

produce symptomatic responses in a putatively hypersensitive subject while appropriately controlling for chance, confounders, and somatization.

METHODS

Subject

In the context of ongoing human, animal, and biophysical studies involving EMF sensory transduction in our laboratory, we were contacted by a 35-year-old female physician with multiple neurologic and somatic symptoms including headaches, hearing and visual disturbances, subjective sleep disturbances and non-restorative sleep, and musculoskeletal complaints, all of which she reported could be precipitated by exposure to environmental EMFs and abated by withdrawal from the fields. Among the environmental triggering sources she identified were cell phones, computers, powerlines, and various common electrical devices. During extensive interviews she credibly explained the reasons for her belief that EMFs from common environmental sources could provoke her symptoms.

After she agreed to medical tests appropriate for evaluating her medical condition, she was admitted as a patient on the neurology service and underwent a physical exam including a comprehensive neurologic exam, a clinical electroencephalogram (EEG) exam, a noncontrast magnetic resonance (MR) imaging of the brain, an overnight sleep study (with video and expanded EEG montage) in which the resulting polysomnogram was scored in accordance with standardized rules (American Academy of Sleep Medicine, 2007), a standard laboratory evaluation of serum electrolytes and blood chemistries, liver function tests, serum fasting cortisol, and complete blood count, and direct evaluations of her EMF sensitivity in a series of EMF provocation and behavioral studies (see below). The institutional review board at the LSU Health Sciences Center approved all experimental procedures, and the subject gave her written informed consent.

EMF Exposure

The subject sat in a comfortable wooden chair with her eyes closed, and uniaxial 60-Hz (unless noted otherwise) sinusoidal electric fields were generated by applying a voltage to parallel 49-cm square metal plates spaced 36 cm apart (Figure 1). The equipment that controlled the field was located outside the subject's view and emitted no visual or auditory stimuli. The background electric field (the field present irrespective of whether or not a voltage was applied to the parallel plates) was about 1 V/m throughout the region occupied by the subject (HI-

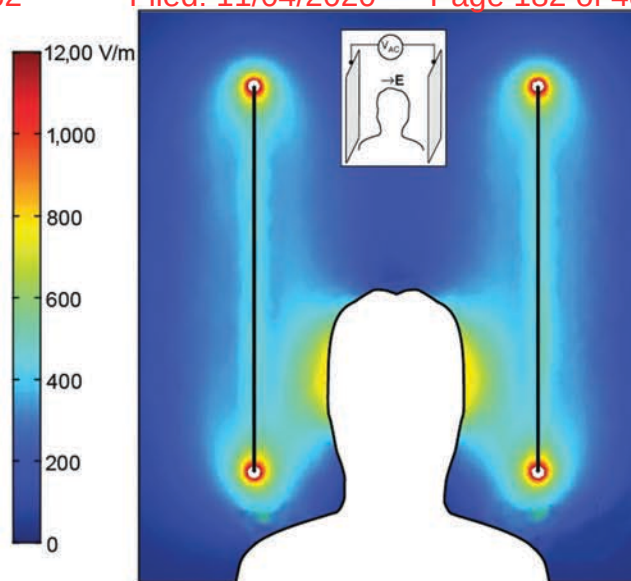


FIGURE 1. Spatial distribution of the external electric field (E) in the mid-sagittal plane. E was generated by applying $V_{AC} = 100$ volts to parallel metal plates while the subject was electrically isolated (insert), and calculated at all points in the subject's environment. Average E surrounding the head was about 300 V/m.

3603, Holaday, Eden Prairie, MN, USA). The plate arrangement did not produce magnetic fields. The continuously present background 60-Hz magnetic field was 0.1 mG, and the geomagnetic field was 599.8 mG, 68.4° below the horizontal component (component along the direction of the applied field, 360.5 mG) (MAG-03, Bartington, GMW, Redwood City, CA, USA). High-frequency signals from cell-phone towers and other distant antennae (1–10 GHz) were less than $0.1 \mu\text{W}/\text{cm}^2$ (the background fields in the sleep-study room were similar; (Spectran, Aaronia, Euscheid, Germany).

In the provocation studies the electric field was applied for 100-s intervals with a duty cycle of 50% and a repetition rate of 10 Hz, which resulted in alternating field-on and field-off pulses of 100 ms (pulsed field); a continuous field (100% duty cycle) was used in one of the provocation studies. Duty cycle, pulse structure, and interval length were regulated by a microcontroller programmed to produce the desired signals. When the duty cycle was 50%, the actual EMF stimuli consisted of (1) 10 onset stimuli per second $\times 100 \text{ s} = 1,000$ field-onset stimuli per interval; (2) an equal number of field-offset stimuli; and (3) the presence of the EMF for a total of 50 s. When the duty cycle was 100%, there was only one field-onset stimulus and one field-offset stimulus, and the EMF was present for 100 s. In the behavioral studies, the electric field was applied in trials consisting of a 2-s epoch when a pulsed field was applied (50%

USCA Case #20-1025 Document #1869762
 duty cycle, 10-Hz repetition rate) and a 10-s field-free control epoch.

Filed: 11/04/2020 Page 183 of 481

Field Strength

The applied electric field was significantly distorted by the subject's body, resulting in strong inhomogeneities in the field surrounding the subject. To overcome the problem of measuring the external field, we used Maxwell's laws to calculate it at every point in the subject's vicinity. The subject was modeled as an electrically isolated composite of rectangular solids representing the trunk and lower extremities and an ellipsoid representing the head. The assumed conductivity was 1 S/m. The total electric field at every point was determined for $V_{AC} = 100$ V using finite-element analysis consisting of approximately 10^6 elements; a more detailed mesh was automatically generated in the head region (Multiphysics, Comsol, Los Angeles, CA, USA). The peak external electric field was about 1,000 V/m (see Figure 1); the average field was about 300 V/m around the head and less than 50 V/m around the body. The peak and average field strength and duration of exposure were far below the levels generally recognized as capable of producing physiological effects in human subjects (International Commission on Non-Ionizing Radiation Protection, 1998).

The external electric field resulted in an induced internal electric field in the brain in accordance with physical law. The strength of the induced brain electric field was comparable with that induced by environmental-strength power-frequency electric and magnetic fields (Carrubba, Frilot, Chesson, & Marino, 2010; Carrubba, Frilot, Hart, Chesson, & Marino, 2009).

Somatic Responses

A pulsed field (50% duty cycle) was applied for 100 s in 10 independent field-exposure intervals. The controls were ten 100-s sham-exposure intervals during which a field was not applied. The order of the field and sham intervals was determined randomly. The environmental conditions during the field-exposure and sham-exposure intervals were identical except that the wires carrying the plate voltage were disconnected during the sham-exposure intervals. At the end of each interval the subject was questioned by an interviewer blinded to whether or not the field had been applied and asked to describe any symptoms she developed during the interval, whether or not the symptoms had persisted into the interview period. She was queried using descriptive terms she had employed. Whenever she reported symptoms, commencement of the next interval was delayed until she reported that they had abated.

We used a pulsed field because we expected it would result in a stronger symptomatic response compared with a continuous field (Carrubba, Frilot, Chesson, & Marino, 2008; Frilot et al., 2011). To test this reasoning, we performed a second study to assess whether the subject developed a differential symptomatic response to the pulsed and continuous fields. The subject was exposed or sham exposed for 100-s intervals and immediately after each interval was interviewed as described above. A sham (S) field, continuous (C) field (100% duty cycle), and pulsed (P) field (50% duty cycle, 10 Hz) were applied, and the SCP pattern was repeated five times. The subject was blinded regarding the use of different EMFs; from her perspective, the laboratory procedures were identical to those followed in the first study. The interviewer was aware that the effects of C and P fields were being compared but was blinded regarding the actual sequence of the fields.

Behavioral Responses

We considered the possibility that any symptomatic response might be a result of the combined processes of conscious awareness of the EMF followed by a somatization reaction based on a fear that EMFs were harmful. We approached the issue by determining whether the subject could consciously perceive a field when it was presented in multiple independent trials. A field having the same strength and spatial distribution as previously (Figure 1) was applied in a series of trials each of which consisted of a 2-s epoch during which a pulsed field (50% duty cycle, 10-Hz repetition rate) was applied and a 10-s field-free control epoch. Eight independent sequences were employed, each with 30–50 trials. In three sequences, the frequency was 60 Hz; in two, it was 1 kHz; and in three others, the respective frequencies were 10, 100, and 500 kHz.

The subject held a small plastic box that housed a buzzer, a button labeled YES and another button labeled NO. In the middle of each on and off epoch the buzzer emitted a 4-kHz tone at 60 dB that lasted 100 ms, and she was instructed to press the YES or NO button whenever she heard the tone, depending on whether or not she had any conscious sensation of a field at that moment. Employing a custom-designed virtual instrument (LabView, National Instruments, Austin, TX, USA), we determined the number of YES and NO responses in the presence and absence of the field in each sequence. In addition, four sham sequences (minimum of 30 trials in each) were conducted in which a field was not applied. The subject had no knowledge that an off-on pattern was being used in the field sequences or that some sequences consisted of sham exposure.

Subject		Normal range
Sleep latency	6 min	13.4 ± 10.1 (Hirshkowitz, Moore, Hamilton, Rando, & Karacan, 1992)
Stage N1 sleep	13.8%	3%–8% (Chokroverty, Thomas, & Bhatt, 2005)
Stage N2 sleep	51.8%	44%–55% (Chokroverty et al., 2005)
Stage N3 sleep	23.6%	10%–15% (Chokroverty et al., 2005)
Stage R sleep	10.7%	20%–25% (Chokroverty et al., 2005)
REM latency	150.5 min	57%–66 min (Pressman, 2002)
WASO index	6/hr	1.3 ± 0.8 (Hirshkowitz et al., 1992)
WASO total	40.5 min	10.7 ± 11 min (Naifeh, Severinghaus, & Kamiya, 1987)
Total sleep time	340.5 min	340.0 ± 70 (Hirshkowitz et al., 1992)
Sleep efficiency	88%	86.4% ± 11.6% (Hirshkowitz et al., 1992)
Arousal index	34.2/hr	16.8 ± 6.2 (Bonnet & Arand, 2007)
PLM index	7.8/hr	< 5/hr (Nicolas, Michaud, Lavigne, & Montplaisir, 1999)
AH index	0.2/hr	< 5/hr (American Academy of Sleep Medicine, 2005)

Note: REM, rapid eye movement; WASO, wake after sleep onset; PLM, periodic limb movement; AH, apnea/hypopnea.

Statistics

The frequencies of the somatic and behavioral responses in the presence and absence of the field were evaluated using the chi-square test (2×2 tables) or the Freeman–Halton extension of the Fisher exact probability test (2×3 tables; Freeman & Halton, 1951).

RESULTS

Clinical Studies

The patient's physical examination was unremarkable. The presence of frequent subjective awakenings from sleep, sometimes with unintended gross motor activity such as muscle twitching and leg jerking, prompted clinical concern for a sleep-related movement disorder, parasomnia, or nocturnal epilepsy. The polysomnogram revealed significant sleep fragmentation and discontinuity (Table 1) but no evidence of significant sleep-disordered breathing, nocturnal epilepsy, or abnormal rapid-eye-movement-related (REM-related) atonia. Periodic limb movements were noted but did not appear to be a major sleep-disrupting force.

Standard and 24-hr video-accompanied EEG recordings revealed normal-appearing background rhythms and no epileptiform activity. EEG performed in the presence of active cellular telephone use provoked a right-sided headache, but produced no unusual EEG waveforms. The MR image revealed evidence of cortical dysplasia in the right temporal lobe, and right parietal polygyria, both without interval change when compared with a study performed 19 months earlier. Laboratory evaluation for common metabolic/endocrine problems and blood count abnormalities was unremarkable.

Somatic Responses

The sequence and characteristics of the symptomological and behavioral experiments are shown in Table 2.

The question of a relation between the presence of the field and the occurrence of symptoms was directly addressed by interviewing the subject immediately following 100-s field-exposure or sham-exposure intervals; both the interviewer and the subject were blinded regarding the exposure condition. During the interviews, the subject reported a range of symptoms including localized pain in her jaw, ear, or the side of her head, a more diffuse head pain, and muscle pain or twitching in the hip, neck, and back. Sometimes she qualified the symptom as "strong" or "mild," and sometimes she denied all symptoms. We grouped the symptoms related to localized head pain as "temporal pain," those related to diffuse head pain as "headache," and those related to muscle effects as "muscle pain/twitching." Symptoms reported more rarely were indicated explicitly (see Table 3a). The subject consistently reported pronounced symptoms that occurred during the field intervals, particularly in intervals 7, 13, 14, 15, and 18. In the sham intervals, she reported no symptoms in intervals 4, 6, 8, 16, and 20; weak temporal pain in intervals 2, 3, and

TABLE 2. Sequence and characteristics of experiments

Experiment	Electric field		Trial	
	Condition	No. of trials	Duration (sec)	Response
1	Pulsed	10	100	Symptoms
	Sham	10	100	
2	Pulsed	5	100	Symptoms
	Continuous	5	100	
3	Sham	5	100	Behavior
	Pulsed	300	1	
	Sham	150	1	

TABLE 3. Evaluation of the relation between presentation of a pulsed electric field and the development of symptoms. (a) Results from the individual 100-s exposure intervals. (b) Summary table

(a)	Interval no.	Condition	Result
	1	Pulsed field	Temporal pain
	2	Sham	Mild temporal pain
	3	Sham	Mild temporal pain
	4	Sham	No symptoms
	5	Pulsed field	Temporal pain; headache
	6	Sham	No symptoms
	7	Pulsed field	Skipped heartbeats; feeling unease
	8	Sham	No symptoms
	9	Pulsed field	Headache
	10	Sham	Mild headache
	11	Pulsed field	Temporal pain
	12	Sham	Mild headache
	13	Pulsed field	Muscle twitch; feeling unease
	14	Pulsed field	Strong headache
	15	Pulsed field	Strong headache
	16	Sham	No symptoms
	17	Pulsed field	Stiff neck
	18	Pulsed field	Muscle twitch; temporal pain
	19	Sham	Mild temporal pain
	20	Sham	No symptoms

Symptoms			
(b)	Field condition	None	Mild ≥ Mild
	Sham	5	5 0
	Pulsed field*	0	0 10

* $p < .05$.

19; and a weak headache in intervals 10 and 12. The field and sham distributions of symptoms differed significantly ($p < .05$; see Table 3b).

In a second study, the relative role of EMF changes (number of onsets and offsets) and steady-state presence of the EMF were directly addressed by interviewing the subject immediately following 100-s exposure intervals in which either a pulsed field or a continuous field was presented. She was queried regarding her symptoms as previously and reported symptoms in both field intervals (see Table 4a). The symptoms triggered by the pulsed field were more intense compared with the sham control ($p < .05$; see Table 4b); the symptoms triggered by the continuous field did not differ from the sham control ($p = .16$). The subject reported no symptoms in four of five sham intervals (intervals 1, 4, 10, 13).

TABLE 4. Evaluation of the comparative effect of continuous and pulsed fields relative to a sham field on the development of symptoms. (a) Results from individual 100-s exposure intervals. (b) Summary table

(a)	Interval no.	Condition	Result
	1	Sham	No symptoms
	2	Continuous field	No symptoms
	3	Pulsed field	Temporal pain
	4	Sham	No symptoms
	5	Continuous field	No symptoms
	6	Pulsed field	Mild headache
	7	Sham	Mild headache
	8	Continuous field	Muscle twitch
	9	Pulsed field	Severe pain
	10	Sham	No symptoms
	11	Continuous field	Temporal pain
	12	Pulsed field	Headache; muscle twitch
	13	Sham	No symptoms
	14	Continuous field	Mild temporal pain
	15	Pulsed field	Mild temporal pain

Symptoms			
(b)	Condition	None	Mild ≥ Mild
	Sham	4	1 0
	Continuous field	2	0 3
	*Pulsed field	0	2 3

* $p < .05$.

Behavioral Responses

The possible influence of conscious awareness of the EMF on the development of symptoms was investigated by assessing whether the subject could consciously perceive the field. A total of 300 independent trials involving carrier frequencies of 60 Hz to 500 kHz were used; the controls consisted of 150 sham trials. The results did not depend on the carrier frequency, and consequently the data were combined for analysis (see Table 5).

The subject failed to respond to the tone seven times while the field was on and seven times while it was off, resulting in a total of 293 responses for each of the two conditions. There were no missed responses in the sham trials. The overall YES response rate in the field trials was $(51/586) \times 100 = 8.7\%$. The occurrence of a YES response was significantly associated with the presence of the field ($p < .05$; see Table 5a), but the sensitivity of the YES responses was low $([32/(32 + 261)] \times 100 = 11\%)$. The YES response rate in the sham trials was slightly higher than that seen in the field trials $([27/273 = 9.9\%])$ (see Table 5b).

Table 5. Evaluation of conscious perception of a pulsed electric field. The subject's responses during the presence (on) and absence (off) of the field, respectively

(a)	Response	Pulsed field	
		On	Off
	Yes*	32	19
	No	261	274
(b)	Response	Sham	
		On	Off
	Yes	15	12
	No	135	138

* $p < .05$.

DISCUSSION

Appropriately controlled provocation studies are required to establish the existence of EMF hypersensitivity and to understand the relative importance of psychological and nonpsychological processes in mediating any observed symptoms. A working laboratory definition of EMF hypersensitivity formulated in symptomological terms is therefore needed to permit recognition of hypersensitivity reactions when they occur. In previous provocation studies, the assumption was made that true hypersensitive subjects would exhibit more or less the same symptoms in response to repeated provocations. The assumption led to experimental designs that involved averaging across exposed and control groups, which is an inherently insensitive statistical procedure for detecting real but variable responses (Rubin *et al.*, 2005, 2010). The assumption is particularly inapplicable to EMF hypersensitivity because intrasubject and intersubject variabilities are its salient features (Levallois *et al.*, 2002; Schreier *et al.*, 2006). We defined EMF hypersensitivity as the occurrence of any medically recognized symptom in response to provocation using an environmentally relevant EMF; there was no requirement that the same symptom must reoccur when the EMF provocation was repeated. This definition avoided the problem of masking real effects and more appropriately matched the laboratory procedure to the known characteristics of EMF hypersensitivity (Levallois *et al.*, 2002; Schreier *et al.*, 2006). We focused on a single self-reported subject and employed a procedure in which she served as her own control. While controlling for artifacts, chance, and somatization, the question whether she reliably exhibited *any* symptomatic responses to an EMF was addressed; the alternative hypothesis was that she did not exhibit EMF-triggered symptoms. The laboratory conditions were controlled in such a way that

a putative role of psychological processes could reasonably be identified.

The subject developed symptoms in association with the presentation of a pulsed electric field significantly ($p < .05$) more often than could reasonably be explained on the basis of chance (see Table 3). Several considerations suggested that the statistical link was a true causal association with a subliminal EMF. First, the subject's environment was carefully controlled to avoid putative confounding factors. The testing took place in an acoustically quiet environment, and the presence of uncontrolled environmental EMFs was nil. The environmental conditions during the field-exposure and sham-exposure intervals were identical except that during the sham-exposure intervals, at a point far removed from the subject's field of view, the wires carrying the plate voltage were disconnected. A key aspect of our laboratory procedure was the elimination of sensory cues that could serve as conscious markers of the electric field leading to a somatization reaction. All appropriate precautions were taken to eliminate potential confounders. Second, the occurrence of symptoms was significantly associated with the type of EMF (see Table 4). The symptomatic response was associated with the pulsed EMF, which maximized occurrence of the number of transient changes in the EMF (off-on and on-off), not with the presence of the field, as expected on the basis of prior animal studies where the issue of somatization was irrelevant (Frilot *et al.*, 2011). Finally, in a behavioral study specifically designed to assess awareness of the field, YES response rates were 8.7% and 9.9% in the field and sham conditions, respectively, which provided no evidence for a psychological role in the development of the subject's symptoms. We therefore conclude with a reasonable level of certainty that the causal association we found between the presence of the EMF and the subject's symptoms was mediated by a subconscious neural process. Although chance was an unlikely explanation for the association, that possibility could not be excluded. The existence of the neurological syndrome reported here was previously suspected but not documented.

The mechanism for the subject's symptoms of headache, visual disturbances, and somatic musculoskeletal discomfort following exposure to EMFs is unknown. On the basis of clinical evaluation, intermittent seizure activity is not a credible explanation, although a deeper epileptic focus with partial seizure activity may have escaped the detection of surface EEG electrodes. The abnormal findings in the subject's medical workup included the abnormal MR image (cortical dysplasia and polygyric changes) and extensive sleep discontinuity and fragmentation manifested in the overnight polysomnogram; the possible association of these

findings with the subject's syndrome of EMF hypersensitivity is unknown.

Our aim here was to concentrate on the previously unaddressed question whether acute exposure to weak EMF could produce real but not precisely predictable somatic effects mediated by nonpsychological processes. Within the limitations of the study, we concluded that we demonstrated the neurological syndrome in the subject we studied. The question of whether EMF hypersensitivity is a significant public-health problem was not addressed here. The EMF we employed was equivalent in strength and pulse structure to EMFs pervasively present in the environment (Levallois et al., 2002; Schreier et al., 2006), and our results were consistent with the possibility that environmental EMFs can directly trigger clinical symptoms. Nevertheless resolution of the public-health issue depends on a deeper understanding of how internal EMFs caused by environmental EMFs are related to physiological process and of the role of psychological factors and comorbidities in the exposed population in exacerbating the processes resulting in disease.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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Radiation Sickness - Children; Dr. Torill Jelter MD. (Petitioner)
Comments, Nov. 17, 2013

Toril H. Jelter, M.D. FAAP
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Walnut Creek, CA 94598

Sept. 2, 2013

Re: The reassessment of FCC radio frequency exposure limits and policies

Dear FCC:

I am writing to you today to request that you reevaluate current FCC safety standards for wireless technologies and “dirty” electricity. The reason I am requesting this is because current research and what I see in my clinical practice indicate a revision of current safety standards is long overdue.

Children are suffering disability and disease in much higher numbers than 30 years ago. Their EMF exposure is clearly a significant contributing factor. The fastest, most reliable way of educating yourselves on this topic is to read and understand the Bioinitiative Reports of 2007 and the 2012 update. Table 1-1 “Summary for the public” would be a good starting point.

1. Children have a right to live and play and learn where their DNA will not be damaged by non-ionizing radiation. This is not the case today. See sections 5 and 6 of the 2012 Bioinitiative Report for evidence for effects on genes and protein expression and genotoxic effects – RFR and ELF DNA damage with current “safety standards.”
2. Children have a right to live and play and learn in locations where their immune systems are adequately protected from detrimental non-ionizing radiation. This is not the case today. See Section 8 of the 2012 Bioinitiative Report “Evidence for effects on immune function.” Children are developing allergies and cancer at much higher rates than before.
3. Children have a right to live and play and learn where non-ionizing radiation will not adversely affect their neurology or behavior. This is not the case today. See Section 9 of the 2012 Bioinitiative Report “Evidence for effects on neurology and behavior”

CASE HISTORY

A four-year-old boy presents to my office with his parents. They request help for their son so he may be able to learn and behave better. He moves around my waiting room like a hurricane, turning over chairs, pulling at the blinds, damaging the blinds, and screaming. His parents look on with their shoulders drooping and their hands in their pockets. They love their son dearly but he is so out of control they have no clue where to begin. We agree on a two-week EMF remediation trial (no Wi-Fi for 12 hours at night, no cordless phones, and Stetzer filters to decrease detrimental EMF from house wiring). Within one week I received an email from his parents. “The EMF remediation trial is working. Our son is now able to have more back and forth conversation. We have better eye contact with him and he is even receptive to the idea of a star chart for good behavior. In addition his bowel movements are now normal.”

At follow-up in my office, which now had RF filters throughout, this child was calm, poised, made good eye contact and could converse at age level. His “bad” behaviors were gone.

CASE HISTORY

A five-year-old boy presents with parents who tell me their child has uncontrollable arm flapping daily and has been diagnosed with an Autism Spectrum Disorder. They disagree with the

diagnosis because when he visits grandma in rural Tennessee for a month, the arm flapping stops completely! When they return to the San Francisco Bay Area the arm flapping returns. The parents also mention that there is no cell-phone reception in grandma's area of Tennessee.

CASE HISTORY

A three-year-old child is being evaluated for speech delay and learning disability. He also has frequent high-pitched screaming and head-bangs and rocks a lot and has great sleep difficulties. But when he visits his aunt in rural Oregon (where there is no cell-phone reception) he sleeps for the first 24 hours and then wakes up like a "new child."

He no longer screams, he is calm, he plays normally, he can sleep at night and be awake during the day. When the family returns to their home in California, their son has high-pitched screaming again when they reach the Sacramento area, and his sleep difficulties and other problems return.

4. Children have a right to live, play and learn in locations that protect them from developing cancer at a young age. This is not the case today.

CASE HISTORY

A 12-year-old girl presents with her dad. She is diagnosed with liver cancer. Six months later, shortly after her 13th birthday, she succumbs.

CASE HISTORY

A five-year-old girl develops a severe headache. She takes the ice cream from the grocery cart and puts it against her head for relief. She has a brain tumor. She spends the next year in and out of the hospital. Finally, she has an uncontrollable seizure and dies.

CASE HISTORY

A two-week-old child is diagnosed with cancer. He spends the rest of his life in and out of the hospital. At age five he says to his mother "I can't do this any more." That night, he breathes his last breath.

See section 11 and 12 of the 2012 Bioinitiative Report for evidence of brain tumors and acoustic neuromas and childhood cancers (leukemia.)

5. Children have a right to a good night's sleep.

See the Bioinitiative Report section 13. Evidence for effects of low-intensity electromagnetic radiation on melatonin (the sleep hormone.)

CASE HISTORY

A four-year-old boy presents with his parents with a complaint of sleep difficulties. He hasn't slept for two years and climbs in his parents' bed every night, so they also have had poor sleep for two years and are exhausted.

The evening before they came to see me, they gave their son some melatonin and it seemed to help. Knowing that EMF can lower melatonin, I suggested a two-week EMF remediation trial. (No Wi-Fi 12 hours at night, no cordless phone, and Stetzer filters to lower extremely low frequency EMF.)

They followed my EMF remediation instructions and stopped the melatonin supplement. Within a few days the son and the parents were sleeping fine without a melatonin supplement.

6. Children have a right to live, play and learn in locations that permit them to retain their fertility so that they may reproduce when they become adults. That is not the case today. Most schools have Wi-Fi and more. Young girls place laptops on their laps where non-ionizing radiation from the laptop can damage their future offspring as all their eggs are mere inches from the laptop.

See section 18 of the 2012 Bioinitiative Report. Fertility and reproduction- effects of EMF.

7. Children have a right to live play and learn in locations that permit them to grow up and have the ability to reproduce and have healthy children.

CASE HISTORY

A young woman with excellent health and good pre-natal care gives birth to a boy with a heart defect. No previous relatives on either side had a heart defect. During her pregnancy, she lived in a building across the street from a power substation. The light bulbs burst frequently in her apartment and needed to be replaced often. This is a sign of too much dirty electricity in the home. Too much dirty electricity (ELF) contributes to birth defects.

See section 19 of the 2012 Bioinitiative Report. Fetal and neonatal effects of EMF.

8. Children have a right to live, play and learn in a location that permits them the ability to speak.

CASE HISTORY

A 12-year-old boy comes to my office with his parents, who are asking for help with his aggressive behavior. He has also been diagnosed with autism and is unable to speak (non-verbal). They agree to a two-week EMF remediation trial. Within three days this young man said a complete sentence much to the disbelief of his mother and himself! His aggressive behaviors disappeared.

See section 20 of the Bioinitiative Report. "Findings in autism consistent with EMF and RFR" Over 1% of America's children now have autism. And the numbers continue to rise. In addition to the pain and suffering these children and families experience, this problem alone threatens to bankrupt whole school systems at a time when we can least afford it.

When I as a physician need to perform a potentially dangerous procedure on a child, such as a spinal tap, I need to explain why it is necessary and what the risks are. Then I need to get written consent from the parents and the parents have the right to refuse.

Currently, we are performing large-scale experiments on America's children without informing children or their parents of the risk. Children and their parents have not given their consent nor have they been given an option to opt out.

See section 2, 3 and 4 of the 2012 Bioinitiative Report. "Statement of the problem, the existing public exposure standards and evidence for inadequacy of current standards."

A nation that does not protect its children has no future. Please reevaluate the FCC Safety Guidelines for non-ionizing radiation.

America's children have the right to sleep, speak, behave, learn and – as adults – to reproduce. Please don't take these from them. Please help America's children and America to have a future. Thank you for your time.

Sincerely,

Toril H. Jelter M.D. FAAP

P.S. – All case histories are real patients, minor details have been omitted or changed to ensure privacy.

Radiation Sickness, Deborah Kopald Comments, Jul. 13, 2016

FCC Proceedings 14-177, 15-256, 10-112, and 97-95
Comment of Deborah Kopald
July 13, 2016

The FCC should put an immediate moratorium on the rollout of 5G or indeed any more transmitter infrastructure. What is needed now is a national accounting of the health effects of the excess level of second-hand and first-hand radiation with which the FCC is permitting people to saturate the entire indoor environment and increasingly the outdoor environment. The levels in many areas of major cities and most of the indoor building environment are already correlated with biological dysfunction that causes cancer, neurotransmitter disease and infertility among other serious diseases. This has been documented by a number of prominent scientists, including but not limited to Dr. David O. Carpenter of the Presidential Cancer Panel, who stated to a Federal Court that

“Chronic exposure to PM MW [Pulse-Modulated Microwave Radiation] radiation harms every individual in a population in some ways, even if these are not always detectable by the individual or consciously attributed to the responsible RF/MW radiation sources. This Agent injures some individuals into a condition in which symptoms will be more easily retriggered with subsequent exposure. And for a priori susceptible individuals and those using electronic medical devices, it can respectively exacerbate the extant medical conditions and disrupt medical device operation, even to the point of death.”¹

The general interest and willingness of government and even the public to address future risks is inversely proportional to the perception of the agent as a “convenience”.

Notwithstanding this dynamic, it is not optional to fail to address the imminent biological dysfunction that members of our population are experiencing from excess levels of radiation in public (and private spaces). While there is a population that has electro-hypersensitivity (EHS) that independent studies have documented as ranging from 1.5% to 13.3% of the population, there is evidence that levels of radiation in a Wi-Fi'ed environment, from too close proximity to a cell tower and increasingly around cell phones and wireless wearables that are sensitizing irritants also exacerbate many medical conditions and are especially dangerous for pregnant women, children and the elderly.² Furthermore, it appears that a double digit percentage of the people reacts with some symptoms of sensitization to this radiation with blood pressure³ and heart rate changes⁴ and/or that have brainwave changes that manifest as cognitive dysfunction

¹ Amended Declaration of Dr. David O. Carpenter, *AHM and David Mark Morrison v. Portland Public Schools* <http://www.magdahavas.com/wordpress/wp-content/uploads/2012/01/Amended-Declaration-of-Dr-David-Carpenter.pdf>, page 23.

² Baby Safe Project News Conference, Environmental Health Trust and Grassroots Environmental Education <http://www.babysafeproject.org/news-conference/>

³ Braune S. et al. Resting blood pressure increase during exposure to a radio-frequency electromagnetic field. *Lancet*: 1998; 351: 1857-1858.

⁴ Havas, M. Marongelle J. et al. Provocation study using heart rate variability shows microwave radiation from DECT phone affects autonomic nervous system. *European Journal of Oncology*, 2010, 273-300. <http://www.magdahavas.com/wordpress/wp-content/uploads/2010/10/Havas-HRV-Ramazzini1.pdf>

and/or sleep disorders⁵ as a result of Wi-Fi and/or passive transmitter radiation in cities or other areas with too many transmitters in the vicinity or on the premises.

This biological dysfunction needs to be addressed by having indoor transmitters turned off when requested in order to facilitate compliance with the Americans with Disabilities Act (ADA) or by finding alternate locations away from cell transmitters and fixed hotspots and/or by shielding indoor locations from the external sources when necessary and by having white zones free of this radiation in public places. 5G with its concomitant radiation increases should not be rolled out when there is evidence that proximity to such sources causes severe biological effects and that chronic exposure from existing radiation levels are responsible for public health problems and increased disease risk. The oft-stated purpose of 5G is to be able to download a movie onto a device within seconds. This is an illegitimate goal when weighed against these costs which include the violation of the civil rights of those who are particularly intolerant to this radiation.

The New York affiliate of CBS News reported in May 2015 that 5% of the population is now intolerant to Wi-Fi and related exposures. The State of California's Department of Health Services found in 2001 (published in 2002)⁶ that 3% of the population is sensitive to Electromagnetic Fields ("EMFs")⁷; the EU stated in a 2012 resolution that the problem is growing "exponentially"⁸, cites a 3-5% number and has expressed that White Zones (shut off of Wi-Fi, etc.) are necessary in public places so that the human rights of the statistically significant numbers of people with EHS are not violated. In 2015, the Canadian Parliament's Standing Committee on Health expressed that accommodation is required for people with EHS under the Canadian Human Rights Act⁹. In Sweden, a country where on information and belief 1/8 people work for Ericsson, a wireless company, 5% of the population is signed up with the Swedish EHS Association. The problem is out in the open there; that is to say that the public is largely aware of it and the government assists people who get symptoms from too close proximity to Wi-Fi, cell towers etc.; people with EHS can call up a municipal officer to get transmitters shut off

⁵ Redmayne M and Johansson O. Radiofrequency exposure in young and old: different sensitivities in light of age-relevant natural differences. *Rev Environ Health* 2015; 30(4): 323-335

⁶ Levallois P, Neutra R, Lee G, Hristova L. Study of self-reported hypersensitivity to electromagnetic fields in California. *Environ Health Perspect* 2002;110 (Suppl. 4):619-23.

⁷ Electromagnetic Fields (EMFs) are packets of energy that constitute radiation of varying frequencies that include extra-low frequency (ELF) fields of the type emanating from high tension electric power lines and even modern appliances; radio waves, including manufactured pulse-modulated microwaves (RF) which are emitted by modern-day wireless devices and transmitters (e.g. Wi-Fi, cell towers, cell phones, smart meters, Bluetooth) ; as well as X-rays (harnessed for medical imaging) and gamma rays (used to kill cancer cells in radiation therapy).

⁸ European Parliament Written declaration on the recognition of multiple chemical sensitivity and electrohypersensitivity in the International Statistical Classification of Diseases and Related Health Problems (ICD), 3/12/12, <http://www.europarl.europa.eu/sides/getDoc.do?type=WDECL&reference=P7-DCL-2012-0014&format=PDF&language=EN>, page 2.

⁹ Radiofrequency Electromagnetic Radiation and the Health of Canadians, Report of the Standing Committee on Health, June 2015: <http://www.parl.gc.ca/HousePublications/Publication.aspx?DocId=8041315&Language=E&Mode=1&Parl=41&Ses=2>

when they need to access an institution. The Stockholm municipality provides shielded apartments and cottages in the countryside for those who are hypersensitive to this radiation. Switzerland also provides apartments without Wi-Fi away from cell towers and provided all of its citizens a comprehensive report that details what the sources of electromagnetic radiation are, explains how to reduce exposure and acknowledges that biological effects occur well below international limits¹⁰. Also, the German Federal Office of Radiation Protection had recommended in 2007 that people use hard-wired connections instead of Wi-Fi and lower their exposure to sources of electromagnetic radiation.

Severe electromagnetic sensitivities are recognized to exist by the Access Board, by the Social Security Administration, by courts in the 10th (Firstenberg v. City of Santa Fe, N.M., 696 F.3d 1018 (10th Cir. 2012)) and 11th Circuit (*Metallo v. Orlando Utilities Commission*, 6:14-cv-1975-Orl-40KRS) and by California Superior Court (*Joshua Hart v. Plumas Sierra Rural Electric*, Plumas County Superior Court, Case # SC SC15-Q0003). The Access Board states:

The Board Recognizes that multiple chemical sensitivities and electromagnetic sensitivities may be considered disabilities under the ADA if they so severely impair the neurological, respiratory or other functions of an individual that it substantially limits life activities.¹¹

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) an organization staffed with people who take a paycheck from industry, stated in 2002:

Different groups in a population may have differences in their ability to tolerate a particular NIR (non-ionizing radiation) exposure. For example, children, the elderly, and some chronically ill people might have a lower tolerance for one or more forms of NIR exposure than the rest of the population. Under such circumstances, it may be useful or necessary to develop separate guideline levels for different groups within the general population, but it may be more effective to adjust guidelines for the general population to include such groups.

Some guidelines may still not provide adequate protection for certain sensitive individuals nor for normal individuals exposed concomitantly to other agents, which may exacerbate the effect of the NIR exposure....Where such situations have been identified, appropriate specific advice should be developed within the context of scientific knowledge.¹²

In other words, ICNIRP effectively acknowledged the existence of a population sensitive to non-ionizing radiation. The “appropriate specific advice” has been developed and offered by the Access Board in conjunction with the National Institute of Buildings Sciences which indicates that hardwiring should be used instead of Wi-Fi, and if Wi-Fi is used, it should be confined by

¹⁰ “Electrosmog in the Environment”, Swiss Agency for the Environment, Forests and Landscapes, June 2005 <http://citizensforsafetechnology.org/uploads/scribd/Electrosmog%20in%20the%20Environment.pdf>

¹¹ Federal Register/ Vol. 67, No. 170/ Tuesday, September 3, 2002/ Rules and Regulations, 36 CFR Part 1191 [Docket No. 98-5] RIN 3014-AA16 Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Recreation Facilities; **Action:** Final Rule, Page 56353.)

¹² International Commission on Non-Ionizing Radiation Protection, ICNIRP Statement: General Approach to Protection Against Non-ionizing Radiation: *Health Physics* 82(4):540-548; 2002.

foil-backed drywall, not spilling out uncontained within the entire premises.¹³ This report also acknowledges the external benefits to the whole population, not just those who need ADA accommodation: “Measures taken to improve indoor environmental quality, such as reducing air pollutants, noise and electromagnetic fields in buildings, will increase their accessibility for people with asthma and chemical and/or electromagnetic sensitivities, as well as provide a more healthful environment for all building occupants¹⁴.” and “By making indoor environments that are safer for the most vulnerable among us, we can create indoor environments that are healthier for everyone, especially children.¹⁵”

The larger problem and risk to all building occupants was noted by Swisscom, which was issued an international patent for a device that reduces Wi-Fi emissions (The Reduction of Electromog in Wireless Local Networks) in which the corporation explicitly acknowledged that Wi-Fi in offices along with other sources of pulse-modulated microwaves and radiofrequency radiation is dangerous to humans at levels below heating thresholds (below international guidelines) in that it is carcinogenic, genotoxic and stress-inducing:

The influence of electromog on the human body is a known problem.

....These findings indicate that the genotoxic effect of electromagnetic radiation is elicited via a non-thermal pathway. Moreover aneuploidy is to be considered as a known phenomenon in the increase of cancer risk.

Thus it has been possible to show that mobile radio radiation can cause damage to genetic material, in particular in human white blood cells, whereby both the DNA itself is damaged and the number of chromosomes changed. This mutation can consequently lead to increased cancer risk.

.... Despite increasingly strict national guidelines with respect to legally specified limits, the impact of electromog in WLANs on the human body can be considerable. Moreover it is to be expected that this impact will continue to increase in the future for many people.

....This means that even when the WLAN is not being used at all, an underlying stress from electromagnetic radiation remains for persons in the Basic Service Area of an access point of the WLAN. For example, in the case of WLANs at places of employment, such as offices, etc., there exists therefore permanent stress from electromog from the WLAN on the employees of the company or organization.¹⁶

¹³ United States Access Board/National Institute of Building Sciences Indoor Environmental Quality Report, 2005 http://web.archive.org/web/20060714175343/ieq.nibs.org/ieq_project.pdf, pages 87-88.

¹⁴ Ibid., page 8.

¹⁵ Ibid, page 87.

¹⁶ World Intellectual Property Organization REDUCTION OF ELECTROSMOG IN WIRELESS LOCAL NETWORKS, International Publication Number WO 2004/075583 A1 http://www.safeschool.ca/uploads/WiFi_Swisscom_Patent.pdf

So, the industry is acknowledging a problem with Wi-Fi and saying its deleterious effects have been proven and that the influence of electrosmog on the body is a “known problem”, while the FCC promotes further rollout of the infrastructure in question.

Furthermore, the World Health Organization (WHO) made the following statements in 1981::

General population exposure from man-made sources of microwave and RF radiation now exceeds that from natural sources by many orders of magnitude. The rapid proliferation of such sources and the substantial increase in radiation levels is likely to produce “electromagnetic pollution”. Man-made sources include: radar...broadcasting and TV networks and telecommunication equipment...it had been observed in some countries that occupational microwave exposure led to the appearance of autonomic and central nervous system disturbances, asthenic syndromes, and other chronic effects (Gordon, 1966; Marha et al., 1971; Dumanski et al., 1975; Serdjuk, 1977)....Similar syndromes were reported in France by Deroche (1971) and in Israel by Moscovici et al. (1974).¹⁷

Some of the occupational microwave exposures that were the subject of studies in the 60's and 70's were in the same power density range as Wi-Fi. Whatever the power density levels of the causative agent(s) were for any persons, once sensitized to this radiation, they often cannot tolerate being in an indoor environment with Wi-Fi and commensurate radiofrequency radiation sources without severe perturbations of their neurological, cardiovascular and other functions.

In the intervening time period, the WHO has taken wireless industry money, sometimes not so overtly; in one instance a \$100,000 contribution was funneled by the wireless industry through Royal Adelaide Hospital for the WHO EMF Project. This incident is recounted by the epidemiologist Dr. Devra Lee Davis in her 2010 book Disconnect: The Truth About Cell Phone Radiation, What the Industry had Done to Hide It, and How to Protect Your Family.¹⁸ In 2011, shortly before the WHO's IARC committee was set to review the evidence on radiofrequency radiation (which includes pulse modulated microwaves from wireless devices), a Swedish journalist outed the head of the committee, Anders Ahlbom, as a paid consultant to the wireless industry. He was summarily kicked off the committee, which met and went on to categorize RF radiation with diesel exhaust, lead, DDT and chloroform.

Still, some members of the committee, including Lennart Hardell, the world's expert on the health effects of wireless devices, whose work was the basis for a European court declaring that cell and cordless phones are causing brain tumors, maintain that evidence exists such that wireless radiation from cell phones should have been categorized as Group 1, if the evidence had been judged the way other agents have been judged according to the Hill criteria¹⁹. If this had

¹⁷ “Radiofrequency and Microwaves” Environmental Health Criteria 16: Published under the joint sponsorship of the United Nations Environment Programme, the World Health Organization, and the International Radiation Protection Association, World Health Organization, Geneva: 1981: 11, 80.
http://apps.who.int/iris/bitstream/10665/39107/1/9241540761_eng.pdf

¹⁸ Davis, Devra L., Disconnect: The Truth About Cell Phone Radiation, What the Industry had Done to Hide It, and How to Protect Your Family. Dutton, 2010. <http://www.disconnectbook.com/>.

