Review Article

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Electromagnetic hypersensitivity close to mobile phone base stations – a case study in Stockholm, Sweden

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Abstract: A previously healthy worker developed symptoms assigned to electromagnetic hypersensitivity (EHS) after moving to an office with exposure to high levels of anthropogenic electromagnetic fields (EMFs). These symptoms consisted of e.g. headache, arthralgia, tinnitus, dizziness, memory loss, fatique, insomnia, transitory cardiovascular abnormalities, and skin lesions. Most of the symptoms were alleviated after 2 weeks sick leave. The highest radiofrequency (RF) field level at the working place was 1.72 V/m (7,852 μW/m^2). Maximum value for extremely low frequency electromagnetic field (ELF-EMF) from electric power at 50 Hz was measured to 285 nT (mean 241 nT). For electric train ELF-EMF at 16.7 Hz was measured to 383 nT (mean 76 nT). Exposure to EMFs at the working place could be the cause for developing EHS related symptoms. The association was strengthened by the symptom reduction outside the working place.

Keywords: electromagnetic hypersensitivity; EMF; radiofrequency radiation; symptoms.

Introduction

Exposure to extremely low frequency (ELF) electromagnetic fields (EMF) and radiofrequency (RF) EMF is in most cases involuntary and unknown to people. Both ELF-EMF and RF-EMF have been evaluated by IARC to be possible human carcinogens, Group 2B [1–3]. In fact EMFs should be regarded to be environmental pollutants that do not smell, have no taste and are invisible.

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Already in the 1970s the 'microwave syndrome' was described in the former Soviet Union [4]. Persons working with radar or radio equipment reported symptoms of fatigue, headache, dizziness, disturbed sleep, concentration and memory problems.

In the 1980s similar symptoms were reported among Swedish persons working in front of cathode ray tube monitors [5]. In Finns such symptoms were attributed to exposure to EMF [6]. This syndrome was termed electromagnetic hypersensitivity (EHS), although still without an International Classification of Diseases (ICD-code) [7].

EHS consists of a wide range of different symptoms that may vary from person to person. EMF sensitivity varies among individuals from mild to severe. The prevalence has been reported to be 1.5% in Sweden [8], 3.2% in California [9], 5% in Switzerland [10], and 13% in Taiwan [11].

We report here on a person who developed symptoms consistent with those described among EHS subjects. The symptoms developed at a work place with exposure to EMFs. Our hypothesis is that the symptoms may be attributed to that exposure. We obtained informed consent by the person to publish the symptoms and work history anonymously.

Methods

The subject attributed the development of EHS symptoms to her office room where she had been working one year since April 2018 for a total of 183 working days. As the source of the adverse health effects was unknown, the investigators devised a broad spectrum approach for EMF measurements, to include all possible sources of EMFs.

The room was thoroughly measured encompassing different types of electromagnetic fields, including:

- Extremely low frequency (ELF) magnetic field (MF)
- Intermediate frequency (IF) magnetic field (MF)
- Radiofrequency (RF) electromagnetic field.

Three types of measurements approaches were utilized characterizing:

- Spatial field distribution
- Temporal field dynamics
- Spectrum analysis of EMF

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Spatial field distribution was done by conducting spot measurements across the room at evenly distributed locations. At each location the field was scanned in circular movements encompassing a one square meter area at the height of 0.7–2 m. Broadband field meter was used for spot measurements to account for any frequency in the monitored electromagnetic field type.

Spot measurement data, were fed to the contour map software 3DFIELD ver. 4.5.2.0 (by Vladimir Galouchko) and spatial field distribution maps were drawn.

Temporal field dynamics were investigated by using exposimeters. The meters were positioned at the location of the subject at the workstation and logging commenced for 40 min period. Electromagnetic fields spectrum was also measured using the same exposimeters with the frequency band discriminating function.

Measurement devices

Extremely low frequencies were investigated using broadband frequency selective electromagnetic field meter NFA400 by Gigahertz Solutions (Langenzenn, Germany). This meter is capable of simultaneous measurements of 6 frequency bands: (1) 16.7 Hz, (2) 50 Hz, (3) 100 Hz, (4) 150 Hz, (5) <2 kHz excluding the aforementioned, 6) >2 kHz. The frequency range covered: 5 Hz to 400 kHz. Measurement range for magnetic flux density is 1 nanoTesla (nT) to 20 microTesla (μT) and for electrical field strength 0.1–1999 Volt per meter (V m^{-1}).

