagnetic Hyper-Sensitivity (EHS), either of the general population or of people with IEI-EMF/EHS. In addition, there are different definitions of IEI-EMF/EHS, with a range of subconscious, mild, moderate or severe symptoms, potentially leading in three stages to hyper-sensitivity. The current evidence is assessed as indicating that, in addition to subconscious sensitivity, the prevalence of IEI-EMF/EHS is between about 5.0 and 30 per cent of the general population for mild cases, 1.5 and 5.0 per cent for moderate cases and < 1.5 per cent for severe cases. The prevalence of people restricted in their access to work in a man-made electromagnetic environment is estimated at 0.65 per cent of the general population, at about 18% of the general population with moderate IEI-EMF/EHS. The estimate of 0.65% equates to 435,500 people in the UK's population of 67 million. Some reasons for possible under-reporting are discussed. Adjustments can enable some people with this disability to remain in employment, suggesting that rates of restriction in access to work may fall as employers become aware of what adjustments are needed.

Keywords: Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF); Electromagnetic Hyper-Sensitivity (EHS); Work; Employment; Retirement; Disability; Functional impairment

Introduction

Some surveys have tried to assess the prevalence of employment among people affected by man-made electromagnetic environments. This condition is known as Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF), or Electromagnetic Hyper-Sensitivity (EHS), and also as Radio Wave Sickness or Intolerance, Microwave Sickness, or Electrosensitivity. There are two types of surveys, either large-scale of the general population, or small-scale and limited to people with IEI-EMF/EHS. Both depend on a method of identifying people with IEI-EMF/EHS.

The differences between the two types of survey are not necessarily a problem. Once the percentage of the general population with IEI-EMF/EHS is known, surveys limited to people with IEI-EMF/EHS can be evaluated in the light of this percentage. Some surveys of the general population are here estimated to show that about 18% of people classified as having IEI-EMF/EHS with moderate symptoms are restricted in access to work.

The criteria for the diagnosis of IEI-EMF/EHS are a greater problem. Many surveys have relied on self-diagnosis, without external objective analysis. The World Health Organization Backgrounder (WHO 296, 2005) did not provide a clear diagnostic test. Only recently have multi-systemic tests been proposed as suitable for diagnosis (Belpomme, et al. 2015).

The two proposed aetiologies of IEI-EMF/EHS are not an issue, since either aetiology could lead to restricted access to work. The psychological aetiology is based on failures to find a comprehensive association between exposure and conscious symptoms, suggesting instead a nocebo effect or electrophobia during sham sessions (Eltiti, et al. 2018; Rubin, et al. 2010), dependent on media reports, which can vary between countries

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(Tseng, et al. 2013), and related to personality traits (Boehmert, et al. 2018; Johansson A, et al. 2010;Withoff, et al. 2018). The alternative, physiological, aetiology, possibly characterising an essentially different condition (Bogers, et al. 2018; Dieudonné, 2016) is based on individual provocation cases (McCarty et al, 2011; Rea, et al. 1991), cerebral blood scans (Irigaray, Lebar, et al. 2018), 3d fMRI (Heuser, et al. 2017) and genetics (De Luca et al, 2014), dependent on mechanisms such as voltage-gated calcium channels (Pall, 2013), cryptochromes (Sherrard, et al. 2018) and oxidative stress (Irigaray, Caccamo, et al. 2018).

There is a growing awareness of the issues concerning people with IEI-EMF/EHS and the duties of society towards them (Johansson, 2015). The analysis presented here is the first to be concerned primarily with restricted access to work.

Two types of surveys of people unable to access work

Surveys of the general population: Most epidemiological surveys have assessed the prevalence of IEI-EMF/EHS in the general population according to their own criteria, by questions on conscious symptoms. Although all humans are naturally sensitive to electromagnetic fields in the form of, for instance, solar radiation, these surveys have concerned only conscious and adverse symptoms of sensitivity, from man-made technology. They have necessarily included people with mild, moderate and severe symptoms of IEI-EMF/EHS. This wide range of sensitivity has age-related differences (Redmayne et al. 2015).

The estimated proportion of the general population with IEI-EMF/EHS has varied considerably, depending on a survey's minimum requirements in terms of the number and extent of the symptoms needed to classify a person with IEI-EMF/EHS. Where the classification is looser, including a wider a range of people with IEI-EMF/EHS, the proportion of the general population with IEI-EMF/EHS may be higher. These cases are likely to include many mild ones, where the condition is less disabling and therefore a smaller subsection is likely to be restricted in access to work. The converse also applies, where a more demanding range of symptoms gives a smaller proportion of the general population, but the cases are likely to be more severe, with a larger subsection identified as restricted in access to work.

The validity of this analysis is apparent from some of the literature. In population-based surveys the prevalence of IEI-EMF/EHS has ranged from 1.5% in Sweden (Hillert et al. 2002), at a low level, to over 30% in Austria (Schröttner, et al. 2008), with an average value for some surveys at 3.6% (Table 1). The comparatively high value of 4.6% (Huang, et al. 2018) was for a survey in Taiwan which did "not find a higher risk of being unable to work in participants with IEI-EMF". In fact the survey asked only whether the person was employed, and not about any restriction on access to work, and its combined percentage of out of work and unable to work was, unusually, lower for people with IEI-EMF/EHS than others, despite its finding that 0.58% of the general population had impairment of daily activities because of their IEI-EMF/EHS.