¹⁹ Hardell L and Carlberg M. Using the Hill viewpoints from 1965 for evaluating strengths of evidence of the risk for brain tumors associated with use of mobile and cordless phones. *Rev Environ Health*. 2013; 28(2-3):97-106.

been done, governments automatically would have been forced to restrict the use of Wi-Fi, cell phones, etc. in public. In the United States, the wireless industry provides more income to the Treasury than any other industry except oil and gas; many experts assert that politicization is at work in the way in which some elements in our society deal with (ignore or deny) the hazards of wireless devices and transmitters. Some asserting this include Frank Clegg, the former head of Microsoft Canada, who told the Wall Street Journal that there are people who cannot attend school due to Wi-Fi and gave a briefing in 2015 on the dangers of Wi-Fi and wireless radiation to the Massachusetts State House²⁰; Gro Harlem Brundtland, former head of the WHO and Prime Minister of Norway; Stephen Sinatra, MD, the integrative cardiologist; the American Academy of Environmental Medicine (“AAEM”)²¹ and even management at the New York State Union of Teachers (“NYSUT”) which held an event in December 2014 called “Our Love Affair with Wireless Technologies is Making Us Sick”²².

In June, Israel’s Supreme Court ruled that the Ministry of Education was illegally forcing parents to buy wireless tablets for children’s use in school after 100 or so parents sued the Ministry for violating its parental rights and ignoring literature that showed that radiation in Wi-Fi’ed schools and in the vicinity of wireless devices were linked with serious biological effects. In April, Israel’s 3rd largest city disconnected the Wi-Fi in the K-12 school system²³ and in March, a bill was introduced in Congress in Argentina, a G-20 nation²⁴ that would ban Wi-Fi in public areas, including hospitals (and would mandate that cell phones be shut off in emergency areas). In November 2015, the Austrian Medical Association recommended that hard-wiring be used instead of Wi-Fi.²⁵

This brings me to the most recent developments in the United States. On May 9th, the National Institute of Environmental Health Sciences (NIEHS) held a seminar at one of its Research

²⁰ Wireless Right to Know Briefing, Massachusetts State House Boston, Environmental Health Trust, 6/10/15: <https://vimeo.com/134411701>

²¹ The American Academy of Environmental Medicine (AAEM) “Recommendations Regarding Electromagnetic and Radiofrequency Exposure”: 7/12/12: <https://www.aeonline.org/pdf/AAEMEMFmedicalconditions.pdf>; The American Academy of Environmental Medicine (AAEM) Position Paper, “Electromagnetic and Radiofrequency Fields Effect on Human Health”: 4/12/12: <https://aaeonline.org/pdf/emfpositionstatement.pdf>.

²² Havas M. Our love affair with wireless technologies is making us sick. New York State Union of Teachers (NYSUT), December 9, 2014: <http://scholar.aci.info/view/14f8fe83eab00130010/1501ef5a51d000115d8>

²³ Haifa municipality disconnects Wi-Fi: הפיח תייריע -ה ירישכמ תא - Wi-Fi רפסה יתבו מידלי ינגב ריעב תקתנמ, 4/18/16. <http://www.local.co.il/haifa/134582/Article/>

²⁴ Argentina seeks a national law against electromagnetic pollution: “Argentina busca una ley nacional contra la contaminacion electromagnetica” *El Nuevo Cronista*, 3/28/16. <http://www.nuevocronista.com/argentina-busca-una-ley-nacional-contra-la-contaminacion-electromagnetica/>

²⁵ Vienna Medical Association, 10 Medical Cell Rules, “10 Medizinische Handy-Regeln”: 11/12/15. http://www2.aekwien.at/1964.py?Page=1&id_news=8972; <http://www.aekwien.at/aekmedia/Medizinische-Handy-Regeln.pdf>

Triangle Park facilities on Electromagnetic Hypersensitivity Syndrome (EHS). On May 26th, the National Toxicology Program (NTP) released some of the data from its \$25 million cell phone study²⁶ that was commissioned in 2001. NTP staff confirmed on a conference call on the same day that 1/15 of the rats irradiated with cell phones for 9 hours a day (10 minutes on and 10 minutes off for 18 hours) for 28 days developed cancer or pre-cancerous lesions.

This study has the weight and imprimatur of the United States Federal government behind it. It is now not possible for credible institutions to say that there is a "controversy" as to whether wireless radiation causes serious biological effects or that the federal government guarantees wireless devices to be safe or that microwave radiation only has thermal effects (causes tissue heating). The federal government now acknowledges what scientists and the industry itself have long known, that microwave radiation causes biological damage well below heating thresholds and legal levels. Scientists such as Dr. Joel Moskowitz, at the University of California, Berkeley, assert that on the basis of this study, there is enough data to categorize radiofrequency radiation as a Group 1 carcinogen as Dr. Hardell previously stated in 2013.

The FCC is promoting more wireless rollout while the re-insurance industry is sounding alarm bells. Note: "Exclusions" from a Lloyd's of London policy:

We will not

- a) make any payment on your behalf for any claim, or
- b) incur any costs and expenses, or
- c) reimburse you for any loss, damage, legal expenses, fees or costs sustained by you, or
- d) pay any medical expenses:

....directly or indirectly arising out of, resulting from or contributed to by electromagnetic fields, electromagnetic radiation, electromagnetism, radio waves or noise.²⁷

The federal government now has acknowledged as of May 26th that cell phones have deleterious effects on animals well below the heating threshold and admitted in 2002 that there is a population of people with severe sensitivities to electromagnetic radiation who are covered under the ADA and who per survey studies and clinical reports appears to be highly statistically significant.

By the FCC's own acknowledgment, the guidelines are only set so that people do not pass out: "The limit on specific absorption associated with the reduced averaging time is conservative

²⁶ Wyde M, Cesta M, Blystone C, Elmore S, Foster P, Hooth M, Kissling G, Malarkey D, Sills R, Stout M, Walker N, Witt K, Wolfe M, Bucher J. Report of Partial Findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley rats (Whole Body Exposure): <http://biorxiv.org/content/early/2016/05/26/055699.full.pdf+html>

²⁷ Exclusions from a Lloyd's of London policy (starting on Page 6 of policy, continuing on Page 8). <http://www.citizensforsafetechnology.org/Lloyds-of-London-excludes-coverage-for-RFEMR-claims,2,4168>

relative to RF-induced unconsciousness and is well above the threshold for auditory effect.”²⁸ (Note: the FCC does admit that some people can hear the radiation frequencies within legal thresholds, so they have long acknowledged that there is a biological effect from publicly allowable exposures.) The FCC also uses standards that were set on the basis of only four studies of acute (not chronic) exposures to what appear to be rhesus, macaque and squirrel monkeys and possibly some rats. In other words, the standards were not set on the basis of chronic exposures to humans:

Despite the greatly expanded database since ANSI C95.1-1982, most reports of biological effects have embodied acute exposures at relatively few frequencies..... the most sensitive measures of potentially harmful biological effects were based on the disruption of ongoing behavior associated with an increase in body temperature in the presence of electromagnetic fields. Because of the paucity of reliable data on chronic exposures, IEEE subcommittee 4 focused on evidence of behavioral disruption under acute exposures...Because the threshold for disruption in non-human primates always exceeded a whole-body SAR of 3.2 to 4 W/Kg [B15, B17, B18, B19], the latter value has again been adopted as the working threshold for unfavorable biological effects in human beings in the frequency range of 100KHz- 300 GHz.²⁹

The Department of the Interior (DOI) wrote the National Telecommunications and Information Administration (NTIA) a letter on February 7, 2014 stating that the FCC standards are “now nearly 30 years out-of-date and inapplicable today”. The FCC has failed to acknowledge a-thermal effects (ones that occur below the heating threshold and legal limits) that other agencies such as DOI, as well as the Air Force, the Defense Intelligence Agency/US Army Medical Intelligence, U.S. Naval Observatory Biosciences Division, NASA, the Radiofrequency Interagency Working Group (RFIAWG), the EPA, the EU, the Canadian Standing Parliamentary Committee on Health and the industry itself have acknowledged exist. (See Appendix A.) To recap: the FCC set standards by ignoring thousands of studies that showed serious effects at levels well below these standards and by selecting a mere four animal behavioral studies with acute exposures that were not appropriate to the chronic exposure conditions the FCC enabled in the human environment; then after they requested comment on said standards around two decades later, the FCC was told by DOI that their standards are three decades out of date, and still nothing has been done three years after the Request for Comment.

The FCC is not a health agency and independent institutions like the Harvard Safra Center have asserted that it is wholly captured by the companies it is supposed to regulate; the FCC allowed them to set the standards. (See Appendix B). The fox effectively is guarding the chicken coop, while other federal agencies have indicated that the FCC’s standards are NOT science-based.

If a federal agency had guidelines that stipulated it was legal to spray DDT, diesel exhaust, chloroform or aerosolized lead in the indoor environment and much of the outdoor environment constantly (these items, like radiofrequency radiation, are Group 2B carcinogens), individual institutions would act and not place such agents inside or around the premises, and Congress

²⁸ IEEE C95.1-1991 "Revision of ANSI C95.1.-1982" IEEE Standard for Safety Levels with Respect to Human Exposure to Radio-Frequency Electromagnetic Fields, 3KHz-300GHz, IEEE: April 27, 1992: 33-34.

²⁹ Ibid., 27, 28, 46.

would have immediate hearings and propose interventions. The agent in question is odorless, colorless, and while the majority does not appear to react overtly, a statistically significant number do and another sizeable tranche appear to be affected who have not made the link between symptoms and exposure.

Judge Frederick Weisberg of the D.C. Superior Court is on record as stating that "Federal law is the supreme law of the land, but there is no constitutional provision that says federal facts are the supreme facts of the land. Federal law can preempt state law, but it cannot preempt scientific fact. The scientific truth, whatever it may be, lies outside of the FCC's regulations about what is 'safe' or 'unsafe.'"

The FCC must cease and desist from compounding an already unacceptable public health problem. Congress must immediately hold hearings and decouple health and standard setting so it is not under the FCC's purview. Presumptions of safety are not based on the scientific record of the health effects of radiofrequency radiation. The FCC should not be acting in ways that make it more difficult to enforce the ADA and that degrades the public's health further.

As long as corporations and lobbyists have disproportionate power and enable the FCC Commissioners to have the power to take the decisions it proposes, its Commissioners should stop, read the literature, look in the mirror and ask themselves what they are doing. Is being able to download a video faster something the FCC should be enabling when such a scheme will cause more biological dysfunction, more suffering and more civil rights violations? The answer is obviously NO. While it seems that the Commissioners do not want to acknowledge what other federal agencies and the scientific community are saying about microwave radiation (again, See Appendices A and B), it should be obvious to the Commissioners that they should not be rolling out more permanent infrastructure and intensifying its use when they asked for comment on the standards almost 3 years ago and have not completed that review.

Deborah Kopald

APPENDIX A

The federal RFIAGW (Radiofrequency Interagency Working Group) asserted in 1999 (16 years ago) that standards are not protective of human health, specifically stating,

"The past approach of basing the exposure limits on acute effects data with an extrapolation to unlimited chronic exposure durations is problematic." The letter goes on to point out that peak exposure isn't factored into guidelines which are averaged. Also, the biological effects of frequency, pulse or intensity modulation aren't factored into the guidelines. It also discusses how Specific Absorption Rate (SAR) limits do not account for the fact that different tissues interact differently with microwave radiation: e.g. brain and bone marrow absorb more radiation than fat or fascia.

Like the ICNIRP statement on page 3, RFIAGW states that there is variation in “susceptibility (response/sensitivity) among individuals” and that this uncertainty should be factored into the guidelines.³⁰

In 1993 the EPA wrote to the FCC saying its safety guidelines are inadequate and that radiofrequency radiation exposures in “uncontrolled environments” (i.e. public areas) were “not well defined” (see pages 2 and 3 of the letter from the EPA’s Director of the Office of Radiation and Indoor Air to FCC’s Chief Engineer at the Office of Engineering and Technology³¹ that prefaces the official comments). The comments go on to state that the FCC does not adequately distinguish between a “controlled” and “uncontrolled” environment; EPA asserts that uncontrolled environments are non-discretionary environments (i.e. public environments) and that de facto awareness of the existence of microwave radiation in the environment does not constitute protection. Comments state that FCC guidelines “lack explanation, consistency and well-founded justifications” and ignore a 1984 EPA report³² that stated that there are **variations in sensitivity amongst subgroups of the population**.

Johnson Liakouris AG. Radiofrequency (RF) sickness in the Lilienfeld Study: an effect of modulated microwaves? Arch Environ Health 1998; 53:236–8 cites occupational and clinical cases of RF sickness/ microwave sickness (Cold War terms for EHS) and explains how repeated and/or prolonged exposure worsens the syndrome and that symptoms come sooner and last longer with subsequent exposures.³³ The paper describes the symptoms

³⁰ W. Gregory Lotz, PhD, Chief, Physical Agents Effects Branch, Division of Biomedical and Behavioral Science, National Institute for Occupational Health and Safety (NIOSH) 1999 letter on behalf of the Radiofrequency Interagency Working Group (RFIAGW) to Richard Tell, Chair IEEE SCC28 (SC4) Risk Assessment Working Group: http://www.emrpolicy.org/litigation/case_law/docs/exhibit_a.pdf

³¹ Environmental Protection Agency (EPA) Comments to the Federal Communications Commission (FCC) on FCC 93-142, April 1993, Notice of Proposed Rulemaking: Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation via Margo T. Oge, Director, Office of Radiation and Indoor Air letter to Thomas P. Stanley, Chief Engineer, Office of Engineering and Technology, FCC: http://www.emrpolicy.org/litigation/case_law/docs/epa_to_fcc_3nov_93.pdf

³² Biological Effects of Radiofrequency Radiation, EPA Health Effects Research Laboratory, September 1984: <http://nepis.epa.gov/Exe/ZyNET.exe/300065H1.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1981+Thru+1985&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D:%5c%5cfiles%5cIndex%20Data%5c81thru85%5cTxt%5c00000001%5c300065H1.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7c-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL>

³³ Johnson Liakouris AG. Radiofrequency (RF) sickness in the Lilienfeld Study: an effect of modulated microwaves? Arch Environ Health 1998;53:236–8 <http://www.emrpolicy.org/fag/liakouris.pdf>

including headache, ocular dysfunction, fatigue, dizziness, irritability, concentration problems and sleep disorders.

In 2001, the EU's Directorate General for Research produced a report, "The Physiological and Environmental Effects of Non-Ionising Electromagnetic Radiation" that acknowledged that

The hypersensitivity of the alive human organism to ultraweak microwave radiation is reflected in the ways in which this kind of radiation has been found to affect a wide variety of brain functions...such as EEG, electrochemistry, permeability of the blood/brain barrier and to degrade the immune system....

....there is an undeniable consistency between some of these non-thermal influences and the nature of many of the health problems reported, such as headache, sleep disruption, impairment of short-term memory...

....Thus the reports of

- a) *headache are consistent with the fact that microwaves are known to thermally affect the dopamine-opiate system of the brain and to increase the permeability of the blood-brain barrier, since both of these have been medically connected with headache.*
- b) *Sleep disruption are consistent with the effect of GSM (European mobile phone) radiation on... REM sleep and on melatonin levels- the latter being found epidemiologically in the case of RF exposure.*
- c) *Memory impairment is consistent with the finding that microwave radiation targets the hippocampus.*³⁴

A pertinent email dated 2010 from the then-head of the California Public Utilities Commission (CPUC) Michael Peevey to Pacific Gas and Electric (PG&E) executive Brian Cherry has recently become public and is on point. Note his written acknowledgment of what is understood by many members of the scientific and medical communities: "**There really are people who feel pain, etc., related to EMF, etc.....**" Peevey goes on to indicate they should be accommodated (by not forcing a wireless electric meter on their homes) if they can produce a doctor's letter saying they suffer "**from EMF and/or related electronic-related illnesses**" or "**expressing concern about likelihood of suffering same.**"³⁵ I make reference to the relationship between wireless electric meters and Wi-Fi routers and cell towers in my article "Legal and Public Health Problems of the Wireless

³⁴ The Physiological and Environmental Effects of Non-Ionising Electromagnetic Radiation, European Parliament Directorate General for Research, 2001:
[http://www.europarl.europa.eu/RegData/etudes/etudes/join/2001/297574/DG-4-JOIN_ET\(2001\)297574_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/etudes/join/2001/297574/DG-4-JOIN_ET(2001)297574_EN.pdf)

³⁵ Michael R. Peevey, Chairman of the California Public Utilities Commission (CPUC) 2010 email to Brian K. Cherry, Pacific, Gas and Electric (PG&E):
ftp://ftp2.cpuc.ca.gov/PG&E20150130ResponseToA1312012Ruling/2010/09/SB_GT&S_0000529.pdf

Age”, which was posted by Stanford Law School Professor Brian Wolfman on the Consumer Law and Policy Blog³⁶. Proximity to all result in the symptoms in question.

Over 200 scientists from 40 countries issued an appeal in May to the World Health Organization (WHO) and the United Nations Environment Programme (UNEP) that requested that “medical professionals be educated about the biological effects of electromagnetic energy” and that “white-zones (radiation-free areas) be established.”³⁷

In 2011, the Council of Europe Parliamentary Assembly cited research showing “there was such a syndrome of intolerance to electromagnetic fields” and refers to accommodation provided in Sweden:

60. Here, too, the rapporteur stresses that some people may be more sensitive than others to electromagnetic radiation or waves. The research performed, for instance, by Professor Dominique Belpomme, President of the Association for Research and Treatments Against Cancer (ARTAC), on more than 200 people describing themselves as “electro-sensitive” **succeeded, with corroborative results of clinical and biological analyses, in proving that there was such a syndrome of intolerance to electromagnetic fields across the whole spectrum of frequencies....Sweden has granted sufferers from (11 Doc. 12608) electromagnetic hypersensitivity the status of persons with reduced capacity so that they receive suitable protection.**

61. In connection with the proven or potential risks of electromagnetic fields, **it should also be noted that after a Lloyd's report, insurance companies tended to withhold coverage for risks linked with electromagnetic fields under civil liability policies,** in the same way as, for example, genetically modified organisms or asbestos, which is hardly reassuring given the potential risks that stem from these electromagnetic fields.³⁸

Among many citations amongst the armed forces, this excerpt from a 1988 Air Force report, “Radiofrequency microwave radiation: biological effects and safety standards: a review” is on point and describes the neurological dysfunction to the central nervous system that has been recorded from so-called low-level radiation:

*“There is documented evidence that exposure to RF/MW radiation can cause a disturbance in the central nervous system (CNS) of living organisms. Soviet investigators claim that **exposure to low-level radiation can induce serious CNS dysfunctions**. Experiments conducted in the Soviet Union and Eastern Europe have exposed live subjects to radiation levels that are near or below the recommended safe levels prescribed by the ANSI Standard and the USAF AFOSH Standard.*

³⁶ Kopald D. Legal and Public Health Problems of the Wireless Age. *Consumer Law and Policy Blog*, September 9, 2014: <http://pubcit.typepad.com/clpblog/2014/09/legal-and-public-health-problems-of-the-wireless-age.html>, PAR 9.

³⁷ International EMF Scientist Appeal: Scientists Call for Protection from Non-ionizing Electromagnetic Field Exposure, 2015: <https://www.emfscientist.org/index.php/emf-scientist-appeal>

³⁸ “The potential dangers of electromagnetic fields and their effect on the environment”, The Council of Europe Parliamentary Assembly, Committee on Environment, Agriculture and Local and Regional Affairs, Huss J. 2011: <http://assembly.coe.int/nw/xml/XRef/Xref-DocDetails-EN.asp?FileID=13137&lang=EN>

*The NIOSH Technical Report [81 summarized the results of a pathological study published by A. A. Letavet and Z. V. Gordon in 1960. They reported that several CNS related disorders were discovered among 525 workers exposed to RF/MW radiation. The symptoms were listed as: **hypotension, slower than normal heart rates, an increase in histamine content of the blood, an increase in the activity of the thyroid gland, disruption of the endocrine-hormonal process, alterations in the sensitivity to smell, headaches, irritability, and increased fatigue**. Other researchers have acknowledged similar biological responses³⁹.*

In fact the increased histamine content in people manifesting symptoms of sensitivity to EMFs reported in the 1960 Letavet and Gordon pathological study that was referenced in the Air Force report above was found in the work of Dominique Belpomme, which was referenced in the Council of Europe citation (see again, footnote 38). Belpomme's research was published in November 2015: (See: Belpomme D, Campagnac C, Irigaray P. Reliable disease biomarkers characterizing and identifying electrohypersensitivity and multiple chemical sensitivity as two etiopathogenic aspects of a unique pathological disorder. *Rev Environ Health*, 2015; 30(4): 251–271).

In 1965, Ford's Research and Scientific Laboratory commissioned a report from a German researcher called "The Effect of Microwaves on the Central Nervous System" by W. Bergman that reported sensitivity to microwave radiation in patients who had previous nerve injuries:

*Gebhardt, Saidman, Cahen, Dausset, and Weissenberg observed that patients who had recovered from neuralgia and neuritis and who were in the vicinity of a short-wave transmitter, in some cases sensed a slightly painful tingling, even though the disease had not been manifest for years. These sensations extended exclusively to the nerve region which had previously been pathologically affected; **thus, a weak high-frequency energy, which is transmitted to the human body in the form of electromagnetic waves, is sufficient to influence sensory nerves**. Weissenberg furthermore reports that when **patients with acute neuralgia were exposed to the condenser field, they suffered such violent pain that the equipment had to be disconnected**.*

This latter finding is consistent with modern day clinical reports.

*Schweitzer even reports that **the severest pain reactions were sometimes observed in cases of neuritis with the application of minimum dosage**.*⁴⁰

In 1969, the U.S. Naval Observatory Biosciences Division chronicled in the proceedings of a symposium it held the biological phenomena that manifested from chronic exposure

³⁹ "Radiofrequency Microwave Radiation: Biological Effects and Safety Standards: A Review" Scott Bolen, Rome Laboratory, Air Force Materiel Command, Griffiss Air Force Base, New York, 1988: <https://electroplague.files.wordpress.com/2014/09/rf-microwave-radiation-biological-effects-rome-labs.pdf> Pages 11-12.

⁴⁰ "The Effect of Microwaves on the Central Nervous System" Translated from the German for Research and Scientific Laboratory, Ford Motor Company, W. Bergman, 1965: http://www.magdahavas.com/wordpress/wp-content/uploads/2010/12/German_Ford_Motor_company_The_Effect_of_Microwaves_on_The_Central_Nervous_System.pdf Pages 10-13.

to microwave radiation in the workplace, citing the development of a syndrome with three stages. The symptoms described are the symptoms of EHS noted by modern day-clinicians and in the Austrian Medical Association's Guidelines for the Diagnosis of EMF Syndrome. The report refers to exposures in the hundredths of milliWatts/cm², which would correspond to exposures being close and in the beam of a cell transmitter and up close to a high-powered public Wi-Fi hotspot. The paper also states that the group exposed to the lowest exposure levels manifested the highest rates of complaints⁴¹. This suggests the evidence of power density windows which prompts a question as to whether any continual exposure to this radiation truly can be safe.

In 1973 the World Health Organization (WHO) in conjunction with the then-named United States Department of Health, Education and Welfare sponsored the Warsaw Symposium: Biological and Health Hazards of Microwave Radiation. In the presentation "The Biologic Action and Hygienic Significance of Electromagnetic Fields of Superhigh and Ultrahigh frequencies in densely populated areas", JD Dumanskij and MG Sandala noted statistically significant changes in the brain cortex of rabbits at levels commensurate with a present-day Wi-Fi'ed environment (.06 µW/cm² in the UHF band; 5 GHz Wi-Fi operates within the UHF band) and in the level of severe concern per the Institute for Building Biology and Ecology Standards.⁴²) It should also be noted that rabbits often are used by researchers as a proxy for teenagers:

...upon prolonged irradiation, the strength of the process of inhibition within the brain hemisphere cortex was appreciably increased, as evidenced by the appearance of slow rhythms in the electroencephalograms. The observed changes in bioelectric activity of the brain cortex of rabbits confirmed previously reported results of studies on conditioned reflex activity of animals and showed that electromagnetic fields in the UHF and SHF ranges appreciably lowered blood cholinesterase activity...

...In addition we studied the influence of electromagnetic energy in the UHF range upon carbohydrate-phosphorous metabolism. These investigations showed that a prolonged exposure to a field of .06-10 µW/cm² intensity resulted in disturbances in glycogen metabolism, i.e. a reduction in the glycogen content in the liver due to increased phosphorylase activity accompanied by simultaneous accumulation of lactic acid. At the same time a marked influence of UHF fields on oxidative coupling and phosphorylation processes in rat liver mitochondria was detected. Long-term irradiation led to a fall of phosphorylation and oxidation functions of hepatic mitochondria.

The biologic experiments were complemented by histomorphologic studies which showed that the lesions which appeared under the influence of electromagnetic energy in the UHF and SHF ranges took the form of dystrophic changes in the brain, liver, spleen, and testes, along with impairment in blood circulation.

Analysing the results of the above experimental investigations, it should be noted that prolonged action of electromagnetic energy of low intensities in the UHF and SHF ranges resulted in

⁴¹ Dodge CH. "Clinical and Hygienic Aspects of Exposure to Electromagnetic Fields." Naval Observatory Biosciences Division Symposium Proceedings, Richmond, VA (BRH/DBE 70-2) September 17-19, 1969. http://www.magdahavas.com/wordpress/wp-content/uploads/2010/08/Dodge_1969.pdf

⁴² IBE RF Standards: <http://hbelc.org/pdf/standards/SBM-2008C-v3.6.pdf>, page 7, (last viewed 02/3/16).

*appreciable changes in the general status of the organism, conditioned reflex activity, bioelectric activity of the brain cortex, a number of biochemical parameters, blood composition, and morphologic structures of the tissues and organs of the animals under study*⁴³.

A 1976 report prepared by US Army Medical Intelligence, Office of the Surgeon General for the Defense Intelligence Agency, "Biological Effects of Electromagnetic Radiation (RadioWaves and Microwaves) Eurasian Communist Countries" records reported effects of RF Sickness/Microwave Sickness/EHS:

*Subjects exposed to microwave radiation exhibited a variety of neurasthenic disorders against a background of angiodystonia (abnormal changes in toxicity of blood vessels). The most common subjective complaints were headache, fatigue, perspiring, dizziness, menstrual disorders, irritability, agitation, tension, drowsiness, sleeplessness, depression, anxiety, forgetfulness, and lack of concentration*⁴⁴

The report goes on to describe heart rate effects which are found in the present-day research of Magda Havas. (See again: footnote 4):

*Heavy emphasis has been placed on investigations involving electromagnetic radiation on the cardiovascular system. Effects on hemodynamics include blood pressure variations and cardiac arrhythmias. Also included are reports of a slowdown of intraventricular and intra-atrial conduction, diffuse cardiac muscular changes, and ventricular extrasystole. As with other effects, animal studies are frequently reported and human reports are typically retrospective in nature. Many of the variations noted on the cardiovascular system result from central nervous system effects.*⁴⁵

A 1981 report by NASA's Goddard Flight Center, "Electromagnetic Field Interactions with the Human Body: Observed Effects and Theories" documents symptoms of sensitization from microwave radiation, citing a 1978 report by Stuchly (headaches, disturbed sleep at night, memory impairment, pain in muscles and heart region, fatigue, dizziness, etc.) and a 1978 report by Dwyer (bradycardia, hypotension, increase in histamine content in the blood, increased fatigability, periodic or constant headaches). A table in the NASA report also cites studies showing symptoms well below Wi-Fi'ed power densities: (Bise: changes in electroencephalogram, loss of memory, inability to concentrate, irritability).⁴⁶

⁴³ World Health Organization and United States Department of Health, Education and Welfare, Warsaw Symposium, "Biological and Health Hazards of Microwave Radiation, 1973, Session E. Occupational Exposure and Public Health Aspects of Microwave Radiation http://mistic.heig-vd.ch/taillard/microwave_effects/, Pages 29-33.

⁴⁴ Biological Effects of Electromagnetic Radiation (Radio-waves and Microwaves) Eurasian Communist Countries, Defense Intelligence Agency, Prepared by US Army Medical Intelligence and Information Agency, Office of the Surgeon General, March 1976, RL Adams, RA Williams: http://www.magdahavas.com/wordpress/wp-content/uploads/2011/02/BIOLOGICAL_EFFECTS_OF_ELECTROMAGNETIC_RADIATION-RADIOWAVES_AND_MICROWAVES-EURASIAN_COMMUNIST_COUNTRIES.pdf, Page 14.

⁴⁵ Ibid, Defense Intelligence Agency, page 11.

⁴⁶ Electromagnetic Field Interactions with the Human Body: Observed Effects and Theories. NASA purchase order No. S-75151B April, 1981. Prepared for Goddard Flight Center, Greenbelt, MD. www.robindestoits.org/attachment/489726/

In 2002, Norbert Hankin, a senior EPA scientist, restated the obvious conclusion of the EPA's findings communicated in their 1993 letter to the FCC (See again: footnote 31), "The generalization by many that the guidelines protect human beings from harm by any and all mechanisms is not justified."⁴⁷

In 2014, U.S Department of the Interior (DOI) sent a letter to the National Telecommunications and Information Administration (NTIA) with effectively the same conclusion: "The electromagnetic radiation standards used by the Federal Communications Commission (FCC) continue to be based on thermal heating, a criterion now 30 years out of date and inapplicable today."⁴⁸

APPENDIX B

Most recently, the Edmond J. Safra Center for Ethics at Harvard University published a paper by journalism fellow Norm Alster that cites (S. Sivani and D. Sudarsanam — Impacts of Radio-Frequency Electromagnetic Field (RF-EMF) from Cell Phone Towers and Wireless Devices on Biosystem and Ecosystem – A Review, *Biology and Medicine* 4.4 (2013): 202) in which they state:

Based on current available literature, it is justified to conclude that . . . [electromagnetic fields] . . . can change neurotransmitter functions, blood-brain barrier, morphology, electrophysiology, cellular metabolism, calcium efflux, and gene and protein expression in certain types of cells even at lower intensities."

The Harvard Safra Center paper also refers to the Levitt and Lai transmitter metastudy⁴⁹ that documents symptoms at sensitization at distances away from cell towers that would create radiation exposures lower than those found in some Wi-Fi'ed environments today. It quotes two studies (Santini, R., Santini, P., Danze, J.M., Le Ruz, P., and Seigne, M. 2002. Enquete sur la sante de riverains de stations relais de telephonie mobile : Incidences de la distance et du sexe. *Pathol. Biol.* 50: 369–373. doi:10.1016/S0369-8114(02)00311-5) and (Abdel-Rassoul, G., El-Fateh, O.A., Salem, M.A., Micgael, A., Farahat, F., and Salem, E. 2007. Neurobehavioral effects among inhabitants around mobile phone base stations. *Neurotoxicology*, 28(2): 434–440. doi:10.1016/j.neuro.2006.07.012) that would have occurred before Wi-Fi was ubiquitous or even very common in those locations (meaning that Wi-Fi would not have been likely to be responsible for the symptoms recorded):

⁴⁷ Norbert Hankin, Center for Science and Risk Assessment, EPA Radiation Protection Division July 6, 2002 letter to Janet L. Newton, President, The EMR Network: <http://www.aemc.gov.au/Media/docs/Market-Review-Submission-EPR0022---Helen-Weir---121009---Supporting-document-3-85f00cf2-edec-4fb3-9ce4-d3166da1e356-0.PDF> Page 3 of PDF (Page 2 of the Hankin letter)

⁴⁸ Willie R. Taylor, Director, Office of Environmental Policy and Compliance, United States Department of the Interior, Office of the Secretary February 7, 2014 letter to Eli Veenendaal, National Telecommunications and Information Administration: http://www.ntia.doc.gov/files/ntia/us_doi_comments.pdf, Page 5.

⁴⁹ Levitt B, Lai H. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. *Environ Rev* 2010; 18:369–95.

They summarized the results on one 2002 study that compared the health of 530 people living at various distances within 300 meters of cell towers with a control group living more than 300 meters away. "Results indicated increased symptoms and complaints the closer a person lived to a tower"...."Significant differences were observed up through 100m for irritability, depressive tendencies, concentration difficulties, memory loss, dizziness and lower libido.

A 2007 study conducted in Egypt found similar results. Levitt and Lai report, "Headaches, memory changes, dizziness, tremors, depressive symptoms and sleep disturbance were significantly higher among exposed inhabitants than controls."⁵⁰

Many of the exposures in the tower studies cited in the Levitt and Lai metastudy were at or below radiation levels found in present day Wi-Fi'ed environments. Rolling out more transmitter infrastructure to enable the use of more Wi-Fi'ed and higher-powered devices will interfere with providing accommodation under the ADA and worsen the public's health. At a minimum, further rollouts should not occur when the 2013 Request for Comment on radiation standards has not been reviewed. Congressional hearings on the scope of the problem are necessary, and the FCC should not be permitted to set its own standards since an adequate performance of that task conflicts with the FCC's stated mission to promote the rollout and use of more of the radiation-emitting technology.

⁵⁰ Captured Agency: How the Federal Communications Commission is Dominated by the Industries it Presumably Regulates: http://ethics.harvard.edu/files/center-for-ethics/files/capturedagency_alster.pdf, Page 11.

Radiation Sickness - Children; Dr. Ann Lee MD.
(Petitioner) Comments; Sep. 30, 2016

Hello,

I am a physician and my training is in physical medicine and rehabilitation. I have a son who was diagnosed with a heart murmur when he was five years old. This was found on a routine physical exam required for admission to public school. An echocardiogram confirmed he had a loose heart valve with regurgitation. My son had no symptoms at the time, so the cardiologist said we could just follow up if he developed any new symptoms in the future.

Two years later, my son started to complain of chest pain for the first time after visiting the second floor of a newly built library in Palo Alto for a tutoring session. This occurred every week when we visited his tutor at the library. We repeated his echocardiogram, which I suspected would show a worsening heart defect. To my surprise, it was normal. His cardiologist said the murmur had resolved and my son had the "heart of an athlete." When I asked what could have caused my son's chest pain, he said he wasn't sure and to come back if there were any worsening symptoms. My son was seven years old then.

The cardiologist's reply didn't satisfy my physician's or mother's instinct. I couldn't find anything in the medical textbooks about chest pain in children with structurally normal hearts, so I resolved to look online through pubmed as well as "google it." On the web, I found several studies which showed adverse biological effects from wireless radiation and reports of children experiencing unusual, sometimes generalized symptoms of nausea, headache, skin rashes and chest pain, etc. after their school installed WiFi routers in the classrooms.

I did some investigation and looked for routers in the library. On the floor where he used to get tutoring, there were seven routers on the ceiling and almost every adult there was accessing them wirelessly on their laptops. My son's school also had WiFi routers in every other classroom. However, he did not complain of chest pain at school. I decided we would avoid going to the library and leave it at that.

Then in April 2016, California public schools performed a standardized test. All the students in his classroom had to access the test using their laptops wirelessly. This was the first time he complained of experiencing chest pain at school. He was eight years old.

I shared some of the studies I found with my friend Amrutha Kattamuri, who was chairperson of the safety committee on our school Site Council. She performed her own investigation and also reached out to several research experts in the field of microwave radiation and health. Since then, we have been laboring to educate as many parents as possible, as well as teachers, school officials, board members, PTA representatives, etc.

My story is one of many but it is the science behind this movement that is compelling.

In May 2016, the United States National Toxicology Program, part of the U.S. Dept of Health and Human Services, released the results of an animal study on cell phone radiation. This study showed a statistically significant increase in brain gliomas and heart schwannomas in exposed rats (900 MHz). The mice protocol will be completed by end of 2017 (1900 MHz exposure).

A few years earlier, in 2013, professor Martin Pall, PhD, of Washington State University had published papers showing how voltage-gated calcium channels (VGCC) may become dysregulated in the presence of wireless radiation of extremely low and microwave frequencies (cell phone and WiFi frequencies) leading to adverse biological effects involving peroxynitrite, an oxidant which promotes inflammation and intracellular damage including DNA.

As VGCC are mostly found in excitable tissues, the brain and heart would likely be most effected from these types of exposures. Inflammatory factors promoted by peroxynitrite may be involved in biomarkers found in patients diagnosed with electrohypersensitivity and multiple chemical sensitivity (Rev Environ Med, 2015). VGCC overexpression has been detected in glioblastomas (Cancers, 2015,7,pg 856).

Although these findings have been reproduced, there is currently much debate in the scientific community whether wireless radiation has any relevance to human health or require further regulation by governing bodies. The Center for Ethics at Harvard University published a paper titled Captured Agency, which addresses the conflict of interest which spurs on much of this debate.

Recently, there have been measures taken by local governments in San Francisco and Berkeley to warn the public of wireless radiation and its possible health effects by labeling mobile phone products with the same warnings that manufacturers place within the legal information page of each product. They were both sued by the Cellular Telephone Industries Association (CTIA), who represent the \$200 billion dollar mobile phone industry.

Organizations which support stricter regulations on wireless radiation include the American Academy of Pediatrics and the California Medical Association. In 2011, the International Agency for Research on Cancer (IARC, a division of the World Health Organization) had classified wireless radiation as a class 2b carcinogen, which is in the same class as lead, DDT and car exhaust. International scientists have appealed to the UN and WHO to promote public awareness and education about wireless radiation and adverse health effects.

Despite this, the FCC, FDA and CDC state there is "no scientific evidence" or that there is no science to link cell phone use to health problems. These statements are untrue as demonstrated by the U.S. NTP study and are not appropriate responses from regulating agencies when there is science to show reasons to take precautionary measures.

The following are a couple of scientific presentations which you may find interesting:

<https://www.youtube.com/watch?v=ma-OVwNnKvU>

<https://www.youtube.com/watch?v=a6wLFeIrCtU>

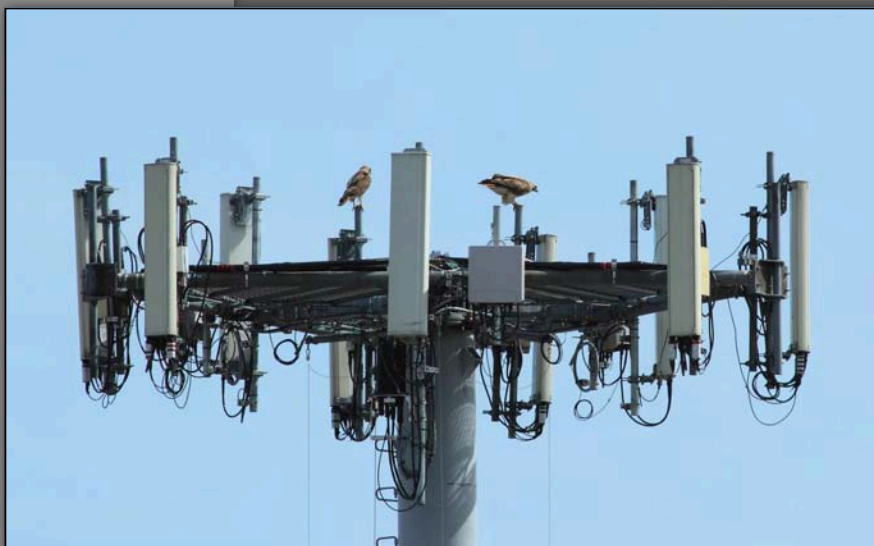
Do not install DSA cell sites in our residential neighborhoods where children reside. We will be sure to contact our representatives to notify them of our concerns.

Sincerely,

Ann Lee MD

Radiation Sickness; Health Effects of Microwave Radio Exposures.
Dr. Paul Dart MD. (Petitioner) Comments, Sep. 3, 2013

Health Effects of Microwave Radio Exposures



Paul Dart MD FCA

The current FCC Limits for Microwave RF Exposure were published in 1999.

These guidelines are only designed to protect the public against the thermal effects of microwave RF.

The FCC has explicitly stated that they do not make any regulations or assurances whatsoever regarding the “nonthermal” biological effects of lower level microwave RF exposures (other physiologic effect besides heat damage).

Many statements from industry spokesmen state that “not enough is known” about these exposures to identify risk, or that there is “insufficient” or “incomplete” evidence regarding such risks, or that there is “no scientific consensus” on this risk.

This implies that there isn’t much scientific information on this subject. But actually, there is a great deal of research documenting adverse biological effects from low level RF exposures.

Acute Symptoms from RF Exposure: “EHS”

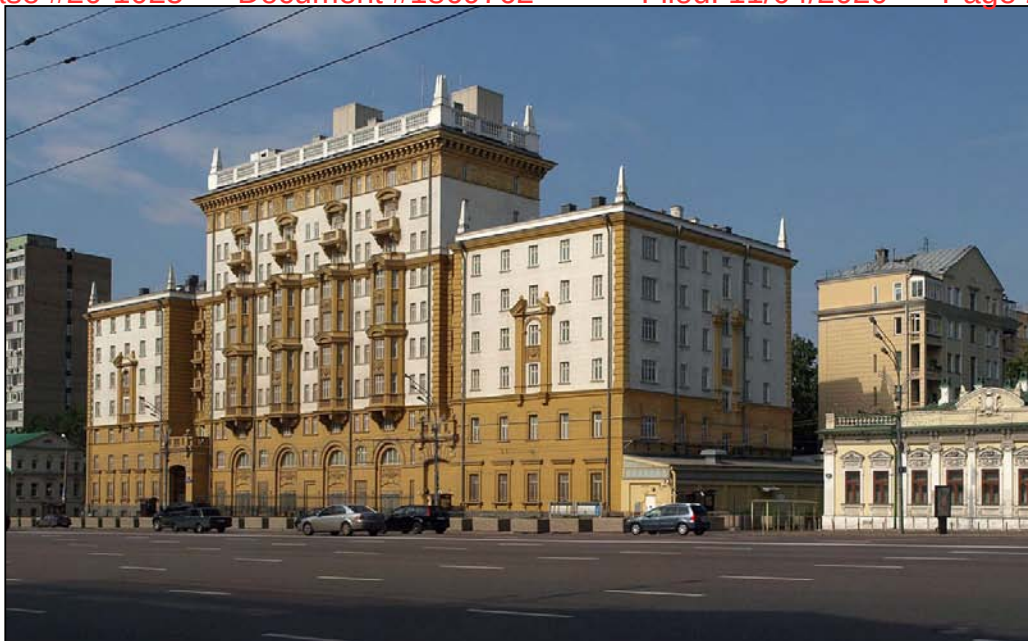


In this presentation, we’re going to take a look at the current scientific evidence for adverse effects of RF exposures.