Both magnetic and electric fields can be measured by the meter. The meter is a three-axial meter for magnetic field, capable of measuring all three axes separately and calculating the resultant field. The measurements are taken in tRMS (true Root Mean Square) mode. In exposimeter setting, logging 3D magnetic field was done at 0.1 s sampling rate.

Radiofrequency spatial mapping was done using RF broadband meter Narda NBM-520, with an E-field probe E0391 (Narda-Safety-Test-Solutions GmbH, Pfullingen, Germany). This Narda NBM-series meter is capable of time and spatial averaging and determining the maximum level during the period monitored. Narda EF0391 probe is produced by the manufacturer for base station measurements and has a frequency range from 100 kHz to 3 GHz, measurement range of 0.2–320 V m^{-1}.

Radiofrequency temporal dynamics and dominant frequencies were determined by using exposimeter EME SPY200 by Satimo. This exposimeter measures 20 predefined frequencies covering the frequencies of most public RF radiation emitting devices. The exposimeter covers frequencies from 87 to 5,850 MHz and measures different telecommunication protocols: FM radio broadcasting; TV broadcasting; TETRA emergency services (police, rescue, etc.); GSM second generation mobile communications; UMTS third generation mobile communications, 3G; long-term evolution (LTE) fourth generation mobile communications standard, 4G; digital European cordless telecommunications (DECT) cordless telephone systems standard; Wi-Fi 2.4 GHz and 5 GHz wireless local area network protocol; worldwide interoperability for microwave access (WiMAX) wireless communication standard for high-speed voice, data and Internet

For frequency modulation (FM), TV3, TETRA, TV4&5, Wi-Fi 2.4 GHz and Wi-Fi 5 GHz, the lower detection limit is 0.01 V m^{-1} (0.27 μW/m^2). For all other bands, the lower detection limit is 0.005 V m^{-1} (0.066 μW/m^2). For all bands, the upper detection limit is 6 V m^{-1} (95,544 μW/m^2). The sampling time used in this study was 4 s which is the fastest for the given exposimeter.

Next to measurements visual observations were conducted to identify openly detectable EMF sources near the investigated premises. Also the distance to the EMF sources was determined by visual assessments.

Conversion from V/m *to* W/m^2

In most of our earlier studies [12–17] we have used the EME Spy 200 from Satimo and preferred to show our results in power flux density in W/m^2 and μW/m^2 for RF radiation. In the current measurements the broadband analyzer Narda NBM-520 measures in V/m and the contour map software 3DFIELD is also constructed for measurements in V/m.

To convert from electric field strength, **E**, in V m^{-1} to power flux density in W/m^2, **S**, use the formula: $\mathbf{S} = 0.002654 * \mathbf{E}^2$.

To convert from power flux density in W/m^2, **S**, to electric field strength, **E**, in V m^{-1}, use the formula: $\mathbf{E} = 19.41 * \sqrt{\mathbf{S}}$.

The aim of the study was to assess the EMF levels at this work place and if they could be related to the symptoms of EHS in this individual.

Results

Case report

A 55 year old previously healthy female office worker changed her work place in April 2018. She had worked in the same building for almost 10 years but at another location. After 3 months job in another place she returned to this building, but this time to another office at the 6th floor close to base stations on the roof. In the surrounding 4G was installed a couple of years before her return. She had full time work in the office. At the previous working place she had no health problems.

During the following months after she had changed office she experienced increasing health problems. She attributed the symptoms to the working place, as the symptoms diminished while being away from the premises and reappeared and increased when back.

She experienced continuous heavy headache during the week, pain in the chest, shortness of breath, cough, fatigue, dizziness, uncontrolled movements of the body, low blood pressure (e.g. 86/57 mmHg), palpitations with rapid heart rate (e.g. 140–145) including fainting at one occasion. She had sensations of 'fever' in the head but not in the body. All these symptoms initially started at work and were aggravated over time including nose bleeding at the work place. She noticed loss of hair on the head and on eyebrows.

