

October 18, 2026
Zichron Yaakov
Israel.

Input on Electromagnetic Fields and Wireless Radiation

1. My name is Amir Borenstein. I am an Electromagnetic Hypersensitive (EHS, also known as EMRS – Electromagnetic Radiation Syndrome) person and an EMF/EMR awareness activist from Israel. My life was massively influenced by EMF/EMR exposure and being EHS. I write this letter in the hope that I will be of some help in the process of evaluating the possible health risks of EMF/EMR, to set new guidelines and regulations, and to acknowledge EHS as a devastating medical condition caused by, influenced by and linked to EMF/EMR exposure.

I am 52 years old, born in 1974. I grew up in Haifa, Israel. I have held a Practical Engineer diploma in Electronic Computer-Controlled Systems since 1994. I am married with 2 daughters (15 & 12).

Please note I am not a native English speaker.

I started feeling headaches when using a cell phone at the age of 22, in 1996/7. I became highly sensitive to EMF/EMR in about 2004. Back then there was almost no information about the possible health risk of EMF/EMR exposure and about EHS. I myself was not aware of either. All official information stated that there were no possible health effects and almost nothing about EHS. My doctors did not know anything about it (most still don't).

I think that this situation, in which the official information is that there are no possible health effects from EMF/EMR exposure and that EHS is not related to it, is unacceptable today. Such a situation, in which people are getting hurt, are not aware of the possible cause, can't get help or relief, and their condition is dismissed and ignored, is unjust and does not serve public health, the economy, technology, progress, or society as a whole.

Since 2004 I slowly started learning about EMF/EMR and EHS. Shortly after, I started measuring and reducing my exposure. Since then I have been managing my EHS condition, and I am slowly getting better and better.

In about 2005, after becoming a bit stronger and better, I started writing about EMR, EHS and my experience in a blog, which later became an info site www.norad4u.com (and www.norad4u.co.il in Hebrew). I started helping other EHS people, both in Israel and worldwide. And I also started making videos about EMF/EMR and EHS on my YouTube channels - <https://www.youtube.com/@NoRadBlog> , <https://www.youtube.com/@amirborenstein-norad4u>

Over the years I have become an activist, trying to share my story, views, knowledge and understanding of EMR/EMF and EHS. I came in contact and cooperated with several activists and scientists worldwide, and was part of several conventions about EMR/EMF and EHS (including Environmental Health Trust (EHT); Devra Davis, PhD, MPH; Prof. Elihu Richter, MD, MPH; Yael Stein, MD; Paul Ben-Ishai, PhD; Dafna Tachover, LL.M; and many others).

From 2006 to 2020 I took part in meetings of the committees of the Israeli parliament (Knesset) many times. I tried to cooperate with the Israeli Ministry of Health and the Ministry of Environmental Protection, regarding the acknowledgement of EHS, and resetting the so-called safety standards. Their final view on the matter was usually summed up in the words "we are working according to the orders and guidelines of the World Health Organization".

I was also part of the petition to the Israeli Supreme Court (2012-2015) to stop the WIFI deployment, and use of wireless radiating devices, in schools, due to the possible health effects it might have on students and several cases of EHS in students who were already suffering.

My career started in 1994 as technical personnel in the Israeli Air Force for 3 years. In 1997 I moved to civilian High-Tech, where I worked for 16 years in leading High-Tech companies such as Zoran, EMS2, VMware. I quit High-Tech in 2013, as the RF radiation exposure in the workplace became higher and higher and as more people started using smart phones and wireless devices all the time and everywhere.

Until now I have been able to cope with every new tech move and deployment of RF-based infrastructure and technology. But the future is not certain for us EHS people, as more cell towers are being erected, 5G and other advanced RF technologies are being deployed. We are all one day away from becoming refugees in our own land, if someone decides to install an EMF/EMR (mainly RF) emitting device next to our house, for example, a cell tower.

Today (10/2026, since 2013), I am working from home, running a small business of supporting other EHS people and manufacturing EMR protection products and meters (see www.4EHSByEHS.com). Over the years I have supported many EHS people both inside Israel and across the world. Many of them had to leave their homes, work and even country in order to ease the suffering.

I run a few Facebook groups, for EHS people and for people who understand the possible health risk of exposure to EMF/EMR and want to reduce it.

My full story (and other people's stories) is available on my site:
Mine - <https://www.norad4u.com/ehs/ehs-stories/amir-borenstein/>

All - <https://www.norad4u.com/ehs/ehs-stories/>

2. Q2 - I am submitting this comment as my daughter and I are patients (EHS).
In addition, I am an activist and a professional in the field of EMF/EMR measurement, mitigation, EHS support, and supplying information to the public.
3. Q3 - Experiences regarding potential adverse health effects I believe are associated with exposure to RF/EMFs:
 - a. Technologies - Mainly RF from smart phones, cell phones, wireless devices, cell towers, smart cars, smart meters, WIFI routers, WIFI/Bluetooth equipment, and also ELF magnetic and electric fields from infrastructure and appliances.
 - b. "The nature, duration, frequency, and approximate timing of the reported exposure(s)" – Daily exposure over years and years, causes and contributes to symptoms, EHS condition, and other health effects.
 - c. "The potential adverse health effects experienced" . – Headaches, Heat sensation, Redness in the face, Rush of blood to the head, Pressure on the head temples, Pressure inside the ears, Restlessness, Concentration problems, Tingling sensations, Fatigue, Memory problems, Depression, Ringing in the ears and noises in the head.
 - d. "When potential adverse health effects first appeared relative to when exposure began and whether any changes in exposure coincided with potential adverse health effects" -

I first noticed that I felt pain from Radio Frequency radiation (then it was mainly headaches), when I used a cell phone for the first time in 1996. When it happened again, I understood it was the RF radiation. This started a 9-year period of what I call "light EHS". In these 9 years I felt symptoms mostly when I tried to use RF emitting devices such as cell phones and WIFI devices. Back then I was OK when standing next to other users, or in front of a cell tower or other environmental source of EMF/EMR.

In about 2004 my condition started to worsen. I started feeling bad, with more and more symptoms, faster, for longer, and in a more drastic way. I noticed that I felt bad when exposed not just to RF radiation from cell phones, but also from cell towers, low-frequency magnetic and electric fields from power lines, infrastructure, home appliances and lab equipment. The symptoms appeared a few minutes after exposure started, and faded away a few hours or days after the exposure ended. This is what I call today "High EHS".

Today (2026) I am usually doing much better. Symptoms usually appear after half an hour of environmental exposure to RF levels of about 0.1-1 $\mu\text{W}/\text{cm}^2$ or higher.

On most days, I can visit stores or shopping centers, walk the streets in my town, and drive my car around, usually with only light symptoms. To some extent I can be (for a short while) around people with smartphones. But if the exposure is higher (for example, a room full of smartphone users for several hours, the main streets of big cities, offices, modern workplaces, hospitals, classrooms), or repeated (day after day), symptoms will appear and become more drastic, and I predict that my EHS condition will become worse again.

I live in a low EMF house (RF lower than $0.0001 \mu\text{W}/\text{cm}^2$, magnetic field lower than 2mG, and electric field lower than 2V/m). I work from home and go outside when needed, for short trips/outings. My home is fully wired. There is some RF and ELF magnetic protection in the house.

We (myself and my daughters 12 & 15) don't use smartphones or wireless devices. Only wired, non-transmitting equipment. My wife doesn't use smartphones in the house (she is not EHS, she uses one only outside or at work).

In 2024, my then 13-year-old daughter started feeling headaches and other symptoms when being around smartphones. The symptoms started after attending a class in her school where everyone used their smart phones as part of the lesson. Since then, I have been helping with her recovery and her continued effort to get better. We are still struggling with her exposure in her high school, where WIFI/Bluetooth equipment is in use in every classroom, and there is also some use of smartphones.

e. "Whether medical evaluation or treatment was sought, including any diagnoses received (if the respondent chooses to share them)." - I went through a round of medical diagnostics and tests (including CT), and when the results came back they were "Everything is OK". When I told my doctors that I believe my condition has something to do with Electromagnetic Radiation (EMR/EMF), they giggled and said "it is not possible".

For my daughter, we did some medical tests (not including CT or MRI), all is OK.

f. "Whether steps to reduce or eliminate exposure were taken and, if so, whether any subsequent changes in potential adverse health effects were observed." -

I started connecting the dots myself back in 2004 after half a year of daily suffering. I started gathering information from several web sites, mainly <https://www.powerwatch.org.uk>, and from a book about cell-towers and EMR/EMF radiation that was written by Iris Atzmon. Then I got an RF meter and started to measure the RF in my house, office, lab (I was running one as part of my job obligations), and car. Then I started drastically minimizing my exposure to several types of EMR.

Soon I became better, at least when my exposure to EMF was relatively low (lower than

0.004 $\mu\text{W}/\text{cm}^2$). When my exposure to EMR/EMF was high (higher than 0.1 $\mu\text{W}/\text{cm}^2$), after a few minutes, I felt more symptoms. When the exposure was lower, I felt better. It usually took a few hours to days for the symptoms to fade away. It was not easy to continue working while being EHS. Pain, symptoms, frustration, the constant struggle to keep my exposure levels as low as possible, and facing disbelief from others. This struggle continues even today. I get better and better at it, but it is still a struggle.

Since then, my condition has been slowly getting better, as I continued to reduce my exposure and to improve my health in other ways.

Regarding my daughter, as she started having symptoms, I guided her and helped her to measure and reduce exposure. Her condition and its severity have improved since.

In both our cases, there are daily challenges.

The biggest challenge we currently face is that my daughter has to attend a high school that is fully packed with WIFI, smartphones, wireless devices and other EMF/EMR sources. It is especially difficult as the Ministry of Health and the Ministry of Education in Israel do not acknowledge that EHS is a real condition caused and influenced by EMF/EMR exposure.

g. "Any supporting documentation, including scientific reports, exposure measurements, or other relevant information." – None.

4. Q4 - "We invite healthcare professionals, researchers, and public health practitioners to describe observations from clinical practice, occupational settings, or research that may help identify patterns, if any, of reported potential adverse health effects associated with RF/EMF radiation and exposure. In describing these observations" -

Since 2006 and to this day (2026), I have been technically supporting EHS people in Israel and all over the world. I help them find, or sell to them, EMF/EMR meters, personal EMF protection, and EMF/EMR home protection. In addition, I teach them the basics of EMF/EMR and EHS. I will gladly share my accumulated knowledge and understanding, within the law and without violating privacy.

h. "The types of potential adverse health effects reported" - EMF/EMR exposure in my opinion contributes to a list of symptoms (EHS), worsening of existing medical conditions, and in the long term may result in what most people fear the most, cancer.

EHS is one of the health effects of EMF/EMR exposure. EHS symptoms are the short-term health effects of EMF/EMR exposure. The exposure affects people from all walks of life. Males and females. Usually without any understanding of RF or EMF. Most don't connect their symptoms to their usage or exposure, or are not aware of the existence of EHS as a condition.