First, we’ll look at the evidence that RF exposures can produce acute symptoms in many individuals.

Then we’ll look at the evidence that RF exposures alter hormone physiology and increase oxidative stress in living systems.

Then we’ll review the evidence that such alterations in physiology can damage DNA, increase the incidence of some forms of cancer, and decrease fertility in animals and in human beings.



Acute symptoms provoked by microwave radiation were first described by Russian medical researchers in the 1950's. They described a constellation of symptoms including headache, ocular dysfunction, fatigue, dizziness, sleep disorders, dermatographism, cardiovascular abnormalities, depression, irritability, and memory impairment.

In the years between 1953 and 1978 the Russian government harrassed the U.S. Embassy in Moscow by targeting it with radiation from a microwave transmitter positioned on the roof of a nearby building.

Exposed embassy staff experienced a statistically significant excess of several problems, including: depression, irritability, difficulty in concentrating, memory loss, ear problems, skin problems, vascular problems, and other health problems. Symptom incidence increased significantly with accrued years of exposure.

Exposure levels inside the building were in the order of 2 to 28 $\mu\text{W}/\text{cm}^2$ (FCC Guidelines: 600 $\mu\text{W}/\text{cm}^2$)

U.S. Embassy, Moscow (1953-1978)

50272-101		1. REPORT NO.		2.	3. P8288163
REPORT DOCUMENTATION PAGE		4. Title and Subtitle		5. Report Date	
		Evaluation of Health Status of Foreign Service and other Employees from Selected Eastern European Posts		July 31, 1973	
7. Author(s)		8. Performing Organization Rept. No.			
Abraham M. Lilienfeld, M.D. Principal Investigator					
9. Performing Organization Name and Address		10. Project/Task/Work Unit No.			
Department of Epidemiology School of Hygiene and Public Health The Johns Hopkins University					
12. Sponsoring Organization Name and Address		11. Contract(C) or Grant(G) No.			
Medical Director Office of Medical Services Department of State Washington, D C		(C) 6025 619073 (G)			
13. Type of Report & Period Covered		14.			
Final 1953 - 1976					
15. Supplementary Notes					
Released publicly November 20 simultaneously by Department of State and The Johns Hopkins University.					
16. Abstract (Limit: 200 words)					
This is a biostatistical study of 1827 Department of State employees and their dependents at the Moscow Embassy and 2561 employees and their dependents from other Eastern European Embassies. Health records, health questionnaires and death certificates were the basic information sources. The study is the impact of the Moscow environment including microwave exposure on the health status and mortality of the employees. It was concluded that personnel working at the American Embassy in Moscow from 1953 to 1976 suffered no ill effects from the microwaves beamed at the Embassy.					

Concern about health effects among Embassy personnel led to a detailed study by A.M. Lilienfeld, an epidemiologist at Johns Hopkins University. The abnormalities found in this study were an embarrassment to the U.S. government, since the levels of exposure experienced by embassy staff inside the building were in the order of 2 to 28 microwatts/cm², a level dramatically below the described U.S. safety standards for microwave exposure. It appears that the conclusions of the study were altered to soft-pedal any abnormal findings.

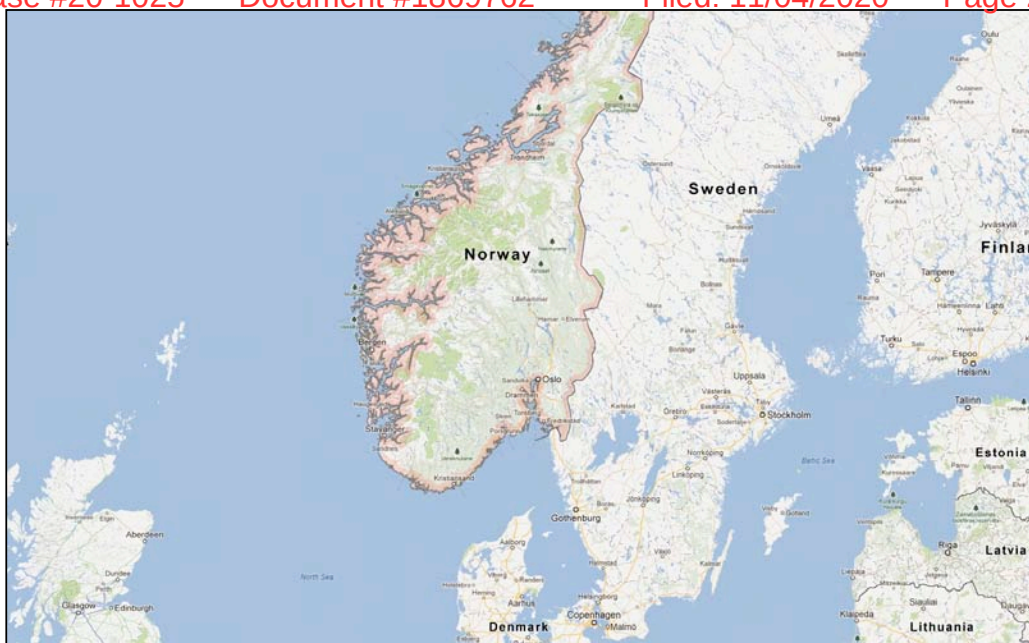
Lilienfeld AM LGM, Cauthen J, Tonascia S, Tonascia J. Evaluation of health status of foreign service and other employees from selected eastern European embassies. *Foreign Service Health Status Study, Final Report*; Contract No. 6025-619037 (NTIS publication P8-288 163/9) (1979); 1-447.

Liakouris AG. Radiofrequency (RF) Sickness in the Lilienfeld Study: An Effect of Modulated Microwaves? *Archives of Environmental Health* (1998); 53(3):236-238.

Goldsmith JR. Where the trail leads. Ethical problems arising when the trail of professional work leads to evidence of a cover-up of serious risk and mis-representation of scientific judgement concerning human exposures to radar. *Eubios Journal of Asian and International Bioethics* (1995b); 5(4):92-94.

Cherry N. Evidence of Health Effects of Electromagnetic Radiation, To the Australian Senate Inquiry into Electromagnetic Radiation (2000): 1-84. http://www.nelc.cherry.com/documents/90_m1_EMR_Australian_Senate_Evidence_8-9-2000.pdf

Norway (1998)



From:

Mild, K.H., Oftedal, G., Sandstrom, M., Wilen, J., Tynes, T., Haugsdal, B. and Hauger E., 1998: "Comparison of symptoms by users of analogue and digital mobile phones - A Swedish- Norwegian epidemiological study". National Institute for Working Life, 1998:23, Umea, Sweden, 84pp.

Norway (1998)

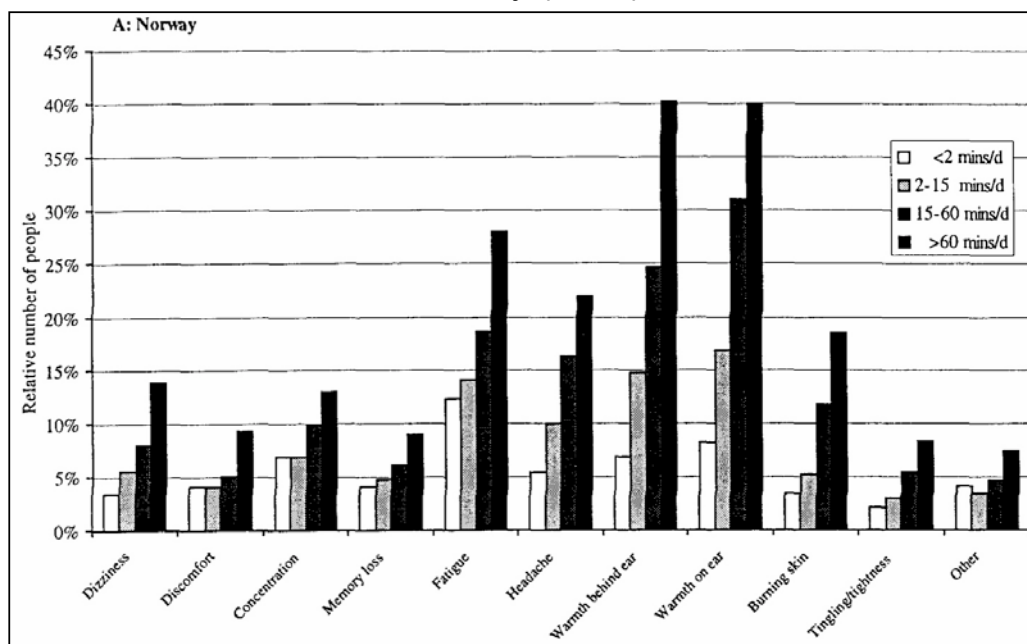


Figure 11: Prevalence of symptoms for Norwegian mobile phone users, mainly analogue, with various categories of length of calling time per day, from Mild et al. (1998).

In:

Cherry N. EMF/EMR Reduces Melatonin in Animals and People. (2002):1-14. <http://www.neilcherry.com/documents.php>

From:

Mild, K.H., Oftedal, G., Sandstrom, M., Wilen, J., Tynes, T., Haugsdal, B. and Hauger E., 1998: "Comparison of symptoms by users of analogue and digital mobile phones - A Swedish- Norwegian epidemiological study". National Institute for Working Life, 1998:23, Umea, Sweden, 84pp.



Town of 1900 inhabitants, with GSM cell phone tower.

Questionnaire distributed, 5% of inhabitants responded. The questionnaire was composed of 25 different items mainly concerning health information about the respondents.

The respondents scored and marked from 0 to 3 the presence of the suffered health dysfunction: 0 never, 1 sometimes, 2 often, 3 very often.

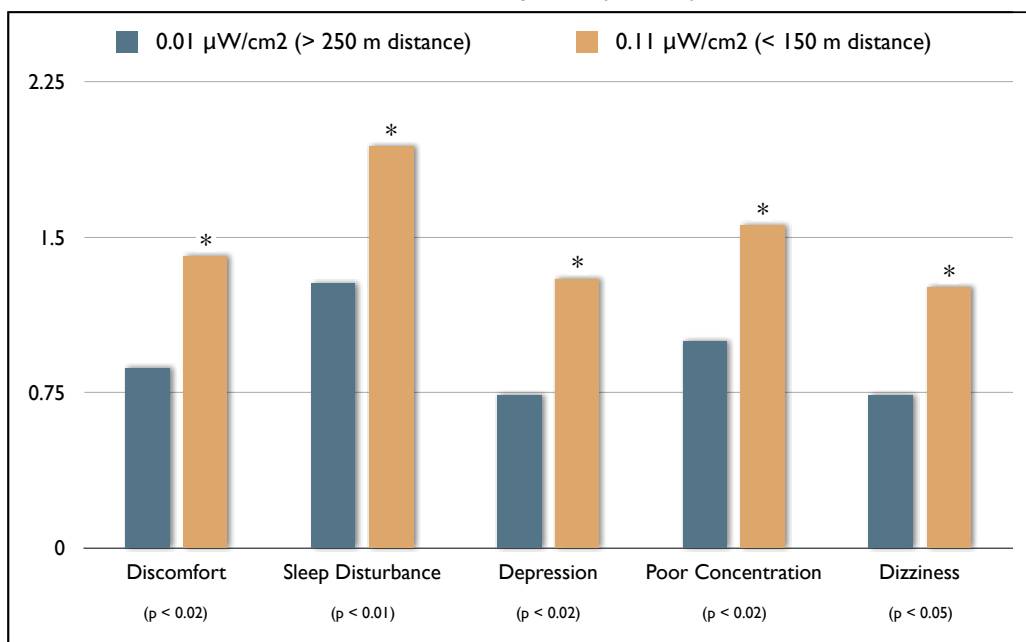
Power density of signal in bedrooms of respondents was measured.

Area A (< 150 meters from tower) = average power density $0.11 \mu\text{W}/\text{cm}^2$.

Area B (> 250 meters from tower) = average power density $0.01 \mu\text{W}/\text{cm}^2$.

Navarro E, Segura J, Portolés M, Gómez-Perretta C. The Microwave Syndrome: A Preliminary Study in Spain. *Electromagn Biol Med* (2003); 22(2-3):161-169.

La Ñora, Spain (2001)



Symptom score (0 – 3) vs Average Bedroom Exposure Levels to Microwave RF

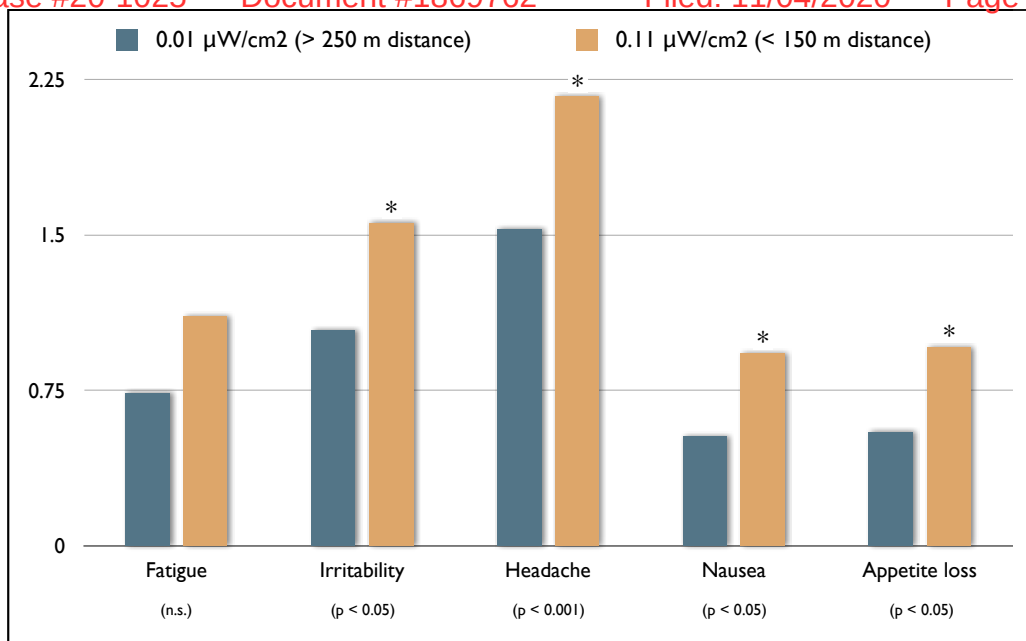
FCC Guidelines: 600 - 1000 $\mu\text{W}/\text{cm}^2$

Navarro E, Segura J, Portolés M, Gómez-Perretta C. The Microwave Syndrome: A Preliminary Study in Spain. *Electromagn Biol Med* (2003); 22(2-3):161-169.

Abstract

A health survey was carried out in Murcia, Spain, in the vicinity of a Cellular Phone Base Station working in DCS-1800 MHz. This survey contained health items related to "microwave sickness" or "RF syndrome." The microwave power density was measured at the respondents' homes. Statistical analysis showed significant correlation between the declared severity of the symptoms and the measured power density. The separation of respondents into two different exposure groups also showed an increase of the declared severity in the group with the higher exposure.

La Nôra Spain (2001)



Symptom score (0 – 3) vs Average Bedroom Exposure Levels to Microwave RF

Based on the data of this study the advice would be to strive for levels not higher than 0.02 V/m for the sum total, which is equal to a power density of 0.0001 $\mu\text{W}/\text{cm}^2$ or 1 $\mu\text{W}/\text{m}^2$, which is the indoor exposure value for GSM base stations proposed on empirical evidence by the Public Health Office of the Government of Salzburg in 2002.

Oberfeld G, Navarro E, Portoles M, Maestu C, Gomez-Perretta C. The Microwave Syndrome -- Further Aspects of a Spanish Study. (2004):1-8. http://www.powerwatch.org.uk/pdfs/20040809_kos.pdf

France (2002)



Questionnaire re multiple symptoms that have been described for “microwave syndrome”.

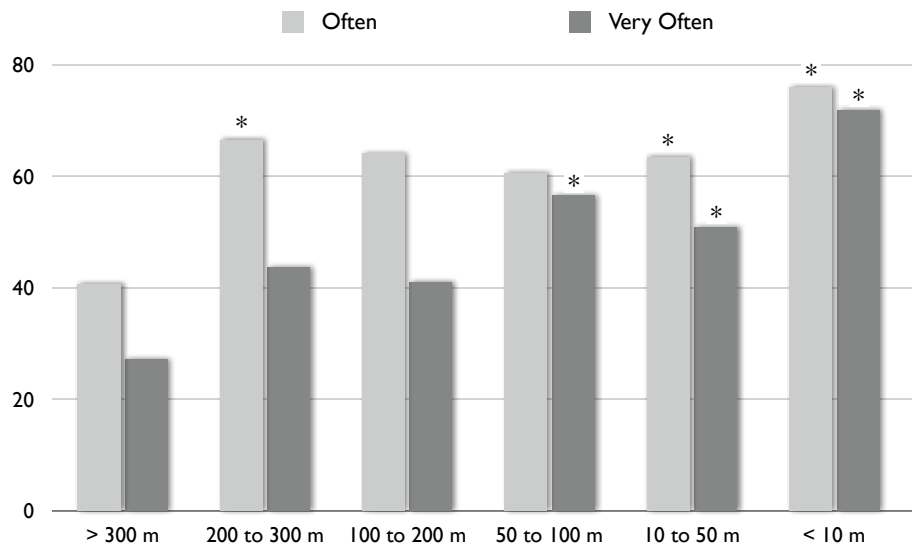
n = 530

Evaluated incidence of symptoms as a function of residential proximity in meters to a cell phone tower.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49.

Fatigue



* p < 0.05 in comparison to residence > 300 meters or not exposed.

X axis = responses grouped by residential proximity to cell phone tower (in meters).

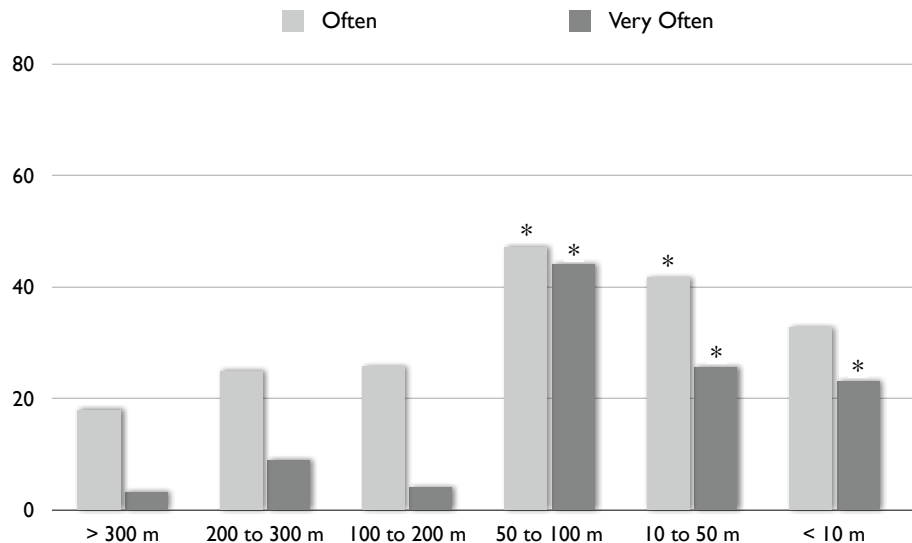
Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49

Irritability



* p < 0.05 in comparison to residence > 300 meters or not exposed.

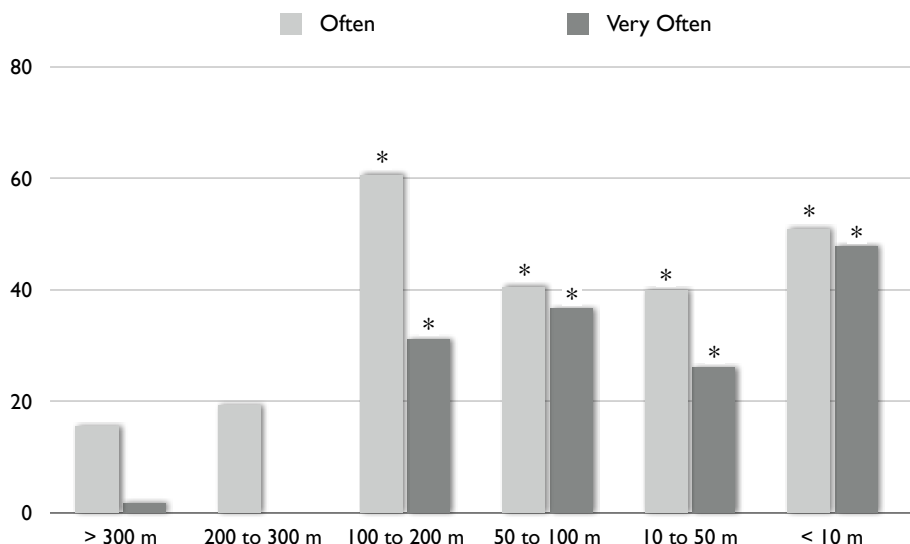
X axis = responses grouped by residential proximity to cell phone tower (in meters).

Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49



* p < 0.05 in comparison to residence > 300 meters or not exposed.

X axis = responses grouped by residential proximity to cell phone tower (in meters).

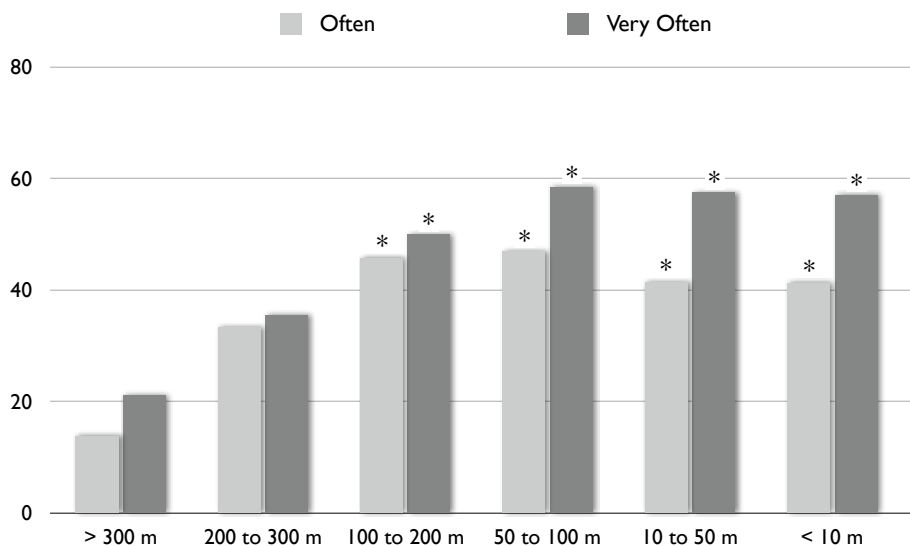
Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49

Sleep Disruption



* p < 0.05 in comparison to residence > 300 meters or not exposed.

X axis = responses grouped by residential proximity to cell phone tower (in meters).

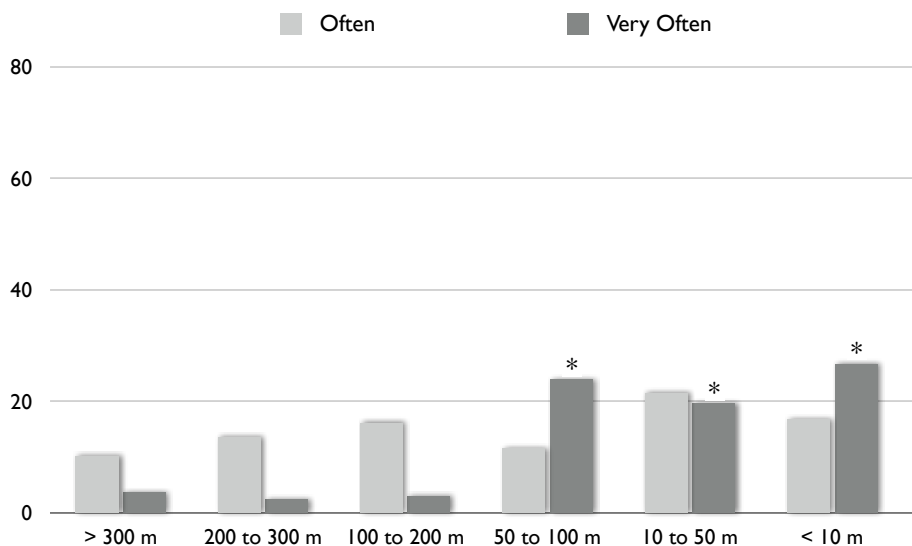
Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49

Depression



* p < 0.05 in comparison to residence > 300 meters or not exposed.

X axis = responses grouped by residential proximity to cell phone tower (in meters).

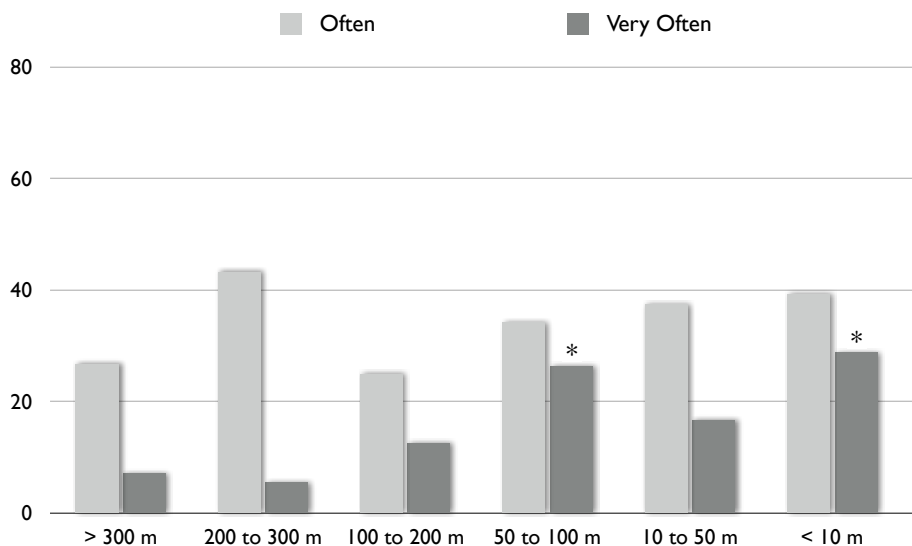
Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49

Difficulty in Concentration



* p < 0.05 in comparison to residence > 300 meters or not exposed.

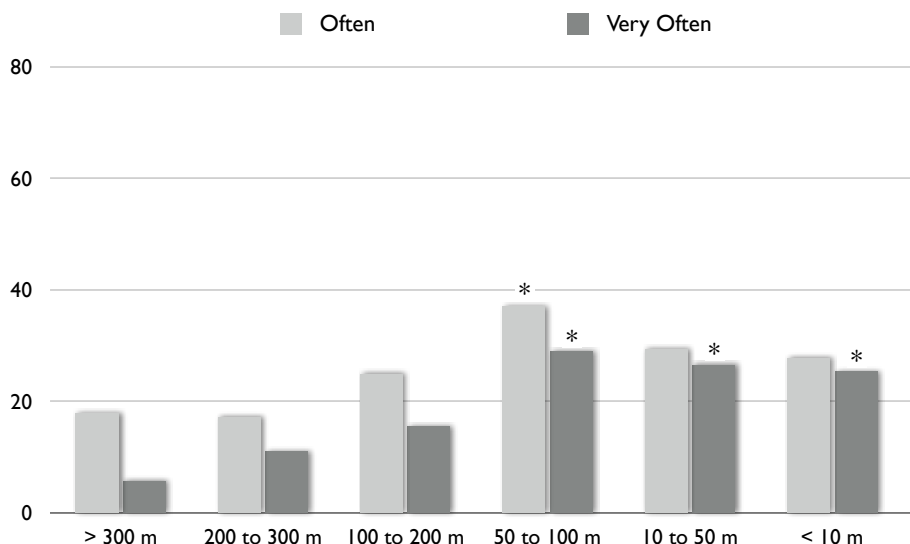
X axis = responses grouped by residential proximity to cell phone tower (in meters).

Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49



* p < 0.05 in comparison to residence > 300 meters or not exposed.

X axis = responses grouped by residential proximity to cell phone tower (in meters).

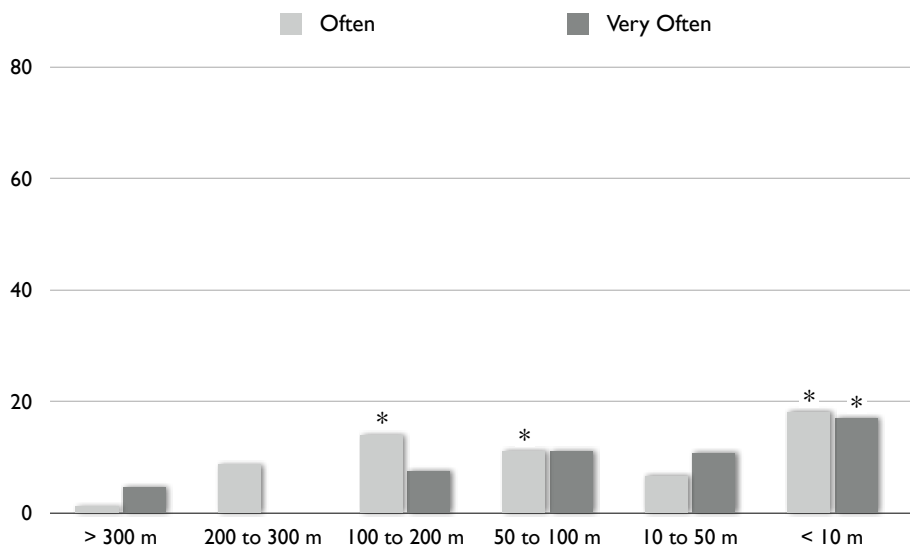
Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49

Skin Problems



* p < 0.05 in comparison to residence > 300 meters or not exposed.

X axis = responses grouped by residential proximity to cell phone tower (in meters).

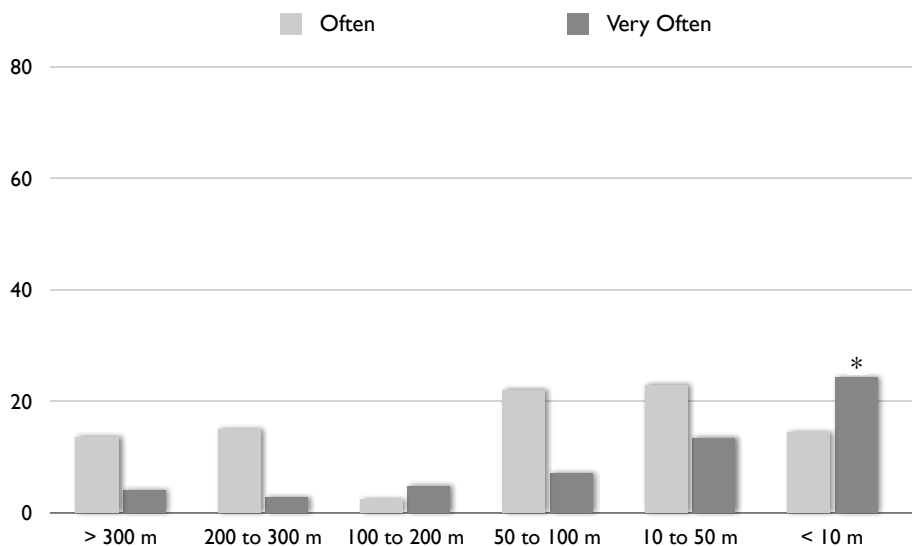
Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49

Visual Disruption



* $p < 0.05$ in comparison to residence > 300 meters or not exposed.

X axis = responses grouped by residential proximity to cell phone tower (in meters).

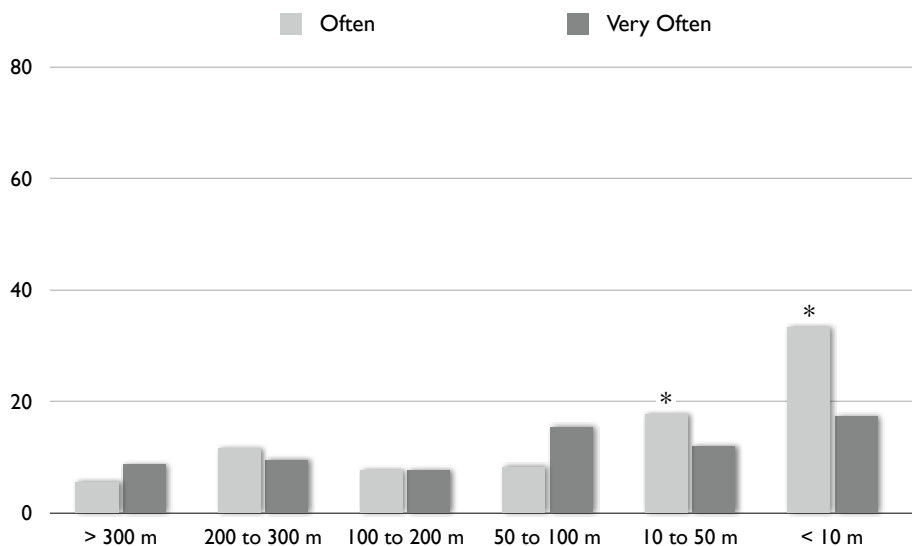
Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49

Hearing Disruption



* $p < 0.05$ in comparison to residence > 300 meters or not exposed.

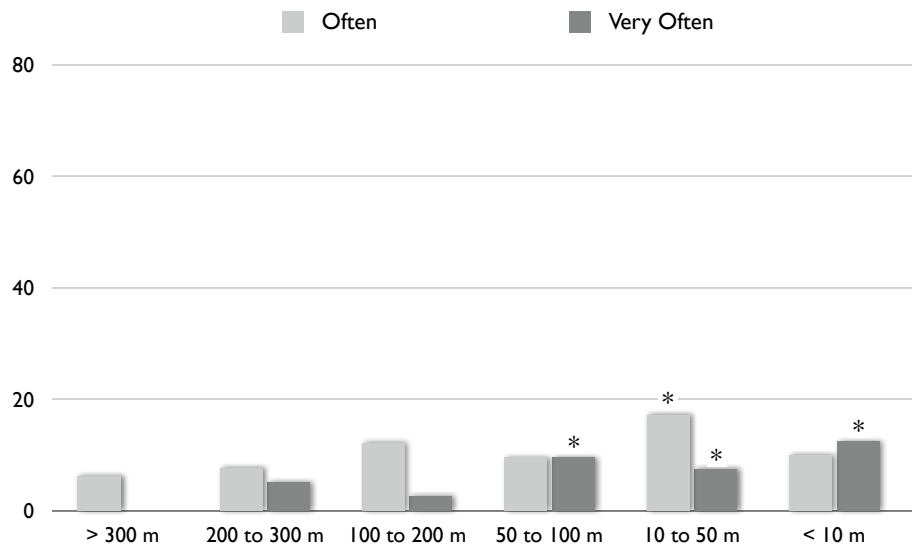
X axis = responses grouped by residential proximity to cell phone tower (in meters).

Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49



* p < 0.05 in comparison to residence > 300 meters or not exposed.

X axis = responses grouped by residential proximity to cell phone tower (in meters).

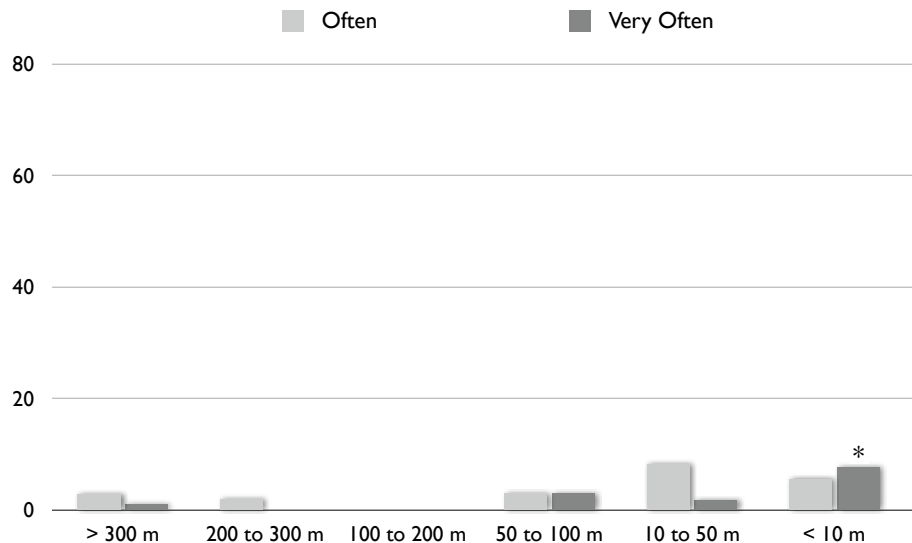
Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49

Movement Difficulties



* p < 0.05 in comparison to residence > 300 meters or not exposed.

X axis = responses grouped by residential proximity to cell phone tower (in meters).

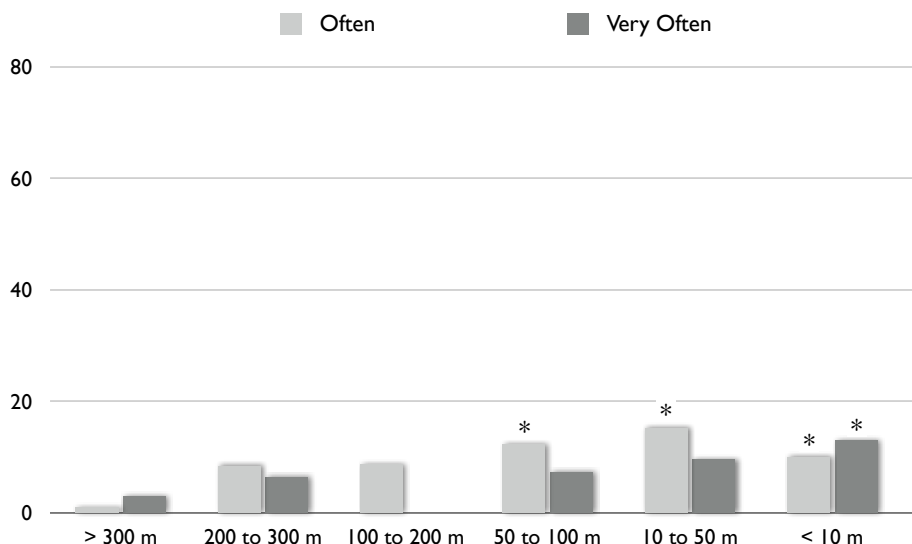
Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49

Cardiovascular Problems



* p < 0.05 in comparison to residence > 300 meters or not exposed.

X axis = responses grouped by residential proximity to cell phone tower (in meters).

Y axis = percentage in exposure category answering "Often" or "Very Often" to a symptom query, in reference to total number of respondents living at that distance who answered "Never" to that symptom query.

* = statistically significant for this sample size.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49

Elderly people are more vulnerable

	≤ 20 years		21-40 years		41-60 years		> 60 years	
	Distances of subjects from antennas (in meters)							
Symptoms	≤ 300	> 300	≤ 300	> 300	≤ 300	> 300	≤ 300	> 300
Fatigue	56.7	62.5	82.4*	25	81.4*	57.8	73.3*	40
Irritability	16.2	11.1	46.2	18.2	50.5	35.3	52.1*	21
Headaches	42.4	26.3	57.6*	18.2	52*	13.3	49.5*	10
Nausea	2	0	12.9	0	9.9	0	15.6	15.7
Loss of appetite	13.3	8.8	12.7	0	11.8	0	15.9	15
Sleep disturbances	26.1	14.8	53*	12.5	73.9	52.6	68.5*	44.4
Depressive tendencies	10.2	5.7	14	5.8	36	20	41.7	27.7
Feeling of discomfort	4.4	2.9	26.3	6	41.6	16.6	45*	19
Difficulties in concentration	30.3	40	42.1	18.7	45.8	36.8	53.3*	20
Memory loss	7.5	8	21.8	6.6	45	40	64	36.8
Skin problems	16.6	9.3	24.2	6.6	18.3	0	20.4	5.2
Visual disturbances	16.3	12.5	14.7	12.5	26.6	26.3	36.8	17.6
Hearing disturbances	9.4	5.1	15.4	0	29.8	21.7	43.8	31.5
Dizziness	6.2	5.2	3.2	6.6	15.4	4.5	39.3*	9.5
Movement difficulties	0	2.3	0	0	3.5	4	21.4	10.5
Cardiovascular problems	0	2.3	5.1	0	19.2*	0	36.4	15

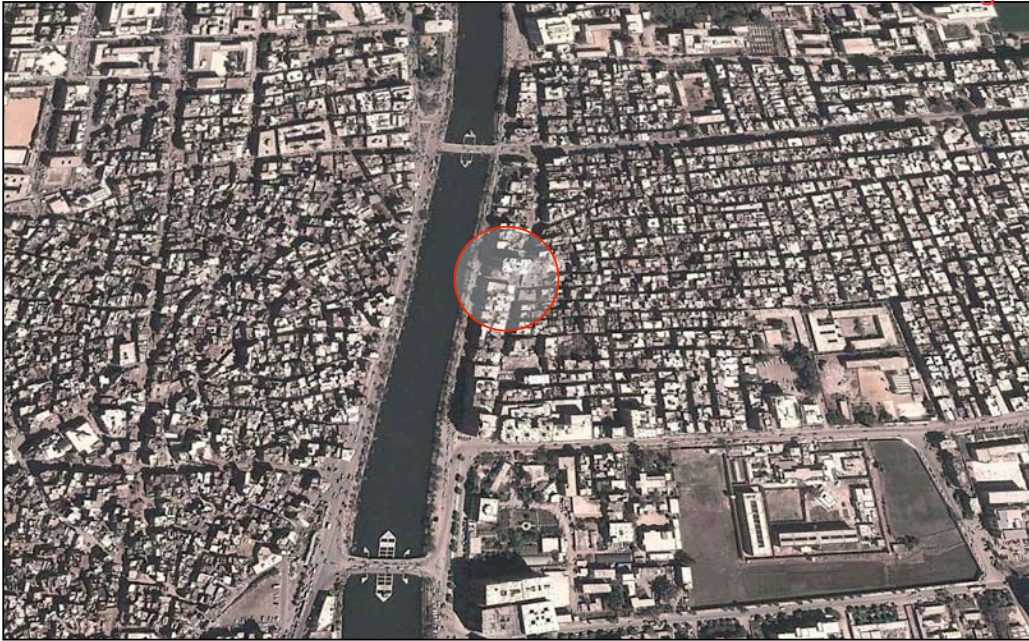
for 16 Non Specific Health Symptoms experienced by 530 people (270 men + 260 women) in relation to their distances from cellular phone base stations (≤ 300 m vs. > 300 m [reference group]).