Table 1: Surveys of the general population showing the prevalence of people with IEI-EMF/EHS with restricted access to work.

Study	Number of general population surveyed	Percentage (and number) of general population classified with IEI-EMF/EHS, or some annoyance	Extrapolated percentage of IEI-EMF/EHS with restricted access to work (differential between IEI-EMF/EHS and general population controls)	Extrapolated percentage of general population with IEI-EMF/EHS with restricted access to work	Percentage of general population with severe symptoms of IEI-EMF/EHS, or with impairment in daily activities, or much annoyance
Tseng, et al. 2011	1,197	13.3 (104)	18.9	2.4	
Carlsson, et al. 2005	13,381	2.7 (367)[1] 13.5 (1812)[2]			0.4 1.9
Eltiti, et al. 2007	3,633	4.0 (145)			1.8
Huang, Li, et al. 2018	3,303	4.6 (155)	-0.63 [3]		0.58
Hojo, et al. 2016	1,306	4.59 (60)	22.1 [4]	1.44	
Levallois, et al. 2002	2,072	3.2 (68)		0.52	
Baliatsas, et al. 2014	5,073	3.5 (202)	13.2	0.46	
Hillert, et al. 2002	10,439	1.5 (166)	12.5	0.19	
Mean (with Tseng and Carlsson)		6.4	13.2	1.00	1.6
Mean (without Tseng and Carlsson) [5]		3.6	11.8 15.9[6]	0.65	1.2

[1]'Other (non-lighting) electrical equipment': some or much annoyance.

[2] Visual display unit (VDU) and Fluorescent tube lighting (FTL): some or much annoyance.

[3] The differential of the combined percentage for out of work and unable to work, for IEI-EMF compared with non IEI-EMF. This negative figure implies proportionately more people with IEI-EMF than non IEI-EMF were working.

[4] The difference in the per centage unemployed, excluding students, between controls identified by screening as EHS and all controls; the differential for homeworking was 12%.

[5] The figures from Tseng, et al. 2011, and Carlsson, et al. 2005, appear to be outliers. Therefore, they are omitted from the averages.

[6] Excluding Huang, Li, et al. 2018, where the anomalous value of -0.63 [see note 3] does not appear to relate to the final column recording severe symptoms, unless Taiwanese employers had already made the necessary adjustments for people with severe cases of IEI-EMF/EHS. The survey's contacts were made by telephone; severe cases of IEI-EMF/EHS often cannot tolerate EMFs from a corded or especially a wireless telephone.

In contrast, a survey which found a relatively lower percentage, identifying 3.2% as having IEI-EMF/EHS in California (Levallois et al. 2002), concluded that "being unable to work might be a consequence of the disorder for the more severe cases". Extrapolated figures give 0.52% of the general population as facing restrictions in accessing work because of IEI-EMF/EHS, similar to the Taiwan figure of 0.58% with impairment of daily activities. In the Swedish survey which found 1.5% with IEI-EMF/EHS (Hillert et al. 2002), rates of unemployment, sick leave and early retirement were higher for those identified as having IEI-EMF/EHS compared with others without IEI-EMF/EHS, by up to 2.7 times. It concluded that those with IEI-EMF/EHS "appeared to have a lower capacity for work", based on 51.8% of those with IEI-EMF/EHS working (compared with 61.1% of others), 12.1% unemployed (4.4% others), 2.5% on sick leave (1.6% others), and 7.7% on early retirement or disability pension (3.8% others). This gives 12.5% of the people classified as having IEI-EMF/EHS as restricted in access to work. In terms of the general population, this is equivalent to 0.19%.

Surveys of people with IEI-EMF/EHS: Where a study is restricted to people with IEI-EMF/EHS, and especially where they are people with a severe rather than mild form of IEI-EMF/EHS, it is likely that a higher proportion will be found to have no, or restricted, access to work. The few studies of this type so far have been limited in scale but half those listed have found between 50% and 67% of their respondents with no, or restricted, access to work (Table 2).

Table 2: Surveys of people with IEI-EMF/EHS showing the prevalence of people with IEI-EMF/EHS with restricted access to work