They usually start to suffer from symptoms when using their smart phones for long hours. Some start having symptoms when living close to a cell tower (20-100 meters away in clear view), after some new device or infrastructure was installed (like a smart meter), and some after getting a hybrid or electric car.

Studies showed more symptoms, and more extreme symptoms, in people who lived near cell towers or used EMF/EMR emitting devices more frequently or heavily (Santini et al., 2002 [1]; Navarro et al., 2003 [2]; Oberfeld et al., 2004 [3]; Gómez-Perretta et al., 2013 [4]; Buchner & Eger, 2011 [5]; Shinjyo & Shinjyo, 2014 [6]; Silva et al., 2015 [7]; López et al., 2021 [8]; Hardell & Nilsson, 2024 [9]; Thomée et al., 2011 [10]; Divan et al., 2008 [11]; Wang et al., 2014 [12]; Hadar et al., 2017 [13]; Alrubaia et al., 2025 [14]; Bijlsma et al., 2024 [15]; Hagström et al., 2013 [16]; Kato & Johansson, 2012 [17]; Hutter et al., 2006 [18]).

When EHS people stop use and reduce exposure, their symptoms and condition usually improve (Hagström et al., 2012 [19]; Hagström et al., 2013 [16]; Kato & Johansson, 2012 [17]; Shinjyo & Shinjyo, 2014 [6]; Hardell & Nilsson, 2024 [9]; Havas, 2006 [20]; Havas & Olstad, 2008 [21]; Belyaev et al. (EUROPAEM EMF Guideline), 2016 [22]; Austrian Medical Association (AG-EMF Guideline), 2012 [23]; Nordic Council of Ministers (ICD-10 Nordic Occupational), 2000 [24]; Council of Europe PACE Resolution 1815, 2011 [25]).

I have a guide for handling EHS on my site - <https://www.norad4u.com/ehs/handling-ehs/>

In addition, there are guides about exposure measurement (<https://www.norad4u.com/guides/step-by-step-emf-measurement-guide/>), exposure reduction (<https://www.norad4u.com/guides/first-steps-in-emf-radiation-exposure-reduction/>), and protection (<https://www.norad4u.com/guides/no-rads-step-by-step-guide-for-rf-home-protection/>).

I call my process “The 4-step plan – Know, monitor, reduce, protect” - <https://www.norad4u.com/guides/no-rads-4-steps-program/>

Studies show that exposure to EMF/EMR can be linked to, lead to, or worsen other health conditions (Havas, 2008 [26]; Havas, 2006 [20]; Havas & Olstad, 2008 [21]; Herbert & Sage, 2013 (Part I) [27]; Herbert & Sage, 2013 (Part II) [28]; Pall, 2024 [29]; Agarwal et al., 2008 [30]; Houston et al., 2016 [31]; Redmayne & Johansson, 2014 [32]).

Studies showed that exposure to EMF/EMR can be linked to, lead to, or promote cancer. The NTP study of the US National Toxicology Program, 2018 [33, 34], found more heart schwannomas and brain gliomas, and more DNA damage, in rats exposed to cell phone radiation. The Interphone study, 2010 [35], showed that people who talked on their phone for more than about 27 minutes a day for 10 years had higher rates of glioma. Hardell and Carlberg, in several case-control studies (2013–2017 [36, 37, 38]), found a

higher risk of glioma and acoustic neuroma in long-term users of mobile and cordless phones, especially on the side of the head where the phone was held. The French CERENAT study (Coureau, 2014 [39]) found about 2–3 times higher risk of glioma and meningioma in the heaviest users. Sadetzki, 2008 [40], found a higher risk of parotid gland tumors in heavy users in Israel. Czerninski, 2011 [41], reported a sharp rise in malignant parotid tumors in Israel. Duan, 2011 [42], in China, linked heavy phone use to parotid gland cancer. West, 2013 [43], described young women who developed breast cancer exactly where they kept their phones in their bras. Myung, 2009 [44], in a meta-analysis, found that the higher-quality studies showed a higher tumor risk. Hallberg and Johansson, 2011 [45], reported rising rates of head melanoma in the Nordic countries. Dobes, 2011 [46], found a rise in primary brain tumors in Australia. Hardell and Carlberg, 2015 [47] and 2017 [48], reported rising brain tumor rates in Swedish registers. Little, 2012 [49], compared US glioma trends with the risks found in phone studies. Luo, 2019 [50], found a suggestive (non-significant) increase in thyroid microcarcinoma in heavy users. Miller, 2018 [51], reviewed the evidence and concluded that RF should be classified as carcinogenic to humans (IARC Group 1).

Dode, 2011 [52], found higher cancer mortality among people living within 500 m of base stations in Belo Horizonte, Brazil. Eger, 2004 [53] (Naila, Germany), found three times more new cancer cases within 400 m of a base station after five years of operation. Wolf and Wolf, 2004 [54] (Netanya, Israel), found about 4.15 times more cancer cases near an antenna. López, 2021 [8] (Vallecas, Madrid), reported more headaches, dizziness and nightmares in residents with higher exposure. Dolk, 1997 [55], found more adult leukemia near the Sutton Coldfield TV and radio transmitter in the UK.

Szmigielski, 1996 [56], found that Polish soldiers exposed to RF and microwaves had about twice the cancer risk. Groves, 2002 [57], found more nonlymphocytic leukemia in US Navy radar technicians from the Korean War. Goldsmith, 1995 [58], reviewed the military and broadcast data and found more cancer of the blood, brain and breast. Richter, 2002 [59], described brain cancers that developed less than 10 years after exposure began in young Israeli radar workers. Kliukiene, 2003 [60], found more breast cancer in Norwegian women working as radio and telegraph operators. Peleg, 2018 [61], found a high share of blood and lymphatic cancers, at a young age, among Israeli military workers exposed to RF. Peleg, 2023 [62], found cancer incidence about 8 times higher than expected among soldiers in ground-to-air missile batteries who were exposed to radio frequency radiation in the Israeli Air Force.

Wertheimer and Leeper, 1979 [63] and 1982 [64], linked childhood and adult cancer to high-current wiring near the home. Savitz, 1988 [65], found more childhood leukemia and cancer at 2 mG and above (not statistically significant). Washburn, 1994 [66], Meinert and Michaelis, 1996 [67], and Angelillo and Villari, 1999 [68], all meta-analyses, found a higher risk of childhood leukemia near power lines. Baldi, 2011 [69], found a higher risk of meningioma with exposure to ELF fields. Beniashvili, 2005 [70], found more use of electrical appliances among elderly women with breast cancer.

Tillmann, 2010 [71], and Lerchl, 2015 [72], showed that RF below the human exposure limits promoted lung and liver tumors in mice. Leszczynski, 2002 [73], found that phone radiation activated a stress pathway in human cells that is linked to cancer. Nazıroğlu, 2012 [74], found that 2.45 GHz Wi-Fi increased the proliferation of human leukemia cells. Yakymenko, 2011, and Belpomme, 2018 [75], reviewed the evidence that long-term low-level exposure promotes cancer.

i. “Onset of potential adverse health effects.” - The symptoms EHS people have are: Mild to heavy headaches, Chronic fatigue, Eye itching, Skin problems and rashes, Ringing ears (tinnitus), noise in the ears, pressure build-up in the ears, Dizziness, Nausea, General weakness, Muscle and joint pain, Sleep disorders, Respiratory problems, Balance Problems, Depression, Memory problems (short term), Cardiac arrhythmia, Muscle tension.

Usually symptoms appear during or shortly after exposure to EMF/EMR. Usually, they fade away a few hours or days after the exposure ends. Sometimes only one symptom appears or is more prominent, sometimes two or more.

As the sensitivity becomes more severe, more symptoms appear, faster, they are stronger and last for longer.

Symptoms and onset

Belpomme et al., 2015 [76]. Studied a large group of patients. The most common symptoms were headache, tinnitus, fatigue, insomnia, attention and memory problems, and depression. They also found biomarkers in the blood and abnormal blood flow in the brain. **Carpenter, 2015 [77].** Shows that the same set of symptoms, called “microwave syndrome”, was described as early as the 1950s–70s in radar and military workers. **Santini et al., 2002 [1], and Navarro et al., 2003 [2].** Found a similar list of symptoms in people living near base stations: fatigue, headache, sleep problems, irritability and concentration problems. Symptoms were more frequent the closer people lived to the antenna, or the higher the measured RF level. **Dieudonné, 2016 [78].** A qualitative study in France. In many people, the symptoms appeared before they suspected EMF, which argues against the idea that the cause is only expectation (nocebo). **Belpomme et al., 2021 [79].** A consensus of 32 scientists calling for EHS to be recognized as a neurological disorder. **Stein & Udasin, 2020 [80].** A review of the mechanisms behind EHS.

Triggers

Hagström et al., 2013 [16] (Finland). The most common triggers were computers (50.8%) and mobile phones (47%), followed by other wireless devices. **Kato & Johansson, 2012 [17] (Japan).** Base stations, mobile phones and other people’s phones on trains and buses were the main triggers. Many people had to change their homes, jobs and daily routine. **McCarty et al., 2011 [81].** In a double-blind test, symptoms such

as headache, muscle twitching and skipped heartbeats appeared mainly when a 60 Hz field was switched on or off. **Hardell & Nilsson, 2024 [9]**. Seven Swedish cases in which microwave syndrome appeared after 5G was installed near the home.

Recurrence

Hardell & Nilsson, 2024 [9]. Symptoms returned each time the person was exposed again, and eased when they moved away from the source. **Hagström et al., 2013 [16]**. Even after the acute phase, many people still reacted to wireless devices. **Nordic Council of Ministers (ICD-10 Nordic), 2000 [24]**. Describes symptoms that appear near electrical equipment and disappear in an “electricity-free” environment.

Reduction

Hagström et al., 2013 [16]. 76% said reducing exposure helped them recover partly or fully. It was the most effective coping method. **Hagström et al., 2012 [19]**. A shielded computer reduced symptoms. Some people with EHS were able to work a full day. **Shinjo & Shinjo, 2014 [6]**. Residents’ symptoms dropped significantly after a base station was removed from the roof. **Johansson, 2015 [82]**. Describes EHS as a functional impairment caused by an environment that people with EHS can’t access, and calls for low-exposure environments. **EUROPAEM guideline (Belyaev et al.), 2016 [22], and the Austrian Medical Association guideline, 2012 [23]**. Both list the typical symptoms, base diagnosis on the link between exposure and symptoms, and recommend reducing exposure as the main treatment.

j. “Characteristics of the individuals or populations involved, excluding any identifying information such as PII or PHI.” – Mostly people who used to be heavy cell phone users (more than 1 hour per day talking/webbing), or living close to a cell tower (20-100 meters away in clear view), and some after getting a hybrid or electric car, or after starting to use a new EMF/EMR emitting device or having it installed next to them. Males and females alike, usually grownups, less commonly children.