* = $P < 0.05$ for levels of complaints 2 + 3 pooled.

Influence of age on the percentage of complaints

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. [Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]. *Pathol Biol (Paris)* (2002); 50(6):369-373.

Santini R SP, Le Ruz P, Danze J, Seigne M. Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine* (2003); 22(1):41-49.



Study of 85 inhabitants living near the first cell phone tower in the city (tower operational since 1998).

Abdel-Rassoul G, El-Fateh OA, Salem MA et al. Neurobehavioral effects among inhabitants around mobile phone base stations. *Neurotoxicology* (2007); 28(2): 434-440.

BACKGROUND: There is a general concern on the possible hazardous health effects of exposure to radiofrequency electromagnetic radiations (RFR) emitted from mobile phone base station antennas on the human nervous system. **AIM:** To identify the possible neurobehavioral deficits among inhabitants living nearby mobile phone base stations. **METHODS:** A cross-sectional study was conducted on (85) inhabitants living nearby the first mobile phone station antenna in Menoufiya governorate, Egypt, 37 are living in a building under the station antenna while 48 opposite the station. A control group (80) participants were matched with the exposed for age, sex, occupation and educational level. All participants completed a structured questionnaire containing: personal, educational and medical histories; general and neurological examinations; neurobehavioral test battery (NBTB) [involving tests for visuomotor speed, problem solving, attention and memory]; in addition to Eysenck personality questionnaire (EPQ). **RESULTS:** The prevalence of neuropsychiatric complaints as headache (23.5%), memory changes (28.2%), dizziness (18.6%), tremors (9.4%), depressive symptoms (21.7%), and sleep disturbance (23.5%) were significantly higher among exposed inhabitants than controls: (10%), (5%), (5%), (0%), (8.8%) and (10%), respectively ($P < 0.05$). The NBTB indicated that the exposed inhabitants exhibited a significantly lower performance than controls in one of the tests of attention and short-term auditory memory [Paced Auditory Serial Addition Test (PASAT)]. Also, the inhabitants opposite the station exhibited a lower performance in the problem solving test (block design) than those under the station. All inhabitants exhibited a better performance in the two tests of visuomotor speed (Digit symbol and Trailmaking B) and one test of attention (Trailmaking A) than controls. The last available measures of RFR emitted from the first mobile phone base station antennas in Menoufiya governorate were less than the allowable standard level. **CONCLUSIONS AND RECOMMENDATIONS:** Inhabitants living nearby mobile phone base stations are at risk for developing neuropsychiatric problems and some changes in the performance of neurobehavioral functions either by facilitation or inhibition. So, revision of standard guidelines for public exposure to RFR from mobile phone base station antennas and using of NBTB for regular assessment and early detection of biological effects among inhabitants around the stations are recommended.

Shebeen El-Kom, Egypt (2003)



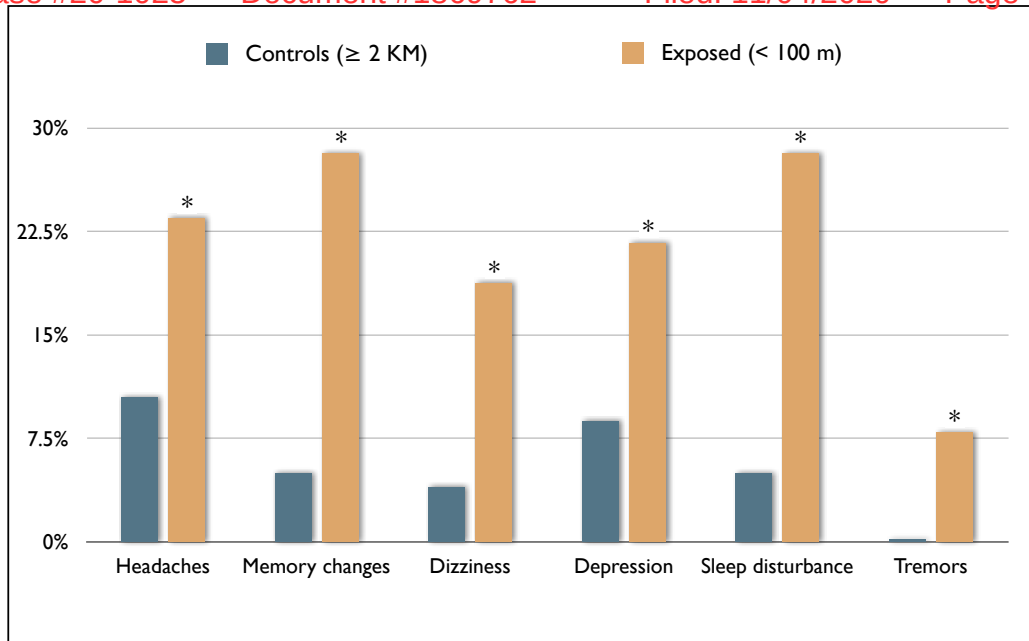
37 subjects lived in the building under the transmitters.

48 others worked in the building across the street.

A control group of 80 individuals worked in a building 2 kilometers away from the towers.

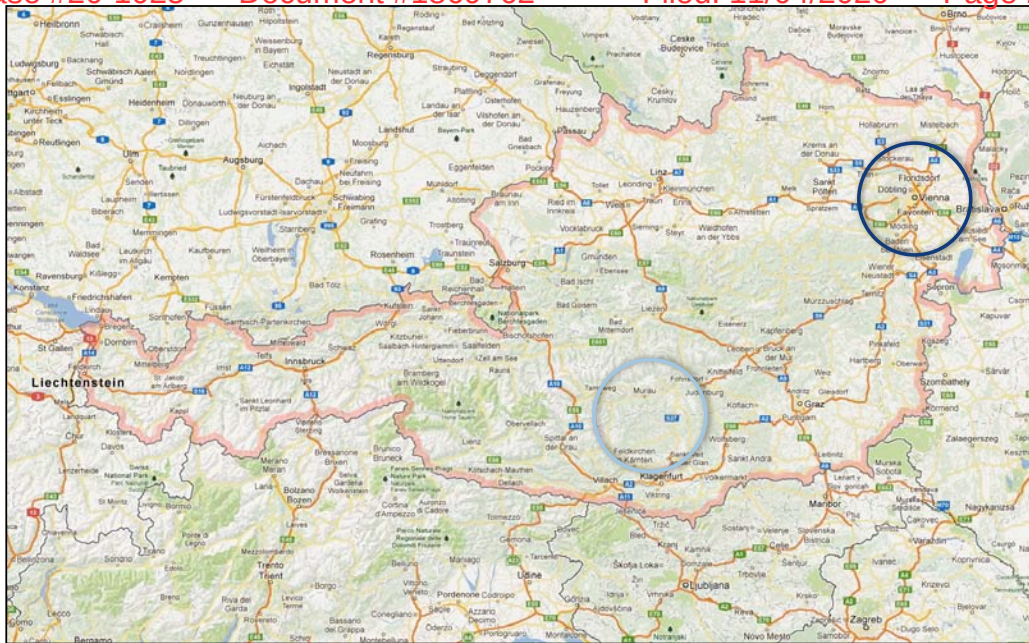
Controls were matched for age, sex, occupation, education level, and mobile phone use.

Shebeen El-Kom, Egypt (2003)



* = statistically significant at this sample size ($p < 0.05$ or better)

Abdel-Rassoul G, El-Fateh OA, Salem MA et al. Neurobehavioral effects among inhabitants around mobile phone base stations. *Neurotoxicology* (2007); 28(2): 434-440.



Study of health effects around 10 cell phone towers ("base stations") in urban and rural Austria.

Criteria:

Towers operational for > 2 years.

No local controversy.

No other towers nearby (when possible).

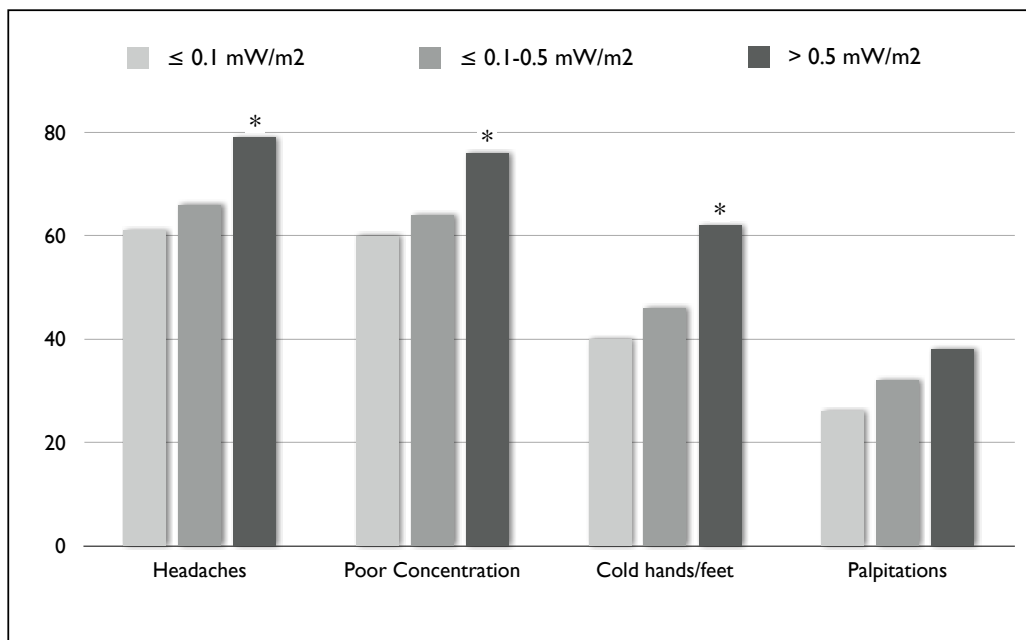
900 MHz transmission.

Random selection of households within the study areas.

Performance tests, symptom questionnaires, exposure measurements in the subject's bedroom.

Hutter HP, Moshammer H, Wallner P, Kundi M. Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. *Occup Environ Med* (2006); 63(5):307-313.

Austria (2004)



Percentage of subjects reporting symptoms, stratified by RF exposure levels as measured in subject's bedroom.

* = statistically significant for this sample size.

FCC Guidelines: 6000 mW/m²

Hutter HP, Moshammer H, Wallner P, Kundi M. Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. *Occup Environ Med* (2006); 63(5):307-313.

BACKGROUND: The erection of mobile telephone base stations in inhabited areas has raised concerns about possible health effects caused by emitted microwaves. METHODS: In a cross-sectional study of randomly selected inhabitants living in urban and rural areas for more than one year near to 10 selected base stations, 365 subjects were investigated. Several cognitive tests were performed, and wellbeing and sleep quality were assessed. Field strength of high-frequency electromagnetic fields (HF-EMF) was measured in the bedrooms of 336 households. RESULTS: Total HF-EMF and exposure related to mobile telecommunication were far below recommended levels (max. 4.1 mW/m²). Distance from antennae was 24-600 m in the rural area and 20-250 m in the urban area. Average power density was slightly higher in the rural area (0.05 mW/m²) than in the urban area (0.02 mW/m²). Despite the influence of confounding variables, including fear of adverse effects from exposure to HF-EMF from the base station, there was a significant relation of some symptoms to measured power density; this was highest for headaches. Perceptual speed increased, while accuracy decreased insignificantly with increasing exposure levels. There was no significant effect on sleep quality. CONCLUSION: Despite very low exposure to HF-EMF, effects on wellbeing and performance cannot be ruled out, as shown by recently obtained experimental results; however, mechanisms of action at these low levels are unknown.

Akrotiri, Cyprus (2005)

USCA Case #20-1025

Document #1869762

Filed: 11/04/2020

Page 229 of 481



Evaluation of health concerns near a military radar antenna:

Measurement of average RF levels in two nearby communities:

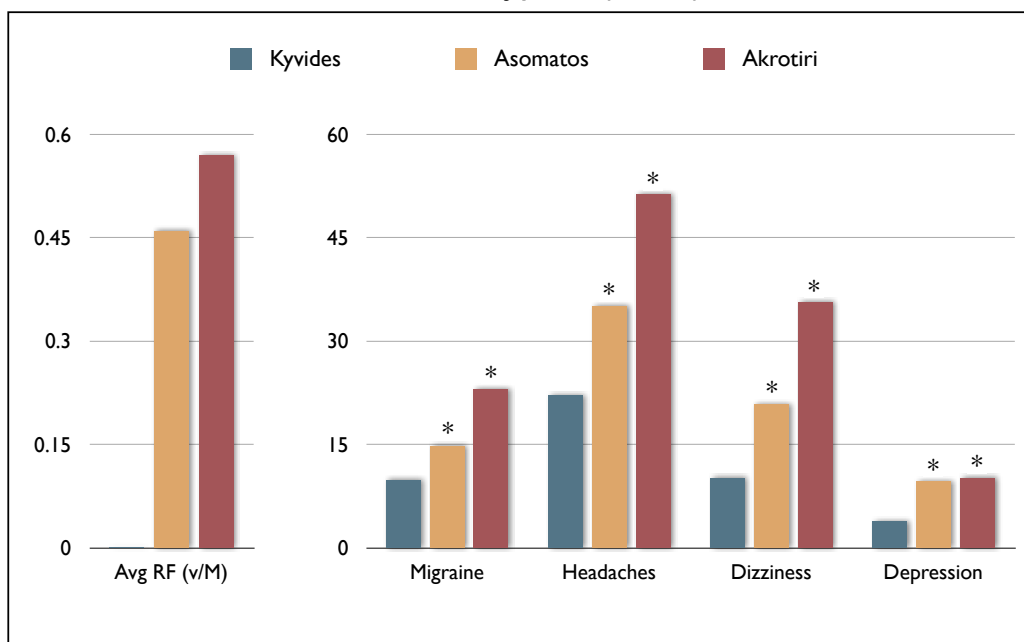
Akrotiri [red circle]

Asomatos [yellow circle]

And as a control, in another village > 20 km distant [blue circle]

Akrotiri also had a cell phone tower.

Preece AW, Georgiou AG, Dunn EJ, Farrow SC. Health response of two communities to military antennae in Cyprus. *Occup Environ Med* (2007); 64(6):402-408.

Akrotiri, Cyprus (2005)

On left, average RF readings in the three communities (in v/m).

On the right, percentages of four reported symptoms were significantly higher in the towns with higher RF exposures.

Average power densities:

Akrotiri: 0.57 v/m = 0.863 $\mu\text{W}/\text{cm}^2$

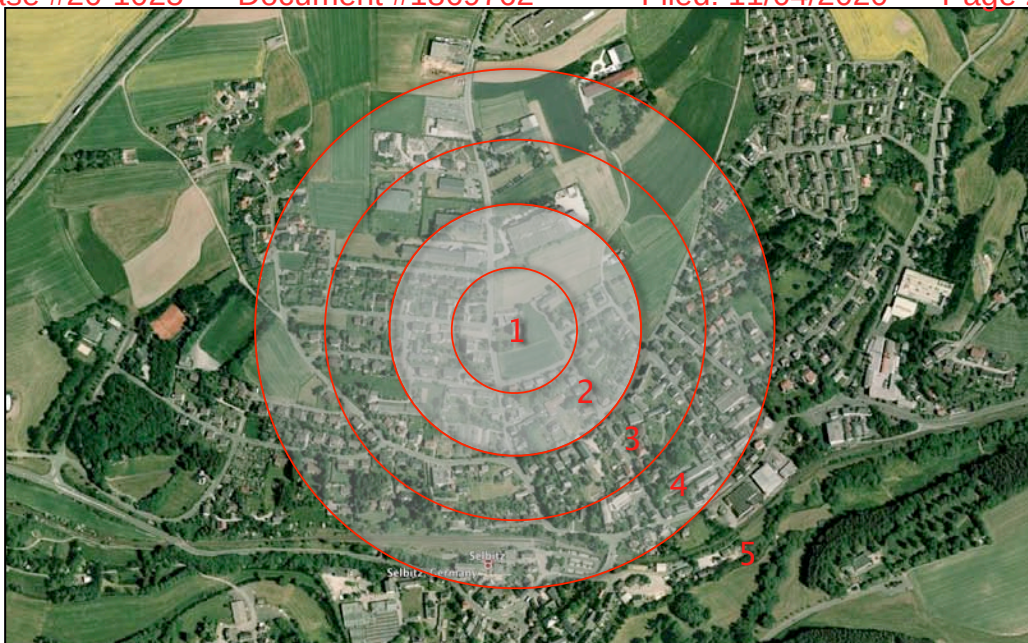
Asomatos: 0.46 v/m = 0.561 $\mu\text{W}/\text{cm}^2$

Pano Kyvides: 0.001 v/m = 0.000001 $\mu\text{W}/\text{cm}^2$

FCC Guidelines: 600–1000 $\mu\text{W}/\text{cm}^2$

Preece AW, Georgiou AG, Dunn EJ, Farrow SC. Health response of two communities to military antennae in Cyprus. *Occup Environ Med* (2007); 64(6):402-408.

Selbitz, Bavaria (2009)



General health survey sent to 1080 residents of the village of Selbitz, Bavaria (population 4644), with 251 responses (23% return).

Two cell tower transmitters in the center of town.

Exposure areas determined by concentric circles of 100 to 400 meters radius.

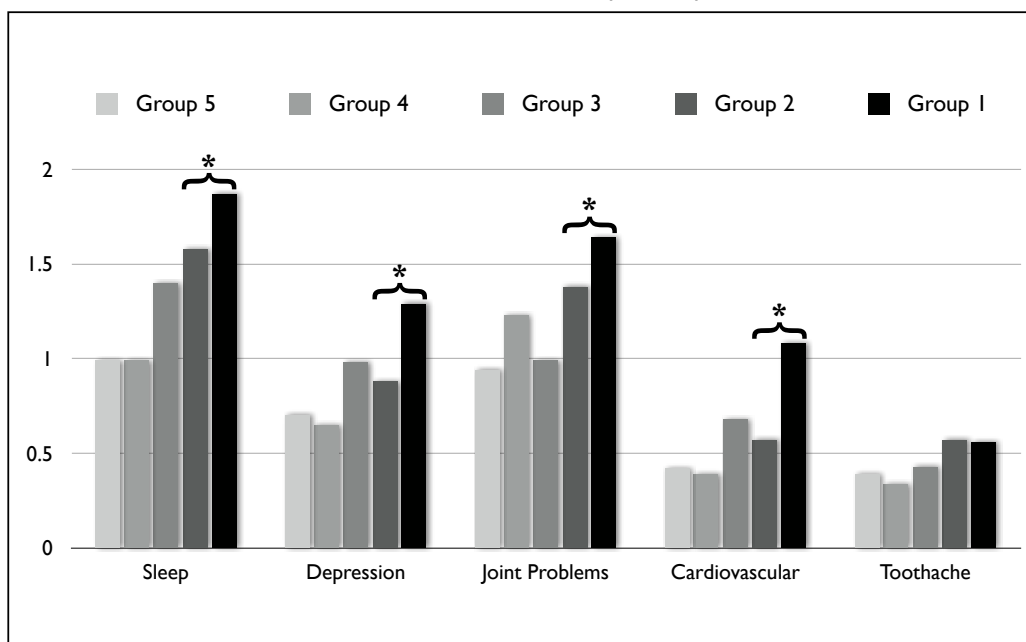
Field measurements stratified exposures into two regions:

Groups 1 and 2 (mean exposure 1.17 V/m)

Groups 3 and 4 (mean exposure 0.70 V/m)

Eger H, Jahn M. Specific Health Symptoms and Cell Phone Radiation in Selbitz (Bavaria, Germany) -- Evidence of a Dose-Response Relationship. *umwelt-medizin-gesellschaft* (2010); 23:1-20.

Selbitz, Bavaria (2009)



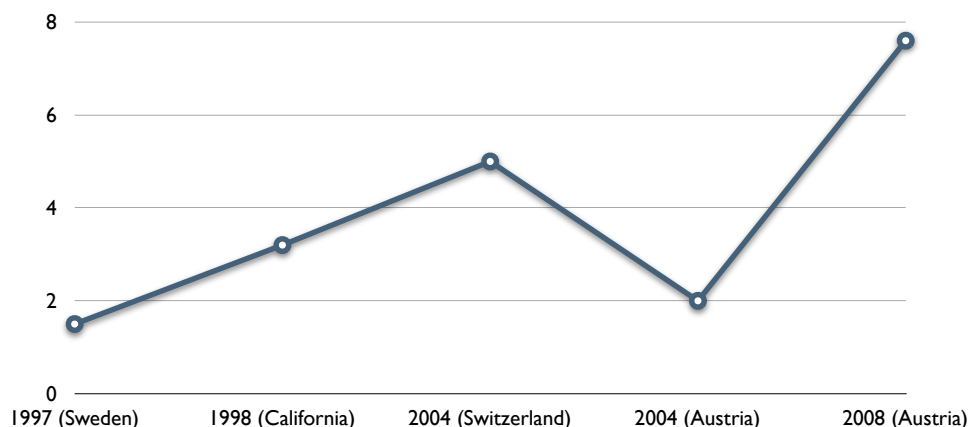
Some sample data from the study. Symptoms scored on 0 - 5 scale.

* = statistically significant (Groups 1 + 2 compared to Groups 3 + 4).

14 of 19 symptom categories showed statistically significant elevations in groups 1 and 2 as compared to groups 3 and 4.

Eger H, Jahn M. Specific Health Symptoms and Cell Phone Radiation in Selbitz (Bavaria, Germany) -- Evidence of a Dose-Response Relationship. *umwelt-medizin-gesellschaft* (2010); 23:1-20.

Incidence of self-identified electrohypersensitivity (%)



In the previous studies, we saw that some symptoms are more common with higher exposure to microwave RF transmissions.

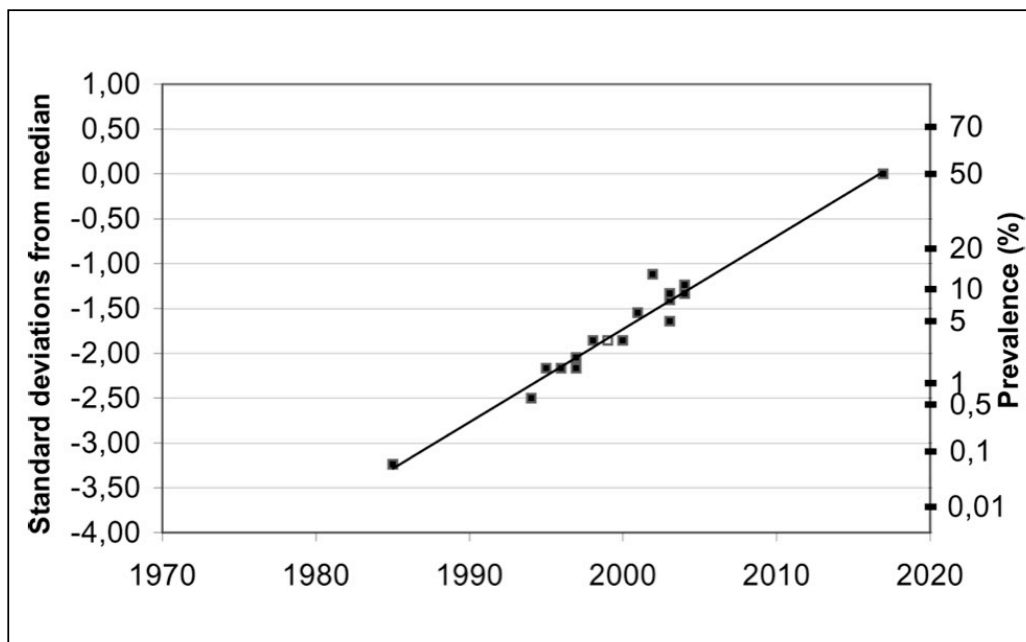
The people who had those symptoms may or may not have been aware that RF was a factor.

But some people with symptoms triggered by microwave RF exposures are aware that this is happening to them.

If these symptoms are sufficiently debilitating, the affected individual may consider themselves to be "electrohypersensitive".

The above graph shows the percentage of the population that self-identified as having "EHS" in surveys done in various countries over the last two decades.

The prevalence of self-reported EHS is increasing.



The prevalence (%) of people around the world who consider themselves to be electrosensitive, as reported in various research studies from 1997 to 2008, plotted over time in a normal distribution graph.

The endpoint at 50% is an extrapolated value.

Hallberg O, Oberfeld G. Letter to the editor: will we all become electrosensitive? *Electromagn Biol Med* (2006); 25(3): 189-191.

Stockholm County, Sweden, 1997: 1.5% of the population reported being hypersensitive to electrical or magnetic fields. (Hillert et al., 2002)

California, 1998: 3.2% of the adult population reported being sensitive to sources of EMF. (Levallois et al., 2002)

Switzerland, 2004: 5% of the population had symptoms attributable to EHS. (Schreier et al., 2006)

Austria, 2004: 2% of the population was estimated to have electrohypersensitivity.

Austria, 2008: 29.3% with some adverse response, 2.1% reported intense disturbance, and 3.5% had experienced enough difficulty that they had consulted a physician about the problem. (Schrottner and Leitgeb, 2008)

Radiation Sickness; Dr. Erica Elliott MD. Comments, Aug. 28, 2013

Erica M. Elliott, M. D.

board certified in family practice and environmental medicine

Received & Inspected

SEP 04 2013

FCC Mail Room

August 28, 2013

Comments on Notice of Inquiry
ET Docket No. 13-84

TO Whom It MAY CONCERN:

As a physician who is treating a Rapidly growing group of patients who have developed disabling radio frequency hypersensitivity, I urge the FCC to make exposure limits more restrictive to avert a national health catastrophe.

Sincerely,

Erica Elliott, M.D.

Radiation Sickness; Electrohypersensitivity Abstracts; 2017

Electrohypersensitivity Abstracts (December 14, 2017)

Andersson B, Berg M, Arnetz BB, Melin L, Langlet I, Lidén S. A cognitive-behavioral treatment of patients suffering from "electric hypersensitivity". Subjective effects and reactions in a double-blind provocation study. J Occup Environ Med. 38(8):752-758, 1996.

This study tested psychological treatment of patients with "electric hypersensitivity." Seventeen patients were randomly assigned to a treatment group or a waiting-list control group in a pretest-posttest control group design. The patients were also taking part in double-blind provocation tests before and after the treatment. Subjective ratings of symptoms were registered and blood samples were taken and analyzed for "stress-related" variables, such as prolactin, cortisol, dehydroepiandrosterone, and cholesterol levels. The patients in the experimental group reduced their evaluations of the disability more than the control group did. This indicates that psychological treatment may be of value in this disease. However, none of the psychophysiological measures or the subjective reactions to the provocation test showed any significant between-group difference. The conclusion from the provocation test is that this group of alleged hypersensitive patients did not react to the electromagnetic fields.

Andrianome S, Gobert J, Hugueville L, Stéphan-Blanchard E, Telliez F, Selmaoui B. An assessment of the autonomic nervous system in the electrohypersensitive population: a heart rate variability and skin conductance study. J Appl Physiol (1985).123(5):1055-1062, 2017.

The aim of the study was twofold: first, to compare the activity of the autonomic nervous system (ANS) between the population self-declared as electrohypersensitive (EHS) and their matched control individuals without intended exposure to electromagnetic fields (EMF). The second objective was to determine whether acute exposure to different radiofrequency signals modifies ANS activity in EHS. For that purpose, two different experiments were undertaken, in which ANS activity was assessed through heart rate variability (HRV) and skin conductance (SC). In the first experiment, a comparison between the EHS group ($n = 30$) and the control group ($n = 25$) showed that the EHS has an increased number of responses to auditory stimuli as measured by skin conductance activity, and that none of the short-term heart rate variability parameters differ between the two matched study groups. The second experiment, performed in a shielded chamber, involved 10 EHS from the first experiment. The volunteers participated in two different sessions (sham and exposure). The participants were consecutively exposed to four EMF signals (GSM 900, GSM 1800, DECT, and Wi-Fi) at environmental level (1 V/m). The experiment was double blinded and counterbalanced. The HRV variables studied did not differ between the two sessions. Concerning electrodermal activity, the data issued from skin conductance and tonic activity did not differ between the sessions, but showed a time variability. In conclusion, the HRV and SC profiles did not significantly differ between the EHS and control populations under no exposure. Exposure did not have an effect on the ANS parameters we have explored. **NEW & NOTEWORTHY** This study provided analysis on the skin conductance parameters using a newly developed method (peak/min, extraction of skin conductance responses) that had not been performed previously. Additionally, the skin conductance signal was decomposed, considering tonic and phasic activities to be a distinct compound. Moreover, this is the first time a study has been designed into two steps to understand whether the autonomic nervous system is disturbed in the EHS population.

Anttila K. Mycotoxins, fungus and 'electrohypersensitivity'. Med Hypotheses. 55(3):208-214, 2000.

'Electrohypersensitivity' is often explained as a psychological syndrome. Our modern environment contains a lot of different substances and some of them are toxic. Mycotoxins are types of toxins that are biologically very active and that affect living organisms. Mycotoxins and fungi capable of producing toxins have been detected in ventilation systems, water damage and in foodstuff. Many of those displaying symptoms caused by electromagnetic fields have fungus infections or have been living in fungus-contaminated environments for long periods. In animal studies mycotoxins have shown the same effects as those seen in the 'electrohypersensitivity' syndrome. Phototoxic reactions are well known in veterinary medicine and in medical science, so the question is whether the 'electrohypersensitivity' syndrome is caused by 'phototoxic' reactions?

Augner C, Gnambs T, Winker R, Barth A. Acute effects of electromagnetic fields emitted by GSM mobile phones on subjective well-being and physiological reactions: a meta-analysis. Sci Total Environ. 424:11-15, 2012.

The potential effects of radiofrequency electromagnetic fields (RF-EMF) emitted by GSM mobile phones on subjective symptoms, well-being and physiological parameters have been investigated in many studies. However, the results have been ambiguous. The current meta-analysis aims to clarify whether RF-EMF have an influence on well-being in self-reported sensitive persons, as well as in non-sensitive people. A literature search revealed 17 studies including 1174 participants. The single effects for various subjective and objective outcomes were meta-analytically combined to yield a single population parameter. Dependant variables were subjective (e.g. headaches) and objective parameters (e.g. heart rate variability) of well-being. The results show no significant impact of short-term RF-EMF exposure on any parameter. Future research should focus on the possible effects of long-term exposure.

Baliatsas C, van Kamp I, Kelfkens G, Schipper M, Bolte J, Yzermans J, Lebre E. Non-specific physical symptoms in relation to actual and perceived proximity to mobile phone base stations and powerlines. BMC Public Health. 11:421, 2011.

BACKGROUND: Evidence about a possible causal relationship between non-specific physical symptoms (NSPS) and exposure to electromagnetic fields (EMF) emitted by sources such as mobile phone base stations (BS) and powerlines is insufficient. So far little epidemiological research has been published on the contribution of psychological components to the occurrence of EMF-related NSPS. The prior objective of the current study is to explore the relative importance of actual and perceived proximity to base stations and psychological components as determinants of NSPS, adjusting for demographic, residency and area characteristics.

METHODS: Analysis was performed on data obtained in a cross-sectional study on environment and health in 2006 in the Netherlands. In the current study, 3611 adult respondents (response rate: 37%) in twenty-two Dutch residential areas completed a questionnaire. Self-reported instruments included a symptom checklist and assessment of environmental and psychological characteristics. The computation of the distance between household addresses and location of base stations and powerlines was based on geo-coding. Multilevel regression models were used to test the hypotheses regarding the determinants related to the occurrence of NSPS. **RESULTS:** After adjustment for demographic and residential characteristics, analyses yielded a number of statistically significant associations: Increased report of NSPS

was predominantly predicted by higher levels of self-reported environmental sensitivity; perceived proximity to base stations and powerlines, lower perceived control and increased avoidance (coping) behavior were also associated with NSPS. A trend towards a moderator effect of perceived environmental sensitivity on the relation between perceived proximity to BS and NSPS was verified ($p = 0.055$). There was no significant association between symptom occurrence and actual distance to BS or powerlines. **CONCLUSIONS:** Perceived proximity to BS, psychological components and socio-demographic characteristics are associated with the report of symptomatology. Actual distance to the EMF source did not show up as determinant of NSPS.

Baliatsas C, Van Kamp I, Lebrecht E, Rubin GJ. Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF): A systematic review of identifying criteria. BMC Public Health. 2012 Aug 11;12:643. doi: 10.1186/1471-2458-12-643.

BACKGROUND: Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) remains a complex and unclear phenomenon, often characterized by the report of various, non-specific physical symptoms (NSPS) when an EMF source is present or perceived by the individual. The lack of validated criteria for defining and assessing IEI-EMF affects the quality of the relevant research, hindering not only the comparison or integration of study findings, but also the identification and management of patients by health care providers. The objective of this review was to evaluate and summarize the criteria that previous studies employed to identify IEI-EMF participants. **METHODS:** An extensive literature search was performed for studies published up to June 2011. We searched EMBASE, Medline, Psychinfo, Scopus and Web of Science. Additionally, citation analyses were performed for key papers, reference sections of relevant papers were searched, conference proceedings were examined and a literature database held by the Mobile Phones Research Unit of King's College London was reviewed. **RESULTS:** Sixty-three studies were included. "Hypersensitivity to EMF" was the most frequently used descriptive term. Despite heterogeneity, the criteria predominantly used to identify IEI-EMF individuals were: 1. Self-report of being (hyper)sensitive to EMF. 2. Attribution of NSPS to at least one EMF source. 3. Absence of medical or psychiatric/psychological disorder capable of accounting for these symptoms 4. Symptoms should occur soon (up to 24 hours) after the individual perceives an exposure source or exposed area. (Hyper)sensitivity to EMF was either generalized (attribution to various EMF sources) or source-specific. Experimental studies used a larger number of criteria than those of observational design and performed more frequently a medical examination or interview as prerequisite for inclusion. **CONCLUSIONS:** Considerable heterogeneity exists in the criteria used by the researchers to identify IEI-EMF, due to explicit differences in their conceptual frameworks. Further work is required to produce consensus criteria not only for research purposes but also for use in clinical practice. This could be achieved by the development of an international protocol enabling a clearly defined case definition for IEI-EMF and a validated screening tool, with active involvement of medical practitioners.

Belpomme D, Campagnac C, Irigaray P. Reliable disease biomarkers characterizing and identifying electrohypersensitivity and multiple chemical sensitivity as two etiopathogenic aspects of a unique pathological disorder. Rev Environ Health. 2015 Dec 1;30(4):251-71. doi: 10.1515/reveh-2015-0027.

Much of the controversy over the causes of electro-hypersensitivity (EHS) and multiple chemical sensitivity (MCS) lies in the absence of both recognized clinical criteria and objective biomarkers for widely accepted diagnosis.

Since 2009, we have prospectively investigated, clinically and biologically, 1216 consecutive EHS and/or MCS-self reporting cases, in an attempt to answer both questions. We report here our preliminary data, based on 727 evaluable of 839 enrolled cases: 521 (71.6%) were diagnosed with EHS, 52 (7.2%) with MCS, and 154 (21.2%) with both EHS and MCS. Two out of three patients with EHS and/or MCS were female; mean age (years) was 47. As inflammation appears to be a key process resulting from electromagnetic field (EMF) and/or chemical effects on tissues, and histamine release is potentially a major mediator of inflammation, we systematically measured histamine in the blood of patients. Near 40% had an increase in histaminemia (especially when both conditions were present), indicating a chronic inflammatory response can be detected in these patients. Oxidative stress is part of inflammation and is a key contributor to damage and response. Nitrotyrosin, a marker of both peroxynitrite (ONOO° -) production and opening of the blood-brain barrier (BBB), was increased in 28% of the cases. Protein S100B, another marker of BBB opening was increased in 15%. Circulating autoantibodies against O-myelin were detected in 23%, indicating EHS and MCS may be associated with autoimmune response. Confirming animal experiments showing the increase of Hsp27 and/or Hsp70 chaperone proteins under the influence of EMF, we found increased Hsp27 and/or Hsp70 in 33% of the patients. As most patients reported chronic insomnia and fatigue, we determined the 24 h urine 6-hydroxymelatonin sulfate (6-OHMS)/creatinin ratio and found it was decreased (<0.8) in all investigated cases. Finally, considering the self-reported symptoms of EHS and MCS, we serially measured the brain blood flow (BBF) in the temporal lobes of each case with pulsed cerebral ultrasound computed tomography. Both disorders were associated with hypoperfusion in the capsulothalamic area, suggesting that the inflammatory process involves the limbic system and the thalamus.

Our data strongly suggest that EHS and MCS can be objectively characterized and routinely diagnosed by commercially available simple tests. Both disorders appear to involve inflammation-related hyper-histaminemia, oxidative stress, autoimmune response, capsulothalamic hypoperfusion and BBB opening, and a deficit in melatonin metabolic availability; suggesting a risk of chronic neurodegenerative disease. Finally the common co-occurrence of EHS and MCS strongly suggests a common pathological mechanism.

Belyaev IY, Hillert L, Protopopova M, Tamm C, Malmgren LO, Persson BR, Selivanova G, Harms-Ringdahl M. 915 MHz microwaves and 50 Hz magnetic field affect chromatin conformation and 53BP1 foci in human lymphocytes from hypersensitive and healthy persons. Bioelectromagnetics. 26(3):173-184, 2005.

We used exposure to microwaves from a global system for mobile communication (GSM) mobile phone (915 MHz, specific absorption rate (SAR) 37 mW/kg) and power frequency magnetic field (50 Hz, 15 μT peak value) to investigate the response of lymphocytes from healthy subjects and from persons reporting hypersensitivity to electromagnetic field (EMF). The

hypersensitive and healthy donors were matched by gender and age and the data were analyzed blind to treatment condition. The changes in chromatin conformation were measured with the method of anomalous viscosity time dependencies (AVTD). 53BP1 protein, which has been shown to colocalize in foci with DNA double strand breaks (DSBs), was analyzed by immunostaining in situ. Exposure at room temperature to either 915 MHz or 50 Hz resulted in significant condensation of chromatin, shown as AVTD changes, which was similar to the effect of heat shock at 41 degrees C. No significant differences in responses between normal and hypersensitive subjects were detected. Neither 915 MHz nor 50 Hz exposure induced 53BP1 foci. On the contrary, a distinct decrease in background level of 53BP1 signaling was observed upon these exposures as well as after heat shock treatments. This decrease correlated with the AVTD data and may indicate decrease in accessibility of 53BP1 to antibodies because of stress-induced chromatin condensation. Apoptosis was determined by morphological changes and by apoptotic fragmentation of DNA as analyzed by pulsed-field gel electrophoresis (PFGE). No apoptosis was induced by exposure to 50 Hz and 915 MHz microwaves. In conclusion, 50 Hz magnetic field and 915 MHz microwaves under specified conditions of exposure induced comparable responses in lymphocytes from healthy and hypersensitive donors that were similar but not identical to stress response induced by heat shock.

Belyaev IY, Markovà E, Hillert L, Malmgren LO, Persson BR. Microwaves from UMTS/GSM mobile phones induce long-lasting inhibition of 53BP1/gamma-H2AX DNA repair foci in human lymphocytes. Bioelectromagnetics 30:129-41, 2009.

We have recently described frequency-dependent effects of mobile phone microwaves (MWs) of global system for mobile communication (GSM) on human lymphocytes from persons reporting hypersensitivity to electromagnetic fields and healthy persons. Contrary to GSM, universal global telecommunications system (UMTS) mobile phones emit wide-band MW signals. Hypothetically, UMTS MWs may result in higher biological effects compared to GSM signal because of eventual "effective" frequencies within the wideband. Here, we report for the first time that UMTS MWs affect chromatin and inhibit formation of DNA double-strand breaks co-localizing 53BP1/gamma-H2AX DNA repair foci in human lymphocytes from hypersensitive and healthy persons and confirm that effects of GSM MWs depend on carrier frequency. Remarkably, the effects of MWs on 53BP1/gamma-H2AX foci persisted up to 72 h following exposure of cells, even longer than the stress response following heat shock. The data are in line with the hypothesis that the type of signal, UMTS MWs, may have higher biological efficiency and possibly larger health risk effects compared to GSM radiation emissions. No significant differences in effects between groups of healthy and hypersensitive subjects were observed, except for the effects of UMTS MWs and GSM-915 MHz MWs on the formation of the DNA repair foci, which were different for hypersensitive ($P < 0.02$ [53BP1]/ 0.01 [gamma-H2AX]) but not for control subjects ($P > 0.05$). The non-parametric statistics used here did not indicate specificity of the differences revealed between the effects of GSM and UMTS MWs on cells from hypersensitive subjects and more data are needed to study the nature of these differences.

Belyaev I, Dean A, Eger H, Hubmann G, Jandrisovits R, Kern M, Kundi M, Moshammer H, Lercher P, Müller K, Oberfeld G, Ohnsorge P, Pelzmann P, Scheingraber C, Thill R. EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. Rev Environ Health. Publ online 2016 Jul 25. doi: 10.1515/reveh-2016-0011.

Chronic diseases and illnesses associated with unspecific symptoms are on the rise. In addition to chronic stress in social and work environments, physical and chemical exposures at home, at work, and during leisure activities are causal or contributing environmental stressors that

deserve attention by the general practitioner as well as by all other members of the health care community. It seems certainly necessary now to take "new exposures" like electromagnetic field (EMF) into account. Physicians are increasingly confronted with health problems from unidentified causes.

Studies, empirical observations, and patient reports clearly indicate interactions between EMF exposure and health problems. Individual susceptibility and environmental factors are frequently neglected. New wireless technologies and applications have been introduced without any certainty about their health effects, raising new challenges for medicine and society. For instance, the issue of so-called non-thermal effects and potential long-term effects of low-dose exposure were scarcely investigated prior to the introduction of these technologies. Common EMF sources include Wi-Fi access points, routers and clients, cordless and mobile phones including their base stations, Bluetooth devices, ELF magnetic fields from net currents, ELF electric fields from electric lamps and wiring close to the bed and office desk. On the one hand, there is strong evidence that long-term-exposure to certain EMF exposures is a risk factor for diseases such as certain cancers, Alzheimer's disease and male infertility. On the other hand, the emerging electromagnetic hypersensitivity (EHS) is more and more recognized by health authorities, disability administrators and case workers, politicians, as well as courts of law.

We recommend treating EHS clinically as part of the group of chronic multisystem illnesses (CMI) leading to a functional impairment (EHS), but still recognizing that the underlying cause remains the environment. In the beginning, EHS symptoms often occur only occasionally, but over time they may increase in frequency and severity. Common EHS symptoms include headaches, concentration difficulties, sleeping problems, depression, lack of energy, fatigue and flu-like symptoms.