This person had never had skin problems, her skin was visually extremely healthy. Now she felt tenderness, burning and itching on the scalp, face and the body. She noticed leathery, exfoliating skin in the face; the skin

Table 1: Clinical symptoms graded 0–10; 0=no symptoms, 1=mild, 10=unbearable pain and/or discomfort. Percentages in parentheses represent frequencies in a survey on 100 patients by Belpomme et al. [18].

Symptoms	Office	After 2 weeks sick leave
Headache	8 (88%)	3
Dysesthesia	0 (82%)	0
Myalgia	3 (48%)	1
Arthralgia	7 (30%)	5
Ear heat/otalgia	2 (70%)	0
Tinnitus	9 (60%)	1
Hyperacousis	0 (40%)	0
Dizziness	8 (70%)	3
Balance disorder	10 (42%)	4
Concentration/attention deficiency	5 (76%)	2
Loss of immediate memory	9 (70%)	7
Confusion	2 (4%)	1
Fatigue	9 (88%)	5
Insomnia	8 (74%)	7
Depression tendency	1 (60%)	1
Suicidal ideation	0 (20%)	0
Transitory cardiovascular abnormalities	10 (50%)	3
Ocular deficiency	2 (48%)	2
Anxiety/panic	0 (38%)	0
Emotivity	2 (20%)	1
Irritability (irritabel)	1 (24%)	0
Skin lesions	10 (16%)	5
Global body dysthermia	0 (14%)	0
Lungs	5	1
Stomach	7	2
-Diarrehea (involuntary)	3	0
-Pricking, burning inside body	9	0
Skin (face, arms, legs)	10	6
-Burning, lancinating skin on hands and arms	7	0
Nose bleeding	7	0
Blood pressure	10	3
Anemia	8	Not evaluated
Hair loss	3	3
Mouth infection	4	3
-Tongue, fungus	10	3

seemed to have grown older in short time becoming aged and wrinkled, and had also burning sensations on the arms and hands. She used to wake up around 3 o'clock in the morning with stomach pain, nausea and sudden vomiting.

She noticed 'vibrating and pulsing' eardrums with tinnitus and pain in the ears. The short-term memory was impaired and she felt restless like being hyperactive with shaky hands, and in addition concentration difficulties.

It is also noteworthy that she had pain in her joints that tended to swell. Anemia was recorded at a health check by a general practitioner.

In Table 1 the different symptoms while at office in April 2019 and after 2 weeks of sick leave are described. This table is based with some additions on a publication by Belpomme et al. [18] on symptoms in the first 100 patients in their case series. It is noteworthy that for this presented person almost all symptoms declined during sick leave, most notably the most serious health problems. Thus headache, tinnitus, dizziness, balance disorder, cardiovascular problems including low blood pressure and mouth infection improved. Also skin lesions and sensations improved.

All these symptoms have been described in persons with EHS [6, 7, 19]. This person contacted our research team and we judged it to be pertinent to make EMF measurements at her work place. The contact was initiated by her observation of the proximity to the base stations.

The work environment

This person does a regular office job, working with a desktop computer. She is using an ergonomic desk, the height of which can be adjusted by a fitted lifting motor. Hence, the worker can choose to work at the desk either on foot or by sitting on a chair.

The lighting in the room was determined to meet the minimum requirement for office work stations (500 lux). There was no noise in the room, nor other detectable occupational health risks.

The building is fairly new so that noise, vibrations, or impaired air quality would not be expected. Also exposure to e.g. asbestos and radon was excluded. Furthermore, since she had worked in the same building, but at another place, for several years detrimental health effects from such working conditions would already have occurred. All health problems appeared after moving to the current office at the 6th floor of the building close to the base stations.

Measurements

Measurements were conducted on a business day afternoon in April 2019.

Visual observations

The working room where the subject had developed EHS symptoms was located on the 6th floor of a 6-floor office building. The closest mobile phone base station mast with several antennas was positioned right above the subjects workstation, distanced about 4 m away on the roof (see Figure 1).