Study	Funding: Government Agency (GA), or Independent (Ind.) and various	Number of IEI-EMF/EHS referents	Percentage (number) female	Percentage (number) of ES (Electrical Sensitivity), but not of EHS (Electromagnetic Hypersensitivity)	Percentage (number) of IEI-EMF/EHS referents: restricted access to work [1] (aggregated)	Percentage (number) of IEI-EMF/EHS referents: death (brain tumour, suicide)
Gibson, et al. 2015	Ind.	465 (IEI)	86 (394)	unspecified	67 (301) [2]	
UK, 2019 current [3]	Ind.	36	47 (17)	3 (1)	67 (24)	8 (3)
Kato, et al. 2012	Ind.	75	95 (71)	5.3 (4)	65 (49)	
Johansson A, et al. 2010	Center for Env. Res., Umeå	71	82 (58)	0	60 (43)	
Levallois, et al. 2002	GA: PUC	68	59 (40)	unspecified	53 (36)	
IDEA, 2005	Ind.	16	38 (6)	unspecified	50 (8)	
Arnetz, et al. 1997	GA: NIRP	116 [4]	92 (12)	89 (103)	41 (47)	
Hojo, et al. 2016	Ind.	82	79.5 (101)	35 (45)	38 (48) [5]	
Kjellqvist, et al. 2016	Center for Env. Res., Umeå	114	85 (75)	unspecified	35 (40)	
Johansson A, et al. 2010	Center for Env. Res., Umeå	0	62 (28)	100 (45) [6]	31 (14)	
Andrianome, et al. 2018	GA: ANSES	52	79 (41)	unspecified	26.9 (14)	
Blomkvist, et al. 1993	GA: Swed. Found. for Occup. H&S	1,650	unspecified	unspecified	9.1 (150)	

[1]Restricted access to work, including: decreased income, disability pension, early retirement, reduced work, sick leave, unable to work, unemployed, work transfer.
[2]Of the 34% in work, 15% worked full or part time from or inside the home, compared with 18% who worked full or part time outside the home. 31% held university degrees. 22 % were recorded as homeless at some time, and 4% were currently homeless. IEI was called environmental sensitivity, comprising chemical and electrical sensitivity.
[3]Analysis of 36 cases of IEI-EMF/EHS reported in UK printed media 2006-2017, including access to work (unpaid) categorized as applicable to one parent-carer, one university student, and two school pupils. Of the 9 remaining in work, 6 had adjustments made for them to continue in work.
[4]A 1993 study of 133 visual display unit (VDU) workers in Sweden, of whom 87% (116) reported sensitivity to health symptoms and 10% (13) hyper-sensitivity (EHS). 35% (47) were unable to use a VDU for more than 3 hours per day without experiencing symptoms.
[5] The aggregated difference between the combined totals for unemployed and homeworker compared with controls.
[6]'Mobile Phone' symptoms, as opposed to 'general EHS'.

A survey of 16 people with IEI-EMF/EHS in Ireland found that 50% were unable to work (IDEA, 2005). A survey of 75 people with IEI-EMF/EHS in Japan found that 50% of 40 had lost their jobs and that, overall, 65% had lost work or experienced a decrease in income after the onset of IEI-EMF/EHS (Kato, et al. 2012). A study in the USA concerned with only severe cases of environmental sensitivities, including IEI-EMF/EHS, reported 67% unemployed out of 465 subjects (Gibson et al. 2015), where it was stated: "We consistently find in my lab that (unless we request working participants), two-thirds of study participants are unemployed" (Gibson, 2017). A similar proportion of unemployment was found among 71 subjects with EHS in Sweden, where only 16% were employed (compared with 73% among 106 controls), 60% were on sick leave or disability pension (16% controls), and 17% were unemployed or retired (11% controls) (Johansson A, et al. 2010).

To help validate these findings, which relied on online, paper or telephone questionnaires among self-help groups, relevant media reports were analyzed on 36 individuals or groups with IEI-EMF/EHS published in the U.K. between 2006 and 2017 (UK

Survey, 2019, Table 2, Supplementary Data). These reports often involved a personal interview by a skeptical journalist, who could more objectively assess how far the subject could access work or needed adjustments. Of the 32 relevant cases of people with IEI-EMF/EHS who started as paid workers, 24 (75%) had been employed and 8 (25%) had been self-employed. Four others comprised of one parent child-carer, one university student, and two school pupils. Of the 36 cases, 24 (67%) stopped working, retired early, or left their place of education, 3 (8%) died, one from a brain tumor and two by suicide, and only 9 (25%) continued in work. Of the nine who continued working, five cases were in or before 2006 when the amount of man-made radiation was lower than now. Six were able to continue work after adjustments were made to their electromagnetic environment by the employer or the self-employed person. The overall result of 67% of people with severe IEI-EMF/EHS being unable to continue work or find work is comparable with the range of 60% to 67% listed above among similar groups in Japan, Sweden, the USA and elsewhere.

Discussion

Numerical relationship between the two types of studies of the prevalence of people restricted in access to work

The percentage of the general population unable to access of work because of IEI-EMF/EHS deduced from surveys of the general population varies from 0.19% to 2.4% (Table 1). It is here argued that 0.65%, the mean of four lower figures, can be considered a valid average, given the nature of the evidence.