Sex and age. Most people who report EHS are women, and most are middle-aged adults. Hagström et al. (2013 [16]) surveyed self-diagnosed EHS people in Finland; 80.9% of the respondents were women. Kato & Johansson (2012 [17]) surveyed 75 EHS people in Japan, and 95% were women. Belpomme et al. (2015 [76]) examined 727 patients; two out of three were female and the mean age was 47. Santini et al. (2002 [1]) found that among residents living near base stations, women reported headache, nausea, sleep problems, depression and visual disturbances significantly more often than men.

Co-existing conditions. EHS often appears together with other sensitivities. In Belpomme et al. (2015 [76]), 71.6% had EHS, 7.2% had multiple chemical sensitivity (MCS), and 21.2% had both. About 40% had raised histamine, which is a sign of chronic inflammation. De Luca et al. (2014 [83]) compared 153 EHS subjects, 147 MCS subjects and 132 controls, and found metabolic and genetic differences, with an overlap between EHS and MCS. In Hagström et al. (2013 [16]), the most common health

problem before the onset of EHS was allergies (35.1%). Piras et al. (2022 [84]) studied 54 fibromyalgia patients whose symptoms are triggered or made worse by electrical devices, and found 19 altered blood metabolites compared with healthy people.

Onset and history. Dieudonné (2016 [78]) interviewed 40 EHS people and found that symptoms usually appeared before they suspected EMF. Heuser & Heuser (2017 [85]) examined 10 adults who developed EHS after long-term repeated exposure, and all of them had abnormal fMRI brain scans. Hedendahl et al. (2015 [86]) described the same symptom pattern in several groups over the years: military radar personnel in the 1970s, Swedish office workers using CRT monitors in the 1980s, and Finns today.

Biological sub-groups. Sonzogni et al. (2025 [87]) took skin cells from 26 adults with EHS and found two distinct sub-groups with different DNA-repair responses.

Daily life and work. In Kato & Johansson (2012 [17]), 53% had a job before EHS, but most lost their work or income. 85% had to take protective measures, including moving home, and 12% could not use public transport at all. Kjellqvist et al. (2016 [88]) compared 114 people with EHS with 104 people from the general population, and the EHS group had more psychological symptoms and a lower health-related quality of life.

Prevalence. Hallberg & Oberfeld (2006 [89]) showed a fast rise in the share of people reporting EHS, and projected that a large part of the population could become electrosensitive.

k. “Any observed exposure patterns.” – When exposure is reduced, symptoms are reduced. When exposure increases, symptoms reappear. In my experience, if the exposure continues or is repeated, the symptoms slowly become worse.

I believe that the number of EHS people is increasing, while most EHS people still don’t understand the sources of their suffering and symptoms, and while most people don’t know anything about the condition, about symptoms related to EMF/EMR exposure, and about their exposure to EMF/EMR.

When exposure is reduced, symptoms are reduced. In a Finnish survey of people with EHS, 76% said that reducing exposure helped them recover partly or fully. It was the most effective coping method (Hagström et al., 2013 [16]). A shielded computer allowed people with EHS to work a full day (Hagström et al., 2012 [19]). Residents’ symptoms dropped significantly after a base station was removed from their roof (Shinjo & Shinjo, 2014 [6]). Health complaints went down after dirty electricity was filtered in schools and homes (Havas, 2006 [20]; Havas & Olstad, 2008 [21]).

When exposure increases, symptoms reappear. Symptoms appeared after 5G was installed near the home, and came back with every new exposure (Hardell & Nilsson, 2024 [9]). In a double-blind test, symptoms appeared mainly when the field was switched on or off (McCarty et al., 2011 [81]). Many people kept reacting to wireless devices even after the acute phase had passed (Hagström et al., 2013 [16]).

Higher exposure, more symptoms. Symptoms were more frequent the closer people lived to a base station (Santini et al., 2002 [1]). Symptom scores rose with the measured RF level in the bedroom (Navarro et al., 2003 [2]). Residents with higher measured exposure reported more headaches, dizziness and sleep problems (López et al., 2021 [8]). Higher exposure was linked to more psychiatric symptoms (Silva et al., 2015 [7]). After an antenna was installed, residents had more symptoms and changes in stress-hormone levels over the following months (Buchner & Eger, 2011 [5]).

The number of people with EHS is increasing, and most don't know the cause. The share of people reporting EHS has risen fast (Hallberg & Oberfeld, 2006 [89]). Several studies describe EHS as a growing problem worldwide, and as an increasing challenge for doctors (Kato & Johansson, 2012 [17]; Hedendahl et al., 2015 [86]). One team alone enrolled 1,216 self-reported cases (Belpomme et al., 2015 [76]). People with EHS usually develop symptoms first and spend a long time without finding a solution before they discover that EMF may be the cause (Dieudonné, 2016 [78]). Because the condition is not recognized, people with EHS often lose work and housing, and many can't use public transport (Kato & Johansson, 2012 [17]; Johansson, 2015 [82]). 32 scientists called for EHS to be recognized so that patients can be identified and diagnosed (Belpomme et al., 2021 [79]).

I. "What standardized methods were used to assess exposure or potential adverse health effects, if any were used." -

In Israel the measurement of EMF is usually done by professional personnel who are trained and approved by the Ministry of Environmental Protection. They follow the so-called "safety standards" of ICNIRP, and sometimes apply lower thresholds and guidelines of the ministry (but still very high and not health based or protective). Usually, the only objective of doing the professional measurements is to determine if the levels are above or below the guidelines. In the process, slow (low sampling rate) EMF meters are used (not picking up RF from phones, WIFI, Bluetooth and other home or personal devices), and the outcome of most, if not all, measurements is "ALL OK". I think this is very problematic as many people who are aware of the possible health risk of EMF/EMR, or who are already suffering, and who rely on these services, wanting to know if there is a long term health risk, or if the measured place is safe for living in, or what can be done in order to reduce exposure, are getting only the "it is within current guidelines" answer.

In contrast, the emphasis I put on the measurement process I guide people to follow is to find sources in the house/office/car, find penetration points to the measured location, find safety distances from ELF EMF sources, and see if exposure reduction/protection was successful. If and when measurements are done to see how much radiation is there, they are done according to BioInitiative, Building Biology and my own recommendations and guidelines, which can be 100,000 times lower than the ICNIRP guidelines.

As part of my “4-step plan”, basic EMR/EMF knowledge is presented for learning so the individuals can learn the types of radiation, sources, how to measure and exposure reduction principles. Learning is done by reading the articles and step by step guides on the info site, printed material that is handed over when buying an EMF meter, or during lectures and tutoring meetings.

The exposure assessment is usually done by the person using fast sampling (>10000 measurement samples per second) EMF meters I recommend or sell. Photos and videos of the measurements are then sent over to me for my evaluation. I then explain and recommend exposure reduction steps (stop using RF emitting device, use wired devices, keep safety distance from ELF magnetic field sources), and personal or Home EMF Protection in case the sources of the exposure are external. We then redo the measurements to verify the exposure is reduced.

I recommend tracking the symptoms and health effects by logging all actions and symptoms in a personal written diary.

I don't keep written records of this activity. I simply teach and explain, some follow, some report back.

Written step-by-step guides are available on my info site - <https://www.norad4u.com/guides/>

m. “Recommendations for future research or surveillance” - The focus should change from “IF IT HAS AN EFFECT” to “HOW IT AFFECTS” & “HOW MUCH”.

There are already lots of studies that show biological & health effects of EMR/EMF, and that prove EHS is real, caused/influenced/affected by EMF/EMR exposure. Most are ignored and rejected by FCC/FDA/ICNIRP/WHO EMF Program. These studies should be reviewed by a study group (or groups) that acknowledge that EMF/EMR is bio-active (not members of FCC or ICNIRP) and may have health effects. These reviews and groups should redefine and establish what the science already shows, and what the gaps are that need to be studied.

For example, some of the studies showing biological mechanisms & effects of [RF radiation](https://www.norad4u.com/emf-science-studies/studies-lists/rf-mechanism/) appear on my info site - <https://www.norad4u.com/emf-science-studies/studies-lists/rf-mechanism/> .

These and other studies, linking EMR/EMF exposure to biological effects and health effects, need to be acknowledged. Then new studies can be done in order to fill the gaps between the Physical effects, the biological effects, the health effects and the link to cancer, neurological, autoimmune diseases, including EHS syndrome.

In the field of EHS, some studies have a faulty exposure logic (repetitive exposure without a real sham exposure) and are based on whether the subject was able to identify if the radiation exists, right away and every time. These faulty studies need to be reviewed and criticized.

For example, in Rubin et al. (2006 [90], <https://pmc.ncbi.nlm.nih.gov/articles/PMC1440612/>), the “sham” condition was treated as no exposure, yet it leaked up to 0.002 W/kg SAR, roughly 4.5 mW/m² (0.45 μW/cm²). In my experience, most moderate-to-severe EHS people react to this level within minutes. The study therefore compared two exposure levels, not exposure versus no exposure, and its conclusion that symptoms during sham were “psychological” is not supported. In addition, Rubin’s studies suffer from several additional flaws, such as multiple exposures with insufficient recovery time, and expecting the subjects to react and recover very fast and guess if the phone is transmitting or not each and every time (100% right).

The WHO EMF Project fact sheet on EHS (2005, never updated, <https://www.who.int/teams/environment-climate-change-and-health/radiation-and-health/non-ionizing/hypersensitivity>) relies mainly on a systematic review by Rubin et al. (2005 [91], <https://europepmc.org/article/MED/15784787>) of provocation studies with the same design flaws. Rubin’s own provocation study (2006 [90]) then used a “sham” condition that leaked up to 0.002 W/kg (roughly 4.5 mW/m², 0.45 μW/cm²), a level many EHS people react to within minutes. This implies that Rubin was not the right person to conduct a systematic review about EHS, but somehow the WHO fact sheet relies on his review.

Please see - Disproving EHS - <https://www.norad4u.com/ehs/studies-disproving-ehs/>

Other studies about EHS that already show objectively measurable effects and changes should be acknowledged and summarized in order to create an official body of science about EHS, and in order to identify the gaps in science that need to be addressed in order to prove and acknowledge EHS as related to and caused by EMF/EMR exposure.

Please see - Acknowledging EHS - <https://www.norad4u.com/ehs/studies-supporting-ehs/>

The paradigm should change from “disproving EHS” to “finding the cause, source and acknowledging EHS as related to EMF/EMR exposure”. Then more studies about ways of coping and improving the condition could be done as well.

In addition, more studies should be done in order to find out how many people are affected daily, how many of them are suffering, and how many know the cause and how to handle it.