A comprehensive medical history, which should include all symptoms and their occurrences in spatial and temporal terms and in the context of EMF exposures, is the key to the diagnosis. The EMF exposure can be assessed by asking for typical sources like Wi-Fi access points, routers and clients, cordless and mobile phones and measurements at home and at work. It is very important to take the individual susceptibility into account.

The primary method of treatment should mainly focus on the prevention or reduction of EMF exposure, that is, reducing or eliminating all sources of EMF at home and in the workplace. The reduction of EMF exposure should also be extended to public spaces such as schools, hospitals, public transport, and libraries to enable persons with EHS an unhindered use (accessibility measure). If a detrimental EMF exposure is reduced sufficiently, the body has a chance to recover and EHS symptoms will be reduced or even disappear. Many examples have shown that such measures can prove effective. Also the survival rate of children with leukemia depends on ELF magnetic field exposure at home.

To increase the effectiveness of the treatment, the broad range of other environmental factors that contribute to the total body burden should also be addressed. Anything that supports a balanced homeostasis will increase a person's resilience against disease and thus against the adverse effects of EMF exposure. There is increasing evidence that EMF exposure has a major impact on the oxidative and nitrosative regulation capacity in affected individuals. This concept also may explain why the level of susceptibility to EMF can change and why the number of symptoms reported in the context of EMF exposures is so large. Based on our current understanding, a treatment approach that minimizes the adverse effects of peroxynitrite - as has been increasingly used in the treatment of multisystem disorders - works best.

This EMF Guideline gives an overview of the current knowledge regarding EMF-related health risks and provides concepts for the diagnosis and treatment and accessibility measures of EHS to improve and restore individual health outcomes as well as for the development of strategies for prevention.

Bensefa-Colas L, Dupas D. [Idiopathic environmental intolerance: 2 disabling entities to recognize]. Rev Prat. 64(3):358-362, 2014. [Article in French]

Idiopathic environmental intolerance is characterized by a variety of non-specific symptoms involving several organs within the same individual, and attributed to the exposure to chemical odors (multiple chemical sensitivities) or to the exposure to electromagnetic fields (electromagnetic hypersensitivity). Symptoms occur following an exposure to agents generally regarded as harmless due to the low levels of exposure, and they do not answer to any definition of organic diseases. The lack of established etiology renders treatment difficult. It is important for practitioner to recognize such disorders and assess the social and professional impact so as to improve patients' quality of life.

Bergdahl J, Tillberg A, Stenman E. Odontologic survey of referred patients with symptoms allegedly caused by electricity or visual display units. Acta Odontol Scand. 56(5):303-307, 1998.

Twenty-eight consecutive patients with symptoms allegedly caused by electricity or visual display units were odontologically investigated according to a specially designed registration form including an anamnestic interview and a clinical protocol. The most common oral and general symptoms reported were burning mouth, craniomandibular dysfunction symptoms, skin complaints, and fatigue. Oral symptoms such as craniomandibular dysfunction and general symptoms such as eye complaints and dizziness scored highest on a visual analog scale regarding mean symptom intensity. The patients reported various numbers of medical diagnoses, such as allergic rhinitis or asthma and hypothyroidism. Various dental diseases were found; the most common were temporomandibular joint and masticatory muscle dysfunctions, lesions in the oral mucosa, and periodontal diseases. Urinary-Hg (U-Hg) analysis showed a mean U-Hg concentration of 8.5 nmol Hg/L urine, and none of the patients exceeded the limit of 50 nmol Hg/L urine. The U-Hg concentration was positively correlated with the number of amalgam fillings ($P < 0.01$) and craniomandibular disorders ($P < 0.05$). No or low secretion of the minor mucous glands was found in 43% of the patients. One patient showed hypersensitivity to gold and cobalt. The present study showed that various odontologic factors might be involved in some of these patients' suffering. Thus, it is important that professionals from other disciplines collaborate with dentistry if these patients are to be properly investigated.

Blettner M, Schlehofer B, Breckenkamp J, Kowall B, Schmiedel S, Reis U, Potthoff P, Schüz J, Berg-Beckhoff G. Mobile phone base stations and adverse health effects: phase 1 of a population-based, cross-sectional study in Germany. Occup Environ Med. 66(2):118-123, 2009.

OBJECTIVE: The aim of this first phase of a cross-sectional study from Germany was to investigate whether proximity of residence to mobile phone base stations as well as risk perception is associated with health complaints. **METHODS:** The researchers conducted a population-based, multi-phase, cross-sectional study within the context of a large panel survey regularly carried out by a private research institute in Germany. In the initial phase, reported on in this paper, 30,047 persons from a total of 51,444 who took part in the nationwide survey also

answered questions on how mobile phone base stations affected their health. A list of 38 health complaints was used. A multiple linear regression model was used to identify predictors of health complaints including proximity of residence to mobile phone base stations and risk perception. **RESULTS:** Of the 30,047 participants (response rate 58.6%), 18.7% of participants were concerned about adverse health effects of mobile phone base stations, while an additional 10.3% attributed their personal adverse health effects to the exposure from them. Participants who were concerned about or attributed adverse health effects to mobile phone base stations and those living in the vicinity of a mobile phone base station (500 m) reported slightly more health complaints than others. **CONCLUSIONS:** A substantial proportion of the German population is concerned about adverse health effects caused by exposure from mobile phone base stations. The observed slightly higher prevalence of health complaints near base stations can not however be fully explained by attributions or concerns.

Bortkiewicz A, Zmyslony M, Szyjowska A, Gadzicka E. [Subjective symptoms reported by people living in the vicinity of cellular phone base stations: review]. Med Pr. 55(4):345-351, 2004. [Article in Polish]

The problem of health effects of electromagnetic fields (EMF) emitted by cellular phone base stations evokes much interest in view of the fact that people living in their vicinity are fated to continuous exposure to EMF. None of the studies carried out throughout the world have revealed excessive values of standards adopted by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). A questionnaire was used as a study tool. The results of the questionnaire survey reveal that people living in the vicinity of base stations report various complaints mostly of the circulatory system, but also of sleep disturbances, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite, headache and vertigo. The performed studies showed the relationship between the incidence of individual symptoms, the level of exposure, and the distance between a residential area and a base station. This association was observed in both groups of persons, those who linked their complaints with the presence of the base station and those who did not notice such a relation. Further studies, clinical and those based on questionnaires, are needed to explain the background of reported complaints.

Carpenter DO. Excessive exposure to radiofrequency electromagnetic fields may cause the development of electrohypersensitivity. Altern Ther Health Med. 20(6):40-42, 2014. (no abstract available)

Carpenter DO. The microwave syndrome or electro-hypersensitivity: historical background. Rev Environ Health. 2015 Nov 10. doi: 10.1515/reveh-2015-0016. [Epub ahead of print]

Microwave generating equipment first became common during World War 2 with the development of radar. Soviet bloc countries reported that individuals exposed to microwaves frequently developed headaches, fatigue, loss of appetite, sleepiness, difficulty in concentration, poor memory, emotional instability, and labile cardiovascular function, and established stringent exposure standards. For a variety of reasons these reports were discounted in Western countries, where the prevailing belief was that there could be no adverse health effects of electromagnetic fields (EMFs) that were not mediated by tissue heating. The reported Soviet effects were at lower intensities than those that cause heating. However, there were several accidental exposures of radar operators in Western countries that resulted in persistent symptoms similar to those described above. The Soviets irradiated the US Embassy in Moscow with microwaves during the period 1953-1975, and while no convincing evidence of elevated

cancer rates was reported, there were reports of "microwave illness." Officials passed these complaints off as being due to anxiety, not effects of the microwave exposure. There is increasing evidence that the "microwave syndrome" or "electro-hypersensitivity" (EHS) is a real disease that is caused by exposure to EMFs, especially those in the microwave range. The reported incidence of the syndrome is increasing along with increasing exposure to EMFs from electricity, WiFi, mobile phones and towers, smart meters and many other wireless devices. Why some individuals are more sensitive is unclear. While most individuals who report having EHS do not have a specific history of an acute exposure, excessive exposure to EMFs, even for a brief period of time, can induce the syndrome.

Dahmen N, Ghezel-Ahmadi D, Engel A. Blood laboratory findings in patients suffering from self-perceived electromagnetic hypersensitivity (EHS). Bioelectromagnetics. 30(4):299-306, 2009.

Risks from electromagnetic devices are of considerable concern. Electrohypersensitive (EHS) persons attribute a variety of rather unspecific symptoms to exposure to electromagnetic fields. The pathophysiology of EHS is unknown and therapy remains a challenge. We hypothesized that some electrosensitive individuals are suffering from common somatic health problems. Toward this end we analysed clinical laboratory parameters including thyroid-stimulating hormone (TSH), alanine transaminase (ALT), aspartate transaminase (AST), creatinine, hemoglobine, hematocrit and c-reactive protein (CRP) in subjects suffering from EHS and in controls that are routinely used in clinical medicine to identify or screen for common somatic disorders. One hundred thirty-two patients (n = 42 males and n = 90 females) and 101 controls (n = 34 males and n = 67 females) were recruited. Our results identified laboratory signs of thyroid dysfunction, liver dysfunction and chronic inflammatory processes in small but remarkable fractions of EHS sufferers as potential sources of symptoms that merit further investigation in future studies. In the cases of TSH and ALT/AST there were significant differences between cases and controls. The hypotheses of anaemia or kidney dysfunction playing a major role in EHS could be unambiguously refuted. Clinically it is recommended to check for signs of treatable somatic conditions when caring for individuals suffering from self-proclaimed EHS.

De Luca et al 2014. Metabolic and Genetic Screening of Electromagnetic Hypersensitive Subjects as a Feasible Tool for Diagnostics and Intervention. Mediators of Inflammation. Volume 2014, Article ID 924184. Open

Access <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4000647/pdf/MI2014-924184.pdf>

Study of self-reported hypersensitivity to electromagnetic fields in California

Dieudonné M. Does electromagnetic hypersensitivity originate from nocebo responses? Indications from a qualitative study. Bioelectromagnetics. 2015 Sep 15. doi: 10.1002/bem.21937. [Epub ahead of print]

Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF) is a condition in which symptoms are attributed to electromagnetic field (EMF) exposure. As electro-hypersensitive (EHS) people have repeatedly been observed, during provocation trials, to report symptoms following perceived rather than actual exposure, the hypothesis has been put forward that IEI-EMF originates from psychological mechanisms, especially nocebo responses. This paper examines this hypothesis, using data from a qualitative study aimed at understanding how EHS people come to regard themselves as such.

Forty self-diagnosed EHS people were interviewed.

A typified model of their attribution process was then elaborated, inductively, from their narratives. This model is linear and composed of seven stages: (1) onset of symptoms; (2) failure to find a solution; (3) discovery of EHS; (4) gathering of information about EHS; (5) implicit appearance of conviction; (6) experimentation; (7) conscious acceptance of conviction.

Overall, symptoms appear before subjects start questioning effects of EMF on their health, which is not consistent with the hypothesis that IEI-EMF originates from nocebo responses to perceived EMF exposure. However, such responses might occur at the sixth stage of the process, potentially reinforcing the attribution. It remains possible that some cases of IEI-EMF originate from other psychological mechanisms.

Dömötör Z, Szemerszky R, Köteles F. Nature relatedness is connected with modern health worries and electromagnetic hypersensitivity. J Health Psychol. 2017 Mar 1;1359105317699681. doi: 10.1177/1359105317699681.

Although nature relatedness is considered a positive characteristic, its relationship to constructs involving worries about the negative effects of artificial environmental factors is also feasible. A questionnaire assessing modern health worries, electrosensitivity, somatosensory amplification, spirituality, and nature relatedness was completed by 510 individuals. Nature relatedness was related to electrosensitivity, modern health worries, and spirituality. In a binary logistic regression analysis, somatosensory amplification, modern health worries, and nature relatedness were associated with electrosensitivity, and nature relatedness moderated the connection between modern health worries and electrosensitivity. In naive representations, "natural" might be associated with health, whereas "modern" and "artificial" evoke negative associations. <https://www.ncbi.nlm.nih.gov/pubmed/28810440>

Eltiti S, Wallace D, Zougkou K, Russo R, Joseph S, Rasor P, Fox E. Development and evaluation of the electromagnetic hypersensitivity questionnaire. Bioelectromagnetics. 28(2):137-151, 2007.

Electromagnetic hypersensitivity (EHS) syndrome is usually defined as a condition where an individual experiences adverse health effects that he or she believes is due to exposure to objects that emit electromagnetic fields. The aim of this study was to develop a questionnaire that would identify the key symptoms associated with EHS and determine how often these symptoms occur in the general population of the United Kingdom. In the pilot study, an EHS questionnaire was developed and tested. In Study 1 the EHS questionnaire was revised and sent to a randomly selected sample of 20,000 people. Principal components analysis of the symptoms resulted in eight subscales: neurovegetative, skin, auditory, headache, cardiorespiratory, cold related, locomotor, and allergy related symptoms. Study 2 established the validity of the questionnaire in that EHS individuals showed a higher severity of symptoms on all subscales compared to the control group. The two key results of this study were the development of a scale that provides an index of the type and intensity of symptoms commonly experienced by people believing themselves to be EHS and a screening tool that researchers can use to pre-select the most sensitive individuals to take part in their research.

Eltiti S, Wallace D, Ridgewell A, Zougkou K, Russo R, Sepulveda F, Mirshekar-Syahkal D, Rasor P, Deeble R, Fox E. Does short-term exposure to mobile phone base station signals increase symptoms in individuals who report sensitivity to electromagnetic fields? A double-blind randomized provocation study. Environ Health Perspect. 115(11):1603-1608, 2007.

BACKGROUND: Individuals with idiopathic environmental illness with attribution to electromagnetic fields (IEI-EMF) believe they suffer negative health effects when exposed to electromagnetic fields from everyday objects such as mobile phone base stations. OBJECTIVES: This study used both open provocation and double-blind tests to determine if sensitive and control individuals experience more negative health effects when exposed to base station-like signals compared with sham. METHODS: Fifty-six self-reported sensitive and 120 control participants were tested in an open provocation test. Of these, 12 sensitive and 6 controls withdrew after the first session. The remainder completed a series of double-blind tests. Subjective measures of well-being and symptoms as well as physiological measures of blood volume pulse, heart rate, and skin conductance were obtained. RESULTS: During the open provocation, sensitive individuals reported lower levels of well-being in both the global system for mobile communication (GSM) and universal mobile telecommunications system (UMTS) compared with sham exposure, whereas controls reported more symptoms during the UMTS exposure. During double-blind tests the GSM signal did not have any effect on either group. Sensitive participants did report elevated levels of arousal during the UMTS condition, whereas the number or severity of symptoms experienced did not increase. Physiological measures did not differ across the three exposure conditions for either group. CONCLUSIONS: Short-term exposure to a typical GSM base station-like signal did not affect well-being or physiological functions in sensitive or control individuals. Sensitive individuals reported elevated levels of arousal when exposed to a UMTS signal. Further analysis, however, indicated that this difference was likely to be due to the effect of order of exposure rather than the exposure itself.

Eltiti S, Wallace D, Ridgewell A, Zougkou K, Russo R, Sepulveda F, Fox E. Short-term exposure to mobile phone base station signals does not affect cognitive functioning or physiological measures in individuals who report sensitivity to electromagnetic fields and controls. Bioelectromagnetics. 30(7):556-563, 2009.

Individuals who report sensitivity to electromagnetic fields often report cognitive impairments that they believe are due to exposure to mobile phone technology. Previous research in this area has revealed mixed results, however, with the majority of research only testing control individuals. Two studies using control and self-reported sensitive participants found inconsistent effects of mobile phone base stations on cognitive functioning. The aim of the present study was to clarify whether short-term (50 min) exposure at 10 mW/m² to typical Global System for Mobile Communication (GSM) and Universal Mobile Telecommunications System (UMTS) base station signals affects attention, memory, and physiological endpoints in sensitive and control participants. Data from 44 sensitive and 44 matched-control participants who performed the digit symbol substitution task (DSST), digit span task (DS), and a mental arithmetic task (MA), while being exposed to GSM, UMTS, and sham signals under double-blind conditions were analyzed. Overall, cognitive functioning was not affected by short-term exposure to either GSM or UMTS signals in the current study. Nor did exposure affect the physiological measurements of blood volume pulse (BVP), heart rate (HR), and skin conductance (SC) that were taken while participants performed the cognitive tasks.

Flodin U, Seneby A, Tegenfeldt C. Provocation of electric hypersensitivity under everyday conditions. Scand J Work Environ Health. 26(2):93-98, 2000.

OBJECTIVES: In most previous provocation studies subjects suffering from "electric hypersensitivity" have not been able to determine correctly whether or not they have been subjected to a sham or true provocation to magnetic or electric fields. However, an often-discussed weakness is that most of the earlier provocation studies have been performed in a laboratory situation, often with simulated fields, which may not be representative of conditions prevailing in the homes or workplaces of the patients. Criticism has also been put forth about neglect of the long latency period of symptoms. Therefore, a provocation study was performed in the homes or workplaces of the patients, where we also studied the symptoms and on-off answer 24 hours after the exposure. **METHODS:** Fifteen subjects selected as having fast and distinct reactions from electric equipment were provoked on 4 occasions: mainly 2 true and 2 sham provocations. The intervals between exposure were a few or more days in order to provide the subjects with an opportunity to recover before the next provocation. A control group of healthy subjects with normal hearing and vision verified that the provocations were performed in a blind manner. **RESULTS:** The patients suffering from "electric hypersensitivity" were no better than the control group in deciding whether or not they were exposed to electric and magnetic fields. **CONCLUSIONS:** Exposure to electric and magnetic fields per se does not seem to be a sufficient cause of the symptoms experienced by this patient group.

Frei P, Mohler E, Braun-Fahrländer C, Fröhlich J, Neubauer G, Rösli M; QUALIFEX-team. Cohort study on the effects of everyday life radio frequency electromagnetic field exposure on non-specific symptoms and tinnitus. Environ Int. 38(1):29-36, 2012.

BACKGROUND: There is public concern regarding potential health effects of radio frequency electromagnetic fields (RF-EMF) exposure, as produced by mobile phones or broadcast transmitters. The objective of this study was to investigate the association between RF-EMF exposure and non-specific symptoms and tinnitus in a prospective cohort study. **METHODS:** In 2008, 1375 randomly selected participants from Basel, Switzerland, were enrolled in a questionnaire survey with follow-up after one year (participation rate 82%). A score for somatic complaints (von Zerssen list) and headache (HIT-6) was assessed. Far-field environmental RF-EMF exposure was predicted using a validated prediction model. Regarding near-field exposure, self-reported mobile and cordless phone use as well as mobile phone operator data were collected. In multivariate regression models, we investigated whether exposure at baseline (cohort analysis) or changes in exposure between baseline and follow-up (change analysis) were related to changes in health scores. **RESULTS:** For participants in the top decile of environmental far-field RF-EMF exposure at baseline, in comparison to participants exposed below the median value, the change in the von Zerssen- and HIT-6-scores between baseline and follow-up was -0.12 (95%-CI: -1.79 to 1.56) and -0.37 (95%-CI: -1.80 to 1.07) units, respectively. Exposure to near-field sources and a change in exposure between baseline and follow-up were not related to non-specific symptoms. Similarly, no association between RF-EMF exposure and tinnitus was observed. **CONCLUSIONS:** In this first cohort study using objective and well-validated RF-EMF exposure measures, we did not observe an association between RF-EMF exposure and non-specific symptoms or tinnitus.

Frick U, Rehm J, Eichhammer P. Risk perception, somatization, and self report of complaints related to electromagnetic fields--a randomized survey study. Int J Hyg Environ Health. 205(5):353-360, 2002.

Exposure to electromagnetic fields (EMF) as well as EMF-related complaints has increased over the past decades. However, it is unclear whether these complaints are related to the

electromagnetic or other physical properties of these fields per se, to salience of EMF in media, or to both. What is the prevalence of EMF-related complaints in the general population? What are the influencing factors on this prevalence? Does reporting of EMF-related symptoms depend on cognitive factors? To answer these questions, a survey with random variation of three cognitive factors was performed. As expected, EMF-related complaints were reported more by females and people with higher somatization tendency. Age had no significant linear effect on EMF-related complaints. The cognitive condition of threat produced a significant contrast effect among people with high somatization tendency on EMF-related complaints. Cognition can influence reporting of EMF-related effects. Thus, in future research of such effects, psychologically influencing factors should be included. Also risk communication should incorporate knowledge about social cognition.

Frick U, Kharraz A, Hauser S, Wiegand R, Rehm J, Kovatsits U, Eichhammer P. Comparison perception of singular transcranial magnetic stimuli by subjectively electrosensitive subjects and general population controls. Bioelectromagnetics. 26(4):287-298, 2005.

Transcranial magnetic stimulation of the dorsolateral prefrontal cortex by single pulses of varying field intensities was used to measure thresholds of individual perception and motor response in three groups of subjects: subjectively electrosensitive people, general population controls with a high burden of complaints related to electromagnetic field (EMF) exposure in the literature (highest decile in complaint burden), and general population controls with a low burden of complaints (lowest decile in complaint burden). The major study endpoint was the ability of the subjects to differentiate between real magnetic stimulation and a sham condition. There were no significant differences between groups in the thresholds, neither of detecting the real magnetic stimulus nor in motor response. But the three groups differed significantly in differentiating between stimulation and sham condition, with the subjectively electrosensitive people having the lowest ability to differentiate and the control group with high level of EMF-related complaints having the best ability to differentiate. Differences between groups were mostly due to false alarm reactions in the sham condition reported by subjectively electrosensitives (SES). We found no objective correlate of the self perception of being "electrosensitive." Overall, our experiment does not support the hypothesis that subjectively electrosensitive patients suffer from a physiological hypersensitivity to EMFs or stimuli. Further research should focus on disposing factors explaining the unspecific sensory hyperresponsiveness of subjectively electrosensitive subjects.

Furubayashi T, Ushiyama A, Terao Y, Mizuno Y, Shirasawa K, Pongpaibool P, Simba AY, Wake K, Nishikawa M, Miyawaki K, Yasuda A, Uchiyama M, Yamashita HK, Masuda H, Hirota S, Takahashi M, Okano T, Inomata-Terada S, Sokejima S, Maruyama E, Watanabe S, Taki M, Ohkubo C, Ugawa Y. Effects of short-term W-CDMA mobile phone base station exposure on women with or without mobile phone related symptoms. Bioelectromagnetics. 30(2):100-113, 2009.

To investigate possible health effects of mobile phone use, we conducted a double-blind, cross-over provocation study to confirm whether subjects with mobile phone related symptoms (MPRS) are more susceptible than control subjects to the effect of electromagnetic fields (EMF) emitted from base stations. We sent questionnaires to 5,000 women and obtained 2,472 valid responses from possible candidates; from these, we recruited 11 subjects with MPRS and 43 controls. There were four EMF exposure conditions, each of which lasted 30 min: continuous, intermittent, and sham exposure with and without noise. Subjects were exposed to EMF of 2.14

GHz, 10 V/m (W-CDMA), in a shielded room to simulate whole-body exposure to EMF from base stations, although the exposure strength we used was higher than that commonly received from base stations. We measured several psychological and cognitive parameters pre- and post-exposure, and monitored autonomic functions. Subjects were asked to report on their perception of EMF and level of discomfort during the experiment. The MPRS group did not differ from the controls in their ability to detect exposure to EMF; nevertheless they consistently experienced more discomfort, regardless of whether or not they were actually exposed to EMF, and despite the lack of significant changes in their autonomic functions. Thus, the two groups did not differ in their responses to real or sham EMF exposure according to any psychological, cognitive or autonomic assessment. In conclusion, we found no evidence of any causal link between hypersensitivity symptoms and exposure to EMF from base stations.

Gangi S, Johansson O. Skin changes in "screen dermatitis" versus classical UV- and ionizing irradiation-related damage--similarities and differences. *Exp Dermatol.* 6(6):283-291, 1997.

An increasing number of persons say that they get cutaneous problems as well as symptoms from certain internal organs, such as the central nervous system (CNS) and the heart, when being close to electric equipment. A major group of these patients are the users of video display terminals (VDTs), who claim to have subjective and objective skin- and mucosa-related symptoms, such as pain, itch, heat sensation, erythema, papules, and pustules. The CNS symptoms are, e.g. dizziness, tiredness, and headache. Erythema, itch, heat sensation, edema and pain are also common symptoms of sunburn (UV dermatitis). Alterations have been observed in cell populations of the skin of patients suffering from so-called "screen dermatitis" similar to those observed in the skin damaged due to ultraviolet (UV) light or ionizing radiation. In "screen dermatitis" patients a much higher number of mast cells have been observed. It is known that UVB irradiation induces mast cell degranulation and release of TNF-alpha. The high number of mast cells present in the "screen dermatitis" patients and the possible release of specific substances, such as histamine, may explain their clinical symptoms of itch, pain, edema and erythema. The most remarkable change among cutaneous cells, after exposure with the above-mentioned irradiation sources, is the disappearance of the Langerhans' cells. This change has also been observed in "screen dermatitis" patients, again pointing to a common cellular and molecular basis. The results of this literature study demonstrate that highly similar changes exist in the skin of "screen dermatitis" patients, as regards the clinical manifestations as well as alterations in the cell populations, and in skin damaged by UV light or ionizing radiation.

Gangi S, Johansson O. A theoretical model based upon mast cells and histamine to explain the recently proclaimed sensitivity to electric and/or magnetic fields in humans. *Med Hypotheses.* 54(4):663-671, 2000.

The relationship between exposure to electromagnetic fields (EMFs) and human health is more and more in focus. This is mainly because of the rapid increasing use of such EMFs within our modern society. Exposure to EMFs has been linked to different cancer forms, e.g. leukemia, brain tumors, neurological diseases, such as Alzheimer's disease, asthma and allergy, and recently to the phenomena of 'electrosupersensitivity' and 'screen dermatitis'. There is an increasing number of reports about cutaneous problems as well as symptoms from internal organs, such as the heart, in people exposed to video display terminals (VDTs). These people suffer from subjective and objective skin and mucosa-related symptoms, such as itch, heat sensation, pain, erythema, papules and pustules. In severe cases, people can not, for instance,

use VDTs or artificial light at all, or be close to mobile telephones. Mast cells (MCs), when activated, release a spectrum of mediators, among them histamine, which is involved in a variety of biological effects with clinical relevance, e.g. allergic hypersensitivity, itch, edema, local erythema and many types of dermatoses. From the results of recent studies, it is clear that EMFs affect the MC, and also the dendritic cell, population and may degranulate these cells. The release of inflammatory substances, such as histamine, from MCs in the skin results in a local erythema, edema and sensation of itch and pain, and the release of somatostatin from the dendritic cells may give rise to subjective sensations of on-going inflammation and sensitivity to ordinary light. These are, as mentioned, the common symptoms reported from patients suffering from 'electrosupersensitivity'/'screen dermatitis'. MCs are also present in the heart tissue and their localization is of particular relevance to their function. Data from studies made on interactions of EMFs with the cardiac function have demonstrated that highly interesting changes are present in the heart after exposure to EMFs. One could speculate that the cardiac MCs are responsible for these changes due to degranulation after exposure to EMFs. However, it is still not known how, and through which mechanisms, all these different cells are affected by EMFs. In this article, we present a theoretical model, based upon observations on EMFs and their cellular effects, to explain the proclaimed sensitivity to electric and/or magnetic fields in humans.

Genuis SJ, Lipp CT. Electromagnetic hypersensitivity: fact or fiction? Sci Total Environ. 414:103-112, 2012.

As the prevalence of wireless telecommunication escalates throughout the world, health professionals are faced with the challenge of patients who report symptoms they claim are connected with exposure to some frequencies of electromagnetic radiation (EMR). Some scientists and clinicians acknowledge the phenomenon of hypersensitivity to EMR resulting from common exposures such as wireless systems and electrical devices in the home or workplace; others suggest that electromagnetic hypersensitivity (EHS) is psychosomatic or fictitious. Various organizations including the World Health Organization as well as some nation states are carefully exploring this clinical phenomenon in order to better explain the rising prevalence of non-specific, multi-system, often debilitating symptoms associated with non-ionizing EMR exposure. As well as an assortment of physiological complaints, patients diagnosed with EHS also report profound social and personal challenges, impairing their ability to function normally in society. This paper offers a review of the sparse literature on this perplexing condition and a discussion of the controversy surrounding the legitimacy of the EHS diagnosis. Recommendations are provided to assist health professionals in caring for individuals complaining of EHS.

Ghezel-Ahmadi D, Engel A, Weidemann J, Budnik LT, Baur X, Frick U, Hauser S, Dahmen N. Heavy metal exposure in patients suffering from electromagnetic hypersensitivity. Sci Total Environ. 408(4):774-778, 2010.

BACKGROUND: Risks from electromagnetic devices are of considerable concern. Electrohypersensitive (EHS) persons attribute a variety of rather unspecific symptoms to the exposure to electromagnetic fields. The pathophysiology of EHS is unknown and therapy remains a challenge. **OBJECTIVES:** Heavy metal load has been discussed as a potential factor in the symptomatology of EHS patients. The main objective of the study was to test the hypothesis of a link between EHS and heavy metal exposure. **METHODS:** We measured lead, mercury and cadmium concentrations in the blood of 132 patients (n=42 males and n=90 females) and 101 controls (n=34 males and n=67 females). **RESULTS:** Our results show that

heavy metal load is of no concern in most cases of EHS but might play a role in exceptional cases. **CONCLUSIONS:** The data do not support the general advice to heavy metal detoxification in EHS.

Gibson PR, Kovach S, Lupfer A. Unmet health care needs for persons with environmental sensitivity. J Multidiscip Healthc. 8:59-66, 2015.

Studies of unmet health care needs have shown that women, people with poor health, and people with lower socioeconomic status are more likely to report having unmet health care needs. In this study, we examined the types of and reasons for unmet health care needs in 465 people with environmental sensitivities. A second area of inquiry involved negative reactions to general anesthesia. Results showed that the most common barriers to receiving care were the inability to find a provider who understands environmental sensitivities and a lack of accessibility due to chemical and electromagnetic exposures in health care environments. Lower income and poorer health (longer illness, a worsening or fluctuating course of illness, and a higher level of disability) were significantly correlated with the total number of reported unmet health care needs. Some people with environmental sensitivities reported having negative reactions to anesthesia of long duration; most common were nausea and vomiting, fatigue, and reduced cognitive ability.

Gobba F. [Subjective non-specific symptoms related with electromagnetic fields: description of 2 cases]. Epidemiol Prev. 26(4):171-175, 2002. [Article in Italian]

In Italy, as in other countries, an apparently increasing number of subjects is reporting a variety of subjective symptoms that the subjects themselves refer to the exposure to electric, magnetic or electromagnetic fields (EMF) from nearby electric appliances, cellular phones, antennas, etc. Terms like electricity hypersensitivity (EHS), EMF hypersensitivity, or other similar, are frequently adopted to describe such symptoms; nevertheless, up to now, these terms are not entered the medical terminology. No accepted diagnostic criteria or procedures for the diagnosis of EHS are currently available. Furthermore, apart from the subject's self-attribution of the symptoms to EMFs, no direct cause-effect relationship between EHS symptoms and electromagnetic fields has been proved; additionally, evidence of a possible pathogenetic mechanism is lacking. In this paper, two cases developing symptoms of EHS ascribed to overhead power line in the proximity of their house are discussed. Nervous system (asthenia, depression, paraesthesias etc.), cardiovascular system (cardiac palpitations) and the skin (tingling, itching, etc.), are mostly (but not exclusively) involved. Based on available scientific knowledge, the rationale for an approach to subjects claiming for EHS is discussed. The establishment of a National archive for the collection of cases is needed.

Gómez-Perretta C, Navarro EA, Segura J, Portolés M. Subjective symptoms related to GSM radiation from mobile phone base stations: a cross-sectional study. BMJ Open. 3(12):e003836, 2013.

OBJECTIVES: We performed a re-analysis of the data from Navarro et al (2003) in which health symptoms related to microwave exposure from mobile phone base stations (BSs) were explored, including data obtained in a retrospective inquiry about fear of exposure from BSs.

DESIGN: Cross-sectional study. **SETTING:** La Ñora (Murcia), Spain. **PARTICIPANTS:** Participants with known illness in 2003 were subsequently disregarded: 88 participants instead of 101 (in 2003) were analysed. Since weather circumstances can influence exposure, we restricted data to measurements made under similar weather conditions. **OUTCOMES AND**

METHODS: A statistical method indifferent to the assumption of normality was employed: namely, binary logistic regression for modelling a binary response (eg, suffering fatigue (1) or not (0)), and so exposure was introduced as a predictor variable. This analysis was carried out on a regular basis and bootstrapping (95% percentile method) was used to provide more accurate CIs. **RESULTS:** The symptoms most related to exposure were lack of appetite (OR=1.58, 95% CI 1.23 to 2.03); lack of concentration (OR=1.54, 95% CI 1.25 to 1.89); irritability (OR=1.51, 95% CI 1.23 to 1.85); and trouble sleeping (OR=1.49, 95% CI 1.20 to 1.84). Changes in -2 log likelihood showed similar results. Concerns about the BSs were strongly related with trouble sleeping (OR =3.12, 95% CI 1.10 to 8.86). The exposure variable remained statistically significant in the multivariate analysis. The bootstrapped values were similar to asymptotic CIs. **CONCLUSIONS:** This study confirms our preliminary results. We observed that the incidence of most of the symptoms was related to exposure levels-independently of the demographic variables and some possible risk factors. Concerns about adverse effects from exposure, despite being strongly related with sleep disturbances, do not influence the direct association between exposure and sleep.

Hagström M, Auranen J, Johansson O, Ekman R. Reducing electromagnetic irradiation and fields alleviates experienced health hazards of VDU work. Pathophysiology. 19(2):81-87, 2012

World Health Organisation (WHO) outlined in 2005 recommendations, how to treat people suffering from the functional impairment electrohypersensitivity in its document "Electromagnetic fields and public health". Unfortunately the reduction of electromagnetic fields was not considered as a treatment option. The aim of the current study was to shield the computer user from the emitted electromagnetic irradiation and fields and to correlate that to the subjective symptoms reported by electrohypersensitive volunteers. The irradiation of the shielding cabinets was recorded. They housed either separate computer screens or whole laptops. When the volunteers had used the shielding cabinet for 1-7 years, they were able work with their computers whole working day, Those who had used the shielding cabined for 2-3 months were partially symptom free. The person who had used the cabinet only for 1 week reported some alleviation of her nausea. In conclusion: it seems that reducing the electromagnetic irradiation of the computer can lessen the symptoms of electrohypersensitivity and permit working without problems. Further studies are needed to clarify how the symptoms of different organ systems recover and make computer users to work also professionally.

Hagström M, Auranen J, Ekman R. Electromagnetic hypersensitive Finns: Symptoms, perceived sources and treatments, a questionnaire study. Pathophysiology. 2013 Apr 1. pii: S0928-4680(13)00002-3.

The aim was to analyze the subjective experiences of Finns who describe themselves as suffering from electromagnetic hypersensitivity (EHS), their symptoms, self-perceived sources of the health complaints and the effectiveness of medical and complementary alternative therapies. A total of 395 questionnaires were mailed to self-diagnosed EHS persons. Of the participants 345 belonged to a Finnish self-help group and 50 came from outside of the group. The return rate of the study was 52.1% (206) and 80.9% of the respondents were women. Before the onset of EHS the most common health complaints were different types of allergies (35.1%, 68). During the acute phase of EHS the most common symptoms were nervous system related: "stress" (60.3%, 117), "sleeping disorders" (59.3%, 115) and "fatigue" (57.2%, 111). The sources that were most often reported to have triggered EHS were: "personal computers" (50.8%, 94) and "mobile phones" (47.0%, 87). The same devices were also claimed to cause the most symptoms during the acute phase. After the acute phase of EHS had passed, the

respondents still claimed to react to these same digital and wireless devices while their reactions to basic electrical appliances were reduced. According to 76% of 157 respondents the reduction or avoidance of electromagnetic fields (EMF) helped in their full or partial recovery. The best treatments for EHS were given as: "dietary change" (69.4%), "nutritional supplements" (67.8%) and "increased physical exercise" (61.6%). The official treatment recommendations of psychotherapy (2.6%) and medication (-4.2%) were not significantly helpful. According to the present results the official treatment protocols should take better account the EHS person's own experiences. The avoidance of electromagnetic radiation and fields effectively removed or lessened the symptoms in EHS persons.

Hardell L, Carlberg M, Söderqvist F, Hardell K, Björnfoth H, van Bavel B, Lindström G. Increased concentrations of certain persistent organic pollutants in subjects with self-reported electromagnetic hypersensitivity--a pilot study. Electromagn Biol Med. 27(2):197-203, 2008.

Electromagnetic hypersensitivity (EHS) is used for a variety of subjective symptoms related to exposure to electromagnetic fields (EMF). The aim of this pilot study was to analyze the concentrations of certain persistent organic pollutants (POPs) in subjects with self-reported EHS. In total, 13 EHS subjects and 21 controls were included, all female. The concentration of several POPs was higher in EHS subjects than in controls. Lower concentrations were found for hexachlorobenzene and two types of chlordanes. The only significantly increased odds ratios (ORs) were found for polybrominated diphenyl ether (PBDE) #47 yielding OR=11.7, 95% confidence interval (CI)=1.45-94.7 and the chlordane metabolite MC6 with OR=11.2, 95% CI=1.18-106. The results were based on low numbers and must be interpreted with caution. This hypothesis generating study indicates the necessity of a larger investigation on this issue.

Havas M Radiation from wireless technology affects the blood, the heart, and the autonomic nervous system. Rev Environ Health. 28(2-3):75-84, 2013.

Exposure to electrosmog generated by electric, electronic, and wireless technology is accelerating to the point that a portion of the population is experiencing adverse reactions when they are exposed. The symptoms of electrohypersensitivity (EHS), best described as rapid aging syndrome, experienced by adults and children resemble symptoms experienced by radar operators in the 1940s to the 1960s and are well described in the literature. An increasingly common response includes clumping (rouleau formation) of the red blood cells, heart palpitations, pain or pressure in the chest accompanied by anxiety, and an upregulation of the sympathetic nervous system coincident with a downregulation of the parasympathetic nervous system typical of the "fight-or-flight" response. Provocation studies presented in this article demonstrate that the response to electrosmog is physiologic and not psychosomatic. Those who experience prolonged and severe EHS may develop psychologic problems as a consequence of their inability to work, their limited ability to travel in our highly technologic environment, and the social stigma that their symptoms are imagined rather than real.

Havas M, Marrongelle J. Replication of heart rate variability provocation study with 2.4-GHz cordless phone confirms original findings. Electromagn Biol Med. 32(2):253-266, 2013.

This is a replication of a study that we previously conducted in Colorado with 25 subjects designed to test the effect of electromagnetic radiation generated by the base station of a cordless phone on heart rate variability (HRV). In this study, we analyzed the response of 69

subjects between the ages of 26 and 80 in both Canada and the USA. Subjects were exposed to radiation for 3-min intervals generated by a 2.4-GHz cordless phone base station (3-8 $\mu\text{W}/\text{cm}^2$). A few participants had a severe reaction to the radiation with an increase in heart rate and altered HRV indicative of an alarm response to stress. Based on the HRV analyses of the 69 subjects, 7% were classified as being "moderately to very" sensitive, 29% were "little to moderately" sensitive, 30% were "not to little" sensitive and 6% were "unknown". These results are not psychosomatic and are not due to electromagnetic interference. Twenty-five percent of the subjects' self-proclaimed sensitivity corresponded to that based on the HRV analysis, while 32% overestimated their sensitivity and 42% did not know whether or not they were electrically sensitive. Of the 39 participants who claimed to experience some electrical hypersensitivity, 36% claimed they also reacted to a cordless phone and experienced heart symptoms and, of these, 64% were classified as having some degree of electrohypersensitivity (EHS) based on their HRV response. Novel findings include documentation of a delayed response to radiation. Orthostatic HRV testing combined with provocation testing may provide a diagnostic tool for some sufferers of EHS when they are exposed to electromagnetic emitting devices. The protocol used underestimates reaction to electromagnetic radiation for those who have a delayed autonomic nervous system reaction and it may under diagnose those who have adrenal exhaustion as their ability to mount a response to a stressor is diminished.

Hedendahl L, Carlberg M, Hardell L. Electromagnetic hypersensitivity - an increasing challenge to the medical profession. *Rev Environ Health*. 2015;30(4):209-15.

BACKGROUND: In 1970, a report from the former Soviet Union described the "microwave syndrome" among military personnel, working with radio and radar equipment, who showed symptoms that included fatigue, dizziness, headaches, problems with concentration and memory, and sleep disturbances. Similar symptoms were found in the 1980s among Swedes working in front of cathode ray tube monitors, with symptoms such as flushing, burning, and tingling of the skin, especially on the face, but also headaches, dizziness, tiredness, and photosensitivity. The same symptoms are reported in Finns, with electromagnetic hypersensitivity (EHS) being attributed to exposure to electromagnetic fields (EMF). Of special concern is involuntary exposure to radiofrequency (RF)-EMF from different sources. Most people are unaware of this type of exposure, which has no smell, color, or visibility. There is an increasing concern that wireless use of laptops and iPads in Swedish schools, where some have even abandoned textbooks, will exacerbate the exposure to EMF.

METHODS: We have surveyed the literature on different aspects of EHS and potential adverse health effects of RF-EMF. This is exemplified by case reports from two students and one teacher who developed symptoms of EHS in schools using Wi-Fi.

RESULTS: In population-based surveys, the prevalence of EHS has ranged from 1.5% in Sweden to 13.3% in Taiwan. Provocation studies on EMF have yielded different results, ranging from where people with EHS cannot discriminate between an active RF signal and placebo, to objectively observed changes following exposure in reactions of the pupil, changes in heart rhythm, damage to erythrocytes, and disturbed glucose metabolism in the brain. The two students and the teacher from the case reports showed similar symptoms, while in school environments, as those mentioned above.

DISCUSSION: Austria is the only country with a written suggestion to guidelines on the diagnosis and treatment of EMF-related health problems. Apart from this, EHS is not recognized as a specific diagnosis in the rest of the world, and no established treatment exists.

CONCLUSION: It seems necessary to give an International Classification of Diseases to EHS to get it accepted as EMF-related health problems. The increasing exposure to RF-EMF in schools is of great concern and needs better attention. Longer-term health effects are unknown. Parents, teachers, and school boards have the responsibility to protect children from unnecessary exposure.

Heuser G, Heuser SA. Functional brain MRI in patients complaining of electrohypersensitivity after long term exposure to electromagnetic fields. Rev Environ Health. 32(3):291-299, 2017.