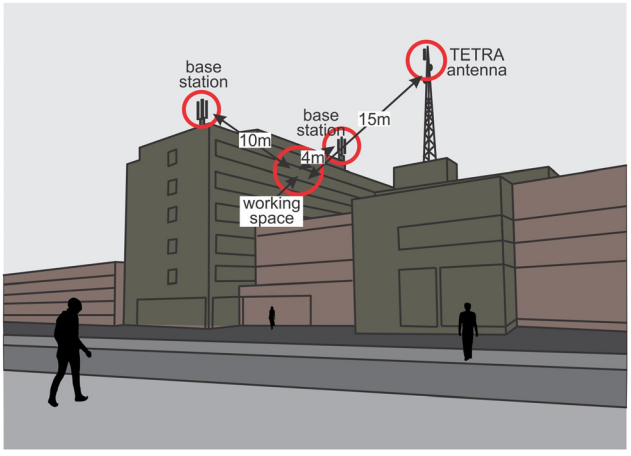


Figure 1: Location of the person's working space with respect to the RF sources indicated by circles.

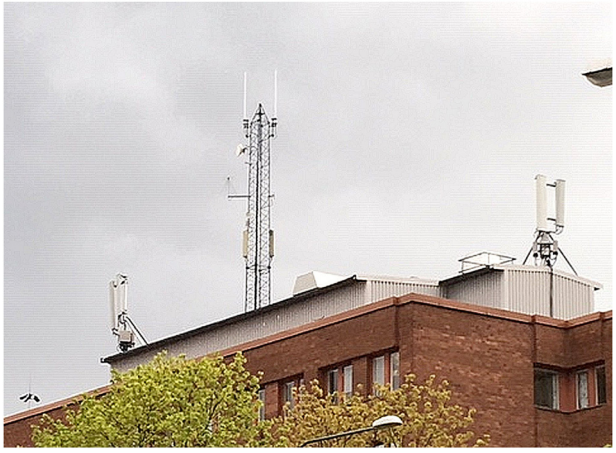


Figure 2: The case study location – several mobile phone base station antennas and TETRA antennas on the roof.

Another mobile phone base station antenna array was positioned 10 m further away on top of the same building. Additionally, a lower radiofrequency communications antenna array (TETRA) was positioned some 15 m away positioned on adjacent wing of the building (see Figure 2).

Radiofrequency spatial mapping

Radiofrequency spatial mapping revealed a strong influence from above installed mobile phone base station. Radiofrequency mobile communications were the highest level type of electromagnetic field in the premises. Field distribution is pictured in Figure 3. The field is not notably higher close to the windows, which indicates that much of the radiofrequency field is penetrating into the room also from other directions, including paths through the walls and ceiling. The RF field level at subjects working position was 1.72 Vm^{-1} (7, 852 $\mu W/m^2$) which happens to be also the highest in the room. The minimum field level in the room was 1.06 Vm^{-1} (2,982 $\mu W/m^2$) and mean 1.21 Vm^{-1} (3,886 $\mu W/m^2$). This illustrates a uniformly exposed room to a high level of radiofrequency fields.

Radiofrequency temporal changes

Radiofrequency temporal changes were assessed based on the exposimeter placed on the subject's workstation (Table 2). The location was at her typical working position. Highest levels were found for LTE 800 DL, GSM + UMTS 900 down load, GSM 800 down load and LTE 2600 DL. These results represent RF electromagnetic radiation from the nearby base stations. Besides base station exposure, other RF sources were quite low and constituted a total mean value of 34.9 $\mu W/m^2$ (excluding down link; DL).

Extremely low frequency magnetic field exposure

Table 3 presents extremely low frequency magnetic field measurements at the subject's work station. 'Edges per hour' column present sharp rise of the measured field intensity. This indicator is used to analyze the number of sudden rising edges in field that can be due to spikes or high frequency transients of the corresponding field. The main frequencies in the room are (1) 50 Hz from electrical power grid and appliances and (2) 16.7 Hz electric train power frequency.

Extremely low and intermediate frequency temporal changes

The main frequency components of magnetic field were assessed with exposimeter total logging time 40 min. The results depict an MF exposure with high amplitude temporal variation. The main fluctuation was because of changing power drain in the railroad power cable due to electric train traffic. MF from power frequency 50 Hz is at stable level with little amplitude variation, indicating a stable consumption of electrical power in the area. MF at frequencies above 2 kHz are at negligent levels and show no abrupt changes over time.