Better new EHS studies are needed, in which the exposure should be measured & reported, subjects should be exposed only to the type of EMF/EMR that they are most affected by, sham exposure should be lower than $0.0001 \mu\text{W}/\text{cm}^2$ (RF), 1mG (0.1uT, ELF magnetic field), and 1 V/m (ELF Electric field), and the effect of the exposure on the subjects should be objectively measured (not asking him/her if he/she feels the radiation right away).

More studies about the way of handling EHS are also needed.

Please see my info site for existing studies about EHS:

General - <https://www.norad4u.com/emf-science-studies/studies-lists/studies-ehs/>

5. Q5 - “What existing national and international exposure standards, guidelines, or regulatory frameworks should federal health agencies consider when evaluating the potential adverse health effects of human exposure to RF/EMF” - Future standards and guidelines should be based on the understanding that there are possible health effects, and biological effects both to long term, and short term exposure to EMR/EMF, even in very low levels (lower than $0.1 \mu\text{W}/\text{cm}^2$), and that EHS is related to, caused by and affected by EMF/EMR exposure.

n. “What scientific, technical, or regulatory changes by federal health agencies, if any, would improve the assessment, disclosure, and regulation of wireless radiation exposure” - A baseline for future standards can be the “BioInitiative Report” from 2012 (<http://www.bioinitiative.org/conclusions/>), the Council of Europe Parliamentary Assembly Resolution 1815 of 2011 [25] - “The potential dangers of electromagnetic fields and their effect on the environment” (<https://pace.coe.int/en/files/17994/html>, <https://pace.coe.int/pdf/233b04ac9f47488394cf2da0c9149dbcaa298c4f4a0c1a7898669d6e85738910/res.%201815.pdf>), and the guidelines of “Building Biology” (https://www.baubiologie.de/downloads/english/richtwerte_2008_englisch.pdf, https://buildingbiology.com/site/downloads/SBM-2024_EVALUATION_GUIDELINES_EN.pdf).

o. “Is additional research needed to develop, test, and evaluate the effectiveness of procedures and techniques for minimizing exposure to electronic product radiation?” – Yes, the largest gap other than the acknowledgement of EMR/EMF as possibly having

health effects & biological effects, even in very low levels (and acknowledging EHS as caused by/related to/influenced by EMF/EMR) is that current measurement of the exposure is done according to the ICNIRP or FCC guidelines, usually using slow sampling rate meters that measure the radiation 2-5 times every second and then average the exposure over several minutes (usually 6). This way, only constant digital and analog RF sources, with 100% duty cycle RF transmissions can be measured correctly. These meters do not correctly measure digital signals with a duty cycle below 100%. These meters usually can't identify or measure RF from fast changing digital exposure such as from cell phones, WIFI, Bluetooth, and similar fast changing sources.

If we want to better measure the exposure, the measurement should be done only by fast sampling rate meters (higher than 10000 times per second) that show the peak value every 500 milliseconds.

Then it should be possible to develop a measuring protocol for long term exposure, occupational, daily, and short exposure.

p. "How, if at all, should a classification system account for exposure-related characteristics" – Peak values over 0.5 second, based on as many samples as possible (at least 10000 per second) should be the cornerstone of the measurement. Max values, average over 1 minute or less, duty cycle, and time span logs should all be calculated based on the peak values.

If possible, there should also be a way to measure the exposure over the frequency span (number of signals, coverage of frequency windows, main frequencies), over time with a resolution of micro- or nanoseconds (since every pulse counts and affects, not just the average), and also number of sources in the area.

FCC and ICNIRP guidelines for meters and measurements should be abandoned, as they are based on the wrong basic assumption that EMF/EMR have no biological and/or health effects other than heating the tissue at very high levels. New guidelines, based on the recognition of biological and health effects of EMF/EMR, while acknowledging EHS as related and caused by EMF/EMR exposure, should be compiled and approved.

The SAR standard should not be used. Instead, new head/body exposure standards should be compiled, based on measuring the RF exposure in the far field and calculating the exposure in the near field. This should then be compared to new guidelines that are based on the acknowledgment of studies showing biological and health effects, even in low levels of exposure.

Finally, faulty provocation studies (like Rubin 2006 [90]) with serious design flaws should be re-evaluated and should not be cited as proof that EHS is not caused/influenced/affected by EMF exposure. The WHO EHS fact sheet should be altered to acknowledge EHS as a medical condition linked to, caused by, or influenced by EMF/EMR exposure. As EHS people are affected by the radiation very quickly and

drastically, compared to non-EHS people, all guidelines (levels, measurement techniques, meters) should have adaptations and recommendations for EHS people.

Please see:

Self-referencing authorships behind the ICNIRP 2020 radiation protection guidelines -

<https://www.degruyterbrill.com/document/doi/10.1515/reveh-2022-0037/html>

Radiation Protection Policy Dominated by Industry-Tied Unscientific Lobby Organization

ICNIRP - <https://ehtrust.org/radiation-protection-policy-dominated-by-industry-tied-unscientific-lobby-organization-icnirp/>

Cell Phone Radiation Exposure Limits and Engineering Solutions

- <https://doi.org/10.3390/ijerph20075398>

Problems in evaluating the health impacts of radio frequency radiation

Paul Ben-Ishai, Devra Davis, Hugh Taylor, Linda Birnbaum

<https://doi.org/10.1016/j.envres.2022.115038>

Main Regularities and Health Risks from Exposure to Non-Thermal Microwaves of

Mobile Communication - doi: [10.1109/TELSIKS46999.2019.9002324](https://doi.org/10.1109/TELSIKS46999.2019.9002324).

Health risks from radiofrequency radiation, including 5G, should be assessed by experts

with no conflicts of interest - <https://doi.org/10.3892/ol.2020.11876>

Scientific evidence invalidates health assumptions underlying the FCC and ICNIRP

exposure limit determinations for radiofrequency radiation: implications for 5G -

International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF)

- PMID: [36253855](https://pubmed.ncbi.nlm.nih.gov/36253855/) - <https://pmc.ncbi.nlm.nih.gov/articles/PMC9576312/>

DOI <https://doi.org/10.1186/s12940-022-00900-9>

6. Q6 - “What scientific evidence exists about potential adverse health effects caused by current exposure limits?” - Current FCC, FDA and ICNIRP standards are based on the assumption that there is no long-term health effect from exposure to EMR/EMF. These standards protect the industry and not public health. They allow exposure of people, young and old, to high levels of EMF/EMR both from the environment and from home/personal devices.

Meanwhile, studies show biological changes, biological damage, health effects, symptoms and possible link to cancer and other diseases related to EMF/EMR.

Reviews and the scientific basis of the limits. The ICBE-EMF (2022 [92]) showed that the FCC and ICNIRP limits rest on behavioral studies from the 1980s in 5 monkeys and 8 rats, and on the assumption that only heating matters. It concluded that more recent evidence invalidates these assumptions. Yakymenko et al. (2016 [93]) found that 93 of 100 studies on low-intensity RF reported oxidative stress effects in living cells. Pall (2013

[94]) showed, from 23 studies, that EMF effects are mediated by activation of voltage-gated calcium channels, at non-thermal levels. Panagopoulos et al. (2025 [95]) described how the modulated, pulsed and variable signals of wireless communication cause biological effects that the heating-based limits don't consider. Belpomme et al. (2018 [75]) and Miller et al. (2018 [51]) reviewed the health effects of low-level exposure and called for stricter limits.

Laboratory studies below the limits. Salford et al. (2003 [96]) found nerve cell damage and leakage of the blood–brain barrier in rats after 2 hours of GSM exposure at SAR levels far below the limits (2–200 mW/kg). Tillmann et al. (2010 [71]) and Lerchl et al. (2015 [72]) showed that RF promotes lung and liver tumors in mice at exposure levels below the human limits. Bijlsma et al. (2024 [15]) found that 2.45 GHz exposure during sleep, similar to a baby monitor, reduced sleep quality. Papageorgiou et al. (2011 [97]) found changes in attention-related brain activity during Wi-Fi exposure. McCarty et al. (2011 [81]) found symptoms in an EHS subject from a low-frequency electric field far weaker than the limits.

Living near base stations (exposure far below the limits). Santini et al. (2002 [1]), Navarro et al. (2003 [2]), Gómez-Perretta et al. (2013 [4]), Hutter et al. (2006 [18]), López et al. (2021 [8]) and Silva et al. (2015 [7]) found more headaches, sleep problems, fatigue and other symptoms the closer people lived to an antenna, or the higher the measured exposure. Buchner & Eger (2011 [5]) found stress-hormone changes after a new antenna was switched on. Shinjyo & Shinjyo (2014 [6]) found that symptoms dropped after an antenna was removed. Meo et al. (2015 [98]) found higher HbA1c in students at the school with higher exposure. Dode et al. (2011 [52]) found higher cancer mortality near base stations in Brazil.

Phones and wireless devices certified within the limits. Volkow et al. (2011 [99]) found that 50 minutes of exposure to a cell phone increased glucose metabolism in the part of the brain closest to the antenna. Foerster et al. (2018 [100]) found poorer memory in adolescents with a higher RF brain dose. Havas & Marrongelle (2013 [101]) found heart-rate variability changes during exposure to a cordless phone. The Interphone Study Group (2010 [35]), Hardell & Carlberg (2015 [37]) and Coureau et al. (2014 [39]) found a higher risk of brain tumors in heavy users of phones that are all certified within the SAR limits.

Low-frequency magnetic fields from power lines (far below the ICNIRP limit of 2,000 mG). Savitz et al. (1988 [65]) found more childhood leukemia at 2 mG and above (not statistically significant). Wertheimer & Leeper (1979 [63], 1982 [64]), Washburn et al. (1994 [66]), Meinert & Michaelis (1996 [67]) and Angelillo & Villari (1999 [68]) found a higher risk of childhood leukemia near power lines. Baldi et al. (2011 [69]) found a higher risk of meningioma.

Please also see:

Science Reports & Declarations on my info site - <https://www.norad4u.com/emf-science-studies/reports-declarations/>

Lists of studies of biological and health effects of EMF/EMR on my info site - <https://www.norad4u.com/emf-science-studies/studies-lists/>

Biological Effects of Non-Ionizing Radiation in Animals - <https://www.tandfonline.com/doi/full/10.1080/09553002.2024.2435329>

A comprehensive mechanism of biological and health effects of anthropogenic extremely low frequency and wireless communication electromagnetic fields
<https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2025.1585441/full>
DOI: 10.3389/fpubh.2025.1585441

7. Q7 - “What scientific methods are currently available for accurately characterizing individual and population-level RF radiation exposure?” – Quick short-term and long-term measurement of the exposure (over a second, minute, hour, day), with high sampling rate meters, showing peak values, when the required levels are as in the BioInitiative report (<http://www.bioinitiative.org/conclusions/>) & “Building Biology” recommendations (https://buildingbiology.com/site/downloads/SBM-2024_EVALUATION_GUIDELINES_EN.pdf).