The low figure of 0.19% of the general population with restricted access to work comes from the detailed survey in Sweden of 10,439 respondents in the general population (Hillert, et al. 2002). This found 1.5% of the population with IEI-EMF/EHS, with a differential for restrictions on work of 12.5%, giving 0.19% of the general population restricted in access to work. A survey in 2007 of 1,197 people in Taiwan gave an extrapolation of 2.4% as having restricted access to work, but this survey identified 13.3 % as having IEI-EMF/EHS, a figure later reduced for Taiwan to 4.6% (Huang, et al. 2018). The latter's finding of +0.58% for impairment of daily activities from IEI-EMF/EHS did not match the -0.63% restrictions on work. In other words, more people with IEI-EMF/EHS, despite their impairments, were in work than the controls, which from other surveys seems unlikely. In addition, this survey did not ask about disability pensions, part-time work or early retirement, and was conducted by telephone, whereas severe cases of IEI-EMF/EHS cannot use telephones. Another study found 4.0% of 3,633 members of the UK general population had IEI-EMF/EHS (Eltiti, et al. 2007). In study 2 it found that 74% of people with IEI-EMF/EHS, or 1.8% of the general population, were classified as having severe symptoms, and these people may be considered most likely to suffer restrictions on access to work. However, since there was no direct assessment of access to work, this figure must be treated cautiously and preference given to other lower figures.

Another approach for assessing the relationship between the two types of surveys, of the general population (Table 1) and of people with IEI-EMF/EHS (Table 2), where the referents are often accessed via self-help groups, is to estimate the number of people with an environmental health condition typically in contact with specialised national self-help groups. Allergy UK in 2017 had 11,383 contacts through its helpline, webchat and by email out of 21 million people with an allergy, at 0.054% (The British Allergy Foundation, 2017). Asthma UK in 2017 had 93,000 downloads of online Action Plans out of 5.4 million people with asthma, at 1.7% (Asthma UK, 2017). Applying these proportions of 0.054% - 1.7% to Electrosensitivity, UK's distribution of 710 printed newsletters in September 2018 (Electrosensitivity UK, 2018) would produce a national prevalence of 0.062% - 1.94%, meaning that the general population with restricted work, based on 67% of people with IEI-EMF/EHS, would be 0.042 - 1.3%, with a midpoint of 0.67%.

These figures show some overlap with the figures of 0.19–2.4 % deduced from general population surveys and the figures of 0.58-2.3% of people with severe symptoms from IEI-EMF/EHS. The mean figure of 0.65 %, suggested here from extrapolations from general population surveys, is close to the average of 0.67% based on UK charity contacts. It is only half of the 1.2% for severe symptoms, but these are less reliable guides to restricted access to work for people with IEI-EMF/EHS than actual surveys. Three of the general population surveys appeared reasonably consistent in giving an average rate of about 15.9% (range 12.5 – 22.1%) for people with IEI-EMF/EHS having restrictions on access to work. For the UK's population of 67 million, the survey mean of 0.65% gives 435,500 people affected in this way.

Prevalence of restricted works in terms of (i) symptom severity and (ii) stages in the progress of IEI-EMF/EHS, and (iii) compared with visual impairment

(i) Subconscious, mild, moderate and severe symptoms: some of the wide variety of the reported prevalence of IEI-EMF/EHS can be explained by the wide variety of definitions typically used. This especially applies to the four ranges of severity in symptoms among the general population, here estimated at: subconscious 30 – 80%, mild 5 –30%, moderate 1.5 – 5%, and severe < 1.5%.

Subconscious symptoms from man-made electromagnetic exposure cover most of the general population, just as all people are affected by, for instance, natural electromagnetic exposure in the form of solar radiation. Although the effects may include conscious ones, they depend on chronic subconscious exposures, usually in a dose-response relationship, as in a study of 180 respondents near a phone mast (Eger, et al. 2010). A study of 217 students at two schools found an association with a general decrease in motor skills, spatial working memory and attention in the school with higher levels of radiation from base stations (Meo, et al. 2018). This dose-response sensitivity was also evident near base stations in Austria, where, of 336 residents, in the highest exposure category 79% reported headaches and 76% concentration difficulties (Hutter, et al. 2006); these and five other health effects, cold hands or feet (62%), sweating (40%), palpitations (38%), vertigo (32%) and loss of appetite (24%), all showed increased incidence for each higher exposure level. The difficulty of attributing effects may explain how 70% of 587 students complained of headaches whereas only 6.8% related these directly to mobile phone use (Szyjkowska, et al. 2005). Another study implied that up to 40% of adults may have subconscious sensitivity owing to their chronic inflammatory or immune conditions, based on responses by 90% of 64 subjects

(Marshall, et al. 2017). For long-term occupational exposure 51% reported cardiovascular impairments (Bortkiewicz, et al. 2012). Cancer, which can be considered as a symptom of IEI-EMF/EHS, increased from 0.00313 to 0.00767% incidence for 967 persons within 400m of a phone mast after 5 years' exposure, and elsewhere to 0.0129% within 350m, with a 10.5 relative risk for women but only 1.4 for men (Kundi, et al. 2009) perhaps reflecting greater female IEI-EMF/EHS sensitivity. Since it is difficult for an individual to identify the exposure source when symptoms are triggered subconsciously, most surveys based on self-diagnosis do not cover these effects.