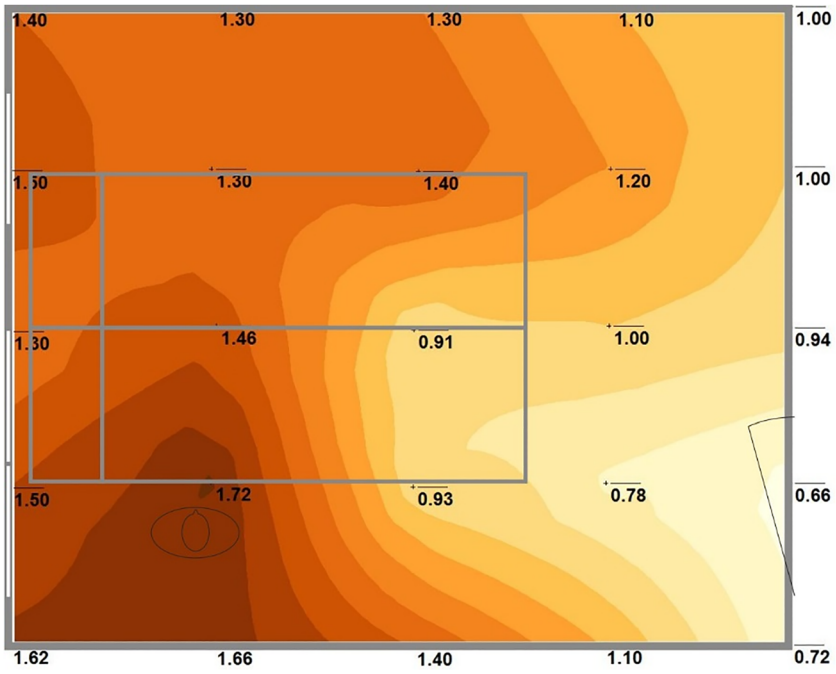


Figure 3: Radiofrequency field distribution in V m^{-1} in the work area; typical position of the person at marked with wireframe at the bottom left of the figure.

Table 2: Analysis of exposimeter data (μW/m^2) treating values at detection limit as 0. Total (n=891).

	Mean	Median	Min	Max
FM	0.8	0.0	0.0	45.5
TV3	0.0	0.0	0.0	0.0
TETRA I	16.3	6.9	0.0	1,520.0
TETRA II	0.0	0.0	0.0	0.4
TETRA III	0.0	0.0	0.0	0.0
TV4&5	1.0	0.0	0.0	40.8
LTE 800 (DL)	132.1	91.8	18.3	1,480.1
LTE 800 (UL)	0.0	0.0	0.0	0.2
GSM + UMTS 900 (UL)	0.0	0.0	0.0	0.4
GSM + UMTS 900 (DL)	269.6	224.6	38.8	1,340.9
GSM 1800 (UL)	16.5	11.9	2.7	175.2
GSM 1800 (DL)	447.6	340.0	114.8	2,506.1
DECT	0.1	0.0	0.0	25.0
UMTS 2100 (UL)	0.0	0.0	0.0	0.4
UMTS 2100 (DL)	32.6	30.9	9.2	113.7
WIFI 2G	0.1	0.0	0.0	4.7
LTE 2600 (UL)	0.1	0.0	0.0	7.7
LTE 2600 (DL)	181.9	136.7	26.0	2,077.5
WIMax	0.0	0.0	0.0	0.0
WIFI 5G	0.0	0.0	0.0	0.0
Total	1,098.7	968.3	423.5	4,183.8
Total excluding DL	34.9	23.2	5.0	1,585.4

Table 3: Magnetic field at work station, time logged exposure over 40 min.

Frequency band	Min	Max	Mean	95th percentile	Edges per hour
5 Hz–400 kHz	135 nT	497 nT	284 nT	319 nT	275/h
16.7 Hz	0 nT	383 nT	76 nT	167 nT	169/h
50 Hz	0 nT	285 nT	241 nT	274 nT	0/h
>2 kHz	0 nT	3.5 nT	1.8 nT	2.8 nT	50/h

Discussion

Within a couple of months, this person developed a series of health problems, after moving to an office with high EMF exposure. These symptoms are typical for persons with EHS [20]. This syndrome has been characterized by fatigue, chronic pain and impaired cognitive function, see the Paris Appeal (http://appel-deparis.com/?lang¼en). This person has all these symptoms in addition to a large number of other health problems as discussed by Belyaev et al. [19].