In addition, measurement across the frequency span with high sampling rate spectrum analyzers.

8. Q8 - “What, if any, improvements in exposure assessment methodologies are needed to better evaluate real-world exposure conditions?” – The goal of the measurements should not be only in order to prove that the exposure is below or above the standard (as done today), but in order to analyze the exposure (across time, frequency, number of sources), find the sources and where the radiation is coming from, and to see that after exposure reduction the levels dropped.

Measurements of Peak values over 0.5 second, based on as many samples as possible (at least 10000 per second) should be the cornerstone of the measurement. Max values, average over 1 minute or less, duty cycle, and time span logs should all be calculated based on the peak values.

If possible, there should also be a way to measure the exposure over the frequency span (number of signals, coverage of frequency windows, main frequencies), over time with a resolution of micro- or nanoseconds (since every pulse counts and affects, not just the average), and also number of sources in the area.

Please see my talk at “2020 Expert Forum: Wireless and Cellphone Radiation and Public Policy” at Tel Aviv University (TAU), about the problems in EMF measurements.

Video link – <http://video.tau.ac.il/events/media/k2/videos/10194.mp4>

9. Q9 - “What, if any, technical and exposure-related information should be disclosed to consumers, residents, workers, schools, healthcare providers, and local governments?”
– Consumers, residents, workers, schools, healthcare providers, and local governments should be informed about the possible biological and health effects of EMF/EMR, about EHS/EMRS condition and its relation to EMF/EMR exposure, about possible sources, about safe distances from devices at which the exposure drops below the level of biological effect, time of exposure before biological effect appears, alternative devices and technologies that can be used for the same goal without exposure to EMF/EMR, and why to reduce the exposure or to completely turn OFF the transmissions.

For consumer electronics, it should be noted on the package of the device, that the device emits EMF/EMR (mainly referring to RF) radiation, and if the transmission can be turned OFF or not. “This device emits RF radiation while working”, “This device can work & function without emitting RF radiation”.

Another option is to note on the device package the distance at which the RF radiation will be lower than $0.1 \mu\text{W}/\text{cm}^2$. For example, “ $0.1 \mu\text{W}/\text{cm}^2$ is expected about 2 meters away from this device when transmitting”.

Regarding healthcare and medical procedures, services, operations and tests, it should be disclosed that the procedure includes RF exposure.

Schools, colleges, universities, public buildings should inform the public about the types of RF transmissions and technologies used in a clear & public way. They should also include which steps are taken to reduce public exposure, and when the last tests were done.

10. Q10 - “What data sources or surveillance systems currently exist to monitor potential adverse health effects associated with RF radiation exposure? Should additional data sources or surveillance systems be developed?” - Today, in Israel and across the world, there is no clear acknowledgment, both by the governments and health professionals of the possible biological and health effects of EMF/EMR, and about EHS and its relation to EMF/EMR. There are no mechanisms (as far as I know) to document the effect of the exposure on public health. Therefore, the effect of EMF/EMR on public health is left unmarked, undocumented and unchecked. In addition, EHS people are left unnoticed, and the public is left in the dark.

The symptoms of exposure to EMR/EMF should be known to the public, and to healthcare professionals, so if a person is starting to experience one or several of them, they will know its possible cause and origin. This might help people stop their usage and

reduce their exposure before their condition (EHS) becomes much worse. This will also allow all healthcare systems to log symptoms and short-term health effects of EMF/EMR exposure.

All medical personnel should be updated on the possible health effects of EMR/EMF and about the possible link between exposure to EMR/EMF, EHS and symptoms. Then the number of EHS people in the population, schools, workplace, city, country, should be surveyed, tracked, documented and reported.

EMR/EMF should be constantly tracked and measured in and around public places and buildings, workplaces, schools & parks, making sure the exposure is restricted only to some areas, for part of the time, and always below health/biology-based safety standards. The outcome of the tests should be public.

In Israel there is a government site with a digital map accessible from every web browser. One of the layers in the map is of active cell towers, showing all active towers, and their info. There is also a layer for soon-to-be-erected cell towers. Most of the time the info includes RF tests results, in some places there is even info from online RF radiation loggers (that sample the RF every few seconds). The test results and logger info are lacking, based on ICNIRP guidelines & test procedure and are done using slow sampling rate meters/loggers. Nationwide cell tower maps (all types) with real info and tests results that will be based on real-time, fast sampling rate RF meters or loggers, will be very helpful to the public.

a. disease registries – EMF/EMR exposure short-term and long-term symptoms, and EHS cases, should be logged and tracked in the general public, in schools, workplaces and neighborhoods, cities, states.

b. occupational monitoring - EMF/EMR exposure short-term and long-term symptoms, and EHS cases, should be logged and tracked also in workplaces, including the Army, Airforce, Navy, National Guard, police, firefighters and other branches of the armed forces.

c. environmental monitoring – RF tests should be done around cell towers. The outcomes should be public. The tests should be done with fast sampling real time meters and according to bio-health-based guidelines.

d. longitudinal cohort studies - Studies should be done incorporating the information from the disease registries, environmental registries and cellphone/smartphone usage info.

e. biomonitoring – bio markers of EMF/EMR exposure should be identified in studies. Then they should be collected from the public during standard blood tests, and/or in medical cases that might be related to EMF/EMR exposure and EHS. This data might also

be used to identify locations in which EMF/EMR exposure might be higher than the bioactive levels causing a peak in the number of people with these bio markers.

f. adverse event reporting – a system open to reports from the public and professionals should be created. Summarized and anonymized info from this system should be public.

g. disease or illness clusters – The medical local and federal health agencies should constantly try to find clusters of high exposures, symptoms, and EHS.

h. The basis for all the above should be the acknowledgement of EMF/EMR possible health effects, and EHS.

11. Q11 - “Should exposure assessment or risk evaluation differ for sensitive populations such as those noted below” – People with EHS require much stricter exposure measurement, lower recommended exposure levels, stricter risk assessment and more thorough exposure reduction.

For EHS people, the effects of exposure are clear, often disabling, and felt within a short time, not after 10 to 50 years, as with the long-term risks discussed for the general population.

In addition, it should also be stricter for people with chronic health issues and cancer, as EMR/EMF exposure can affect their condition and their ability to function and recover.

a. children – based on the assumption that children will have more years of exposure than today’s grownups (used to be true 20 years ago), and that they are still developing, used to be considered more sensitive. I believe children adapt to technology quickly and therefore can become heavy users, very quickly. Therefore, their use and exposure should be limited. For example, not allowing cellphones and smartphones under the age of 16. Authorities should inform parents of the possible health risk of EMF/EMR on their children, and wired alternatives should be specified and promoted.

b. pregnant women - should be informed about the possible health risk and should be encouraged not to use smartphones or wireless devices before & during the pregnancy.

c. older adults – should be informed about the possible health risk and should be encouraged not to use smartphones or wireless devices and use wired technology instead. In Israel the government encourages older adults to use applications, smartphones and wireless devices to improve their communication and even for medical tracking. This should be avoided.

d. individuals with implanted medical devices - should be informed about the possible health risk and the possible interference EMF/EMR can cause to their implants. If an implant emits EMF/EMR (mainly RF), it should be noted to the user, and the

transmission should be limited in power and time.

e. workers with elevated occupational exposure – according to ICNIRP guidelines, workers can be exposed to up to 5 times more radiation. This should be altered. Workers should have the same or stricter exposure guidelines, since their exposure can be mandatory, daily, and at higher levels than for the public.

f. individuals with preexisting medical conditions - should also be stricter for people with chronic health issues and cancer, as EMR/EMF exposure can affect their condition and their ability to function and recover.

g. Other populations that may uniquely experience potential adverse health effects in response to RF radiation – EHS people should be considered as the most receptive and sensitive people to EMF/EMR exposure. The outcome of that exposure to EHS people is fast coming, debilitating, real, and short term. They are not going to be sick in 10, 20 or 30 years; they are suffering today. Therefore, their exposure assessment and risk evaluation should be more focused on reducing exposure, to much lower levels, reducing current symptoms, and improving their condition (reducing sensitivity) as soon and as effectively as possible.

12. Q12 - “What scientific evidence exists regarding potential adverse health effects associated with RF radiation exposure at levels below current federal exposure limits?” - The scientific base that supports the assumption that RF exposure has biological effects and can lead to health effects, is becoming larger as years go by.

Current science shows several biological effects that are caused after a rather short-term exposure to low levels of EMF (not causing heat effect), such as the case of the ELF magnetic field from electric infrastructure and appliances, and to RF radiation from wireless devices, mobile phones, WIFI equipment, cellular masts, and more, in levels of exposure far below the so-called “safe level” of FCC and ICNIRP.

For example, blood-brain barrier disruption and nerve cell damage in the brains of rats (Salford, 2003 [96]), DNA breaks (Lai, 1996 [102]), formation of free radicals and disruption of communication within the cell (Seger and Friedman, 2007 [103]), damage through the activation of voltage-gated calcium channels (Pall, 2013 [94]), changes in brain glucose metabolism from mobile phone exposure (Volkow, 2011 [99]), tumor promotion in mice at exposure below the standards (Lerchl, 2015 [72]), cognitive impairment, increased stress hormone and DNA damage from chronic low-level exposure (Indian team, 2015 [104]), damage to the myelin sheath and hyperactivity in mice (Korean team, 2017 [105]), heating of sweat ducts in the skin at very high frequencies (Feldman and Ben-Ishai, 2018 [106]), a variety of mechanisms through which radiation affects animals (Henshaw and Philips, 2025 [107]), changes in the direction and speed of white blood cells at very low strength (Aly et al., 2008 [108]), and the combination of a carrier wave, modulated information and pulsing as the unique

cause of the effects of man-made radio frequency radiation (Panagopoulos et al., 2025 [95]).

These biological effects and influences, over time and with continued exposure, can lead to health effects, poor health, EHS and other long-term conditions such as cancer.

From biological effects to disease: RF studies on my site

Cancer. Yakymenko et al. (2011 [109]) reviewed evidence that long-term low-intensity microwave exposure from radar and mobile communication causes oxidative stress and promotes cancer growth. Tillmann et al. (2010 [71]) and Lerchl et al. (2015 [72]) showed that RF below the human limits promotes lung and liver tumors that were started by a carcinogen. Leszczynski et al. (2002 [73]) found that phone radiation activated a cellular stress pathway (hsp27/p38MAPK) linked to cancer and to damage of the blood–brain barrier. Nazıroğlu et al. (2012 [74]) found that 2.45 GHz Wi-Fi increased calcium influx and oxidative stress, and caused human leukemia cells to multiply.

The Interphone Study from 2010 [35] showed an increased risk of brain cancer in people who used a cell phone for more than 27 minutes per day for 10 years. The NTP Study showed in 2018 [33] increased cancer rates in rats that were exposed to RF radiation. Lennart Hardell showed in several of his studies an increase in brain cancer in cell phone and cordless phone users.