INTRODUCTION: Ten adult patients with electromagnetic hypersensitivity underwent functional magnetic resonance imaging (fMRI) brain scans. All scans were abnormal with abnormalities which were consistent and similar. It is proposed that fMRI brain scans be used as a diagnostic aid for determining whether or not a patient has electromagnetic hypersensitivity. Over the years we have seen an increasing number of patients who had developed multi system complaints after long term repeated exposure to electromagnetic fields (EMFs). These complaints included headaches, intermittent cognitive and memory problems, intermittent disorientation, and also sensitivity to EMF exposure. Regular laboratory tests were within normal limits in these patients. The patients refused to be exposed to radioactivity. This of course ruled out positron emission tomography (PET) and single-photon emission computed tomography (SPECT) brain scanning. This is why we ordered fMRI brain scans on these patients. We hoped that we could document objective abnormalities in these patients who had often been labeled as psychiatric cases.

MATERIALS AND METHODS: Ten patients first underwent a regular magnetic resonance imaging (MRI) brain scan, using a 3 Tesla Siemens Verio MRI open system. A functional MRI study was then performed in the resting state using the following sequences: A three-dimensional, T1-weighted, gradient-echo (MPRAGE) Resting state network. The echo-planar imaging (EPI) sequences for this resting state blood oxygenation level dependent (BOLD) scan were then post processed on a 3D workstation and the independent component analysis was performed separating out the various networks. Arterial spin labeling. Tractography and fractional anisotropy. **RESULTS:** All ten patients had abnormal functional MRI brain scans. The abnormality was often described as hyper connectivity of the anterior component of the default mode in the medial orbitofrontal area. Other abnormalities were usually found. Regular MRI studies of the brain were mostly unremarkable in these patients. **CONCLUSION:** We propose that functional MRI studies should become a diagnostic aid when evaluating a patient who claims electrohypersensitivity (EHS) and has otherwise normal studies. Interestingly, the differential diagnosis for the abnormalities seen on the fMRI includes head injury. It turns out that many of our patients indeed had a history of head injury which was then followed sometime later by the development of EHS. Many of our patients also had a history of exposure to potentially neurotoxic chemicals, especially mold. Head injury and neurotoxic chemical exposure may make a patient more vulnerable to develop EHS.

Hietanen M, Hämmäläinen AM, Husman T. Hypersensitivity symptoms associated with exposure to cellular telephones: no causal link. Bioelectromagnetics. 23(4):264-270, 2002.

The hypothesis that there exist hypersensitive persons who perceive subjective symptoms from radiofrequency (RF) fields emitted by hand held mobile phones (cellular phones) was tested using double blind provocation experiments. We also tested whether sensitive subjects are able to determine whether the phone is on or off by sensing RF fields. The study group consisted of 20 volunteers (13 women and 7 men) who reported themselves as being sensitive to cellular phones. The RF exposure sources were one analogue NMT phone (900 MHz) and two digital

GSM phones (900 and 1800 MHz). The duration of a test session was 30 min, and three or four sessions were performed in random order for each subject during 1 day. The subjects were asked to report symptoms or sensations as soon as they perceived any abnormal feelings. In addition, the subjects' blood pressure, heart rate, and breathing frequency were monitored every 5 min. The results of the study indicated that various symptoms were reported, and most of them appeared in the head region. However, the number of reported symptoms was higher during sham exposure than during real exposure conditions. In addition, none of the test persons could distinguish real RF exposure from sham exposure. Hence, we conclude that adverse subjective symptoms or sensations, though unquestionably perceived by the test subjects, were not produced by cellular phones.

Hillert L, Kolmodin Hedman B, Dörling BF, Arnetz BB. Cognitive behavioural therapy for patients with electric sensitivity - a multidisciplinary approach in a controlled study. *Psychother Psychosom.* 67(6):302-310, 1998.

BACKGROUND: Electric sensitivity is a syndrome that still lacks diagnostic criteria and proven aetiology. The suffering of afflicted persons motivates development and evaluation of effective handling and treatments. The aim of the study was to evaluate the effect of cognitive behavioural therapy in patients with electric sensitivity. **METHODS:** Cognitive behavioural treatment, as part of a multidisciplinary treatment package for patients with electric sensitivity, was evaluated in a controlled trial. Ten patients who received treatment were compared to 12 controls. Outcome measures included different dimensions such as symptoms, beliefs, behaviour, and biochemical measurements of stress-related variables. All outcome measures were collected prior to the study, post-treatment, and after an additional 6-month follow-up. **RESULTS:** The therapy group rated their electric sensitivity as significantly lower than did the control group at the 6-month follow-up, and reduction of self-rated discomforts from triggering factors was significant in the therapy group. There were no systematic changes in the biochemical variables. The symptom indices were significantly reduced over time, and ability to work continued to be good in both groups. **CONCLUSION:** The prognosis for this syndrome is good with early intervention and cognitive therapy may further reduce the perceived hypersensitivity. This may have important implications on handling of patients with electric sensitivity.

Hillert L, Flato S, Georgellis A, Arnetz BB, Kolmodin-Hedman B. Environmental illness: fatigue and cholinesterase activity in patients reporting hypersensitivity to electricity. *Environ Res.* 85(3):200-206, 2001.

The lack of a pathophysiological marker hinders studies on environmental illnesses of unknown origin. Hence, research focused on the identification of such a marker is a priority. This study investigated the nature and a possible etiology of fatigue in hypersensitivity to electricity (the most commonly reported environmental illness in Sweden). The aim was to test the hypothesis that perceived fatigue was due to alterations in cholinesterase activity. The study group consisted of 14 people who reported a hypersensitivity to electricity, including disabling fatigue. We assessed cholinesterase activity three times: twice based on current symptoms reported by the subjects (severe fatigue attributed to electromagnetic fields and absence of this symptom) and once at a randomly selected time. No significant reduction in acetylcholinesterase was identified in any subject. Examined on a group level, no significant reduction in activity was identified at the time of severe fatigue, and no correlation between reported degree of fatigue and cholinesterase activity was observed. Fatigue attributed to electromagnetic fields was nonphysical and showed a significant correlation to difficulties in concentrating. The results do

not support the hypothesis that a change in cholinesterase activity mediates fatigue in people reporting hypersensitivity to electricity.

Hillert L, Berglind N, Arnetz BB, Bellander T. Prevalence of self-reported hypersensitivity to electric or magnetic fields in a population-based questionnaire survey. Scand J Work Environ Health. 28(1):33-41, 2002.

OBJECTIVES: The prevalence of medically unexplained symptoms attributed to exposure to electromagnetic fields is still largely unknown. Previous studies have investigated reported hypersensitivity to electricity in selected groups recruited from workplaces or outpatient clinics. The aim of this study was to estimate the prevalence of self-reported hypersensitivity to electric or magnetic fields in the general population and to describe characteristics of the group reporting such hypersensitivity with regard to demographics, other complaints, hypersensitivities, and traditional allergies. **METHODS:** A cross-sectional questionnaire survey was conducted in 1997 among 15,000 men and women between 19 and 80 years of age in Stockholm County. The response rate was 73%. **RESULTS:** One and a half percent of the respondents reported hypersensitivity to electric or magnetic fields. Prevalence was highest among women and in the 60- to 69-year age group. The hypersensitive group reported all symptoms, allergies, and other types of hypersensitivities included in the survey (as well as being disturbed by various factors in the home) to a significantly greater extent than the rest of the respondents. No specific symptom profile set off the hypersensitive group from the rest of the respondents. **CONCLUSIONS:** The results should be interpreted with caution. But they suggest that there is widespread concern among the general population about risks to health posed by electric and magnetic fields. More research is warranted to explore ill health among people reporting hypersensitivity to electric or magnetic fields.

Huiberts A, Hjørnevik M, Mykletun A, Skogen JC. Electromagnetic hypersensitivity (EHS) in the media - a qualitative content analysis of Norwegian newspapers. JRSN Short Rep. 2013 Oct 4;4(11):2042533313487332

OBJECTIVES: Electromagnetic hypersensitivity (EHS) is a condition characterized by experiencing symptoms after perceived exposure to weak electromagnetic fields (EMFs). There is substantial debate concerning the aetiology of EHS, but experimental data indicate no association between EHS and actual presence of EMFs. Newspapers play a key role in shaping peoples' understanding of health-related issues. The aim of this study was to describe the content of newspaper articles concerning aetiology and treatment of EHS. **DESIGN:** Qualitative content analysis of newspaper articles. **SETTING:** Norwegian newspaper articles were identified using a comprehensive electronic media archive. **PARTICIPANTS:** Norwegian newspaper articles published between 1 February 2006 and 11 August 2010. **MAIN OUTCOME MEASURES:** Statements coded according to source of information, whether it was pro or con scientific evidence on EHS aetiology, and type of intervention presented as treatment option for EHS. **RESULTS:** Of the statements concerning EHS aetiology (n = 196), 35% (n = 69) were categorized as pro evidence, 65% (n = 127) as con evidence. Of the statements about EHS interventions assessed, 78% (n = 99) were categorized as 'radiance reduction', 4% (n = 5) as 'complementary medicine', and 18% (n = 23) as 'other'. Cognitive behavioural therapy (CBT) and psychotropic drugs were never presented as possible treatment options for EHS. **CONCLUSIONS:** The newspaper media discourse of EHS aetiology and recommended treatment interventions is much in conflict with the current evidence in the field. The majority of statements concerning aetiology convey that EHS is related to the presence of weak EMFs, and radiance reduction as the most frequently conveyed measure to reduce EHS-related symptoms.

Huss A, Röögli M. Consultations in primary care for symptoms attributed to electromagnetic fields--a survey among general practitioners. BMC Public Health. 6:267, 2006.

BACKGROUND: Five percent of the Swiss population attribute symptoms to electromagnetic fields (EMF). General practitioners (GPs) might play a key role in recognising an emerging health risk, since they are the first to observe and follow up persons who attribute symptoms to EMF. It is unclear to what extent EMFs have become an issue in general practice and which experiences GPs report from the consultations. **METHODS:** We conducted telephone interviews in a random sample of GPs in Switzerland in order to assess the frequency of consultations in primary care due to EMF and the GPs' experience with these patients. **RESULTS:** 342 general practitioners were interviewed, corresponding to a response rate of 28.2%. 69% of the GPs reported at least one consultation due to EMF, but GPs with a certificate in complementary medicine were much more likely to report EMF consultations. The median of EMF consultation numbers within one year was three. An overview of the most recent EMF-related consultation per GP yielded sleep disorders, headaches and fatigue as the most often reported symptoms and mobile phone base stations, power lines and the own use of mobile phones as the main EMF sources suspected to be associated to symptoms. GPs judged the association between EMF and the symptoms to be plausible in 54% of the cases. There was no combination of symptoms and EMF sources that was remarkably and consistently judged to be a plausible cause of the symptoms. **CONCLUSION:** In our survey, GPs often judged the association between the health problems and the suspected exposure to be plausible. This plausibility assessment seems to be based on grounds of preventive positions in a situation of scientific uncertainty. More research effort is needed to obtain more insight on a potential association between long term EMF exposure and unspecific symptoms.

Johansson A, Forsgren S, Stenberg B, Wilén J, Kalezic N, Sandström M. No effect of mobile phone-like RF exposure on patients with atopic dermatitis. Bioelectromagnetics. 29(5):353-362, 2008.

This study investigates the effect of exposure to a mobile phone-like radiofrequency (RF) electromagnetic field on people with atopic dermatitis (AD). Fifteen subjects with AD were recruited and matched with 15 controls without AD. The subjects were exposed for 30 min to an RF field at 1 W/kg via an indoor base station antenna attached to a 900 MHz GSM mobile phone. Blood samples for ELISA analysis of the concentration of substance P (SP), tumor necrosis factor receptor 1 (TNF R1), and brain derived neurotrophic factor (BDNF) in serum were drawn before and after the provocation (exposure/sham). Baseline heart rate and heart rate variability, local blood flow, and electrodermal activity were also recorded. No significant differences between the subject groups were found for baseline neurophysiological data. The cases displayed a serum concentration of TNF R1 significantly higher than the control subjects and a significantly lower serum concentration of BDNF in the baseline condition. For SP there was no difference between groups. However, no effects related to RF exposure condition were encountered for any of the measured substances. As to symptoms, a possible correlation with exposure could not be evaluated, due to too few symptom reports. The result of the study does not support the hypothesis of an effect of mobile phone-like RF exposure on serum levels of SP, TNF R1, and BDNF in persons with AD.

Johansson A, Nordin S, Heiden M, Sandström M. Symptoms, personality traits, and stress in people with mobile phone-related symptoms and electromagnetic hypersensitivity. J Psychosom Res. 68(1):37-45, 2010.

OBJECTIVE: Some people report symptoms that they associate with electromagnetic field (EMF) exposure. These symptoms may be related to specific EMF sources or to electrical equipment in general (perceived electromagnetic hypersensitivity, EHS). Research and clinical observations suggest a difference between mobile phone (MP)-related symptoms and EHS with respect to symptom prevalence, psychological factors, and health prognosis. This study assessed prevalence of EMF-related and EMF-nonrelated symptoms, anxiety, depression, somatization, exhaustion, and stress in people with MP-related symptoms or EHS versus a population-based sample and a control sample without EMF-related symptoms. **METHODS:** Forty-five participants with MP-related symptoms and 71 with EHS were compared with a population-based sample (n=106) and a control group (n=63) using self-report questionnaires. **RESULTS:** The EHS group reported more symptoms than the MP group, both EMF-related and EMF-nonrelated. The MP group reported a high prevalence of somatosensory symptoms, whereas the EHS group reported more neurasthenic symptoms. As to self-reported personality traits and stress, the case groups differed only on somatization and listlessness in a direct comparison. In comparison with the reference groups, the MP group showed increased levels of exhaustion and depression but not of anxiety, somatization, and stress; the EHS group showed increased levels for all of the conditions except for stress. **CONCLUSION:** The findings support the idea of a difference between people with symptoms related to specific EMF sources and people with general EHS with respect to symptoms and anxiety, depression, somatization, exhaustion, and stress. The differences are likely to be important in the management of patients.

Johansson O, Hilliges M, Han SW. A screening of skin changes, with special emphasis on neurochemical marker antibody evaluation, in patients claiming to suffer from "screen dermatitis" as compared to normal healthy controls. Exp Dermatol. 5(5):279-285, 1996.

In the present study, facial skin from so-called "screen dermatitis" patients were compared with corresponding material from normal healthy volunteers. The aim of the study was to evaluate possible markers to be used for future double-blind or blind provocation investigations. Differences were found for the biological markers calcitonin gene-related peptide (CGRP), somatostatin (SOM), vasoactive intestinal polypeptide (VIP), peptide histidine isoleucine amide (PHI), neuropeptide tyrosine (NPY), protein S-100 (S-100), neuron-specific enolase (NSE), protein gene product (PGP) 9.5 and phenylethanolamine N-methyltransferase (PNMT). The overall impression in the blind-coded material was such that it turned out easy to blindly separate the two groups from each other. However, no single marker was 100% able to pinpoint the difference, although some were quite powerful in doing so (CGRP, SOM, S-100). However, it has to be pointed out that we cannot, based upon the present results, draw any definitive conclusions about the cause of the changes observed. Whether this is due to electric or magnetic fields, a surrounding airborne chemical, humidity, heating, stress factors, or something else, still remains an open question. Blind or double-blind provocations in a controlled environment are necessary to elucidate possible underlying causes for the changes reported in this investigation.

Johansson O. Electrohypersensitivity: state-of-the-art of a functional impairment. Electromagn Biol Med. 25(4):245-258, 2006.

Recently, a new category of persons, claiming to suffer from exposure to electromagnetic fields, has been described in the literature. In Sweden, electrohypersensitivity (EHS) is an officially fully recognized functional impairment (i.e., it is not regarded as a disease). Survey studies

show that somewhere between 230,000-290,000 Swedish men and women report a variety of symptoms when being in contact with electromagnetic field (EMF) sources. The aim of our studies has been to investigate possible alterations, in the cellular and neuronal systems of these person' skin. As controls, age- and sex-matched persons, without any subjective or clinical symptoms or dermatological history, served. Immunohistochemistry using antisera to the previously characterized marker substances of interest has been utilized. In summary, it is evident from our preliminary data that various alterations are present in the electrohypersensitive person' skin. In view of recent epidemiological studies, pointing to a correlation between long-term exposure from power-frequent magnetic fields or microwaves and cancer, our data ought to be taken seriously and further analyzed.

Johansson O. Electrohypersensitivity: a functional impairment due to an inaccessible environment. Rev Environ Health. 2015 Dec 1;30(4):311-21. doi: 10.1515/reveh-2015-0018.

In Sweden, electrohypersensitivity is recognized as a functional impairment which implies only the environment as the culprit. The Swedish view provides persons with this impairment a maximal legal protection, it gives them the right to get accessibility measures for free, as well as governmental subsidies and municipality economic support, and to provide them with special Ombudsmen (at the municipality, the EU, and the UN level, respectively), the right and economic means to form disability organizations and allow these to be part of national and international counterparts, all with the simple and single aim to allow persons with the functional impairment electrohypersensitivity to live an equal life in a society based on equality. They are not seen as patients, they do not have an overriding medical diagnosis, but the 'patient' is only the inferior and potentially toxic environment. This does not mean that a subjective symptom of a functionally impaired can not be treated by a physician, as well as get sick-leave from their workplace as well as economic compensation, and already in the year 2000 such symptoms were identified in the Internal Code of Diagnoses, version 10 (ICD-10; R68.8/now W90), and have been since. But the underlying cause still remains only the environment.
<http://1.usa.gov/1YFwzkd>

Kim DW, Lee JH, Ji HC, Kim SC, Nam KC, Cha EJ. Physiological effects of RF exposure on hypersensitive people by a cell phone. Conf Proc IEEE Eng Med Biol Soc. 2008:2322-2325, 2008.

Persons with electromagnetic hypersensitivity (EHS) complain of subjective symptoms such as headaches, insomnia, memory loss etc. resulting from radio frequency (RF) radiation by cellular phones. There have been various EHS provocation studies on heart rate, blood pressure, and subjective symptoms using GSM phones. However, there are few provocation studies on case-control study investigating simultaneously physiological parameters from CDMA phones. In this study, two volunteer groups of 18 self-declared EHS and 19 controls were exposed to both sham and real RF exposures by a CDMA cellular phone for half an hour each. We investigated the physiological parameters such as heart rates, respiration rates, and hear rate variability (HRV). In conclusion, the RF exposure by a CDMA cellular phone did not have any effects on the physiological parameters for both groups.

Kim DW, Choi JL, Nam KC, Yang DI, Kwon MK. Origins of electromagnetic hypersensitivity to 60 Hz magnetic fields: A provocation study. Bioelectromagnetics. 2011 Oct 19. doi: 10.1002/bem.20711. [Epub ahead of print]

With increasing electrical device usage, social concerns about the possible effects of 60 Hz electromagnetic fields on human health have increased. The number of people with self-

attributed electromagnetic hypersensitivity (EHS) who complain of various subjective symptoms such as headache and insomnia has also increased. However, it is unclear whether EHS results from physiological or other origins. In this double-blinded study, we simultaneously investigated physiological changes (heart rate, respiration rate, and heart rate variability), subjective symptoms, and perception of the magnetic field to assess origins of the subjective symptoms. Two volunteer groups of 15 self-reported EHS and 16 non-EHS individuals were tested with exposure to sham and real (60 Hz, 12.5 μ T) magnetic fields for 30 min. Magnetic field exposure did not have any effects on physiological parameters or eight subjective symptoms in either group. There was also no evidence that the EHS group perceived the magnetic field better than the non-EHS group. In conclusion, the subjective symptoms did not result from the 60 Hz, 12.5 μ T magnetic field exposures but from other non-physiological factors.

Küçer N, Pamukçu T. Self-reported symptoms associated with exposure to electromagnetic fields: a questionnaire study. *Electromagn Biol Med.* 33(1):15-17, 2014.

In the last years, it has been discussed frequently whether there are any harmful effects of electromagnetic fields on human health. Electromagnetic fields are generated by several natural and man-made sources. Part of the electromagnetic spectrum called Radiofrequency is used in communication systems such as mobile (cellular) phone and computer. The aim of our study was to explore different self-reported symptoms that may be associated with exposure to electromagnetic fields. This survey study was conducted, using a questionnaire, on 350 people aged +9 years in Turkey. The chi-square test was used for data analysis. Self-reported symptoms were headache, vertigo/dizziness, fatigue, forgetfulness, sleep disturbance-insomnia, tension-anxiety, joint and bone pain, lacrimation of the eyes, hearing loss and tinnitus. As a result of the survey, the study has shown that users of mobile phone and computer more often complained of headache, joint and bone pain, hearing loss, vertigo/dizziness, tension-anxiety symptoms according to time of daily usage ($p < 0.05$). In users of mobile phone and computer, women significantly ($p < 0.05$) complained more often of headache, vertigo/dizziness, fatigue, forgetfulness and tension-anxiety than men.

Kwon MK, Nam KC, Lee da S, Jang KH, Kim DW. Effects of RF fields emitted from smart phones on cardio-respiratory parameters: a preliminary provocation study. *Conf Proc IEEE Eng Med Biol Soc.* 2011:1961-1964, 2011.

This paper describes an experimental setup for evaluating the physiological effects of radiofrequency (RF) emitted from a Wideband Code Division Multiple Access (WCDMA) module with a 24 dBm at 1950 MHz for specific absorption rate (SAR(1g)) of 1.57 W/kg. This provocation study was executed in a double-blind study of two volunteer groups of 10 self-reported electromagnetic hypersensitivity (EHS) and 10 non-EHS subjects under both sham and real exposures in a randomly assigned and counter-balanced order. In the preliminary results, WCDMA RF exposure of 30 min did not have any effects on physiological changes in either group.

Kwon MK, Choi JY, Kim SK, Yoo TK, Kim DW. Effects of radiation emitted by WCDMA mobile phones on electromagnetic hypersensitive subjects. *Environ Health.* 11:69. 2012. doi: 10.1186/1476-069X-11-69.

BACKGROUND: With the use of the third generation (3 G) mobile phones on the rise, social concerns have arisen concerning the possible health effects of radio frequency-electromagnetic fields (RF-EMFs) emitted by wideband code division multiple access (WCDMA) mobile phones

in humans. The number of people with self-reported electromagnetic hypersensitivity (EHS), who complain of various subjective symptoms such as headache, dizziness and fatigue, has also increased. However, the origins of EHS remain unclear. METHODS: In this double-blind study, two volunteer groups of 17 EHS and 20 non-EHS subjects were simultaneously investigated for physiological changes (heart rate, heart rate variability, and respiration rate), eight subjective symptoms, and perception of RF-EMFs during real and sham exposure sessions. Experiments were conducted using a dummy phone containing a WCDMA module (average power, 24 dBm at 1950 MHz; specific absorption rate, 1.57 W/kg) within a headset placed on the head for 32 min. RESULTS: WCDMA RF-EMFs generated no physiological changes or subjective symptoms in either group. There was no evidence that EHS subjects perceived RF-EMFs better than non-EHS subjects. CONCLUSIONS: Considering the analyzed physiological data, the subjective symptoms surveyed, and the percentages of those who believed they were being exposed, 32 min of RF radiation emitted by WCDMA mobile phones demonstrated no effects in either EHS or non-EHS subjects.

Kwon MK, Kim SK, Koo JM, Choi JY, Kim DW. EHS subjects do not perceive RF EMF emitted from smart phones better than non-EHS subjects. Conf Proc IEEE Eng Med Biol Soc. 2012:2190-2193, 2012.

As the use of smart phones increases, social concerns have arisen concerning the possible effects of radio frequency-electromagnetic fields (RF-EMFs) emitted from wideband code division multiple access (WCDMA) mobile phones on human health. The number of people with self-reported electromagnetic hypersensitivity (EHS) who complain of various subjective symptoms, such as headache, insomnia, etc., has also recently increased. However, it is unclear whether EHS subjects can detect RF-EMFs exposure or not. In this double-blind study, two volunteer groups of 17 EHS and 20 non-EHS subjects were investigated in regards to their perception of RF-EMFs with real and sham exposure sessions. Experiments were conducted using a WCDMA module inside a dummy phone with an average power of 24 dBm at 1950 MHz and a specific absorption rate of 1.57 W/kg using a dummy headphone for 32 min. In conclusion, there was no indication that EHS subjects perceive RF-EMFs better than non-EHS subjects.

Landgrebe M, Frick U, Hauser S, Langguth B, Rosner R, Hajak G, Eichhammer P. Cognitive and neurobiological alterations in electromagnetic hypersensitive patients: results of a case-control study. Psychol Med. 38(12):1781-1791, 2008.

BACKGROUND: Hypersensitivity to electromagnetic fields (EMF) is frequently claimed to be linked to a variety of non-specific somatic and neuropsychological complaints. Whereas provocation studies often failed to demonstrate a causal relationship between EMF exposure and symptom formation, recent studies point to a complex interplay of neurophysiological and cognitive alterations contributing to symptom manifestation in electromagnetic hypersensitive patients (EHS). However, these studies have examined only small sample sizes or have focused on selected aspects. Therefore this study examined in the largest sample of EHS EMF-specific cognitive correlates, discrimination ability and neurobiological parameters in order to get further insight into the pathophysiology of electromagnetic hypersensitivity. METHOD: In a case-control design 89 EHS and 107 age- and gender-matched controls were included in the study. Health status and EMF-specific cognitions were evaluated using standardized questionnaires. Perception thresholds following single transcranial magnetic stimulation (TMS) pulses to the dorsolateral prefrontal cortex were determined using a standardized blinded measurement protocol. Cortical excitability parameters were measured by TMS. RESULTS: Discrimination ability was significantly reduced in EHS (only 40% of the EHS but 60% of the

controls felt no sensation under sham stimulation during the complete series), whereas the perception thresholds for real magnetic pulses were comparable in both groups (median 21% versus 24% of maximum pulse intensity). Intra-cortical facilitation was decreased in younger and increased in older EHS. In addition, typical EMF-related cognitions (aspects of rumination, symptom intolerance, vulnerability and stabilizing self-esteem) specifically differentiated EHS from their controls. **CONCLUSIONS:** These results demonstrate significant cognitive and neurobiological alterations pointing to a higher genuine individual vulnerability of electromagnetic hypersensitive patients.

Landgrebe M, Hauser S, Langguth B, Frick U, Hajak G, Eichhammer P. Altered cortical excitability in subjectively electrosensitive patients: results of a pilot study. J Psychosom Res. 62(3):283-288, 2007.

OBJECTIVE: Hypersensitivity to electromagnetic fields is frequently claimed to be linked to a variety of unspecific somatic and/or neuropsychological complaints. Whereas provocation studies often failed to demonstrate a causal relationship between electromagnetic field exposure and symptom formation, neurophysiological examinations highlight baseline deviations in people claiming to be electrosensitive. **METHODS:** To elucidate a potential role of dysfunctional cortical regulations in mediating hypersensitivity to electromagnetic fields, cortical excitability parameters were measured by transcranial magnetic stimulation in subjectively electrosensitive patients (n=23) and two control groups (n=49) differing in their level of unspecific health complaints. **RESULTS:** Electrosensitive patients showed reduced intracortical facilitation as compared to both control groups, while motor thresholds and intracortical inhibition were unaffected. **CONCLUSIONS:** This pilot study gives additional evidence that altered central nervous system function may account for symptom manifestation in subjectively electrosensitive patients as has been postulated for several chronic multisymptom illnesses sharing a similar clustering of symptoms.

Landgrebe M, Frick U, Hauser S, Hajak G, Langguth B. Association of tinnitus and electromagnetic hypersensitivity: hints for a shared pathophysiology? PLoS One. 4(3):e5026, 2009.

BACKGROUND: Tinnitus is a frequent condition with high morbidity and impairment in quality of life. The pathophysiology is still incompletely understood. Electromagnetic fields are discussed to be involved in the multi-factorial pathogenesis of tinnitus, but data proofing this relationship are very limited. Potential health hazards of electromagnetic fields (EMF) have been under discussion for long. Especially, individuals claiming themselves to be electromagnetic hypersensitive suffer from a variety of unspecific symptoms, which they attribute to EMF-exposure. The aim of the study was to elucidate the relationship between EMF-exposure, electromagnetic hypersensitivity and tinnitus using a case-control design. **METHODOLOGY:** Tinnitus occurrence and tinnitus severity were assessed by questionnaires in 89 electromagnetic hypersensitive patients and 107 controls matched for age-, gender, living surroundings and workplace. Using a logistic regression approach, potential risk factors for the development of tinnitus were evaluated. **FINDINGS:** Tinnitus was significantly more frequent in the electromagnetic hypersensitive group (50.72% vs. 17.5%) whereas tinnitus duration and severity did not differ between groups. Electromagnetic hypersensitivity and tinnitus were independent risk factors for sleep disturbances. However, measures of individual EMF-exposure like e.g. cell phone use did not show any association with tinnitus. **CONCLUSIONS:** Our data indicate that tinnitus is associated with subjective electromagnetic hypersensitivity. An individual vulnerability probably due to an over activated cortical distress network seems to be responsible

for, both, electromagnetic hypersensitivity and tinnitus. Hence, therapeutic efforts should focus on treatment strategies (e.g. cognitive behavioral therapy) aiming at normalizing this dysfunctional distress network.

Leitgeb N, Schröttner J. Electrosensitivity and electromagnetic hypersensitivity. Bioelectromagnetics. 24(6):387-394, 2003.

Electromagnetic sensibility, the ability to perceive electric and electromagnetic exposure, and electromagnetic hypersensitivity (EHS), developing health symptoms due to exposure to environmental electromagnetic fields, need to be distinguished. Increased electrosensitivity is a necessary, however, not a sufficient condition for electromagnetic hypersensitivity. At an extended sample of the general population of 708 adults, including 349 men and 359 women aged between 17 and 60 years, electrosensitivity was investigated and characterized by perception threshold and its standard deviation. By analyzing the probability distributions of the perception threshold of electric 50 Hz currents, evidence could be found for the existence of a subgroup of people with significantly increased electrosensitivity (hypersensitivity) who as a group could be differentiated from the general population. The presented data show that the variation of the electrosensitivity among the general population is significantly larger than has yet been estimated by nonionizing radiation protection bodies, but much smaller than claimed by hypersensitivity self-aid groups. These quantitative results should contribute to a less emotional discussion of this problem. The investigation method presented, is capable of exclusion diagnostics for persons suffering from the hypersensitivity syndrome.

Levallois P. Hypersensitivity of human subjects to environmental electric and magnetic field exposure: a review of the literature. Environ Health Perspect. 110 Suppl 4:613-618, 2002.

Hypersensitivity to exposure to electric and magnetic fields (EMFs) has been reported for nearly 20 years; however, the literature on the subject is still very limited. Nearly all the literature published concerns a dermatological syndrome that consists of mainly subjective symptoms (itching, burning, dryness) and a few objective symptoms (redness, dryness) appearing after individuals begin working with video display units and decreasing during absence from work. Case-control studies as well as some good but limited double-blind trials have not found any clear relationship between this syndrome and exposure to EMFs. A "general syndrome" with more general symptoms has been rarely described but seems to have a worse prognosis. The symptoms often associated with skin disorders are mainly of neurasthenic type and can cover a lot of nonspecific symptoms present in other atypical syndromes such as multiple chemical sensitivity or chronic fatigue. Most of these symptoms are allegedly triggered by exposure to different sources of EMFs, but there have been no valid etiological studies published on this more general syndrome. It appears that the so-called hypersensitivity to environmental electric and magnetic fields is an unclear health problem whose nature has yet to be determined.

Levallois P, Neutra R, Lee G, Hristova L. Study of self-reported hypersensitivity to electromagnetic fields in California. Environ Health Perspect. 110 Suppl 4:619-623, 2002.

Cases of alleged hypersensitivity to electromagnetic fields (EMFs) have been reported for more than 20 years, and some authors have suggested some connection with the "multiple chemical sensitivity" illness. We report the results of a telephone survey among a sample of 2,072 Californians. Being "allergic or very sensitive" to being near electrical devices was reported by 68 subjects, resulting in an adjusted prevalence of 3.2% (95% confidence interval = 2.8, 3.7).

Twenty-seven subjects (1.3%) reported sensitivity to electrical devices but no sensitivity to chemicals. Characteristics of the people reporting hypersensitivity to EMFs were generally different from those of people reporting being allergic to everyday chemicals. Alleging environmental illness or multiple chemical sensitivity diagnosed by a doctor was the strongest predictor of reporting being hypersensitive to EMFs in this population. Other predictive factors apart from self-reporting chemical sensitivity were race/ethnicity other than White, Black, or Hispanic; having low income; and being unable to work. The perception of risk of exposure to EMFs through the use of hair dryers (vs. exposure to power and distribution lines) was the factor the most associated with self-reporting about hypersensitivity to EMFs. However, risk perception was not sufficient to explain the characteristics of people reporting this disorder.

Lidén S, Reizenstein P, Sedvall G, Ehn L. [A study and treatment of a group of patients with electro-hypersensitivity. More than half of the patients were able to return to work]. Lakartidningen. 93(23):2265-2268, 1996. [Article in Swedish] (no abstract available)

Lonne-Rahm S, Andersson B, Melin L, Schultzberg M, Arnetz B, Berg M. Provocation with stress and electricity of patients with "sensitivity to electricity". J Occup Environ Med. 42(5):512-516, 2000.

Twenty-four patients with self-reported "sensitivity to electricity" were divided into two groups and tested in a double-blind provocation study. These patients, who reported increased skin symptoms when exposed to electromagnetic fields, were compared with 12 age- and sex-matched controls. Both groups were exposed to 30-minute periods of high or low stress situations, with and without simultaneous exposure to electromagnetic fields from a visual display unit. The matched controls were tested twice and given the same exposure as the patients but had the fields turned on every time. Stress was induced by requiring the participants to act in accordance with a random sequence of flashing lights while simultaneously solving complicated mathematical problems. Blood samples were analyzed for levels of the stress-related hormones melatonin, prolactin, adrenocorticotrophic hormone, neuropeptide Y, and growth hormone, and the expression of different peptides, cellular markers, and cytokines (somatostatin, CD1, factor XIIIa, and tumor necrosis factor-alpha). Skin biopsies were also analyzed for the occurrence of mast cells. Stress provocation resulted in feelings of more intense mental stress and elevated heart rate. The patients reported increased skin symptoms when they knew or believed that the electromagnetic field was turned on. With the blind conditions there were no differences between "on" or "off." Inflammatory mediators and mast cells in the skin were not affected by the stress exposure or by exposure to electromagnetic fields. The main conclusion was that the patients did not react to the fields.

Lyskov E, Sandström M, Hansson Mild K. Neurophysiological study of patients with perceived 'electrical hypersensitivity'. Int J Psychophysiol. 42(3):233-241, 2001.

The aim of the present study was to investigate baseline neurophysiological characteristics of the central and autonomous regulation and their reactivity to different tests in a group of persons with so-called 'electrical hypersensitivity', which is often considered as a form of psychosomatic disorders. Twenty patients with combinations of neuroasthenic symptoms (general fatigue, weakness, dizziness, headache) and facial skin (itching, tingling, redness) have been

investigated. An equal number of symptom-free persons served as a control group. The examination comprised self-reported measures, testing of visual functions, measurements of blood pressure, heart rate and its variability, electrodermal activity, respiration, EEG and visual evoked potentials (VEP). Several variables were found to differ between the patient and the control groups. The mean value of heart rate in rest condition was higher in the patient group compared to the controls (mean value of inter-beat intervals were 0.80 and 0.90 s, respectively). Heart rate variability and response to standing test were decreased in the patient group compared to the controls. Patients had faster onset, higher amplitudes, and left-right hand asymmetry of the sympathetic skin responses. They had a higher critical fusion frequency (43 vs. 40 Hz), and a trend to increased amplitude of steady-state VEPs at stimulation frequencies of 30-70 Hz. The data indicated that the observed group of patients had a trend to hyper sympathotone, hyperresponsiveness to sensor stimulation and heightened arousal.

Lyskov E, Sandström M, Mild KH. Provocation study of persons with perceived electrical hypersensitivity and controls using magnetic field exposure and recording of electrophysiological characteristics. Bioelectromagnetics. 22(7):457-462, 2001.

The aim of the present study was to investigate possible neurophysiological effects of intermittent 15 sec on/off cycle, 60 Hz, 10 microT magnetic field exposure on patients with perceived "electromagnetic hypersensitivity" (EHS), and control subjects during rest and performance of a mental arithmetic task. Twenty participants (15 female, 5 male, 31-60 years old, mean 45.8 +/- 0.7 years) were invited from the group of EHS patients. Twenty volunteers (15 female, 5 male, 31-59 years old, mean 45.0 +/- 0.7 years?) served as a control group. The test protocol consisted of a set of examinations: EEG, visual evoked potentials, electrodermal activity, ECG, and blood pressure. The total duration of the test was 40 min, divided into two 10 min rest periods and two 10 min periods of mathematical performance. Magnetic field and sham exposures were presented randomly during these periods, resulting in four different conditions: Field-Rest, Sham-Rest, Field-Math, and Sham-Math. The data showed significant main effects of the Group factor (EHS vs. control subjects) on heart rate ($F(1,80) = 20.6$; $P < 0.01$), heart rate spectrum ratio ($F(1,80) = 9.5$; $P = 0.02$), and electrodermal activity ($F(1,76) = 4.2$; $P = 0.04$), whereas EEG characteristics did not differ between groups. The Condition factor (mathematical task vs. relaxed) showed main effects for heart rate ($F(1,80) = 14.8$; $P < 0.01$), heart rate spectrum ratio ($F(1,80) = 7.8$; $P = 0.06$), electrodermal activity ($F(1,76) = 56.8$; $P < 0.01$), and alpha and theta spectral bands of EEG. Magnetic field exposure did not affect autonomous system or electroencephalographic variables of either group. These data do not indicate that EHS patients or control are affected by low-level 60 Hz magnetic field exposure. However, persons reporting EHS differed from the control subjects in baseline values of investigated physiological characteristics. Perhaps EHS patients have a rather distinctive physiological predisposition to sensitivity to physical and psychosocial environmental stressors.

Manjunatha N, Jayaram N, Benegal V, Murthy P. Idiopathic environmental intolerance (electromagnetic hypersensitivity syndrome). Natl Med J India. 24(5):314, 2011. (Correspondence, no abstract available)

Markovà E, Hillert L, Malmgren L, Persson BR, Belyaev IY. Microwaves from GSM mobile telephones affect 53BP1 and gamma-H2AX foci in human lymphocytes from hypersensitive and healthy persons. Environ Health Perspect. 113(9):1172-1177, 2005.

The data on biologic effects of nonthermal microwaves (MWs) from mobile telephones are diverse, and these effects are presently ignored by safety standards of the International Commission for Non-Ionizing Radiation Protection (ICNIRP). In the present study, we

investigated effects of MWs of Global System for Mobile Communication (GSM) at different carrier frequencies on human lymphocytes from healthy persons and from persons reporting hypersensitivity to electromagnetic fields (EMFs). We measured the changes in chromatin conformation, which are indicative of stress response and genotoxic effects, by the method of anomalous viscosity time dependence, and we analyzed tumor suppressor p53-binding protein 1 (53BP1) and phosphorylated histone H2AX (gamma-H2AX), which have been shown to colocalize in distinct foci with DNA double-strand breaks (DSBs), using immunofluorescence confocal laser microscopy. We found that MWs from GSM mobile telephones affect chromatin conformation and 53BP1/gamma-H2AX foci similar to heat shock. For the first time, we report here that effects of MWs from mobile telephones on human lymphocytes are dependent on carrier frequency. On average, the same response was observed in lymphocytes from hypersensitive and healthy subjects.

McCarty DE, Carrubba S, Chesson AL, Frilot C, Gonzalez-Toledo E, Marino AA. Electromagnetic hypersensitivity: evidence for a novel neurological syndrome. Int J Neurosci. 121(12):670-676, 2011.

OBJECTIVE: We sought direct evidence that acute exposure to environmental-strength electromagnetic fields (EMFs) could induce somatic reactions (EMF hypersensitivity). **METHODS:** The subject, a female physician self-diagnosed with EMF hypersensitivity, was exposed to an average (over the head) 60-Hz electric field of 300 V/m (comparable with typical environmental-strength EMFs) during controlled provocation and behavioral studies. **RESULTS:** In a double-blinded EMF provocation procedure specifically designed to minimize unintentional sensory cues, the subject developed temporal pain, headache, muscle twitching, and skipped heartbeats within 100 s after initiation of EMF exposure ($p < .05$). The symptoms were caused primarily by field transitions (off-on, on-off) rather than the presence of the field, as assessed by comparing the frequency and severity of the effects of pulsed and continuous fields in relation to sham exposure. The subject had no conscious perception of the field as judged by her inability to report its presence more often than in the sham control. **DISCUSSION:** The subject demonstrated statistically reliable somatic reactions in response to exposure to subliminal EMFs under conditions that reasonably excluded a causative role for psychological processes. **CONCLUSION:** EMF hypersensitivity can occur as a bona fide environmentally inducible neurological syndrome.

Medeiros LN, Sanchez TG. Tinnitus and cell phones: the role of electromagnetic radiofrequency radiation. Brazilian Journal of Otorhinolaryngology. 82(1):97-104. January–February 2016. doi:10.1016/j.bjorl.2015.04.013

Introduction Tinnitus is a multifactorial condition and its prevalence has increased on the past decades. The worldwide progressive increase of the use of cell phones has exposed the peripheral auditory pathways to a higher dose of electromagnetic radiofrequency radiation (EMRFR). Some tinnitus patients report that the abusive use of mobiles, especially when repeated in the same ear, might worsen ipsilateral tinnitus. **Objective** The aim of this study was to evaluate the available evidence about the possible causal association between tinnitus and exposure to electromagnetic waves. **Methods** A literature review was performed searching for the following keywords: tinnitus, electromagnetic field, mobile phones, radio frequency, and electromagnetic hypersensitivity. We selected 165 articles that were considered clinically relevant in at least one of the subjects. **Results** EMRFR can penetrate exposed tissues and safety exposure levels have been established. These waves provoke proved thermogenic effects and potential biological and genotoxic effects. Some individuals are more sensitive to

electromagnetic exposure (electrosensitivity), and thus, present earlier symptoms. There may be a common pathophysiology between this electrosensitivity and tinnitus. Conclusion There are already reasonable evidences to suggest caution for using mobile phones to prevent auditory damage and the onset or worsening of tinnitus.

Meg Tseng MC, Lin YP, Cheng TJ. Prevalence and psychiatric comorbidity of self-reported electromagnetic field sensitivity in Taiwan: a population-based study. J Formos Med Assoc. 110(10):634-641, 2011.