We will here take some of the symptoms this office worker presented and compare these with published scientific studies showing detrimental effects from ELF-EMF and RF radiation on humans, animals and biological material.

The symptoms may vary from person to person. There are no reliable biomarkers for EHS. In a case series by Belpomme et al. [18] a number of biomarkers were described. The 24 h urine 6-hydroxymelatonin sulfate (6-OHMS)/creatinin ratio was found to be decreased (<0.8) in all investigated cases which might be of interest. It may indicate one reason for the sleep problems in 74% of the

participants, see Table 1. Our case person graded her sleep problems as 8 on the 0–10 scale during her work time in the office and still as 7 during sick-leave and afterwards while working in another office at floor 2. Earlier she had had no sleeping problems at all.

Electroencephalografic (EEG) activity in the brain can be altered by RF radiation. Especially the second non-rapid eye movement (NREM) sleep after 2–3 h sleep was effected when 30 young healthy men were exposed to two different 900 MHz pulse modulated signal 30 min directly before sleep. The 14 Hz pulse modulated condition had a stronger influence on EEG than 217 Hz [21]. Also during the day when awake, RF radiation can have considerable influence on EEG [22, 23]. Pulsed extremely low frequency magnetic field (ELF MF) has been shown to lower the alpha frequency activity over the parietal-occipital regions of the brain [24]. Decreased β-trace protein, which is a key enzyme in the synthesis of a sleep-promoting neurohormone, has been seen in young adults with high-cumulative amounts of hours of mobile phone use [25]. RF radiation showed disturbed glucose metabolism in the brain after 50 min exposure from a mobile phone [26].

Our case person noticed loss of hair on her head and on her eyebrows and was severely affected by a burning sensation from her skin. A study on healthy human subjects showed DNA damage in hair root cells after 30 min of mobile phone talk [27]. A Finnish study showed that proteins in the skin could be affected after RF radiation exposure on the skin [28]. Dermatitis has also been seen near electronic wireless devices like lap tops [29].

Two studies from India have shown how long term, high users of mobile phones can get more micronuclei in oral mucosal cells from the same side as they hold their mobile phone, compared to low users. This indicates a genotoxic effect of RF radiation [30, 31]. Salivary oxidative stress has been seen in mobile phone users with decrease in salivary flow, total protein, albumin and amylase activity [32, 33]. It should be noted that Arbabi-Kalati et al. [33] did not provide details if the study groups were controlled for age and dietary intakes, which are crucial determinants of the antioxidant status. Salivary cortisol can increase after 50 min of RF radiation of GSM 900 MHz [34]. Also thyroid hormones have been effected for people living near mobile phone base stations [35]. A study in Germany showed that the neurotransmitters adrenaline, noradrenaline, dopamine and phenyletylamine increased or decreased after a 900 MHz base station was activated in 2004. The neurotransmitters were not normalized after 18 months especially not in children and chronically ill adults. Several of the 60 participants had got new symptoms like sleep disturbances, headache, dizziness, concentration problems and allergies [36].

In India 40 healthy people living <80 meter from a base station had lowered antioxidant levels and higher frequency of micronuclei in their blood lymphocytes compared to a control group living >300 m from a base station [37].

A study on mice showed that 900 MHz RF radiation exposure delayed wound healing several days in experimentally induced cutaneous candidiasis. The mortality rate also increased in the RF radiation exposed group, probably due to higher yeast loads in skin lesions and systemic infection [38].

Our case person had long lasting problems with candidiasis on her tongue. According to the above studies RF radiation may decrease her immune system defense, increase stress reactions and oxidative stress. Decreased production of melatonin can give sleep problems and has an important role on the antíoxidant system and wound healing [39]. Reduced immune functions, such as natural killer lymphocytes, as well as higher stress levels were reported in women in residencies with high levels of RF EMFs from radio-television broadcasting stations [40].

This case person had severe problems with tinnitus during her work in the office. After two weeks of sick-leave it had almost disappeared. Prolonged use of mobile phones can increase the risk of tinnitus on the same side as the mobile phone is used [41, 42]. There is also a higher degree of hearing loss in high amount users with over 2 h mobile phone talk per day [43, 44]. A study from Turkey showed that DNA damage of hair follicle cells in human ear canal increased with the daily duration of exposure from mobile phones. It was highest in the group that talked more than 60 min per day in their mobile phone [45].