Brain and nervous system. Salford et al. (2003 [96]) showed that leakage through the blood–brain barrier after GSM exposure was followed by damage to nerve cells in the brain. Redmayne & Johansson (2014 [32]) proposed that myelin damage from RF exposure may explain the functional impairment in EHS.

EHS. Pall (2013 [94]) showed that microwave fields activate voltage-gated calcium channels, which leads to oxidative stress and to neurological and other effects. Belpomme et al. (2015 [76]) found raised histamine (a sign of inflammation), oxidative stress markers and reduced brain blood flow in EHS patients. Sonzogni et al. (2025 [87]) found impaired DNA repair in skin cells from EHS individuals. Stein & Udasin (2020 [80]), Belpomme et al. (2021 [79]) and Henshaw & Philips (2025 [107]) reviewed the mechanisms that lead from biological effects to EHS as a neurological condition.

Autism and broad mechanisms. Herbert & Sage (2013 [27, 28]) and Pall (2024 [29]) described how RF/EMF may contribute to autism, through oxidative stress, calcium overload and effects on brain development. Panagopoulos et al. (2025 [95]) described a comprehensive mechanism by which modulated and pulsed wireless signals cause oxidative stress and DNA damage that can lead to cancer, EHS and infertility.

The BioInitiative (www.bioinitiative.org) report, which was first published in 2007 and

updated in 2012, quotes more than 3800 studies that show many non-thermal effects of both Radio Frequency and Extremely Low-Frequency Electromagnetic Radiation. On the [BioInitiative](#) website, there is a color table of studies, named “RF Color Charts”, that show the studies alongside the RF levels at which biological effects and changes are caused. To view the chart, go to the [main page](#) and search for the “[RF Color Charts](#)”.

Please also see lists of studies and reports regarding EMR/EMF and EHS on my info site:

- a. Biological Mechanism of RF - <https://www.norad4u.com/emf-science-studies/studies-lists/rf-mechanism/>
- b. Reports & Reviews about the possible biological & health effects of EMR/EMF radiation (mainly RF) - <https://www.norad4u.com/emf-science-studies/studies-lists/reports-reviews-emr-emf/>
- c. Cellphones Radiation - <https://www.norad4u.com/emf-science-studies/studies-lists/cell-phone-studies/>
- d. Cell towers health effect & cancer - <https://www.norad4u.com/emf-science-studies/studies-lists/cellular-towers-health-cancer/>
- e. WIFI (a type of RF) health effect & cancer - <https://www.norad4u.com/emf-science-studies/studies-lists/studies-wifi/>
- f. health effects and Cancer from RF Radiation from Radar & military equipment - <https://www.norad4u.com/emf-science-studies/studies-lists/studies-rf-military/>
- g. EMF/EMR from power lines - <https://www.norad4u.com/emf-science-studies/studies-lists/studies-emr-emr-power-lines-and-electrical-systems/>

13. Q13 - “According to scientific evidence, how do the technologies below affect cumulative exposure patterns? a. 5G b. 6G c. Wi-Fi d. Satellite-based communications e. Internet of Things (IoT) f. Wearable technologies g. Smart homes/appliances h. Smart cities i. Autonomous vehicles j. Wireless medical devices k. Communication enabled smart meters” - Each and every technology adds some exposure to the overall personal exposure & in some cases also to the environment.

I believe that exposure to RF from cellphones/smartphones (Low Power but Very Close) and exposure from wearable technologies (Low Power but Very Close), are the biggest contributors to people’s exposure to RF radiation.

Next is the exposure in the house and workplace from WIFI (WIFI routers, WIFI access points, WIFI range extenders and devices), Wireless and smart home electronics and appliances, Smart meters (smart mesh configuration, adding to the exposure in the house) and RF that enters the house from neighbors and/or from cell towers (High Power, but usually from a distance).

In some cases, cars with RF communication technologies are also a dominant cause of RF radiation exposure, but limited to the users.

Autonomous vehicles and wireless medical devices contribute a lot of exposure to the

users, and lower exposure to the environment.

Smart cities can become a more prominent cause of exposure, as the number of cell towers and technologies used as the infrastructure of these smart cities will increase. I have seen videos and reports of measurements from smart cities in the US, and I also measure in Israel's main cities (which can be considered smart) and what I see as the cause and source of most of the RF radiation is the increasing number of cell towers, close to people, in public areas, on lamp poles, on & next to buildings, and in residential areas. At some point, in some cases, this can turn into the main source of exposure to people living in these cities.

This is according to my personal experience as an EHS person, according to measurements I have done over the years, and according to complaints & reports from people I support and work with.

Personal exposure studies support this: own mobile phone use dominates personal RF exposure and brain dose (Roser et al., 2017 [110]; van Wel et al., 2021 [111]; Foerster et al., 2018 [100]), and the highest environmental levels are found in transport (Frei et al., 2009 [112]).

14. Q14 - "What scientific evidence exists regarding potential adverse environmental effects associated with RF radiation?" - Over the past decades, a growing number of studies have examined the effects of man-made electromagnetic radiation on nature. The most comprehensive series of reviews in the field was published in 2021 by Levitt, Lai and Manville [113, 114, 115], in 3 parts: rising radiation levels in the environment, the effects on animals and plants, and the need to update standards and policy. The same researchers published updates in 2022 [116] and 2025 [117].

On plants, Halgamuge's review (2017 [118]) found that about 90% of the experiments examined reported changes in plants exposed to mobile phone radiation. Waldmann-Selsam et al. (2016 [119]) documented damage to trees on the side facing mobile phone antennas. Three studies examined duckweed, a plant often used for environmental monitoring. Tkalec et al. (2005 [120], 2007 [121]) found that radio frequency radiation reduces plant growth and causes oxidative stress, and that the effect depends on frequency, field strength, and exposure time. Ben-Izhak Monselise et al. (2011 [122]) found signs of stress in the plant's cells near AM radio transmitting antennas, at a strength that matched the level of exposure.

On animals, Balmori (2021 [123]) proposed radiation as one of the possible factors in the decline of insect populations. The meta-analysis by Thill, Cammaerts and Balmori (2023 [124]) found biological effects on insects. Engels et al. (2014 [125]), in a study published in Nature, showed that weak urban electromagnetic noise disrupts the magnetic orientation of migratory birds. Henshaw and Philips (2025 [107]) reviewed the literature on magnetoreception in animals and argue that radiation affects them even at

levels below the standards.

Honeybees are especially important for pollination, so the effect of electromagnetic fields and radio frequency radiation on them has also been studied. Favre (2011 [126]), Odemer and Odemer (2019 [127]), and Treder et al. (2023 [128]) found effects of man-made radio frequency radiation on honeybees, and a meta-analysis by Thill, Cammaerts, and Balmori (2023 [124]) found biological effects of electromagnetic fields on insects, including honeybees. Shepherd et al. (2018 [129]) and Molina-Montenegro et al. (2023 [130]) found effects of low-frequency magnetic fields on honeybees.

Hässig et al. (2009 [131], 2014 [132]) found a possible link between mobile phone antennas and cataracts in calves, but no proof of causation. Hutchison et al. (2020 [133]) found that the fields from a subsea power cable change the exploratory behavior of cartilaginous fish and lobsters.

Bormusov et al. (Israel and USA, 2008 [134]) found non-thermal electromagnetic radiation damage to the lens epithelium.

Please see - <https://www.norad4u.com/emf-science-studies/studies-lists/studies-emf-environment-wildlife/>

15. Q15 – “What types of scientific evidence should be considered when evaluating RF exposure associated with wireless infrastructure?” - Assessment of RF exposure should be done across the time span (sub-second, minutes, hours and days), frequency span (number of transmissions across the frequency measured by a very quick Spectrum Analyzer), and Geographically (number of sources around the measuring location/subject and the distance from them).

Levels as low as $0.00001 \mu\text{W}/\text{cm}^2$ should be documented, while using fast sampling rate meters measuring peak values per second or 0.5 of a second.

Exposure analysis should be done according to new exposure guidelines that acknowledge and accept that EMF/EMR exposure has possible biological and health effects in very low levels, and that EHS is linked to, affected by and caused by the exposure.

Studies show that symptoms increase with proximity to antennas and with measured exposure, even at very low levels (Santini et al., 2002 [1]; Navarro et al., 2003 [2]; López et al., 2021 [8]), and that the modulation and pulsing of wireless signals, not only average power, drive biological effects (Panagopoulos et al., 2025 [95]). Building Biology (SBM-2024) already requires peak-value measurement.

Other studies show the appearance of symptoms at very low levels. Navarro et al., 2003 [2], and Oberfeld et al., 2004 [3]: Symptoms increased with the RF level measured in the bedroom. Oberfeld proposed a safe level below 0.02 V/m , which is about 0.0001

$\mu\text{W}/\text{cm}^2$. This is in the same range as the levels that I recommend documenting. Hutter et al., 2006 [18]: Headaches were linked to RF exposure at average levels of only 0.02–0.05 mW/m^2 , which is 0.002–0.005 $\mu\text{W}/\text{cm}^2$.

Panagopoulos et al., 2025 [95], showed that the modulation, pulsing and high variability of wireless communication signals are what cause the biological effects. Measurements that average the exposure over time miss exactly these features.

16. Q16 - “What are the highest priority research gaps regarding EMF and RF radiation and public health that the federal health agencies should address?” – Several:

- Studies that show and uncover the Physical effects, that turn into chemical effects, that turn into biological effects, that turn into health effects, that turn into health conditions and sickness. These studies need to be robust and bulletproof so they will disprove the theory that non-ionizing radiation can only heat tissue or influence heartbeats at very high levels.
- Proving EHS is caused, affected and influenced by EMF/EMR exposure.
- Mapping the mechanisms by which EMF/EMR exposure affects EHS people and their condition.
- Studies about the health condition of long-term users (15-40 years), with real usage data (logged by phone and providers), and real day to day conditions and exposure (hours of using the phone for voice, text messaging, surfing the web, using apps, and just staying next to the phone or device), with clear identification of the type of devices used (cellphone, smartphone, smart watch, wireless earpieces, wireless laptops, wireless tablets), compared to real non-users, or users of wired equipment.
- Surveys and reports about how many people are already suffering from symptoms due to EMF/EMR exposure, and their breakdown (men, women, age, living area, job, usage).

17. Q17 - “How can federal health agencies improve coordination of EMF and RF radiation research? Please comment on potential roles for federal health agencies including, but not limited to: a. HHS Food and Drug Administration (FDA) b. HHS National Institutes of Health (NIH) c. HHS Centers for Disease Control and Prevention (CDC)”

All Agencies should acknowledge that there are biological and health effects of exposure to EMF/EMR, and that EHS is caused/linked/related/influenced by & to exposure to EMF/EMR.