BACKGROUND/PURPOSE: Psychological factors have been implicated in the etiology of idiopathic environmental illness in many studies. Few studies have ever reported psychiatric morbidity among individuals with electromagnetic hypersensitivity. We aimed to estimate the prevalence and identify the associated factors of self-reported electromagnetic field sensitivity (SREMFS) in adults of Taiwan. **METHODS:** A total of 1251 adults selected from a nationwide Computer-Assisted Telephone Interviewing system received a telephone survey about the perception of risk from various environmental agents and their effects on health and well-being. **RESULTS:** The estimated prevalence of people with SREMFS was 13.3 % (95% confidence interval: 11.2-15.3). People aged >65 years were associated with a lower risk of reporting sensitivity to electromagnetic fields, whereas people with a very poor self-reported health status, those who were unable to work, and those who had psychiatric morbidity were associated with a higher risk of having SREMFS. **CONCLUSION:** The prevalence of SREMFS in the general population of Taiwan is higher than that reported in western countries. People with psychiatric morbidity are more likely to report sensitivity to electromagnetic fields. The cross-sectional design precludes the causal inference of all identified correlates and electromagnetic field sensitivity.

Mortazavi SM, Ahmadi J, Shariati M. Prevalence of subjective poor health symptoms associated with exposure to electromagnetic fields among university students. Bioelectromagnetics. 28(4):326-330, 2007. Erratum in Bioelectromagnetics. 28(5):392, 2007.

The number of people complaining about different symptoms that may be associated with exposure to electromagnetic fields (EMF) has increased rapidly during past years. Students use both mobile phones and video display terminals frequently. The purpose of this study was to investigate the association of mobile phone use and EMF health hazards. Basic demographic data and self-reported symptoms were sought using a questionnaire administered to all apparently healthy students at Rafsanjan University of Medical Sciences (RUMS) and Vali-e-Asr University (VAU). Questions about some major confounding factors such as age, gender, amount of video display terminal work were also included. Exact Fischer Test was used for data analysis. Among self-reported symptoms, headache (53.5%), fatigue (35.6%), difficulties in concentration (32.5%), vertigo/dizziness (30.4%), attention disorders (28.8%), nervousness (28.1%), palpitation (14.7%), low back pain (14.3%), myalgia (12.4%), and tinnitus (9.9%) were the main self-reported symptoms. No significant differences in the prevalence of these symptoms were found between CRT users and those who did not use CRTs. A significant association was found between cordless phone use and difficulties in concentration ($P < .05$) or attention disorders ($P < .05$). However, after correction of the gender role, these differences were not significant. No association was found between mobile phone use and the above-mentioned symptoms. No significantly higher prevalence of self-reported symptoms was found in individuals who had used mobile phones, video display terminals or cordless phones more frequently than others. Mass-media's lack of interest in the possible hazards of exposure to EMF in developing countries can explain the difference observed between the results of this study and those of other researchers in some developed countries who have shown an

association between EMF exposure and the prevalence of self-reported subjective symptoms. This finding can confirm the results obtained in provocative studies which indicated the role of psychological factors in electromagnetic hypersensitivity. More research is needed to clarify whether daily environmental EMF may cause health problems.

Mortazavi SM, Mahbudi A, Atefi M, Bagheri Sh, Bahaedini N, Besharati A. An old issue and a new look: electromagnetic hypersensitivity caused by radiations emitted by GSM mobile phones. Technol Health Care. 19(6):435-443, 2011.

University students use mobile phones frequently. We previously showed that there was no association between mobile phone use and EMF health hazards among university students. As our previous study was based only on self-reported symptoms this double-blind study was designed to answer two basic questions. Firstly, are self-reported hypersensitive individuals capable of sensing whether there is a real/sham microwave exposure? Secondly, do hypersensitive patients show alterations in their biological parameters such as heart rate, respiration, and blood pressure during microwave exposure? The study consisted of a preliminary screening phase and two subsequent complementary phases. In the 1st phase, 700 students were screened for EMF hypersensitivity. Fifty two participants were hypersensitive individuals but after applying the exclusion criteria only 28 students were invited to take part in the 2nd and 3rd phase of the study, but only 20 students (71.4%) declared their informed consent. In the 2nd phase, these self reported hypersensitive participants, were exposed/sham exposed to microwave radiation emitted from a mobile phone for 10 minutes and they were asked if they could sense the existence of microwave radiation. In the 3rd phase, all students were connected to ICU monitoring devices and their basic physiological parameters were recorded precisely. Among self-reported symptoms reported in our previous study, in this study only problem in concentration ($P < 0.05$) and low back pain ($P < 0.05$) were associated with mobile phone use. Furthermore, there was a significant association between the location of mobile phone during talk and the overall score of the severity of the symptoms ($P < 0.001$). When the participants were asked to report their perception about the real and sham exposures, only 5 students (25%) could discriminate the real exposure/sham exposure phases. This relative frequency can be only due to chance. In the 3rd phase all of the 20 participants were connected to intensive care unit monitors and the changes in their heart rate, respiration, and blood pressure during real/sham exposure were recorded. No statistically significant changes between the means of these parameters in real/sham exposure were observed. Our findings clearly confirm the results obtained in other provocative studies. These data also indicate the possible role of psychological factors in electromagnetic hypersensitivity.

Mueller CH, Krueger H, Schierz C. Project NEMESIS: perception of a 50 Hz electric and magnetic field at low intensities (laboratory experiment). Bioelectromagnetics. 23(1):26-36, 2002.

The Electrical Hypersensitivity Syndrome (EHS) is a condition where people suffer from various nonspecific health symptoms attributed to an assumed adverse effect of electric and magnetic fields (EMF). Many EHS patients report the ability to consciously perceive EMF at very low intensities. The existence of a direct EMF perception could be the key to explain at least partially the aetiology of EHS through stress mechanisms and allow the comparison with well known environmental stressors such as noise or odor. The double blind laboratory experiment tested the hypothesis that there are subjects with the ability to perceive 50 Hz EMF at 100 V/m and 6 microT (EMF sensitive) and to investigate the prevalence of EMF sensitivity in a group consisting of subjects with or without self-reported EHS. A total of 63 volunteers, 49 with EHS

and 14 controls, took part in the EMF perception experiment, where 10 sham and 10 exposed 2 min blocks had to be judged in randomized sequence (field on/field off). Seven out of 63 subjects reached a statistically significant result which points to the existence of a small EMF sensitive subgroup within the study group. There was no relevant difference between the subjects with self reported EHS and those without in terms of the success rate in the field perception experiment, as well as the number and types of symptoms encountered during the test. The results of the EMF perception experiment suggest that EHS is not a prerequisite for the ability to consciously perceive weak EMF and vice versa.

Nam KC, Kim SW, Kim SC, Kim DW. Effects of RF exposure of teenagers and adults by CDMA cellular phones. Bioelectromagnetics. 27(7):509-514, 2006.

Many cellular phone provocation studies have been conducted since the question of increased health risk from extended usage of cellular phones became a social issue. Internationally, most studies have been conducted regarding the effects of GSM cellular phones on blood pressure and heart rate of adult volunteers. On the other hand, very few provocation studies have been conducted regarding the physiological effects of CDMA phones on teenagers. In this study, two volunteer groups consisting of 21 teenagers and 21 adults were exposed to 300 mW of radio frequency (RF) electromagnetic field emitted by a CDMA cellular phone for half an hour. Physiological parameters such as systolic and diastolic blood pressures, heart rate, respiration rate, and skin resistance were simultaneously measured. All the parameters for both groups were unaffected during the exposure except for decreased skin resistance of the teenager group ($P < .0001$). For the regrouped 23 male and 19 female subjects, all the parameters for both groups were unaffected during the exposure except for decreased skin resistance of the male subjects ($P = .0026$). Those resistances at 10 min after the terminated exposure returned to the resistances at rest regardless of the different groups of age and sex.

Nam KC, Lee JH, Noh HW, Cha EJ, Kim NH, Kim DW. Hypersensitivity to RF fields emitted from CDMA cellular phones: a provocation study. Bioelectromagnetics. 30(8):641-650, 2009.

With the number of cellular phone users rapidly increasing, there is a considerable amount of public concern regarding the effects that electromagnetic fields (EMFs) from cellular phones have on health. People with self-attributed electromagnetic hypersensitivity (EHS) complain of subjective symptoms such as headaches, insomnia, and memory loss, and attribute these symptoms to radio frequency (RF) radiation from cellular phones and/or base stations. However, EHS is difficult to diagnose because it relies on a person's subjective judgment. Various provocation studies have been conducted on EHS caused by Global System for Mobile Communications (GSM) phones in which heart rate and blood pressure or subjective symptoms were investigated. However, there have been few sham-controlled provocation studies on EHS with Code Division Multiple Access (CDMA) phones where physiological parameters, subjective symptoms, and perception of RF radiation for EHS and non-EHS groups were simultaneously investigated. In this study, two volunteer groups of 18 self-reported EHS and 19 non-EHS persons were tested for both sham and real RF exposure from CDMA cellular phones with a 300 mW maximum exposure that lasted half an hour. We investigated not only the physiological parameters such as heart rate, respiration rate, and heart rate variability (HRV), but also various subjective symptoms and the perception of EMF. In conclusion, RF exposure did not have any effects on physiological parameters or subjective symptoms in either group. As for EMF perception, there was no evidence that the EHS group better perceived EMF than the non-EHS group.

Nam KC, Choi JL, Kwon MK, Jang KH, Kim DW. Physiological variables and subjective symptoms by 60 Hz magnetic field in EHS and non-EHS persons. Conf Proc IEEE Eng Med Biol Soc. 2011:1925-1928, 2011.

Electromagnetic hypersensitivity (EHS) is a set of claims of adverse medical symptoms self attributed by exposure to electromagnetic field. In this study, we simultaneously investigated both physiological changes (heart rate, respiration rate, and heart rate variability) and subjective symptoms to determine the origin of EHS. Two volunteer groups (15 self-reported EHS and 16 non-EHS participants) were tested under both sham and real exposure to 12.5 μ T magnetic fields at 60 Hz that lasted a half an hour. The magnetic field exposure did not have any effect on physiological variables or subjective symptoms in either group. We conclude that the subjective symptoms did not result from exposure to 12.5 μ T magnetic field at 60 Hz.

Nieto-Hernandez R, Rubin GJ, Cleare AJ, Weinman JA, Wessely S. Can evidence change belief? Reported mobile phone sensitivity following individual feedback of an inability to discriminate active from sham signals. J Psychosom Res. 65(5):453-460, 2008.

OBJECTIVE: In this study, we tested whether providing individuals, who described being sensitive to mobile phone signals, with accurate feedback about their ability to discriminate an active mobile phone signal from a sham signal had any impact on their subsequent symptom levels or their perceived sensitivity to mobile phones. METHODS: Sixty-nine participants who reported sensitivity to mobile phones took part in a double-blind, placebo-controlled provocation study. Perceived sensitivity to mobile phones was assessed using a version of the Sensitive Soma Assessment Scale (SSAS) and the severity of any symptoms attributed to mobile phones was recorded. Both the overall ("negative") findings of the provocation study and the participant's own individual results ("correct" or "incorrect" at detecting a mobile phone signal) were then described to them. Six months later, perceived sensitivity and symptom severity were measured again. RESULTS: Fifty-eight participants (84%) received feedback and participated in the 6-month follow-up. No significant differences in SSAS scores or in symptom severity scores were found between individuals told that they were correct (n=31) or incorrect (n=27) in their ability to detect mobile phone signals in the provocation study. CONCLUSION: The provision of accurate feedback was insufficient to change attributions or reduce symptoms in this study. However, an overtly negative reaction to feedback was not observed among most participants, and some participants were willing to consider that factors other than electromagnetic field may be relevant in causing or exacerbating their symptoms. Discussing possible psychological factors with electromagnetic hypersensitivity patients may be beneficial for some.

Nordin S, Neely G, Olsson D, Sandström M. Odor and Noise Intolerance in Persons with Self-Reported Electromagnetic Hypersensitivity. Int J Environ Res Public Health. 11(9):8794-8805, 2014.

Lack of confirmation of symptoms attributed to electromagnetic fields (EMF) and triggered by EMF exposure has highlighted the role of individual factors. Prior observations indicate intolerance to other types of environmental exposures among persons with electromagnetic hypersensitivity (EHS). This study assessed differences in odor and noise intolerance between persons with EHS and healthy controls by use of subscales and global measures of the Chemical Sensitivity Scale (CSS) and the Noise Sensitivity Scale (NSS). The EHS group scored significantly higher than the controls on all CSS and NSS scales. Correlation coefficients between CSS and NSS scores ranged from 0.60 to 0.65 across measures. The findings suggest an association between EHS and odor and noise intolerance, encouraging further investigation of individual factors for understanding EMF-related symptoms.

Redmayne M, Johansson O. Could myelin damage from radiofrequency electromagnetic field exposure help explain the functional impairment electrohypersensitivity? A review of the evidence. J Toxicol Environ Health B Crit Rev. 17(5):247-258, 2014.

Myelin provides the electrical insulation for the central and peripheral nervous system and develops rapidly in the first years of life, but continues into mid-life or later. Myelin integrity is vital to healthy nervous system development and functioning. This review outlines the development of myelin through life, and then considers the evidence for an association between myelin integrity and exposure to low-intensity radiofrequency electromagnetic fields (RF-EMFs) typical in the modern world. In RF-EMF peer-reviewed literature examining relevant impacts such as myelin sheath, multiple sclerosis, and other myelin-related diseases, cellular examination was included. There are surprisingly little data available in each area, but considered together a picture begins to emerge in RF-EMF-exposed cases: (1) significant morphological lesions in the myelin sheath of rats; (2) a greater risk of multiple sclerosis in a study subgroup; (3) effects in proteins related to myelin production; and (4) physical symptoms in individuals with functional impairment electrohypersensitivity, many of which are the same as if myelin were affected by RF-EMF exposure, giving rise to symptoms of demyelination. In the latter, there are exceptions; headache is common only in electrohypersensitivity, while ataxia is typical of demyelination but infrequently found in the former group. Overall, evidence from in vivo and in vitro and epidemiological studies suggests an association between RF-EMF exposure and either myelin deterioration or a direct impact on neuronal conduction, which may account for many electrohypersensitivity symptoms. The most vulnerable are likely to be those in utero through to at least mid-teen years, as well as ill and elderly individuals.

Regel SJ, Negovetic S, Rösli M, Berdiñas V, Schuderer J, Huss A, Lott U, Kuster N, Achermann P. UMTS base station-like exposure, well-being, and cognitive performance. Environ Health Perspect. 114(8):1270-1275, 2006.

BACKGROUND: Radio-frequency electromagnetic fields (RF EMF) of mobile communication systems are widespread in the living environment, yet their effects on humans are uncertain despite a growing body of literature. **OBJECTIVES:** We investigated the influence of a Universal Mobile Telecommunications System (UMTS) base station-like signal on well-being and cognitive performance in subjects with and without self-reported sensitivity to RF EMF. **METHODS:** We performed a controlled exposure experiment (45 min at an electric field strength of 0, 1, or 10 V/m, incident with a polarization of 45 degrees from the left back side of the subject, weekly intervals) in a randomized, double-blind crossover design. A total of 117 healthy subjects (33 self-reported sensitive, 84 nonsensitive subjects) participated in the study. We assessed well-being, perceived field strength, and cognitive performance with questionnaires and cognitive tasks and conducted statistical analyses using linear mixed models. Organ-specific and brain tissue-specific dosimetry including uncertainty and variation analysis was performed. **RESULTS:** In both groups, well-being and perceived field strength were not associated with actual exposure levels. We observed no consistent condition-induced changes in cognitive performance except for two marginal effects. At 10 V/m we observed a slight effect on speed in one of six tasks in the sensitive subjects and an effect on accuracy in another task in nonsensitive subjects. Both effects disappeared after multiple end point adjustment. **CONCLUSIONS:** In contrast to a recent Dutch study, we could not confirm a short-term effect of UMTS base station-like exposure on well-being. The reported effects on brain functioning were marginal and may have occurred by chance. Peak spatial absorption in brain tissue was considerably smaller than during use of a mobile phone. No conclusions can be drawn

regarding short-term effects of cell phone exposure or the effects of long-term base station-like exposure on human health.

Riddervold IS, Pedersen GF, Andersen NT, Pedersen AD, Andersen JB, Zachariae R, Mølhav L, Sigsgaard T, Kjaergaard SK. Cognitive function and symptoms in adults and adolescents in relation to rf radiation from UMTS base stations. Bioelectromagnetics. 29(4):257-267, 2008.

There is widespread public concern about the potential adverse health effects of mobile phones in general and their associated base stations in particular. This study was designed to investigate the acute effects of radio frequency (RF) electromagnetic fields (EMF) emitted by the Universal Mobile Telecommunication System (UMTS) mobile phone base stations on human cognitive function and symptoms. Forty adolescents (15-16 years) and 40 adults (25-40 years) were exposed to four conditions: (1) sham, (2) a Continuous Wave (CW) at 2140 MHz, (3) a signal at 2140 MHz modulated as UMTS and (4) UMTS at 2140 MHz including all control features in a randomized, double blinded cross-over design. Each exposure lasted 45 min. During exposure the participants performed different cognitive tasks with the Trail Making B (TMB) test as the main outcome and completed a questionnaire measuring self reported subjective symptoms. No statistically significant differences between the UMTS and sham conditions were found for performance on TMB. For the adults, the estimated difference between UMTS and sham was -3.2% (-9.2%; 2.9%) and for the adolescents 5.5% (-1.1%; 12.2%). No significant changes were found in any of the cognitive tasks. An increase in 'headache rating' was observed when data from the adolescents and adults were combined ($P = 0.027$), an effect that may be due to differences at baseline. In conclusion, the primary hypothesis that UMTS radiation reduces general performance in the TMB test was not confirmed. However, we suggest that the hypothesis of subjective symptoms and EMF exposure needs further research.

Röösli M, Moser M, Baldinini Y, Meier M, Braun-Fahrlander C. Symptoms of ill health ascribed to electromagnetic field exposure--a questionnaire survey. Int J Hyg Environ Health. 207(2):141-150, 2004.

From June 2001, health questionnaires were distributed to people who complained about symptoms of ill health which they ascribed to exposure to electromagnetic fields (EMF). The objective of the survey was to gain a better knowledge of the anxieties of complainants, to obtain hints of possible problems and of actions that should be taken to solve the problems. The survey was not designed to establish a causal association between exposure to EMF and symptoms of ill health. Within one year, 429 questionnaires were returned of which 394 persons reported symptoms. The average age of the complainants was 51.0 years and 57 percent were female. The complainants were older, had a higher educational level and were more likely to be married compared to the general Swiss population. A mean of 2.7 different symptoms were reported. Sleep disorders (58%), headaches (41%), nervousness or distress (19%), fatigue (18%), and concentration difficulties (16%) were most common complaints. Complainants related their symptoms most frequently to exposure to mobile phone base stations (74%), followed by mobile phones (36%), cordless phones (29%) and power lines (27%). No distinct symptoms related to a specific field source could be identified. Eighty-five percent of the people who consulted a public authority because of their symptoms were unsatisfied with the response, whereas consultation of self-help groups or building ecologists usually fulfilled expectations. Two thirds of complainants had taken some action to reduce their symptoms. The most

common measure was to avoid exposure if possible. Removing or disconnecting indoor sources was judged to be the most effective action.

Röösli M. Radiofrequency electromagnetic field exposure and non-specific symptoms of ill health: a systematic review. *Environ Res.* 107(2):277-287, 2008.

This article is a systematic review of whether everyday exposure to radiofrequency electromagnetic field (RF-EMF) causes symptoms, and whether some individuals are able to detect low-level RF-EMF (below the ICNIRP [International Commission on Non-Ionizing Radiation Protection] guidelines). Peer-reviewed articles published before August 2007 were identified by means of a systematic literature search. Meta-analytic techniques were used to pool the results from studies investigating the ability to discriminate active from sham RF-EMF exposure. RF-EMF discrimination was investigated in seven studies including a total of 182 self-declared electromagnetic hypersensitive (EHS) individuals and 332 non-EHS individuals. The pooled correct field detection rate was 4.2% better than expected by chance (95% CI: -2.1 to 10.5). There was no evidence that EHS individuals could detect presence or absence of RF-EMF better than other persons. There was little evidence that short-term exposure to a mobile phone or base station causes symptoms based on the results of eight randomized trials investigating 194 EHS and 346 non-EHS individuals in a laboratory. Some of the trials provided evidence for the occurrence of placebo effects. In population based studies an association between symptoms and exposure to RF-EMF in the everyday environment was repeatedly observed. This review showed that the large majority of individuals who claims to be able to detect low level RF-EMF are not able to do so under double-blind conditions. If such individuals exist, they represent a small minority and have not been identified yet. The available observational studies do not allow differentiating between biophysical from EMF and placebo effects.

Röösli M, Moser M, Baldinini Y, Meier M, Braun-Fahrlander C. Symptoms of ill health ascribed to electromagnetic field exposure--a questionnaire survey. *Int J Hyg Environ Health.* 207(2):141-150, 2004.

From June 2001, health questionnaires were distributed to people who complained about symptoms of ill health which they ascribed to exposure to electromagnetic fields (EMF). The objective of the survey was to gain a better knowledge of the anxieties of complainants, to obtain hints of possible problems and of actions that should be taken to solve the problems. The survey was not designed to establish a causal association between exposure to EMF and symptoms of ill health. Within one year, 429 questionnaires were returned of which 394 persons reported symptoms. The average age of the complainants was 51.0 years and 57 percent were female. The complainants were older, had a higher educational level and were more likely to be married compared to the general Swiss population. A mean of 2.7 different symptoms were reported. Sleep disorders (58%), headaches (41%), nervousness or distress (19%), fatigue (18%), and concentration difficulties (16%) were most common complaints. Complainants related their symptoms most frequently to exposure to mobile phone base stations (74%), followed by mobile phones (36%), cordless phones (29%) and power lines (27%). No distinct symptoms related to a specific field source could be identified. Eighty-five percent of the people who consulted a public authority because of their symptoms were unsatisfied with the response, whereas consultation of self-help groups or building ecologists usually fulfilled expectations. Two thirds of complainants had taken some action to reduce their symptoms. The most common measure was to avoid exposure if possible. Removing or disconnecting indoor sources was judged to be the most effective action.

Rubin GJ, Das Munshi J, Wessely S. Electromagnetic hypersensitivity: a systematic review of provocation studies. Psychosom Med. 67(2):224-232, 2005.

OBJECTIVES: The objectives of this study were to assess whether people who report hypersensitivity to weak electromagnetic fields (EMFs) are better at detecting EMF under blind or double-blind conditions than nonhypersensitive individuals, and to test whether they respond to the presence of EMF with increased symptom reporting. **METHODS:** An extensive systematic search was used to identify relevant blind or double-blind provocation studies. This involved searching numerous literature databases and conference proceedings, and examining the citations of reviews and included studies. The results of relevant studies were tabulated and metaanalyses were used to compare the proportions of "hypersensitive" and control participants able to discriminate active from sham EMF exposures. **RESULTS:** Thirty-one experiments testing 725 "electromagnetically hypersensitive" participants were identified. Twenty-four of these found no evidence to support the existence of a biophysical hypersensitivity, whereas 7 reported some supporting evidence. For 2 of these 7, the same research groups subsequently tried and failed to replicate their findings. In 3 more, the positive results appear to be statistical artefacts. The final 2 studies gave mutually incompatible results. Our metaanalyses found no evidence of an improved ability to detect EMF in "hypersensitive" participants. **CONCLUSIONS:** The symptoms described by "electromagnetic hypersensitivity" sufferers can be severe and are sometimes disabling. However, it has proved difficult to show under blind conditions that exposure to EMF can trigger these symptoms. This suggests that "electromagnetic hypersensitivity" is unrelated to the presence of EMF, although more research into this phenomenon is required.

Rubin GJ, Das Munshi J, Wessely S. A systematic review of treatments for electromagnetic hypersensitivity. Psychother Psychosom. 75(1):12-18, 2006.

BACKGROUND: Electromagnetic hypersensitivity (EHS) is a poorly understood condition in which patients report symptoms following perceived exposure to weak electromagnetic fields (EMFs) such as those produced by mobile phones or visual display units. Little is known about the aetiology of the condition although experimental data suggest that EMFs are an unlikely causal agent. In this systematic review we assessed the efficacy of any treatment for people reporting EHS. **METHODS:** Twelve literature databases were examined to identify relevant studies. We also hand-searched conference proceedings and examined the reference sections of reviews and other papers. Only clinical trials that compared the efficacy of a potential treatment for EHS against a control condition were included in the review. **RESULTS:** Nine controlled clinical trials were identified, examining the effects of cognitive behavioural therapy (4 studies), visual display unit screen filters (2 studies), 'shielding' EMF emitters (1 study), supplementary antioxidant therapy (1 study) and acupuncture (1 study). The quality of these studies was limited. Nevertheless, their results suggest that cognitive behavioural therapy is more effective than providing no treatment. None of the other therapies have had their efficacy adequately demonstrated. **CONCLUSIONS:** The evidence base concerning treatment options for EHS is limited and more research is needed before any definitive clinical recommendations can be made. However, the best evidence currently available suggests that cognitive behavioural therapy is effective for patients who report being hypersensitive to weak EMFs.

Rubin GJ, Cleare AJ, Wessely S. Psychological factors associated with self-reported sensitivity to mobile phones. J Psychosom Res. 64(1):1-9; discussion 11-12, 2008

OBJECTIVE: Some people report symptoms associated with mobile phone use. A minority also report "electrosensitivity," experiencing symptoms following exposure to other electrical devices. Research suggests that electromagnetic fields do not trigger these symptoms. In this study, we examined the differences between these two "sensitive" groups and healthy controls.

METHODS: Fifty-two people who reported sensitivity to mobile phones, 19 people who reported sensitivity to mobile phones and "electrosensitivity," and 60 nonsensitive controls completed a questionnaire assessing the following: primary reason for using a mobile phone, psychological health, symptoms of depression, modern health worries (MHW), general health status, symptom severity, and the presence of other medically unexplained syndromes. **RESULTS:** Perceived sensitivity was associated with an increased likelihood of using a mobile phone predominantly for work (3% of controls, 13% of those sensitive to mobile phones, and 21% of those reporting "electrosensitivity") and greater MHW concerning radiation [mean (S.D.) on a scale of 1-5: 2.0 (1.0), 2.7 (0.9), and 4.0 (0.8), respectively]. Participants who reported "electrosensitivity" also experienced greater depression, greater worries about tainted food and toxic interventions, worse general health on almost every measure, and a greater number of other medically unexplained syndromes compared to participants from the other two groups. No group differences were observed with regards to psychiatric cases. **CONCLUSIONS:** The data illustrate that patients reporting "electrosensitivity" experience substantially worse health than either healthy individuals or people who report sensitivity to mobile phones but who do not adopt the label "electrosensitivity." Clinicians and researchers would be wise to pay greater attention to this subdivision.

Rubin GJ, Nieto-Hernandez R, Wessely S. Idiopathic environmental intolerance attributed to electromagnetic fields (formerly 'electromagnetic hypersensitivity'): An updated systematic review of provocation studies. Bioelectromagnetics. 31(1):1-11, 2010.

Idiopathic Environmental Intolerance attributed to electromagnetic fields (IEI-EMF; formerly 'electromagnetic hypersensitivity') is a medically unexplained illness in which subjective symptoms are reported following exposure to electrical devices. In an earlier systematic review, we reported data from 31 blind provocation studies which had exposed IEI-EMF volunteers to active or sham electromagnetic fields and assessed whether volunteers could detect these fields or whether they reported worse symptoms when exposed to them. In this article, we report an update to that review. An extensive literature search identified 15 new experiments. Including studies reported in our earlier review, 46 blind or double-blind provocation studies in all, involving 1175 IEI-EMF volunteers, have tested whether exposure to electromagnetic fields is responsible for triggering symptoms in IEI-EMF. No robust evidence could be found to support this theory. However, the studies included in the review did support the role of the nocebo effect in triggering acute symptoms in IEI-EMF sufferers. Despite the conviction of IEI-EMF sufferers that their symptoms are triggered by exposure to electromagnetic fields, repeated experiments have been unable to replicate this phenomenon under controlled conditions. A narrow focus by clinicians or policy makers on bioelectromagnetic mechanisms is therefore, unlikely to help IEI-EMF patients in the long-term.

Rubin GJ, Hillert L, Nieto-Hernandez R, van Rongen E, Oftedal G. Do people with idiopathic environmental intolerance attributed to electromagnetic fields display physiological effects when exposed to electromagnetic fields? A systematic review of provocation studies. Bioelectromagnetics. 32(8):593-609, 2011.

Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) is a controversial illness in which people report symptoms that they believe are triggered by exposure to EMF. Double-blind experiments have found no association between the presence

of EMF and self-reported outcomes in people with IEI-EMF. No systematic review has assessed whether EMF exposure triggers physiological or cognitive changes in this group. Using a systematic literature search, we identified 29 single or double-blind experiments in which participants with IEI-EMF were exposed to different EMF levels and in which objectively measured outcomes were assessed. Five studies identified significant effects of exposure such as reduced heart rate and blood pressure, altered pupillary light reflex, reduced visual attention and perception, improved spatial memory, movement away from an EMF source during sleep and altered EEG during sleep. In most cases, these were isolated results that other studies failed to replicate. For the sleep EEG findings, the results reflected similar changes in the IEI-EMF participants and a non-IEI-EMF control group. At present, there is no reliable evidence to suggest that people with IEI-EMF experience unusual physiological reactions as a result of exposure to EMF. This supports suggestions that EMF is not the main cause of their ill health.

Sage C. The implications of non-linear biological oscillations on human electrophysiology for electrohypersensitivity (EHS) and multiple chemical sensitivity (MCS). Rev Environ Health. 2015 Sep 12.

The 'informational content' of Earth's electromagnetic signaling is like a set of operating instructions for human life. These environmental cues are dynamic and involve exquisitely low inputs (intensities) of critical frequencies with which all life on Earth evolved. Circadian and other temporal biological rhythms depend on these fluctuating electromagnetic inputs to direct gene expression, cell communication and metabolism, neural development, brainwave activity, neural synchrony, a diversity of immune functions, sleep and wake cycles, behavior and cognition. Oscillation is also a universal phenomenon, and biological systems of the heart, brain and gut are dependent on the cooperative actions of cells that function according to principles of non-linear, coupled biological oscillations for their synchrony. They are dependent on exquisitely timed cues from the environment at vanishingly small levels. Altered 'informational content' of environmental cues can swamp natural electromagnetic cues and result in dysregulation of normal biological rhythms that direct growth, development, metabolism and repair mechanisms. Pulsed electromagnetic fields (PEMF) and radiofrequency radiation (RFR) can have the devastating biological effects of disrupting homeostasis and desynchronizing normal biological rhythms that maintain health. Non-linear, weak field biological oscillations govern body electrophysiology, organize cell and tissue functions and maintain organ systems. Artificial bioelectrical interference can give false information (disruptive signaling) sufficient to affect critical pacemaker cells (of the heart, gut and brain) and desynchronize functions of these important cells that orchestrate function and maintain health. Chronic physiological stress undermines homeostasis whether it is chemically induced or electromagnetically induced (or both exposures are simultaneous contributors). This can eventually break down adaptive biological responses critical to health maintenance; and resilience can be compromised. Electrohypersensitivity can be caused by successive assaults on human bioelectrochemical dynamics from exogenous electromagnetic fields (EMF) and RFR or a single acute exposure. Once sensitized, further exposures are widely reported to cause reactivity to lower and lower intensities of EMF/RFR, at which point thousand-fold lower levels can cause adverse health impacts to the electrosensitive person. Electrohypersensitivity (EHS) can be a precursor to, or linked with, multiple chemical sensitivity (MCS) based on reports of individuals who first develop one condition, then rapidly develop the other. Similarity of chemical biomarkers is seen in both conditions [histamines, markers of oxidative stress, auto-antibodies, heat shock protein (HSP), melatonin markers and leakage of the blood-brain barrier]. Low intensity pulsed microwave activation of voltage-gated calcium channels (VGCCs) is postulated as a mechanism of action for non-thermal health effects.

Sandström M, Lyskov E, Berglund A, Medvedev S, Mild KH. Neurophysiological effects of flickering light in patients with perceived electrical hypersensitivity. J Occup Environ Med. 39(1):15-22, 1997.

An increasing number of people in Sweden are claiming that they are hypersensitive to electricity. These patients suffer from skin as well as neurological symptoms when they are near computer monitors, fluorescent tubes, or other electrical appliances. Provocation studies with electromagnetic fields emitted from these appliances have, with only one exception, all been negative, indicating that there are other factors in the office environment that can effect the autonomic and/or central nervous system, resulting in the symptoms reported. Flickering light is one such factor and was therefore chosen as the exposure parameter in this study. Ten patients complaining of electrical hypersensitivity and the same number of healthy voluntary control subjects were exposed to amplitude-modulated light. The sensitivity of the brain to this type of visual stimulation was tested by means of objective electrophysiological methods such as electroretinography and visual evoked potential. A higher amplitude of brain cortical responses at all frequencies of stimulation was found when comparing patients with the control subjects, whereas no differences in retinal responses were revealed.

Sandström M, Lyskov E, Hörnsten R, Hansson Mild K, Wiklund U, Rask P, Klucharev V, Stenberg B, Bjerle P. Holter ECG monitoring in patients with perceived electrical hypersensitivity. Int J Psychophysiol. 49(3):227-235, 2003.

Earlier studies have indicated that patients claiming to be sensitive to electromagnetic fields, so-called electrical hypersensitivity (EHS), have a dysbalance of the autonomic nervous system (ANS) regulation. This paper focuses on a possible dysbalance in the ANS among EHS patients by the use of long-term monitoring of electrocardiogram (ECG) in both a patient and a matched control group. At the same time, the environmental power frequency magnetic field was recorded for both groups in order to see if there was any difference in exposure between the groups. ECG, heart rate (HR) and heart rate variability (HRV) as well as the magnetic field exposure were monitored for 24 h. Fourteen patients with perceived EHS symptoms were selected from the University Hospital, Umeå, Sweden. Symptoms indicating autonomic nervous dysregulation were not part of the inclusion criteria of the patient group. Age and sex matched healthy subjects were used as controls. No differences were found between the groups regarding magnetic field exposure or the mean HR for 24 h. The HRV analyses showed that the high-frequency (HF) component did not have the expected increase with sleep onset and during nighttime in the EHS group. When separating the sleeping and awake time even less differences between the two conditions in the EHS patients, both for the low-frequency and HF components in the HRV spectrum, were seen. EHS patients had a disturbed pattern of circadian rhythms of HRV and showed a relatively 'flat' representation of hourly-recorded spectral power of the HF component of HRV.

Schreier N, Huss A, Rösli M. The prevalence of symptoms attributed to electromagnetic field exposure: a cross-sectional representative survey in Switzerland. Soz Präventivmed. 51(4):202-209, 2006.

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.

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Schröttner J, Leitgeb N, Hillert L. Investigation of electric current perception thresholds of different EHS groups. Bioelectromagnetics. 28(3):208-213, 2007.

An increasing number of persons with health symptoms of unclear origin take refuge in the hypothesis that they suffer from electromagnetic hypersensitivity (EHS). So far EHS is not an accepted diagnosis and there is no validated test to verify the proposed relationship between electromagnetic fields and symptoms. Groups reporting EHS are very heterogeneous but share a belief that they have an increased sensitivity to electromagnetic fields. It was studied to which extent a quantitative indicator for electrosensitivity, the electric current perception threshold, and its variability coefficient, depend on the recruitment strategy for self-declared hypersensitive persons. Individual electrosensitivity was investigated by provocation of the lower arms to directly coupled 50 Hz electric currents. Self-declared EHS persons were selected from members of a self aid group, from responders to a newspaper call, and from persons actively asking for investigations in their search for help. It turned out that quantitative electrosensitivity was quite different among the three groups. It is interesting that the members of the EHS self aid group exhibit a considerable overlap with general population sample. Pooled together it could be shown that hypersensitive persons as a group differ significantly from the general population sample, however with a pronounced overlap with the normal range. It can be concluded that EHS groups are very inhomogeneous and contain numerous persons with no increased ability to perceive low frequency electric or magnetic fields. This investigation shows the importance of the study design, in particular of the recruitment strategies of EHS persons for the final outcome.

Schröttner J, Leitgeb N. Sensitivity to electricity--temporal changes in Austria. BMC Public Health. 8:310, 2008.

BACKGROUND: An increasing number of persons suffer from non-specific health symptoms such as headache, sleep disturbances, difficulties in concentrating and more. In lack of a medical explanation, more and more persons take refuge to the assumption that they were electromagnetic hypersensitive (EHS) and electromagnetic pollution causes their problems. The discussion whether electromagnetic fields (EMF) could cause such adverse health effects is still ongoing. **METHODS:** Based on the Austrian inhabitants a statistical cross-sample of the general population with regard to age, gender and federal state had been investigated to assess the actual situation and potential temporal changes in comparison with a former study of 1994. In a telephone survey a total number of 526 persons were included. **RESULTS:** This study showed an actual EHS prevalence of 3.5% compared with 2% estimated in 1994. About 70% of the sample believed that electromagnetic pollution could be a risk factor for health. More than 30% declared to at least some degree to be concerned about their well-being near mobile phone base stations or power lines. However, only 10% were actively looking for specific information. Media triggered EHS hypothesis in 24% of the cases. **CONCLUSION:** The results show that concerns about EMF did not decrease with time in spite of scientific studies and health risk assessments concluding that a causal relationship of EMF below recommended reference levels and non-specific health symptoms would be implausible.

Seitz H, Stinner D, Eikmann T, Herr C, Röösl M. Electromagnetic hypersensitivity (EHS) and subjective health complaints associated with electromagnetic fields of mobile phone communication--a literature review published between 2000 and 2004. Sci Total Environ. 349(1-3):45-55, 2005.

Literature published between 2000 to 2004 concerning electromagnetic fields (EMF) of mobile communication and electromagnetic hypersensitivity (EHS) or unspecific symptoms of ill health, respectively, is reviewed. Basically, literature from established databases was systematically searched for. For each study, the design and quality were evaluated by means of a criteria list in order to judge evidence for causality of exposures on effects. Finally, 13 studies of sufficient quality were considered for this review. In only one provocation study, individuals with self-reported electromagnetic hypersensitivity were exposed to EMF. Their perception of field status was no better than would have been expected by chance. Results of five randomised cross-over studies on impaired well-being due to mobile phone exposure were contradictory. Even though these studies would allow more reliable exposure assessment, they are limited due to short exposure period and the small study size. No firm conclusion could be drawn from a few observational epidemiological studies finding a positive association between exposure and unspecific symptoms of ill health due to methodological limitations. Causality of exposure and effect was not derivable from these cross-sectional studies as field status and health complaints were assessed at the same time. In addition, exposure assessment has not been validated. In conclusion, based on the limited studies available, there is no valid evidence for an association between impaired well-being and exposure to mobile phone radiation presently. However, the limited quantity and quality of research in this area do not allow to exclude long-term health effects definitely.

Silny J. Electrical hypersensitivity in humans--fact or fiction? Zentralbl Hyg Umweltmed. 202(2-4):219-233,1999.

The phenomenon of the so-called electrical hypersensitivity in the weak electromagnetic fields of everyday life, potentially causing different health symptoms, is reviewed under consideration of current results from in-vivo and in-vitro investigations as well as of statistical data. Electrical hypersensitivity cannot be explained by means of the known and validated influence mechanisms of electromagnetic fields in humans, as their thresholds are at least 50 times higher for harmless effects, and more than 1000 times higher for adverse effects than the strengths of the environmental fields. Present statistical data reveal clear inconsistencies in many respects. The prevalence varies by a factor 1000 although the reporting countries have comparable field and exposure situations. Neither the apparently random combination of symptoms on the side of the suffering patients nor the problematic attribution of the symptoms to certain electromagnetic field situations do support the hypothesis of a electrical hypersensitivity. On the other hand, the statistical data must be considered unsubstantiated because of the small number of cases and the procedures of survey. Consequently, there is a need for additional, systematic investigations of this group of patients under participation of different medical and biomedical disciplines.

Sobiczewska E, Szmigielski S. [Electromagnetic fields hypersensitivity]. Med Pr. 60(3):235-241, 2009. [Article in Polish]

The development of industry, particularly of new technologies in communication systems, gives rise to the number and diversity of electromagnetic field (EMF) sources in the environment. These sources, including power-frequent, radiofrequent and microwaves, make human life richer, safer and easier. But at the same time, there is growing concern about possible health risks connected with EMF exposure. An increasing number of persons have recently reported on a variety of health problems induced, in their opinion, by exposure to EMF. It is important to note that EMF levels to which these individuals are exposed are generally well below the recommended exposure limits and are certainly far below those known to produce any adverse effects. These persons call themselves "electromagnetic hypersensitivity individuals" And complain about experiencing various types of non-specific symptoms, including dermatological, neurological and vegetative. In the present paper, the problem of electromagnetic hypersensitivity phenomenon is discussed based on the recently published literature.

Swanbeck G, Bleeker T. Skin problems from visual display units. Provocation of skin symptoms under experimental conditions. Acta Derm Venereol. 69(1):46-51, 1989.

Thirty patients having skin problems experienced being caused by work with visual display units (VDU) were tested double-blind with two VDUs. One VDU had strong electrostatic and electromagnetic fields and the other VDU had an identical appearance but the electrostatic field and electromagnetic fields were practically eliminated. Approximately 80% of the patients reacted with stinging or itching in the face during the 3 hours working period with 25% relative humidity in the room. No difference between the VDUs was found with regard to provoking these symptoms. At 60% relative humidity 13 patients of 19 experienced stinging or itching in the face. Those 13 that reacted were asked to come another time and were informed that the VDU was not turned on and that all electric fields that were present came from the cable to the VDU. A green cloth was put over the VDUs. This time 11 of the 13 patients reacted with stinging and itching in spite of the fact that the VDU was turned off. The present study does not indicate that electric and electromagnetic fields are of major importance in provoking subjective skin symptoms in patients experiencing skin problems when working with VDUs.

Tseng MC, Lin YP, Hu FC, Cheng TJ. Risks Perception of Electromagnetic Fields in Taiwan: The Influence of Psychopathology and the Degree of Sensitivity to Electromagnetic Fields. Risk Anal. 2013 Mar 28. doi: 10.1111/risa.12041. [Epub ahead of print]

Little is known about the perceived health risks of electromagnetic fields (EMFs) and factors associated with risk perception in non-Western countries. Psychological conditions and risk perception have been postulated as factors that facilitate the attribution of health complaints to environmental factors. This study investigated people's perceived risks of EMFs and other environmental sources, as well as the relationships between risk perception, psychopathology, and the degree of self-reported sensitivity to EMFs. A total of 1,251 adults selected from a nationwide telephone interviewing system database responded to a telephone survey about the relationships between environmental sources and human health. The interview included questions assessing participants' psychiatric conditions and the presence and degree of sensitivity to EMFs. One hundred and seventy participants were self-identified as having sensitivity to EMFs, and 141 met the criteria for psychiatric conditions without EMF sensitivity. More than half of the survey respondents considered power lines and mobile phone base stations to affect people's health to a big extent. Higher sensitivity to EMFs, psychopathology, being female, being married, more years of education, and having a catastrophic illness had positive associations with perceived risks of EMF-related environmental sources as well as for all environmental sources combined. We observed no moderating effect of psychopathology on the association between degree of sensitivity to EMF and risk perception. Thus, psychopathology had influence on general people's risk perception without having influence on the relationship between people's degree of sensitivity to EMF and risk perception. The plausible explanations are discussed in the text.