Mild forms of self-reported IEI-EMF/EHS are often characterized as specific sensitivities and intolerances to specific EMF devices, typically up to about 30% of the general population. A survey of 2,048 of the general population found 29.3% who were "slightly disturbed" (Schröttner, et al. 2008). Of 1,375 respondents "20.9% of our study population was electrohypersensitive according to our definition" (Mohler, et al. 2010), although other authors would define "hypersensitive" more narrowly. Some studies in this range overlap the previous, subconscious, category. A study of inhabitants near a base station found a prevalence of 28.2% for the most common symptom associated with exposure and over 20% for 5 other symptoms, compared with none among controls (Abdel-Rassoul, et al. 2007). At this level IEI-EMF/EHS is usually seen in a dose-response relationship to the EMFs and is often called 'intolerance' or 'sensitivity', but not 'hyper-sensitivity'.

Moderate levels of conscious reactions are more often described as 'hyper-sensitivity' or IEI-EMF/EHS. These are typically found in about 5% or under of the population. Among 2,048 Swiss respondents, 5% were classified as 'EHS' (Schreier, et al. 2006). "Intolerance" to EMFs was used for 2.7% of 3,406 Swedish and 1.6% of 1,535 Finnish respondents (Karvala, et al. 2017). Moderate and severe forms of IEI-EMF/EHS can be non-linear in the relationship of the severity of symptoms and the exposure, rather than dose-response as in mild and subconscious forms.

Severe forms of IEI-EMF/EHS, below the 1.5 - 5.0% of the general population with moderate symptoms, are most likely to lead to restrictions on access to work. Here it is suggested that these severe symptoms are found in about 1.2 % of the general population, based on a mean from the range 0.58 - 2.3 % (Table 1), or 33% of people with moderate IEI-EMF/EHS, averaged at 3.6%, as having a severe form. One study argued that "The results show that very electrosensitive people do exist and are more common in groups reporting EHS", and that while 2% of the general population were "very sensitive individuals", "more than 11% of the EHS persons were classified as very sensitive" (Schröttner, et al. 2007). Here it is also suggested that about a half the people with severe IEI-EMF/EHS, at 0.65% of the general population, based on a mean for the range 0.19 – 1.44% (with 2.4% as an outlier) face restrictions in access to work (Table 1).

(ii) Three stages in the progress of IEI-EMF/EHS: the condition of IEI-EMF/EHS often develops over the years, starting with mild and occasional sensitivity to a single device, but moving into moderate or severe hyper-sensitivity to many sources of EMFs. IEI-EMF/EHS was divided into three stages by A.G. Panov and N.V. Tyagin in 1966 (Petrov, 1970). Its progression is considered non-linear, since adaptive immunological reactions can restore a limited degree of homeostasis in mild forms of IEI-EMF/EHS, as shown in markers for chronic stress reactions (Buchner, et al. 2011), where cumulative effects of Wifi and cordless phones were sometimes seen as reinforcing the phone mast effects. The term 'electromagnetic hyper-sensitivity' is usually reserved for the final and most severe stage, with more frequent and more intense reactions (Hecht, 2012). Only a few surveys have attempted to differentiate the three stages of IEI-EMF/EHS, but some have distinguished between the lengths of EMF exposure (Baliatsas, et al. 2012), or found that most people with IEI-EMF/EHS reported that their "hyper-sensitivity started after high-dose or long-term EMF exposure" (Gruber, et al. 2018).

(iii) The prevalence and severity of IEI-EMF/EHS compared with visual impairment: the variations in prevalence and severity of IEI-EMF/EHS can be paralleled in some respects with visual impairment and loss (Table 3). About 25% of children suffer visual impairment in the form of myopia, usually corrected with glasses (Williams. et al. 2015), while some 30% of the population has limited sensitivity to a specific EMF device, which they may be able to avoid. About 3.0% of the population suffers visual loss, while a mean of about 3.6% of the population suffers IEI-EMF/EHS with moderate severity. About 0.54% of the population is registered blind or partially sighted (UK NHS, 2018), while 0.65% of the population is estimated here as restricted in access to work because of IEI-EMF/EHS (Table 1).

Table 3: Comparison of the prevalence and severity of (a) IEI-EMF/EHS and (b) Visual Impairment and Visual Loss

	(a)IEI-EMF/EHS Sub-conscious effects[1]	IEI-EMF/EHS Mild symptoms [2]	IEI-EMF/EHS Moderate symptoms (estimated mean)[3]	IEI-EMF/EHS Severe symptoms (estimated mean)[4]	IEI-EMF/EHS Restricted work (estimated mean)[5]	(b) Visual Impair-ment: Myopia (children)[6]	Visual Loss [7]	Visual Loss: Registered blind or partially sighted [8]
Percentage (general population)	79	29	3.6	1.2	0.65	25	3.0	0.54
Number (UK, 67 million)	52,930,000	19,430,000	2,412,000	804,000	435,500	16,750,000	2,000,000	360,000

[1]Long-term exposure at high levels > 0.5 mW/m^2 [= > 500microW/m^2] (Hutter, et al. 2006).
[2](Schröttner, et al. 2008).
[3,4,5]Table 1.
[6](Williams, et al. 2015).
[7](UK NHS, 2018).
[8](UK NHS, 2018).