Then the agencies should define guidelines for measurement of exposure, measurement of effect, reduction of exposure, usage guidelines, and research guidelines so that the information that will be added by new studies and surveys will

allow us to better understand the influence, exposure, effects and changes caused by the exposure.

It seems to me that today most of the work these agencies do in this field is to push back the growing scientific body of proof, and to stall and delay the acknowledgment that EMF/EMR is bio-active and has some possible biological and health effects. The agencies should acknowledge the possible effect, possible risk, and EHS, and then move forward by trying to launch new studies that will further improve our knowledge of “how it causes harm” and not “if it causes harm”.

They should also address the growing EHS population, acknowledge their condition and offer them treatment based on exposure reduction and improvement of general health.

18. More info

About EHS on my info site - <https://www.norad4u.com/ehs/>

Studies on EHS are available on my info site - <https://www.norad4u.com/ehs/studies-supporting-ehs/>

My review on studies that “disprove” EHS - <https://www.norad4u.com/ehs/studies-disproving-ehs/>

Studies about EMR/EMF - <https://www.norad4u.com/emf-science-studies/studies-lists/>

Best regards

Amir Borenstein.

For more info please contact me at:

norad4u@gmail.com

References

- [1] 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 [in French]. *Pathol Biol* (Paris). 2002;50(6):369-373. [https://doi.org/10.1016/S0369-8114\(02\)00311-5](https://doi.org/10.1016/S0369-8114(02)00311-5). PMID: 12168254.
- [2] Navarro EA, Segura J, Portolés M, Gómez-Perretta de Mateo C. The microwave syndrome: a preliminary study in Spain. *Electromagn Biol Med*. 2003;22(2-3):161-169. <https://doi.org/10.1081/JBC-120024625>.
- [3] Oberfeld G, Navarro EA, Portolés M, Maestu C, Gómez-Perretta C. The microwave syndrome – further aspects of a Spanish study. *Proceedings of the 3rd International Workshop on Biological Effects of Electromagnetic Fields*, Kos, Greece; 2004.
- [4] 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*. 2013;3(12):e003836. <https://doi.org/10.1136/bmjopen-2013-003836>. PMID: 24381254.

- [5] Buchner K, Eger H. Changes of clinically important neurotransmitters under the influence of modulated RF fields – a long-term study under real-life conditions [in German]. *Umwelt-Medizin-Gesellschaft*. 2011;24(1):44-57.
- [6] Shinjyo T, Shinjyo A. Significant decrease of clinical symptoms after mobile phone base station removal – an intervention study [in German]. *Umwelt-Medizin-Gesellschaft*. 2014;27(4):294-301.
- [7] Silva DF, Barros WR, Almeida Mda C, Rêgo MA. Exposure to non-ionizing electromagnetic radiation from mobile telephony and the association with psychiatric symptoms. *Cad Saude Publica*. 2015;31(10):2110-2126. <https://doi.org/10.1590/0102-311X00104114>. PMID: 26735379.
- [8] López I, Félix N, Rivera M, Alonso A, Maestú C. What is the radiation before 5G? A correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas, Madrid. *Environ Res*. 2021;194:110734. <https://doi.org/10.1016/j.envres.2021.110734>. PMID: 33434609.
- [9] Hardell L, Nilsson M. Summary of seven Swedish case reports on the microwave syndrome associated with 5G radiofrequency radiation. *Rev Environ Health*. 2025;40(1):147-157. Published online 2024. <https://doi.org/10.1515/reveh-2024-0017>. PMID: 38889394.
- [10] Thomée S, Härenstam A, Hagberg M. Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults--a prospective cohort study. *BMC Public Health*. 2011;11:66. <https://doi.org/10.1186/1471-2458-11-66>. PMID: 21281471.
- [11] Divan HA, Kheifets L, Obel C, Olsen J. Prenatal and postnatal exposure to cell phone use and behavioral problems in children. *Epidemiology*. 2008;19(4):523-529. <https://doi.org/10.1097/EDE.0b013e318175dd47>. PMID: 18467962.
- [12] Wang PW, Liu TL, Ko CH, Lin HC, Huang MF, Yeh YC, et al. Association between problematic cellular phone use and suicide: the moderating effect of family function and depression. *Compr Psychiatry*. 2014;55(2):342-348. <https://doi.org/10.1016/j.comppsy.2013.09.006>. PMID: 24262117.
- [13] Hadar A, Hadas I, Lazarovits A, Alyagon U, Eliraz D, Zangen A. Answering the missed call: Initial exploration of cognitive and electrophysiological changes associated with smartphone use and abuse. *PLoS One*. 2017;12(7):e0180094. <https://doi.org/10.1371/journal.pone.0180094>. PMID: 28678870.
- [14] Alrubaia H, Alabdi Z, Alnaim M, Alkhateeb N, Almulhim A, Alsalem A, et al. The impact of cell phone use after light out on sleep quality, headache, tiredness, and distractibility among high school students: Cross sectional study. *Heliyon*. 2025;11(4):e42655. <https://doi.org/10.1016/j.heliyon.2025.e42655>. PMID: 41477504.
- [15] Bijlsma N, Conduit R, Kennedy G, Cohen M. Does radiofrequency radiation impact sleep? A double-blind, randomised, placebo-controlled, crossover pilot study. *Front Public Health*. 2024;12:1481537. <https://doi.org/10.3389/fpubh.2024.1481537>. PMID: 39534742.
- [16] Hagström M, Auranen J, Ekman R. Electromagnetic hypersensitive Finns: Symptoms, perceived sources and treatments, a questionnaire study. *Pathophysiology*. 2013;20(2):117-122. <https://doi.org/10.1016/j.pathophys.2013.02.001>. PMID: 23557856.
- [17] Kato Y, Johansson O. Reported functional impairments of electrohypersensitive Japanese: A questionnaire survey. *Pathophysiology*. 2012;19(2):95-100. <https://doi.org/10.1016/j.pathophys.2012.02.002>. PMID: 22458999.
- [18] Hutter HP, Moshhammer 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. <https://doi.org/10.1136/oem.2005.020784>. PMID: 16621850.

- [19] Hagström M, Auranen J, Johansson O, Ekman R. Reducing electromagnetic irradiation and fields alleviates experienced health hazards of VDU work. *Pathophysiology*. 2012;19(2):81-87. <https://doi.org/10.1016/j.pathophys.2012.01.005>. PMID: 22364840.
- [20] Havas M. Electromagnetic hypersensitivity: biological effects of dirty electricity with emphasis on diabetes and multiple sclerosis. *Electromagn Biol Med*. 2006;25(4):259-268. <https://doi.org/10.1080/15368370601044192>. PMID: 17178585.
- [21] Havas M, Olstad A. Power quality affects teacher wellbeing and student behavior in three Minnesota Schools. *Sci Total Environ*. 2008;402(2-3):157-162. <https://doi.org/10.1016/j.scitotenv.2008.04.046>. PMID: 18556048.
- [22] Belyaev I, Dean A, Eger H, Hubmann G, Jandrisovits R, Kern M, et al. EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. *Rev Environ Health*. 2016;31(3):363-397. <https://doi.org/10.1515/reveh-2016-0011>. PMID: 27454111.
- [23] Austrian Medical Association. Guideline of the Austrian Medical Association for the diagnosis and treatment of EMF-related health problems and illnesses (EMF syndrome). Vienna: Austrian Medical Association; 2012.
- [24] Nordic Council of Ministers. Nordic adaptation of classification of occupationally related disorders (diseases and symptoms) to ICD-10. Copenhagen: Nordic Council of Ministers; 2000.
- [25] Council of Europe, Parliamentary Assembly. Resolution 1815 (2011): The potential dangers of electromagnetic fields and their effect on the environment. Strasbourg: Council of Europe; 2011. <https://pace.coe.int/en/files/17994/html>
- [26] Havas M. Dirty electricity elevates blood sugar among electrically sensitive diabetics and may explain brittle diabetes. *Electromagn Biol Med*. 2008;27(2):135-146. <https://doi.org/10.1080/15368370802072075>. PMID: 18568931.
- [27] Herbert MR, Sage C. Autism and EMF? Plausibility of a pathophysiological link - Part I. *Pathophysiology*. 2013;20(3):191-209. <https://doi.org/10.1016/j.pathophys.2013.08.001>. PMID: 24095003.
- [28] Herbert MR, Sage C. Autism and EMF? Plausibility of a pathophysiological link part II. *Pathophysiology*. 2013;20(3):211-234. <https://doi.org/10.1016/j.pathophys.2013.08.002>. PMID: 24113318.
- [29] Pall ML. Central causation of autism/ASDs via excessive [Ca²⁺]_i impacting six mechanisms controlling synaptogenesis during the perinatal period: the role of electromagnetic fields and chemicals and the NO/ONOO(-) cycle, as well as specific mutations. *Brain Sci*. 2024;14(5):454. <https://doi.org/10.3390/brainsci14050454>. PMID: 38790433.
- [30] Agarwal A, Deepinder F, Sharma RK, Ranga G, Li J. Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study. *Fertil Steril*. 2008;89(1):124-128. <https://doi.org/10.1016/j.fertnstert.2007.01.166>. PMID: 17482179.
- [31] Houston BJ, Nixon B, King BV, De Iuliis GN, Aitken RJ. The effects of radiofrequency electromagnetic radiation on sperm function. *Reproduction*. 2016;152(6):R263-R276. <https://doi.org/10.1530/REP-16-0126>. PMID: 27601711.
- [32] 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*. 2014;17(5):247-258. <https://doi.org/10.1080/10937404.2014.923356>. PMID: 25205214.
- [33] National Toxicology Program. Toxicology and carcinogenesis studies in Hsd:Sprague Dawley SD rats exposed to whole-body radio frequency radiation at a frequency (900 MHz) and modulations (GSM

and CDMA) used by cell phones. NTP Technical Report 595. Natl Toxicol Program Tech Rep Ser. 2018;(595). <https://doi.org/10.22427/NTP-TR-595>. PMID: 33562898.