An association between chemicals and EHS is not well studied. Regarding persistent organic pollutants a small study indicated increases concentration of the flame retardant PBDE #47 in EHS persons. This might be of interest since flame retardants have been used in electronic devices such as computer screens [46]. However, we had not information on chemical exposure to the study person.

In this case report certainly the decline or even disappearance of some symptoms during sick leave avoiding EMF exposure in the office might be a diagnostic criteria. The most promising treatment must be avoiding high EMF exposure. Today it is almost impossible to find any environment without any EMF exposure at all.

Although all the measured field levels are within the current safety limits, the working premises were demonstrating elevated exposure levels both to the radiofrequency electromagnetic field and the extremely low frequency magnetic field.

In our paper on long term glioma risk from occupational exposure to ELF MF [47] all the workers were divided

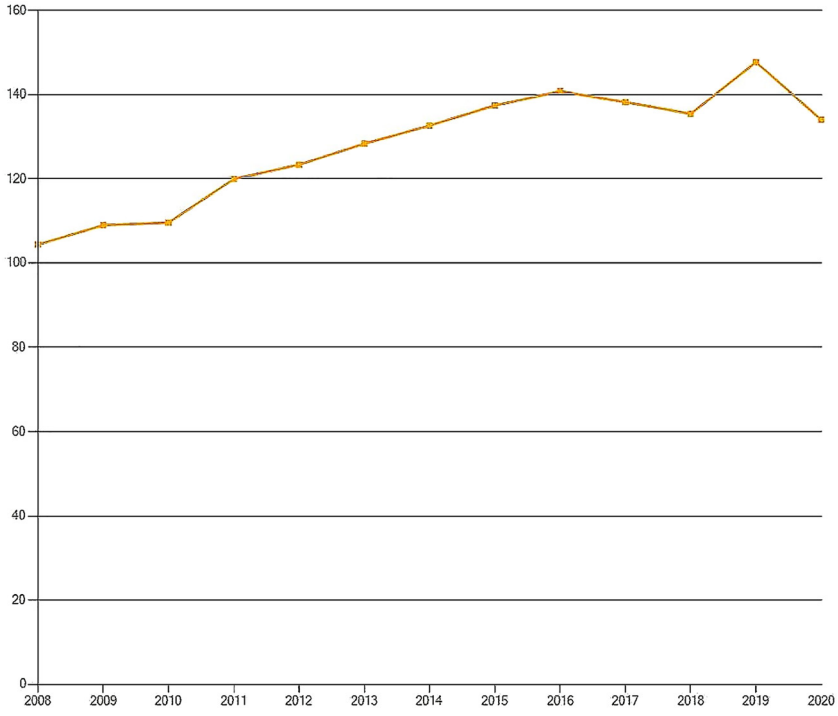


Figure 4: Number of patients per 100,000, both genders combined, diagnosed with myelin damage in CNS, ICD-codes G35-37, according to registers for in-patients and out-patients in Sweden during 2008–2020 (Statistikdatabaser – Diagnoser – Val (socialstyrelsen.se)).

into five groups based on the average exposure level: (1) low exposure group (<0.11 μT); (2) low-medium exposure group (0.11 to <0.13 μT); (3) medium exposure group (0.13 to <0.18 μT); (4) medium-high exposure group (0.18 to <0.27 μT) and (5) highly exposed workers group (≥0.27 μT). Odds ratio (OR) 1.3, 95% confidence interval (CI) = 1.003–1.6 for glioma risk was found for average exposure ≥0.27 μT.

In the current study, the mean exposure level to extremely low frequency magnetic field at the subject's workstation was determined to be = 0.284 μT, which places the person into highly exposed workers' group in our study [47].

This person was in December 2021, much improved and is working full time at another office in the same building. The visible properties are similar to her previous office. There are no known problems with mold, dust or fabrics and the cleaning is similar in the whole building. However, she experiences some numbness, tremor and tingling in her extremities, especially fingers and toes, almost on a daily basis. The reason for those symptoms is unclear. RF radiation has been associated with neuron damage [48] including myelin damage [49].