Temporal changes in the prevalence of (i) IEI-EMF/EHS and (ii) restrictions in access to work

(i) Temporal changes in the prevalence of IEI-EMF/EHS: A temporal change in prevalence with a reduction in perceived symptoms of sensitivity is evident from the two Taiwan surveys, unless it depends on different definitions: from 13.3% in 2007 (Hedendah, Let al. 2015), it fell to 4.6% by 2012 (Huang, et al. 2018). This was also true in the UK, where it fell from 11% of 3,600 respondents with "some sensitivity" in 2004 (Mild, 2004) to 4% in 2007 (Eltiti, et al. 2007). In contrast, Swedish prevalence remained at 3.1 or 3.2% from 1999 to 2007 (The Swedish National Board of Health. 2009. p.192), although another Swedish survey gave 1.5% in between in 2002 (Hillert, et al. 2002).

If correct, a fall may reflect a variety of factors, such as societal attitudes to wireless radiation, including dependence on, and addiction to, devices, as well as possible psychological or physiological adaptation over the time between surveys, along with differences in the surveys themselves. It does not appear that conscious sensitivity has developed to the 50% extrapolated for 2017 (Hallberg, et al. 2006). However, a fall may also reflect an increased acceptance among the general population of ill health as normal, for instance, frequent insomnia, tinnitus or headache. A survey of 526 of the Austrian general population found that 24% would accept a higher health risk from new technologies for the "increased comfort they provided" (Schröttner, et al. 2008). Since the symptoms are also seen as results of aging, this evidence of general worsening health has led IEI-EMF/EHS to be described as the "Rapid Aging Syndrome" (Havas, 2013).

(ii) Temporal changes in the prevalence of restrictions in access to work for people with IEI-EMF/EHS: There is limited evidence at present whether the prevalence in restrictions in access to work for people with IEI-EMF/EHS is changing. In the UK survey of 36 cases of people with IEI-EMF/EHS, there appeared to be an increase in numbers of cases after 2004, where cases triggered in each quinquennial period were: 1991-95: 3; 1996-2000: 6; 2001-05: 4; 2006-10: 11; 2011-15: 12 (Supplementary Data). This could reflect the growing use of mobile phones and Wifi from about 2004, but may be an artefact. A 2009-15 general survey (Hojo, et al. 2016) showed people with IEI-EMF/EHS facing work restrictions about 7.5 times higher than a survey in 1997 (Hillert, et al. 2002), and a prevalence of IEI-EMF/EHS of 4.59% compared with a similar survey from 2004 of 4.0% (Eltiti, et al. 2007). On the other hand, if more employers make the necessary adjustments, then restrictions on access to work may be decreasing. This could be offset, however, by more people suffering from IEI-EMF/EHS. Countries adopting long-term exposure guidelines like EUROPAEM 2016 (Belyaev, et al, 2016) could also see a reduction in both IEI-EMF/EHS and restrictions to work. Among 145 Finns unable to work because of IEI-EMF/EHS, avoidance of EMFs removed or lessened symptoms, whereas psychotherapy was useful in only 42% of cases (Hagström, et al. 2013).

Factors behind possible under-reporting of the prevalence of restrictions in access to work

A number of socio-economic factors may help explain why this area of public health has not received greater attention in the literature so far. In addition to any temporal changes, the following factors may be relevant to under-reporting.

(i) Gender difference: a gender difference was found with a factor of 0.77 in sensitivity to ELF currents, where 4.2% women and 1.7% men were very sensible, and 0.6% women and 1.2% men very insensible, and women also had a larger range for perception thresholds than men, 15 times below the mean, compared with 8 for men (Leitgeb, et al. 2003). Where IEI-EMF/EHS was found to be 3.2% in Sweden in 2007, the gender differential was 1.2%, based on 3.8 % women and 2.6 % men (The Swedish National Board of Health. 2009. p.192). Since in some cultures female employment has in the past been socially less the norm than male, unemployment in severe cases may have been under-reported where women predominated.

(ii) Difficulty in diagnosing adults with IEI-EMF/EHS: It is often difficult to identify IEI-EMF/EHS and to link EMF exposure with health effects which restrict access to work. In one case a physician with 25 years' experience spent nine months researching before he discovered that he had developed IEI-EMF/EHS (Eberle, 2014). Three out of the four cases in another study showed that it took from 3 to 17 years to identify EMF exposure as a cause of symptoms (Genuis, 2008). Another case (#3, UK survey 2019; Supplementary Data) took 14 years to discover that the cause of her varied symptoms was probably IEI-EMF/EHS; in fact, of the 34 individual adults in this survey, 7 (21%) were graduates of Oxford or Cambridge universities, an unusually high proportion given that these graduates form under 1% of the UK's adult population. In another study 50% of people considered IEI-EMF/EHS had the equivalent of university education compared with 11% of others (Schröttner, et al. 2008), while of 107 with IEI-EMF/EHS, 27.3% were classified as having 'high' education compared with 12.2% as 'low' (Schreier, et al. 2006). No known psychological or neurological factors explain this preponderance towards higher education. Instead, it may reflect the intellectual challenge of linking unseen radiation with ill health, especially given the shortage of information about IEI-EMF/EHS in some medical literature and in some official sources. In Japan it was reported that in 2012 only 1% of the general population had heard of IEI-EMF/EHS (Hojo, et al. 2016). This difficulty of diagnosis may also explain under-reporting in some studies on IEI-EMF/EHS based on self-diagnosis.