Tuengler A, von Klitzing L. Hypothesis on how to measure electromagnetic hypersensitivity. Electromagn Biol Med. 32(3):281-290, 2013.

Electromagnetic hypersensitivity (EHS) is an ill-defined term to describe the fact that people who experience health symptoms in the vicinity of electromagnetic fields (EMFs) regard them as causal for their complaints. Up to now most scientists assume a psychological cause for the suffering of electromagnetic hypersensitive individuals. This paper addresses reasons why most provocation studies could not find any association between EMF exposure and EHS and presents a hypothesis on diagnosis and differentiation of this condition. Simultaneous recordings of heart rate variability, microcirculation and electric skin potentials are used for classification of EHS. Thus, it could be possible to distinguish "genuine" electromagnetic hypersensitive individuals from those who suffer from other conditions.

Wallace D, Eltiti S, Ridgewell A, Garner K, Russo R, Sepulveda F, Walker S, Quinlan T, Dudley S, Maung S, Deeble R, Fox E. Do TETRA (Airwave) base station signals have a short-term impact on health and well-being? A randomized double-blind provocation study. Environ Health Perspect. 118(6):735-741, 2012.

BACKGROUND: "Airwave" is the new communication system currently being rolled out across the United Kingdom for the police and emergency services, based on the Terrestrial Trunked Radio Telecommunications System (TETRA). Some police officers have complained about skin rashes, nausea, headaches, and depression as a consequence of using their Airwave handsets. In addition, a small subgroup in the population self-report being sensitive to electromagnetic fields (EMFs) in general. OBJECTIVES: We conducted a randomized double-blind provocation

study to establish whether short-term exposure to a TETRA base station signal has an impact on the health and well-being of individuals with self-reported "electrosensitivity" and of participants who served as controls. METHODS: Fifty-one individuals with self-reported electrosensitivity and 132 age- and sex-matched controls participated in an open provocation test; 48 sensitive and 132 control participants went on to complete double-blind tests in a fully screened semianechoic chamber. Heart rate, skin conductance, and blood pressure readings provided objective indices of short-term physiological response. Visual analog scales and symptom scales provided subjective indices of well-being. RESULTS: We found no differences on any measure between TETRA and sham (no signal) under double-blind conditions for either controls or electrosensitive participants, and neither group could detect the presence of a TETRA signal at rates greater than chance (50%). When conditions were not double blind, however, the self-reported electrosensitive individuals did report feeling worse and experienced more severe symptoms during TETRA compared with sham. CONCLUSIONS: Our findings suggest that the adverse symptoms experienced by electrosensitive individuals are due to the belief of harm from TETRA base stations rather than to the low-level EMF exposure itself.

Wallace D, Eltiti S, Ridgewell A, Garner K, Russo R, Sepulveda F, Walker S, Quinlan T, Dudley S, Maung S, Deeble R, Fox E. Cognitive and physiological responses in humans exposed to a TETRA base station signal in relation to perceived electromagnetic hypersensitivity. Bioelectromagnetics. 33(1):23-39, 2012.

Terrestrial Trunked Radio (TETRA) technology ("Airwave") has led to public concern because of its potential interference with electrical activity in the brain. The present study is the first to examine whether acute exposure to a TETRA base station signal has an impact on cognitive functioning and physiological responses. Participants were exposed to a 420 MHz TETRA signal at a power flux density of 10 mW/m² as well as sham (no signal) under double-blind conditions. Fifty-one people who reported a perceived sensitivity to electromagnetic fields as well as 132 controls participated in a double-blind provocation study. Forty-eight sensitive and 132 control participants completed all three sessions. Measures of short-term memory, working memory, and attention were administered while physiological responses (blood volume pulse, heart rate, skin conductance) were monitored. After applying exclusion criteria based on task performance for each aforementioned cognitive measure, data were analyzed for 36, 43, and 48 sensitive participants for these respective tasks and, likewise, 107, 125, and 129 controls. We observed no differences in cognitive performance between sham and TETRA exposure in either group; physiological response also did not differ between the exposure conditions. These findings are similar to previous double-blind studies with other mobile phone signals (900-2100 MHz), which could not establish any clear evidence that mobile phone signals affect health or cognitive function.

Wang J, Su H1, Xie W, Yu S. Mobile Phone Use and The Risk of Headache: A Systematic Review and Meta-analysis of Cross-sectional Studies. Sci Rep. 2017 Oct 3;7(1):12595. doi: 10.1038/s41598-017-12802-9.

Headache is increasingly being reported as a detrimental effect of mobile phone (MP) use. However, studies aimed to investigate the association between MP use and headache yielded conflicting results. To assess the consistency of the data on the topic, we performed a systematic review and meta-analysis of the available cross-sectional studies. Published literature from PubMed and other databases were retrieved and screened, and 7 cross-sectional studies were finally included in this meta-analysis. The pooled odds ratio (OR) and 95% confidence interval (CI) were calculated. We found that the risk of headache was increased by 38% in MP user compared with non-MP user (OR, 1.38; 95% CI, 1.18-1.61, $p < 0.001$). Among

MP users, the risk of headache was also increased in those who had longer daily call duration (2-15 min vs. <2 min: OR, 1.62; 95% CI, 1.34-1.98, $p < 0.001$; >15 min vs. <2 min: OR, 2.50; 95% CI, 1.76-3.54, $p < 0.001$) and higher daily call frequency (2-4 calls vs. <2 calls: OR, 1.37; 95% CI, 1.07-1.76, $p < 0.001$; >4 calls vs. <2 calls: OR, 2.52; 95% CI, 1.78-3.58, $p < 0.001$). Our data indicate that MP use is significantly associated with headache, further epidemiologic and experimental studies are required to affirm and understand this association.

Wilén J, Sandström M, Hansson Mild K. Subjective symptoms among mobile phone users--a consequence of absorption of radiofrequency fields? Bioelectromagnetics. 24(3):152-159, 2003.

In a previous epidemiological study, where we studied the prevalence of subjective symptoms among mobile phone (MP) users, we found as an interesting side finding that the prevalence of many of the subjective symptoms increased with increasing calling time and number of calls per day. In this extrapolative study, we have selected 2402 people from the epidemiological study who used any of the four most common GSM MP. We used the information about the prevalence of symptoms, calling time per day, and number of calls per day and combined it with measurements of the Specific Absorption Rate (SAR). We defined three volumes in the head and measured the maximum SAR averaged over a cube of 1 g tissue (SAR(1g)) in each volume. Two new exposure parameters Specific Absorption per Day (SAD) and Specific Absorption per Call (SAC) have been devised and are obtained as combinations of SAR, calling time per day, and number of calls per day, respectively. The results indicates that SAR values >0.5 W/kg may be an important factor for the prevalence of some of the symptoms, especially in combination with long calling times per day.

Wilen J, Johansson A, Kalezic N, Lyskov E, Sandstrom M. Psychophysiological tests and provocation of subjects with mobile phone related symptoms. Bioelectromagnetics. 27(3):204-214, 2006.

The aim of the present study was to investigate the effect of exposure to a mobile phone-like radiofrequency (RF) electromagnetic field on persons experiencing subjective symptoms when using mobile phones (MP). Twenty subjects with MP-related symptoms were recruited and matched with 20 controls without MP-related symptoms. Each subject participated in two experimental sessions, one with true exposure and one with sham exposure, in random order. In the true exposure condition, the test subjects were exposed for 30 min to an RF field generating a maximum SAR(1g) in the head of 1 W/kg through an indoor base station antenna attached to a 900 MHz GSM MP. The following physiological and cognitive parameters were measured during the experiment: heart rate and heart rate variability (HRV), respiration, local blood flow, electrodermal activity, critical flicker fusion threshold (CFFT), short-term memory, and reaction time. No significant differences related to RF exposure conditions were detected. Also no differences in baseline data were found between subject groups, except for the reaction time, which was significantly longer among the cases than among the controls the first time the test was performed. This difference disappeared when the test was repeated. However, the cases differed significantly from the controls with respect to HRV as measured in the frequency domain. The cases displayed a shift in low/high frequency ratio towards a sympathetic dominance in the autonomous nervous system during the CFFT and memory tests, regardless of exposure condition. This might be interpreted as a sign of differences in the autonomous nervous system regulation between persons with MP related subjective symptoms and persons with no such symptoms.

Wilén J, Wiklund U, Hörnsten R, Sandström M. Changes in heart rate variability among RF plastic sealer operators. Bioelectromagnetics. 28(1):76-79, 2007.

In a previous study, we showed that operators of radiofrequency (RF) plastic sealers, RF operators (n = 35) had a lower heart rate during nighttime compared to a control group (n = 37). We have analyzed the heart rate variability (HRV) on the same group of people to better understand the possible underlying rhythm disturbances. We found a significantly increased total HRV and very low frequency (VLF) power during nighttime among the RF operators compared to a control group. Together with our previous finding of a significantly lower heart rate during nighttime among the RF operators compared to the controls, this finding indicates a relative increase in parasympathetic cardiac modulation in RF operators. This could in turn be due to an adaptation of the thermoregulatory system and the cardiac autonomic modulation to a long-term low-level thermal exposure in the RF operators.

Ziskin MC; Committee on Man and Radiation. Electromagnetic hypersensitivity--a COMAR Technical Information Statement. June 27, 2002. IEEE Eng Med Biol Mag. 21(5):173-175, 2002. (no abstract available)

Radiation Sickness; Could Myelin Damage from Radiofrequency Electromagnetic Field Exposure Help Explain the Functional Impairment Electrohypersensitivity? A Review of the Evidence. Journal of Toxicology and Environmental Health. (Redmayne and Johansson); 2014

COULD MYELIN DAMAGE FROM RADIOFREQUENCY ELECTROMAGNETIC FIELD EXPOSURE HELP EXPLAIN THE FUNCTIONAL IMPAIRMENT ELECTROHYPERSENSITIVITY? A REVIEW OF THE EVIDENCE

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Myelin provides the electrical insulation for the central and peripheral nervous system and develops rapidly in the first years of life, but continues into mid-life or later. Myelin integrity is vital to healthy nervous system development and functioning. This review outlines the development of myelin through life, and then considers the evidence for an association between myelin integrity and exposure to low-intensity radiofrequency electromagnetic fields (RF-EMFs) typical in the modern world. In RF-EMF peer-reviewed literature examining relevant impacts such as myelin sheath, multiple sclerosis, and other myelin-related diseases, cellular examination was included. There are surprisingly little data available in each area, but considered together a picture begins to emerge in RF-EMF-exposed cases: (1) significant morphological lesions in the myelin sheath of rats; (2) a greater risk of multiple sclerosis in a study subgroup; (3) effects in proteins related to myelin production; and (4) physical symptoms in individuals with functional impairment electrohypersensitivity, many of which are the same as if myelin were affected by RF-EMF exposure, giving rise to symptoms of demyelination. In the latter, there are exceptions; headache is common only in electrohypersensitivity, while ataxia is typical of demyelination but infrequently found in the former group. Overall, evidence from in vivo and in vitro and epidemiological studies suggests an association between RF-EMF exposure and either myelin deterioration or a direct impact on neuronal conduction, which may account for many electrohypersensitivity symptoms. The most vulnerable are likely to be those in utero through to at least mid-teen years, as well as ill and elderly individuals.

A recent report by the Health Council of the Netherlands highlighted the importance of myelination because of its role in providing electrical insulation to the nerve fibers (Health Council of the Netherlands, 2011). The council raised an important question: Can exposure to external electromagnetic fields, which create an electrical field in the brain, affect natural development and pruning of synapses during human development? This conservative advisory body stated that it is of “great

importance to gather more information on this” (20). The council refers to both radiofrequency and extremely low-frequency electromagnetic field (RF-EMF and ELF-EMF) exposures at intensities too low to produce thermal damage. These are omnipresent, both environmentally (such as from mobile phone base stations and WiFi routers) and individually (such as from mobile phones, tablets, laptops, and iPods). The council’s question is relevant and particularly important in the unborn and very young. The

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brain develops rapidly in utero, and at critical stages of development from infancy through adolescence and early adulthood, when axons and dendrites undergo pruning and synapses are formed. The process occurs under the influence of the brain's internally generated electrical activity in concert with an intricate chemical crosstalk using growth and differentiating factors as well as modulators and co-modulators (Fuxe et al., 1986).

Individuals claiming to suffer from exposure to electromagnetic fields (EMF) have been reported. In Sweden, electrohypersensitivity (EHS) is an officially fully recognized functional impairment (i.e., it is not regarded as a disease). Those who are electrosensitive commonly indicate having particular sources of exposures to which they are sensitive, which vary among those with the condition (Röösli et al., 2004). A rudimentary analysis comparing reported symptoms of those having EHS with those in a Swiss Health Survey showed significantly increased incidence of sleep disorders and severe headaches, and a reduced incidence of asthma in those with EHS (Röösli et al., 2004). With repeated exposures, response time reduces and reaction tends to grow more severe than when symptoms from the same source were first experienced, unless there has been an unexposed period of months, after which recurrence of symptoms may take a day or more (personal communication, Rob Hutchins, spokesperson for ElectroSensitivity New Zealand, April 2014).

Different sources may elicit different responses in any one person. Röösli et al. (2004) noted a trend toward more headaches in those using (cathode ray) display terminals, concentration problems and tinnitus with use of communication devices (RF), and nervousness or distress from ELF exposures. This is in agreement with the findings of Gordon et al. (1963), who suggested that "with low-intensity irradiations [1 mW/cm²], the degree and sometimes even the nature of the functional and morphological changes depended on the wavelength." It may also explain why double-blind exposure studies with electrohypersensitives and a control group have not generally or consistently found a significant

relationship (Rubin et al., 2005), as responses appear not to be uniform (Havas, 2013) and depend upon the stage of EHS and the time since the last exposure.

In Sweden, the prevalence of EHS was first estimated at 1.5% of the population in a survey undertaken in 1997 (Hillert et al., 2002), and a newer estimate is 2.6–3.2% (Johansson, 2006). In Austria the prevalence was estimated to be less than 2% in 1994 but rose to 3.5% in 2001 (Schrottner and Leitgeb, 2008). In California, the prevalence of self-reported sensitivity to electromagnetic fields was 3.2%, with 24.4% of those surveyed also reporting sensitivity to chemicals (Levallois et al., 2002). In Switzerland, 5% of the population was estimated to suffer from EHS in a survey undertaken in 2004 (Schreier et al., 2006). Finally, the Canadian Human Rights Commission noted that approximately 3% of Canadians have been diagnosed with environmental sensitivities, including to chemicals and EMF in their environment (Sears, 2007). In the report, Sears (2007) recommended improving the environmental quality at workplaces.

In yet unpublished studies by Johansson et al. (personal communication), the epidermal nerve fibers of electrohypersensitive persons were markedly reduced in length and number of nerve terminals, indicating apparent damage. The question is whether this occurred due to myelin sheath destruction or functional axonal conduction disruption. In neuroscience it is a well-established fact that reduction of the number of nerve fibers and concomitantly axonal terminals leads to an elevation in sensitivity, the so-called supersensitivity phenomenon (Gerfen, 2003). Can these also be underlying mechanisms for electrohypersensitivity?

This review focuses on effects attributed to RF-EMF. Extremely low-frequency (ELF) effects are also important to explore with relation to myelin, as there have been studies conducted regarding the use of ELF for therapeutic purposes (Sherafat et al., 2012; Baptista et al., 2009; Protasoni et al., 2009; Aydin et al., 2006; Mert et al., 2006). Perhaps the most important observation regarding these is that they present vital evidence that biological effects are

frequency dependent: that is, responses may be positive, neutral, or negative, depending upon the frequency of the exposure. However, the associations of ELF and myelin integrity were not examined.

It is also pertinent to ask whether nonmyelinated nerves are more susceptible to direct interference from RF EMF, but this also lies outside the scope of this article. Briefly, there are studies that demonstrated redistribution of transmembrane sodium channels after exposure to pulsed RF EMF (Schneider and Pekker, 2013), and changes in neuronal firing rate and plasma membrane properties after extremely low, brief exposures of neonatal rat cerebral cortical tissue (Pikov et al., 2010).

In this review, we examined whether there may be a connection between symptoms reported after exposure to RF-EMF (chronic and acute nonthermal exposures) and compromised myelin integrity. Is there any evidence to suggest it, and is the hypothesis reasonable? These are important questions because loss of myelin is critical in several diseases, including multiple sclerosis (MS).

The aim of this review is to outline what myelin is and its normal course of development over the life span. Animal studies examining effects of RF-EMF on myelin sheathing and epidemiological research examining multiple sclerosis with relation to RF-EMF exposure are presented.

METHODOLOGY

Published information was collected on myelin and myelin damage, related diseases such as multiple sclerosis, relevant cellular changes, and the functional impairment electrohypersensitivity, by using conventional scientific literature databases, such as biomedical literature from PubMed, Medline, life science journals, EMF-Portal, and online books, available on the Internet.

MYELIN AND ITS DEVELOPMENT

Myelin is a fatty membrane that provides insulation that enables rapid propagation of

electrical impulses along nerves. Myelin is produced by two types of glial cell, oligodendrocytes and Schwann cells, and is primarily composed of water, lipids, and protein. Within the myelin, there are interlinked hydrocarbon chains of sphingomyelin, which provides a strengthening framework (Mandal, 2014). Sphingolipids also play important roles in signal transduction (Healy, 2008). Disorders in sphingomyelin result in lack of sphingomyelin phosphodiesterase (SMase). SMase is a hydrolase enzyme whose role is to degrade sphingolmyelin in phosphocholine and ceremide. This prevents buildup of sphingomyelin in the brain, bone marrow, and liver, which would otherwise result in impaired motor skills, muscle strength, vision and hearing problems, and ultimately death (Healy, 2008).

Myelin develops spirally around neuronal axons, creating a sheath that increases in effectiveness as it thickens. Oligodendrocyte cells are found only in the central nervous system (CNS), and each cell myelinates the axons of several neurons, while Schwann cells are responsible for myelinating the peripheral nervous system (PNS), there being one cell for each axon (Bear et al., 2007). There are small gaps in the myelin sheath at the axon hillock and at locations called the nodes of Ranvier. At these points, ions cross the axon to create action potential, thus boosting the signal along the axon.

If myelin is damaged, the impulses traveling along the nerves slow down. Apart from crush injuries, initiation and mechanism for myelin damage are not understood but are considered to be related to environmental or genetic factors. If myelin is not repaired, this results in a variety of symptoms and diseases. The most common of these is the autoimmune condition multiple sclerosis, which affects the CNS (Table 1). Conditions that affect the PNS include Guillain-Barré syndrome and chronic inflammatory demyelinating polyradiculoneuropathy (CIDP). CIDP is thought to be an autoimmune condition and is generally characterized by fatigue and increasing weakness, tingling, and pain in the limbs, beginning at the toes and fingers (National Institute of Neurological

TABLE 1. Symptoms Reported by People After Exposure (or Presumed Exposure) to RF-EMFs With Symptoms of Demyelination

	Symptoms of electrohypersensitivity	Symptoms of demyelination
Vision	Difficulty in seeing, smarting, pain	Blurred vision Progressive vision loss/blurring (children), pain, light flashes (children)
Motor	Trunk/limb/joints aches, pain Numbness Weakness	Trunk/limb weakness Numbness Weakness and fatigue Balance problems
Sensory	Tickling, prickling, burning sensations (ie numbness, paraesthesia)	Numbness, paresthesia (i.e., tickling, prickling, burning sensations)
Cerebellar	Tremor Faintness Dizziness Sleep problems Headaches Abnormally tired/sleep problems	Tremor Ataxia (reduced muscle control, incoordination) Seizures (children) Balance problems (children) Lethargy (children)
Cognitive/neuropsychiatric/ emotional	Short and long term memory impairment Lack of concentration Difficulty learning new things Irritability Anxiety Stress (feeling of lack of control) Mood changes (including anger) Depression	Memory impairment Concentration impairment Irritability Anxiety Confusion (children)

Note. Sources: ESUK (2014); Mar (2014); National Multiple Sclerosis Society (2014).

Disorders and Stroke, 2014). It is most common in young men.

Humans are born with scant electrical insulation of their nervous system. During development, a sheath of fatty myelin begins developing, first around axons in the CNS, then also sheathing peripheral and increasingly thinner axons (Wheeler, 2009). Once developed, it acts as electrical insulation and prevents the electrical signaling along the neuron from leaking out through the walls of the neuron. Its purpose is to enable efficient, speedy conduction of electrical nerve impulses. The major development of CNS sheathing occurs during the fourth and fifth months of gestation, continuing from the wk 25 of gestation until the age of 2 yr (Rathus, 2010), but age-related changes to axon thickness and white matter density visible in magnetic resonance imaging (MRI) scans indicate that it continues throughout childhood and adolescence (Paus et al., 1999). Myelination begins in the brainstem and cerebellar regions, progressing through to

the frontal lobes during adolescence (Yakovlev and Lecours, 1967), and thereafter repeating in cycles. Wheeler (2009) suggested that myelination development, repair, and replacement continue throughout the CNS and PNS until late middle age, coating smaller and smaller diameter axons in increasingly thinner layers. The myelination of the splenium (located at the posterior end of the corpus callosum) is central to the efficiency of interhemispheric synchronization; this occurs over a protracted period (Knyazeva, 2013). Bartzokis (2011) proposed a theory that optimal brain function relies on finely tuned action potential synchronization, which myelin enables, but that in the presence of oxidative and environmental abnormalities and stressors, epigenetic changes result, leading to developmental and degenerative diseases. Being fatty, myelin does not contain free ions. Keshvari et al. (2006) postulated that this indicates that as the myelin sheath develops there is also a reduction in electrical conductivity of brain tissue. The reverse side of this coin is

that there is a higher overall electrical conductivity in the fetus, infant, and young child brain, as well as in those whose myelin has begun degenerating. Myelin deposition is delayed in malnourished children (Rodier, 2004), thereby possibly leaving some of lower socioeconomic status more vulnerable.

Excessive production of synaptic connections during fetal development is followed by heavy perinatal pruning; a second round, in the prefrontal cortex, occurs later with a marked rise in synapses at the onset of puberty (Huttenlocher, 1979), followed by pruning and reorganization during adolescence (Blakemore and Choudhury, 2006). This process is not complete until early adulthood. Rodier (2004) suggested that because prenatal CNS and myelination developmental processes are highly vulnerable to damage by environmental agents, it is reasonable to expect that brain development during childhood and adolescence also faces particular risks.

RF-EMF RESEARCH

The most relevant studies available were undertaken in the 1970s. In considering chronic effects, Switzer and Mitchell (1977) exposed 6-wk-old rats (5 h/d, 5 d/wk for 22 wk) to continuous-wave 2450-MHz RF-EMR (SAR 2.3 W/kg). There was a gap of 6 wk after exposure before analysis. Analysis using an electron microscope indicated a significant elevation in the number of myelin figures protruding into the cortical dendrites of the radiated, compared to control, subjects. No other striking structural changes were apparent. Baranski (1972) exposed guinea pigs and rabbits. Different guinea pig groups had exposures of 3.5 mW/cm² or 25 mW/cm², each being either continuous or pulse modulated. Exposure was at 3000 MHz, for 3 h daily for 3 mo, or the same frequency for a single 3-h session. The rabbits experienced 3 mo of chronic exposure at 5 mW/cm². Resulting damage was the same with both types of irradiation, but lesions were more marked and extensive from pulsed transmissions. Baranski (1972)

found spherical metachromatic bodies in the myelin with large spheres in nervous tracts and glial cells, and smaller ones near the third ventricle and reticular formation structures, particularly around blood vessels within the myelin. These spheres were attributed to metabolic disturbances in the myelin sheath and particularly in the oligodendrocytes. Demyelination was indicated by a Marchi's reaction test. Some hyperchromatic cell bodies in the white matter had spirally twisted neurites typical of "chronic Nissl's disease." It should be noted that exposure at 25 mW/cm² produced thermal damage, and that 3.5 mW/cm² exceeds the public exposure reference levels, although falling within occupational exposures. Further, 2.3 W/kg is higher than permitted under International Commission on Non-Ionizing Radiation Protection (ICNIRP) or Institute of Electrical and Electronics Engineers (IEEE) standards. However, no temperature increases were evident at 3.5 mW/cm² or 2.3 W/kg. The greater impact of pulse-modulated exposures reported by Baranski (1972) is of great importance, since all present-day digital microwave radiation types are pulsed. This occurrence is explained by the ion forced-vibration theory (Panagopoulos et al., 2002), supported theoretically more recently by Halgamuge and Abeyranthe (2011).

OTHER RESEARCH RELEVANT TO MYELIN LOSS AND RELATED SYMPTOMS

A national Danish cohort study compared the country's MS register against private mobile phone subscription holders and nonholders prior to 1996 (Poulson et al., 2012). Despite the most basic estimate of exposure (phone ownership or not), there was one subgroup of account holders with significant elevated incidence, namely, women with >10 yr of mobile phone subscription (RR 2.08, 95%CI: 1.08–4.01; *n* = 9). A few MS onset symptoms were also significantly related, although different for men and women. Women had an increased incidence of fatigue (RR 3.02, CI: 3.02–6.28),

while men experienced an elevated frequency of optic neuritis (RR 1.38 CI: 1.03–1.86). Diplopia (blurred vision) was not significant in either group separately, but together the incidence risk rate was 1.38 (CI: 1.02–1.86). Finally, there was an elevated risk of death in MS patients with subscriptions 7–9 yr after MS diagnosis compared to those without subscriptions (RR, 2.44; 95% CI: 1.20–4.98; $n = 8$); however, it should be noted that the number in this category was small. The study excluded corporate subscriptions, which are likely to have been the highest users at that time. Since these are also likely to have been predominantly accounts for use by men, this may explain the significant MS results being in a subgroup of women.

Schüz et al. (2007) investigated a possible link between cellular telephone use and risks for various CNS diseases. In their large nationwide cohort study of 420,095 persons in Denmark, no marked associations for amyotrophic lateral sclerosis, multiple sclerosis, or epilepsy (in women) were observed, but there was an excess of migraine and vertigo connected to the mobile phone use. Elsewhere, rats were exposed to both 1.5 W/kg and 6 W/kg (GSM [global system for mobile communications] pulsed modulation) (Anane et al., 2003). There was a significant rise in amplitude of induced experimental allergic encephalomyelitis crisis between sham and real exposure at 1.5 W/kg (which is a permitted exposure in the ICNIRP and IEEE guidelines) but not at 6 W/kg, despite no marked difference in onset, duration, or termination. This condition is an inflammatory demyelinating disease of the CNS. The abstract does not mention this increase.

A small study published in 2007 found no gross effects on measured human cortical parameters in either healthy participants ($n = 10$) or MS participants ($n = 2$) (Inomata-Terada et al. 2007). Subjects were exposed to an 800-MHz pulsed signal for 30 min at the maximum permitted power output, using an adapted hand-held phone. For those with MS, exposure was before and after a hot bath, which generally brought on MS-related

weakness. These data were unable to be analyzed statistically and were assessed individually by observation.

Symptoms of myelin loss include numbness and paraesthesia. An explanation is that alterations of myelin as well as Schwann cells of the sensory nerves may lead to functional alterations, slowing down of nerve signal conductance, and changes of nerve terminal sensitivity, which would lead to sensations of numbness and paresthesia, with the latter forming conscious thoughts via the spinal cord, thalamus, and primary as well as associative sensory brain cortex.

The skin is the organ most exposed to RF-EMF. Effects of EMF exposure on the skin were published in the 1960s. In experiments with rats, low-intensity exposure (≤ 1 mW/cm²) reduced nucleoprotein content of various cells and tissues. Thereafter, marked morphological changes were observed in the receptor and interoceptor apparatuses for skin after exposures of 1 mW/cm², with slight changes noted elsewhere, including intestinal wall, the wall of the bladder, and aorta (Gordon et al., 1963). This study also found slight morphological changes in the axon-soma and axon-dendrite interneuron connections of the cerebral cortex. These effects were reversible, disappearing after 3 to 4 wk. Some reactions were only seen with frequencies below 3GHz, suggesting that the degree of functional and morphological changes depended on the wavelength.

There are also studies indicating involvement of cells or proteins related to production of myelin. Peinnequin et al. (2000) found that 2.45-GHz nonthermal exposure of Jurkat T cells over 48 h initiated Fas-induced apoptosis. When considered with other results, there was the potential that exposure affected either membrane proteins through the Fas receptor or SMase activation, or the Fas pathway between receptor and caspase-3 activation. In a study exposing human bone-marrow mesenchymal stem cells to a 1-mT 50-Hz field for 12 d, oligodendrocyte protein O4 was induced (Cho et al., 2012). Data indicated that in toto ELF might induce neural differentiation in these

cells. Hardell et al. (2010) determined the risk of oligodendroglioma and mobile or cordless phone exposure in deceased cases from certain areas of Sweden who were diagnosed with this tumor between 1997 and 2003. Results revealed a high odds ratio (OR) for those with >10 yr of phone use (OR = 10, 95% confidence interval [CI] = 1.1–89), but this was based on only 2 cases in this category, out of 9 who died from this tumor.

The presence of intraepidermal nerve fibers was investigated in normal human skin from healthy volunteers using the new marker PGP 9.5 (Wang et al., 1990). The intraepidermal nerve fibers are found as close as 20–40 μm from the surface, which makes it highly possible that weak EMF may affect them. In facial skin samples of electrohypersensitive persons, the most common finding was a marked rise of mast cells (Johansson and Liu, 1995). From these studies, it is clear that the number of mast cells in the upper dermis is increased in the EHS group. A different pattern of mast cell distribution also occurred in the EHS group, namely, the normally empty zone between the dermo-epidermal junction and mid- to-upper dermis disappeared in the EHS group and, instead, this zone had a high density of mast-cell infiltration. These cells also seemed to have a tendency to migrate toward the epidermis (= epidermotrophism), and many of them emptied their granular content (= degranulation) in the dermal papillary layer. Further, more degranulated mast cells could be seen in the dermal reticular layer in the EHS group, especially in those cases that had the mast-cell epidermotrophism phenomenon just described. Finally, in the EHS group, the cytoplasmic granules were more densely distributed and more strongly stained than control, and generally, the size of the infiltrating mast cells was noted to be larger in the EHS group. It is noteworthy that increases of a similar nature were demonstrated at a later experimental study employing normal healthy volunteers in front of cathode ray tube (CRT) monitors, including ordinary household television sets (Johansson et al., 2001).

A COMPARISON OF SYMPTOMS OF ELECTROHYPERSENSITIVITY AND DEMYELINATION

If myelin sheathing were compromised by repeated or chronic exposures to RF-EMF, one might expect to see an elevation in typical symptoms of demyelination. Specific symptoms depend upon the particular disease, which are diverse and include blurred vision, trunk/limb weakness, numbness, paresthesia, tremor or reduced coordination, memory impairment, reduced concentration or processing speed, depression, irritability, and anxiety (National Multiple Sclerosis Society, 2014). MS is unusual in children; however, symptoms they encounter include confusion, alteration of consciousness, lethargy, and visual symptoms including pain and flashes of light (Mar, 2014).

These symptoms have also been described as symptoms of EHS, although generally in lay language such as tickling/prickling sensations as opposed to paresthesia (Table 1).

Onset of any of these symptoms in these circumstances has come to be called electrohypersensitivity, although any one person may have a different set of symptoms from another. It should be noted that in a systematic review of both short-term exposure and epidemiological studies to investigate such claims, the overall evidence to support them was thin (17 out of 117 potentially eligible papers were included after checking the qualifying criteria set by the research group) (Röösli et al., 2010). Johansson (2006, pp. 245–246) recorded early symptoms of electrohypersensitivity as “itch, smarting, pain, heat sensation, redness, papules, pustules . . . [and] frequently [symptoms related to] internal organ systems, such as the heart and the central nervous system, are also encountered.” According to Sweden’s National Board of Health and Welfare, the most commonly reported symptoms of electrohypersensitivity are fatigue, difficulty in concentrating, dizziness, nausea, palpitations and digestive disturbances (Socialstyrelsen (The National Board of Health and Welfare) 2014).

The British organization ElectroSensitivity United Kingdom (ESUK) describes symptoms

such as those itemized in the left column of [Table 1](#) (ESUK, 2014). There have been reports of cardiovascular problems such as tachycardia and arrhythmia, although these are relatively rare. Havas (2013) demonstrated these symptoms in double-blind, sham-controlled circumstances.

DISCUSSION

Despite early indications of damage to myelin sheathing in animals exposed to RF-EMF in the 1970s, there has been remarkably little research follow-up. There is still a lack of basic experimental evidence for a clear association between myelin damage and electrohypersensitivity, but given the preceding hypothesis it would be of great interest to investigate this in more detail using classical immunohistochemical markers for healthy and degenerated myelin, respectively, and for Schwann cells in general. Since myelin is the main electrical insulation that ensures efficient electrical functioning of the CNS, its integrity is vital to this, and healthy development of the neuronal system may also be. Therefore, it is important to know whether or not it is damaged by exogenous RF-EMF exposures.

What evidence is there that it may be? There do not appear to be national registers for MS, but the UK Multiple Sclerosis Trust reports that prevalence in women is increasing (Multiple Sclerosis Trust 2014). Race and latitude have been identified as influential in risk, but that incidence may be modified by the environment (Rosati 2001). When a child uses a wireless phone against the head (held at the usual angle), the most exposed area in that child's brain is the cerebellum (Christ et al. 2010); this is one of the first areas myelinated. As the head size nears adulthood, and depending upon head geometry, the most exposed area becomes the temporal lobes. This suggests that during adolescence the temporal lobes may be more susceptible to RF-EMF interference, not only because this region is not yet fully myelinated at that age, but because of enhanced vulnerability during active synaptic

rearrangement and pruning in progress at that age.

Demyelination and electrohypersensitivity have many symptoms in common. This latter condition is frequently regarded as psychosomatic, with the symptoms being claimed to be subjective, nonspecific, and hard to test objectively. However, these symptoms clearly point to a common, highly specific, biological and behavioral avoidance reaction and most can easily be objectively studied and quantified. For instance, the subjective sensations of tingling in the skin, itching, and heat may all be explained by changes in biochemical markers, especially histamine of the mast cells, observed by Johansson (2006).

A review of provocation studies of electrohypersensitives investigations generally did not show a significant response compared with control groups (van Rongen et al., 2009); however, it was acknowledged that such studies are often disadvantaged by short exposure durations.

The symptoms of the two conditions, demyelination and electrohypersensitivity, are not entirely matched. Reduced muscle control (ataxia) is an important symptom of demyelination, as are seizures and balance problems in children, but infrequently reported as a symptom of RF-EMF exposure, although the more minor cerebellar conditions of tremors and dizziness are. On the other hand, there are a few symptoms such as headache, tinnitus, heart arrhythmia, and skin problems that are commonly reported from RF-EMF exposure but are not symptoms of demyelination.

An increased heart rate, altered heart-rate variation, and changes in the sympathetic and parasympathetic control of the autonomic nervous system have been objectively tested and demonstrated as associated with RF-EMR exposure in more than one study (Havas and Marrongelle 2013). Headaches have been associated with exposure in several epidemiological studies. In a review by Augner et al. (2012), there were in total 737 participants in 8 studies who evaluated headaches with relation to RF-EMF exposure and demonstrated an overall marginal association of headaches

with RF-EMFs. Such a link was also found by Redmayne et al. (2013). It is possible that these or other non-myelin-related conditions are a result of stress due to worry regarding exposures. It is also possible that there is another as yet unidentified mechanism responsible.

It is risky to identify a cause by linking it backwards to symptoms such as discussed in this review because these symptoms are also intrinsic to other diseases. Therefore, this review began by asking, is there any evidence to support the hypothesis that RF-EMF exposure symptoms are related to demyelination, and is the hypothesis reasonable? It appears that the hypothesis is reasonable and that the evidence from in vivo, in vitro, and epidemiological studies is sufficiently strong to warrant urging that RF-EMF exposure from prebirth through to at least mid teens should be minimized until this issue is clarified. Overall, evidence suggests an association between RF-EMF exposure and either myelin deterioration or a direct impact on neuronal conduction, which may account for many electrohypersensitivity symptoms.

If myelin integrity is compromised by RF-EMF exposure, the greatest impact for humans would most likely be at each end of the life span. The CNS of the fetus, infant, child, and adolescent, whose myelination is incomplete, especially peripherally, and whose neural connections are rapidly forming and being pruned may be most susceptible, as may that of older people whose myelin protection is already degenerating, notably those with MS or other diseases in which loss of myelin is instrumental. It is not clear whether myelin deterioration from repeated RF exposure may initiate MS or whether it might exacerbate an existing condition. It may also be that before myelin sheath has developed or after it has begun deteriorating, functional axonal conduction may be disrupted directly, but this needs exploring. The similarities of demyelination and electrohypersensitivity cannot be taken as any proof of cause and effect, but it is believed they, and other evidence provided here, highlight the necessity for research in this area. Knowing whether myelin integrity or the natural development and pruning of synapses during

human development are affected by RF-EMF is of great importance because of the serious consequences it implies for personal and public health if that is the case.

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Radiation Sickness; No Safe Place - shattered lives, healthcare set to crash – you can't fix this fast enough; Letter to a Mayor, Olga Sheean, Jun. 15, 2016

NO SAFE PLACE

shattered lives, healthcare set to crash – you can't fix this fast enough



A letter to Mayor Gregor Robertson
by Olga Sheean

Main themes in this document:

Ignored, excluded and incapacitated—citizens forced to flee	3
Evidence of harmful effects: quick facts	5
Scientific fact <i>versus</i> political spin and misinformation	7
Physical effects of EMR.....	13
The key symptoms of EHS	13
Important landmarks on the EMF lifeline	16
Human rights and human wrongdoings	17
Questions for you and the government to answer	20
A taste of what's to come: the real cost of electromagnetic radiation.....	23
Scientists call for more protective measures, given increasing evidence of risk from EMFs	24

Also sent to:

- Prime Minister Justin Trudeau
- David Eby, MLA
- Hedi Fry, MP
- Elizabeth May, MP
- Joyce Murray, MP
- The David Suzuki Foundation
- Dr Erica Mallery-Blythe, PHIRE/Radiation Research Trust
- Dr Dietrich Klinghardt, the Klinghardt Academy
- Elizabeth Kelley, Director, EMFscientist.org
- Dr Joel Moskowitz, Electromagnetic Radiation Safety, saferemr.com
- *The Vancouver Sun*
- *Metro News*
- *The Globe and Mail*
- *The Tyee*

15 June 2016

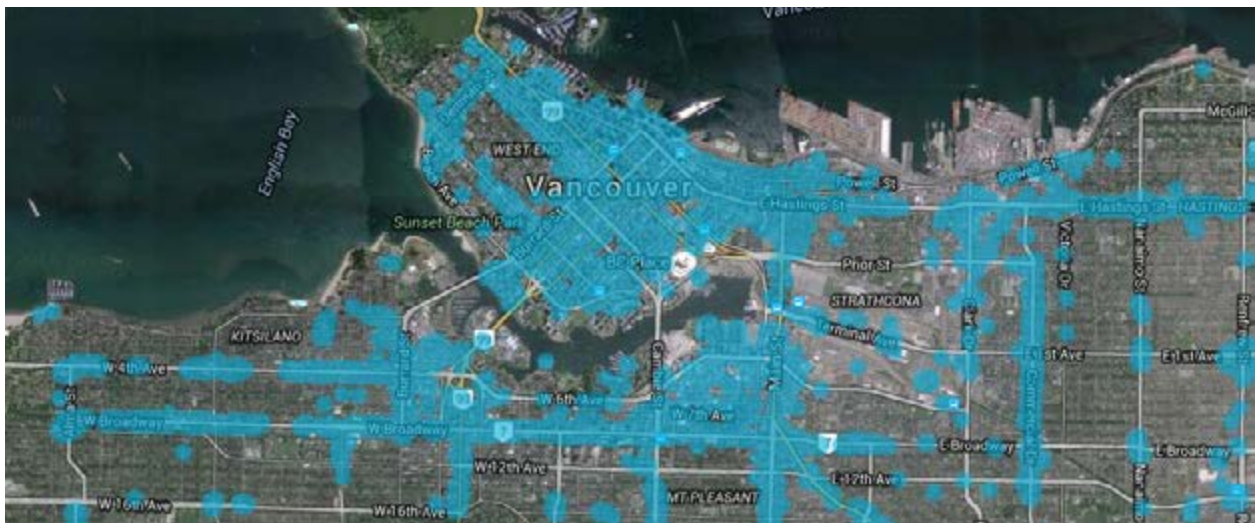
Dear Mr Robertson,

In 2003, when I worked for the World Health Organization (WHO) in Geneva, the Director General Dr Gro Harlem Brundtland resigned because cell phone radiation was making her ill. Along with countless other doctors, researchers and scientists, Brundtland has stated that “research shows deleterious effects” from the use of cell phones and other devices emitting radiation. “This is not an innocent technology,”¹ she says. It’s an inconvenient truth that we ignore because we’re so far down the rabbit hole of wireless living.

Your campaign to bombard the city with harmful radiation (benignly referred to as Wi-Fi) clearly demonstrates that you are uninformed about the scientifically proven harmful effects of non-ionizing/non-thermal Wi-Fi and other electromagnetic radiation (EMR). It also shows that, as an elected public servant, you have failed to do your own due diligence. In promoting free Wi-Fi as a positive enhancement to the community, you have led people to believe that there is no danger involved and that they can use their various electronic gadgets to their hearts’ content—with no regard for others (babies, children, transit passengers, neighbours etc) affected by them doing so.

Ignored, excluded and incapacitated: citizens forced to flee

Because of this, I’m being forced to leave Vancouver, where I have happily lived since 1992. I am one of a rapidly growing number of people with electromagnetic hypersensitivity (EHS), and I can no longer tolerate the radiation bombarding our beaches, community centres, libraries, cafés, schools, doctors’ offices and even hospitals. **You might appreciate the irony of someone recovering from brain surgery at VGH for the removal of a life-threatening acoustic neuroma, while being bombarded by the very same radiation known to have caused the tumour in the first place.** I’d prefer not to get another one.



The greenest city in the world? Blue areas show Wi-Fi coverage by just one of several Internet service-providers in Vancouver.

¹ See: <http://bit.ly/1V7KBvd> for an interview with Brundtland on the effects of EMR.