Register data without personal identification is available in Sweden for hospital discharges and out-ward specialists (Statistikdatabaser – Diagnoser – Val (socialstyrelsen.se)). We report numbers per 100,000 inhabitants for both genders combined. Age-standardized rates are not available in the registre. We found a clearly increasing number of patients per 100,000 diagnosed with myelin damage, ICD codes G35-37, during 2008–2020, Figure 4. Also for diseases of basal ganglia and movement disorders, G20-26, the numbers increased during the same time period, Figure 5. Note that data for 2020 are less reliable due to lag time for reporting to the register. The register started in 2008 and it should be considered that registration has improved over the years. Thus, the trends must be evaluated with caution, but indicate anyhow increasing rates.

Conclusions

This investigation established three possible reasons for developing health symptoms associated with the EMF exposure, including the following.

(1) The working room was right below the mobile phone base station antenna, located on the roof of the building. The close proximity to these antennas caused significantly high RF radiation exposure in the working area.
(2) The working room is also positioned close to lower radiofrequency transmitter (TETRA emergency services), located on the neighboring roof of the same building.
(3) The working room was positioned within 20 m from the electric train railroad. 16 Hz magnetic field from the railroad power cable was on some instances the

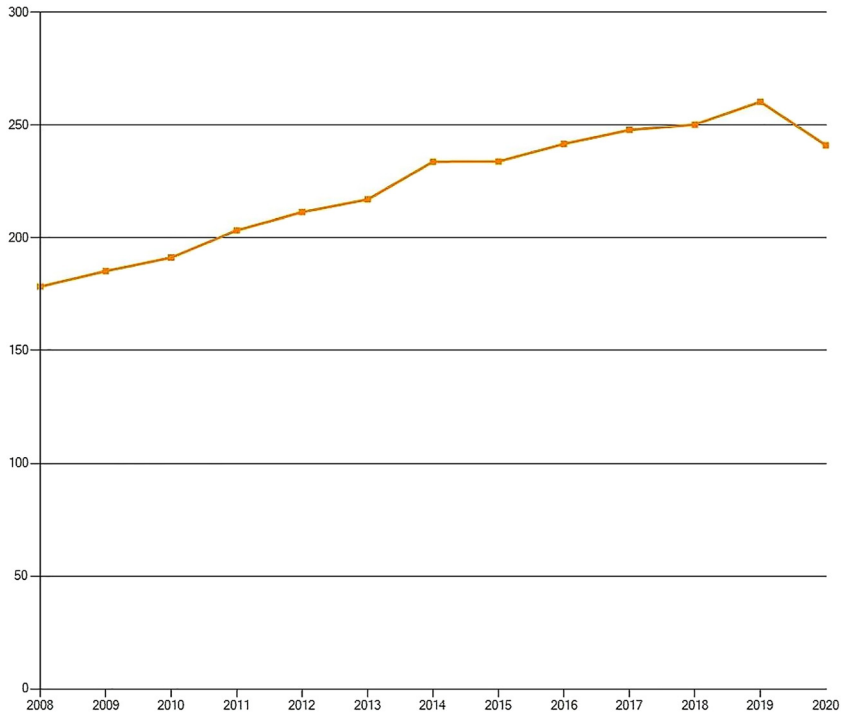


Figure 5: Number of patients per 100,000, both genders combined, diagnosed with diseases of basal ganglia and movement disorders, G20-26, according to the in-patient and out-patient registers during 2008–2020 (Statistikdatabaser – Diagnoser – Val (socialstyrelsen.se)).

highest ELF MF component in the room, exceeding even the power grid 50 Hz MFs. Also, railroad power cable induced a fluctuating magnetic field in the office due to the coming and passing electric trains. As trains come and go, this introduces a change in the electric power supplied by the railroad electric cable. Consequently the magnetic field also changes in great amplitude.

In conclusion, there are at least three types of electromagnetic fields present in the working room, which cause a long term exposure to the workers. Exposure to multiple source electromagnetic fields could be the cause for developing EHS related symptoms. However, the person had been exposed to ELF-EMF also at other locations in the building, so exposure to RF-EMF seems to be the most probable cause to her developed health problems.

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Competing interests: Authors state no conflict of interest.
Informed consent: Informed consent was obtained by the study person for anonymous publication.
Ethical approval: Not applicable.

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