(iii) Difficulty in diagnosing children with IEI-EMF/EHS: It can be especially difficult to diagnose IEI-EMF/EHS as the cause of symptoms among children. In one case it took 10 years for physicians and therapists to establish that the child had IEI-EMF/EHS (case 1, Hedendahl, et al. 2015), suggesting that there may be significant under-reporting for children, who need adjustments to prevent restriction or exclusion from their school work situations.

(iv) Difficulty in differential diagnosis of IEI-EMF/EHS and MCS: During the ten years before a survey in 2012-15, IEI-EMF/EHS became the second most common trigger for Multiple Chemical Sensitivity (MCS) at 26.9%, with 17.1% affected at home and 11.7% at work or school, after construction and renovation (35.1%), whereas it did not feature at all in a survey of 1999-2003 (Hojo, et al. 2018). This link between IEI-EMF/EHS and MCS matches earlier findings (Rea, et al. 1991; Belpomme, et al. 2015), but can make diagnosis difficult, where MCS is a better known and more prevalent environmental intolerance.

(v) Difficulty in differential diagnosis of IEI-EMF/EHS and cancer: markers for some cases of IEI-EMF/EHS, such as genetic haplotypes (De Luca, et al, 2014) and chronic inflammation and oxidative stress (Irigaray, Caccamo, et al. 2018), are also linked with cancers, a common health outcome among many people with IEI-EMF/EHS, related by dose-response to exposures (Kundi, et al. 2009) and supported by WHO's IARC 2B possible human carcinogen classification, making a differential diagnosis often problematical.

(vi) Enforced relocation: some people with IEI-EMF/EHS have felt forced to move to remote areas (Evans, 2017), or even emigrate from their country of birth to seek an environment with less wireless radiation. This makes it difficult to document their removal from a particular employment.

(vii) Perceived shame: people with IEI-EMF/EHS often feel shame and are reluctant to admit their situation, especially when they have been made redundant or dismissed from employment (Eberle, 2017). They see themselves as failing their family by being unable to earn money to support them and also by preventing their family from having the same wireless environment as other people. As a result they are often unwilling to complete surveys and thus they remain hidden from statistics.

(viii) Denial because of ridicule, dismissal, and the fear of involuntary incarceration: where the person with IEI-EMF/EHS has been verbally ridiculed by their employers and peers, or dismissed unsympathetically by their physician, or detained against their will in a psychiatric unit, the perceived danger of further ridicule, dismissal, and involuntary incarceration can lead to a state of denial (Crumpler, 2017). This can make them refuse to admit their actual health condition to themselves or to others. Such people often actively avoid all surveys in their refusal to be labelled as having IEI-EMF/EHS.

(ix) Helplessness syndrome: people with severe cases of IEI-EMF/EHS are prone to developing helplessness (Hecht, 2012). Because they cannot change their situation, they develop depression and other psycho neuroimmunological disorders. This can lead to under-reporting of the original condition which triggered their helplessness.

(x) Mortality ending work: in cases where death was concurrent with, or subsequent to, IEI-EMF/EHS, the referent may not be recorded as losing employment or 'work' because of their IEI-EMF/EHS. In one survey, three people with IEI-EMF/EHS died, one from a brain tumour and two from suicide (UK survey, 2019, Table 2; Supplementary Data), but such cases are not always recorded as relating to work.

(xi) Financial reward and legal 'gagging' clauses to end employment of people with IEI-EMF/EHS: some employers have paid employees with IEI-EMF/EHS to terminate their work (Aschermann, 2011). According to verbal reports, some people with IEI-EMF/EHS in the UK have been subject to "gagging" clauses requiring secrecy in the financial settlement ending employment because of their IEI-EMF/EHS. Such cases cannot, by their nature, appear in published surveys.

(xii) Secondary unemployment: few if any surveys include secondary unemployment caused by IEI-EMF/EHS. In such cases people are kept from employment because they are required to care full time for the needs of a close relative or friend suffering from IEI-EMF/EHS (Granlund-Lind, et al. 2004).

Adjustments enabling access to work

In some countries it appears that people disabled by IEI-EMF/EHS experience a higher rate of restrictions on access to work than people with other disabilities. In 2012 in the UK there were 30.1% fewer disabled people in work compared with non-disabled (UK Government, 2014). A Swedish survey (Hillert, et al. 2002) found that 175% more people with IEI-EMF/EHS were unemployed compared with others, 103% more on early retirement or disability pension, and 56% more on sick leave.

One factor behind this higher rate may be that, for people with IEI-EMF/EHS, there is a greater range in the severity of functional impairment between mild and severe cases than in some other disability groups. Therefore, within the overall figure of people with IEI-EMF/EHS, the proportion of very severe cases is likely to be higher. This matches the small surveys limited to often severe cases of IEI-EMF/EHS, where half gave 50-67% out of work (Table 2).

Some countries recognise IEI-EMF/EHS as a specific functional impairment, such as Sweden from 2000, Canada, and the USA under its Americans with Disabilities Act. Governments, local authorities and employers are required to ensure health and equality of access to workplaces, in addition to accommodation and transport (Johansson O, 2015). Some countries have suggested ideas for accommodation to enable people with IEI-EMF/EHS to continue working (US Department of Labour, 2015). Biological guidelines, such as EUROPAEM EMF Guidelines 2016 (Belyaev, et al. 2016), are applicable to workplaces with people suffering from IEI-EMF/EHS, who need low-level and long-term limits. Where an employee suffers initial symptoms of IEI-EMF/EHS, however, lengthy delay in making adjustments can worsen the condition, as in one case where it took the employer two years to make the necessary adjustments, during which time the employee developed hyper-sensitivity, something which might have been avoided if the employer had reacted promptly (case 3, Hedendahl, et al. 2015).

Conclusions

There is a variety of evidence, both from surveys of the general population and from surveys limited to people with IEI-EMF/EHS, establishing that people with IEI-EMF/EHS, especially in

a severe form, can face restrictions in access to work. Surveys have shown that, in addition to subconscious symptoms for up to 79% of the general population, the numbers of people with IEI-EMF/EHS typically range between 5.0 and 30 per cent of the general population for mild cases, 1.5 and 5.0 per cent for moderate cases, and under 1.5 per cent for severe cases. From such surveys it can be deduced that the average prevalence of people with severe IEI-EMF/EHS who are restricted in access to work is in the region of 0.65% of the general population, at about 18% of the general population having moderate IEI-EMF/EHS. The estimate of 0.65% equates to 435,500 people in the UK's population of 67 million. Further surveys and more accurate diagnosis are necessary to confirm these numbers, but over 150 subjects in the general population are needed to ensure that a survey is likely to identify at least one such person. When the necessary adjustments are made, some people even with severe IEI-EMF/EHS can continue to work, suggesting that the percentage facing restrictions could fall once employers are aware of what is needed.

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Supplementary Data: Survey of people with IEI-EMF/EHS facing restrictions in access to work in the UK (n = 36).

Case Number; Source	Demographics: M/F; <18, 18-65, >65	Original Work Status: Employed, Self-employed, School/Student/Carer	Work Outcome: Continued, Adjustments, Left/Retired early	Graduate of Oxford or Cambridge	Year
1 a	M 18-65	Self-Employed	Left/Retired		1990s
2 b	M 18-65	Employed	Continued	Yes	1993
3 c	F 18-65	Self-Employed	Left/Retired		1994
4 d	F 18-65	Employed	Left/Retired		1999
5 e	F 18-65	Employed	Left/Retired		1990s
6 f	F 18-65	Employed	Left/Retired		c.2000s
7 g	M 18-65	Employed	Adjustments		2000
8 h	F 18-65	Employed	Left/Retired		2000
9 i	18-65	Employed	(Continued)		2000
10 j	F 18-65	Employed	Left/Retired		2003
11 k	M 18-65	Student	Left/Retired		2004
12 d	M 18-65	Employed	Left/Retired		2004
13 l	M 18-65	Employed	Left/Retired		2004
14 m	M 18-65	Employed	Adjustments	Yes	c.2006
15 n	M 18-65	Employed	Adjustments	Yes	2006
16 o	F 18-65	Employed	Left/Retired		2007
17 p	F 18-65	Employed	Left/Retired		2007
18 q	M 18-65	Employed	Left/Retired		c.2007
19 d	M 18-65	Employed	Left/Retired		2008
20 b	F 18-65	Self-Employed	Adjustments		2008
21 r	F 18-65	Employed	(Left/Retired)	Yes	c.2008
22 s	M 18-65	Employed	Left/Retired		2009
23 t	M 18-65	Self-Employed	Adjustments		c.2009
24 u	F 18-65	Parent-carer	(Continued)	Yes	c.2010
25 j	F 18-65	Employed	Left/Retired		2011
26 a	F 18-65	Employed	Left/Retired		2011
27 v	F <18	School pupil	Left/Retired		2011
28 d	M 18-65	Self-Employed	Adjustments		c.2012
29 w	M 18-65	Self-Employed	Suicide	Yes	2012
30 a	F 18-65	(Employed)	(Left/Retired)	Yes	2012
31 x	F <18	School pupil	Suicide		2012
32 y	M 18-65	Employed	Left/Retired		c.2012
33 z	M 18-65	Self-Employed	Left/Retired		2013
34 aa	M 18-65	Employed	brain tumour		<2016
35 bb	M >65	Self-Employed	(Left/Retired)		2015
36 cc	F 18-65	Employed	Left/Retired		2015
Totals	F: 17	Employed: 24	Continued: 3	Oxbridge: 7	1991-95: 3
	M: 18	Self-Employed: 8	Adjustments: 6	(21% of 34)	1996-2000: 6
	<18: 2	School pupil: 2	Left/Retired: 24		2001-05: 4
	18-65: 33	Student: 1	Brain tumour: 1		2006-10: 11
	>65: 1	Parent-carer: 1	Suicide: 2		2011-15: 12

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