- [34] Smith-Roe SL, Wyde ME, Stout MD, Winters JW, Hobbs CA, Shepard KG, et al. Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure. *Environ Mol Mutagen*. 2020;61(2):276-290. <https://doi.org/10.1002/em.22343>. PMID: 31633839.
- [35] INTERPHONE Study Group. Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. *Int J Epidemiol*. 2010;39(3):675-694. <https://doi.org/10.1093/ije/dyq079>. PMID: 20483835.
- [36] Hardell L, 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. <https://doi.org/10.1515/reveh-2013-0006>. PMID: 24192496.
- [37] Hardell L, Carlberg M. Mobile phone and cordless phone use and the risk for glioma - Analysis of pooled case-control studies in Sweden, 1997-2003 and 2007-2009. *Pathophysiology*. 2015;22(1):1-13. <https://doi.org/10.1016/j.pathophys.2014.10.001>. PMID: 25466607.
- [38] Carlberg M, Hardell L. Evaluation of mobile phone and cordless phone use and glioma risk using the Bradford Hill viewpoints from 1965 on association or causation. *Biomed Res Int*. 2017;2017:9218486. <https://doi.org/10.1155/2017/9218486>. PMID: 28401165.
- [39] Coureau G, Bouvier G, Lebailly P, Fabbro-Peray P, Gruber A, Leffondre K, et al. Mobile phone use and brain tumours in the CERENAT case-control study. *Occup Environ Med*. 2014;71(7):514-522. <https://doi.org/10.1136/oemed-2013-101754>. PMID: 24816517.
- [40] Sadetzki S, Chetrit A, Jarus-Hakak A, Cardis E, Deutch Y, Duvdevani S, et al. Cellular phone use and risk of benign and malignant parotid gland tumors--a nationwide case-control study. *Am J Epidemiol*. 2008;167(4):457-467. <https://doi.org/10.1093/aje/kwm325>. PMID: 18063591.
- [41] Czerninski R, Zini A, Sgan-Cohen HD. Risk of parotid malignant tumors in Israel (1970-2006). *Epidemiology*. 2011;22(1):130-131. <https://doi.org/10.1097/EDE.0b013e3181feb9f0>. PMID: 21150362.
- [42] Duan Y, Zhang HZ, Bu RF. Correlation between cellular phone use and epithelial parotid gland malignancies. *Int J Oral Maxillofac Surg*. 2011;40(9):966-972. <https://doi.org/10.1016/j.ijom.2011.03.007>. PMID: 21474287.
- [43] West JG, Kapoor NS, Liao SY, Chen JW, Bailey L, Nagourney RA. Multifocal breast cancer in young women with prolonged contact between their breasts and their cellular phones. *Case Rep Med*. 2013;2013:354682. <https://doi.org/10.1155/2013/354682>. PMID: 24151509.
- [44] Myung SK, Ju W, McDonnell DD, Lee YJ, Kazinets G, Cheng CT, et al. Mobile phone use and risk of tumors: a meta-analysis. *J Clin Oncol*. 2009;27(33):5565-5572. <https://doi.org/10.1200/JCO.2008.21.6366>. PMID: 19826127.
- [45] Hallberg O, Johansson O. Increasing rates of head melanoma in Nordic countries. *Pathophysiology*. 2011;18(4):313-315. <https://doi.org/10.1016/j.pathophys.2011.05.002>. PMID: 21683561.
- [46] Dobes M, Shadbolt B, Khurana VG, Jain S, Smith SF, Smee R, et al. A multicenter study of primary brain tumor incidence in Australia (2000-2008). *Neuro Oncol*. 2011;13(7):783-790. <https://doi.org/10.1093/neuonc/nor052>. PMID: 21727214.
- [47] Hardell L, Carlberg M. Increasing rates of brain tumours in the Swedish national inpatient register and the causes of death register. *Int J Environ Res Public Health*. 2015;12(4):3793-3813. <https://doi.org/10.3390/ijerph120403793>. PMID: 25854296.

- [48] Hardell L, Carlberg M. Mobile phones, cordless phones and rates of brain tumors in different age groups in the Swedish National Inpatient Register and the Swedish Cancer Register during 1998-2015. *PLoS One*. 2017;12(10):e0185461. <https://doi.org/10.1371/journal.pone.0185461>. PMID: 28976991.
- [49] Little MP, Rajaraman P, Curtis RE, Devesa SS, Inskip PD, Check DP, et al. Mobile phone use and glioma risk: comparison of epidemiological study results with incidence trends in the United States. *BMJ*. 2012;344:e1147. <https://doi.org/10.1136/bmj.e1147>. PMID: 22403263.
- [50] Luo J, Deziel NC, Huang H, Chen Y, Ni X, Ma S, et al. Cell phone use and risk of thyroid cancer: a population-based case-control study in Connecticut. *Ann Epidemiol*. 2019;29:39-45. <https://doi.org/10.1016/j.annepidem.2018.10.004>. PMID: 30446214.
- [51] Miller AB, Morgan LL, Udasin I, Davis DL. Cancer epidemiology update, following the 2011 IARC evaluation of radiofrequency electromagnetic fields (Monograph 102). *Environ Res*. 2018;167:673-683. <https://doi.org/10.1016/j.envres.2018.06.043>. PMID: 30196934.
- [52] Dode AC, Leão MM, Tejo Fde A, Gomes AC, Dode DC, Dode MC, et al. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. *Sci Total Environ*. 2011;409(19):3649-3665. <https://doi.org/10.1016/j.scitotenv.2011.05.051>. PMID: 21741680.
- [53] Eger H, Hagen KU, Lucas B, Vogel P, Voit H. The influence of being physically near to a cell phone transmission mast on the incidence of cancer [in German]. *Umwelt-Medizin-Gesellschaft*. 2004;17(4):326-332.
- [54] Wolf R, Wolf D. Increased incidence of cancer near a cell-phone transmitter station. *Int J Cancer Prev*. 2004;1(2):123-128.
- [55] Dolk H, Shaddick G, Walls P, Grundy C, Thakrar B, Kleinschmidt I, et al. Cancer incidence near radio and television transmitters in Great Britain. I. Sutton Coldfield transmitter. *Am J Epidemiol*. 1997;145(1):1-9. <https://doi.org/10.1093/oxfordjournals.aje.a009025>. PMID: 8982016.
- [56] Szmigielski S. Cancer morbidity in subjects occupationally exposed to high frequency (radiofrequency and microwave) electromagnetic radiation. *Sci Total Environ*. 1996;180(1):9-17. [https://doi.org/10.1016/0048-9697\(95\)04915-0](https://doi.org/10.1016/0048-9697(95)04915-0). PMID: 8717316.
- [57] Groves FD, Page WF, Gridley G, Lisimaque L, Stewart PA, Tarone RE, et al. Cancer in Korean war navy technicians: mortality survey after 40 years. *Am J Epidemiol*. 2002;155(9):810-818. <https://doi.org/10.1093/aje/155.9.810>. PMID: 11978584.
- [58] Goldsmith JR. Epidemiologic evidence of radiofrequency radiation (microwave) effects on health in military, broadcasting, and occupational studies. *Int J Occup Environ Health*. 1995;1(1):47-57. <https://doi.org/10.1179/oeh.1995.1.1.47>. PMID: 9990158.
- [59] Richter ED, Berman T, Levy O. Brain cancer with induction periods of less than 10 years in young military radar workers. *Arch Environ Health*. 2002;57(4):270-272. <https://doi.org/10.1080/00039890209601409>. PMID: 12530592.
- [60] Kliukiene J, Tynes T, Andersen A. Follow-up of radio and telegraph operators with exposure to electromagnetic fields and risk of breast cancer. *Eur J Cancer Prev*. 2003;12(4):301-307. <https://doi.org/10.1097/00008469-200308000-00010>. PMID: 12883383.
- [61] Peleg M, Nativ O, Richter ED. Radio frequency radiation-related cancer: assessing causation in the occupational/military setting. *Environ Res*. 2018;163:123-133. <https://doi.org/10.1016/j.envres.2018.01.003>. PMID: 29433020.

- [62] Peleg M, Berry EM, Deitch M, Nativ O, Richter E. On radar and radio exposure and cancer in the military setting. *Environ Res.* 2023;216(Pt 2):114610. <https://doi.org/10.1016/j.envres.2022.114610>. PMID: 36279918.
- [63] Wertheimer N, Leeper E. Electrical wiring configurations and childhood cancer. *Am J Epidemiol.* 1979;109(3):273-284. <https://doi.org/10.1093/oxfordjournals.aje.a112681>. PMID: 453167.
- [64] Wertheimer N, Leeper E. Adult cancer related to electrical wires near the home. *Int J Epidemiol.* 1982;11(4):345-355. <https://doi.org/10.1093/ije/11.4.345>. PMID: 7152787.
- [65] Savitz DA, Wachtel H, Barnes FA, John EM, Tvrdik JG. Case-control study of childhood cancer and exposure to 60-Hz magnetic fields. *Am J Epidemiol.* 1988;128(1):21-38. <https://doi.org/10.1093/oxfordjournals.aje.a114943>. PMID: 3164167.
- [66] Washburn EP, Orza MJ, Berlin JA, Nicholson WJ, Todd AC, Frumkin H, et al. Residential proximity to electricity transmission and distribution equipment and risk of childhood leukemia, childhood lymphoma, and childhood nervous system tumors: systematic review, evaluation, and meta-analysis. *Cancer Causes Control.* 1994;5(4):299-309. <https://doi.org/10.1007/BF01804980>. PMID: 8080941.
- [67] Meinert R, Michaelis J. Meta-analyses of studies on the association between electromagnetic fields and childhood cancer. *Radiat Environ Biophys.* 1996;35(1):11-18. <https://doi.org/10.1007/BF01211237>. PMID: 8907639.
- [68] Angelillo IF, Villari P. Residential exposure to electromagnetic fields and childhood leukaemia: a meta-analysis. *Bull World Health Organ.* 1999;77(11):906-915. PMID: 10612886.
- [69] Baldi I, Coureau G, Jaffré A, Gruber A, Ducamp S, Provost D, et al. Occupational and residential exposure to electromagnetic fields and risk of brain tumors in adults: a case-control study in Gironde, France. *Int J Cancer.* 2011;129(6):1477-1484. <https://doi.org/10.1002/ijc.25765>. PMID: 21792884.
- [70] Beniashvili D, Avinoach I, Baazov D, Zusman I. Household electromagnetic fields and breast cancer in elderly women. *In Vivo.* 2005;19(3):563-566. PMID: 15875777.
- [71] Tillmann T, Ernst H, Streckert J, Zhou Y, Taugner F, Hansen V, et al. Indication of cocarcinogenic potential of chronic UMTS-modulated radiofrequency exposure in an ethylnitrosourea mouse model. *Int J Radiat Biol.* 2010;86(7):529-541. <https://doi.org/10.3109/09553001003734501>. PMID: 20545575.
- [72] Lerchl A, Klose M, Grote K, Wilhelm AF, Spathmann O, Fiedler T, et al. Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans. *Biochem Biophys Res Commun.* 2015;459(4):585-590. <https://doi.org/10.1016/j.bbrc.2015.02.151>. PMID: 25749340.
- [73] Leszczynski D, Joenväärä S, Reivinen J, Kuokka R. Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: molecular mechanism for cancer- and blood-brain barrier-related effects. *Differentiation.* 2002;70(2-3):120-129. <https://doi.org/10.1046/j.1432-0436.2002.700207.x>. PMID: 12076339.
- [74] Nazıroğlu M, Cığ B, Doğan S, Uğuz AC, Dilek S, Faouzi D. 2.45-Gz wireless devices induce oxidative stress and proliferation through cytosolic Ca²⁺ influx in human leukemia cancer cells. *Int J Radiat Biol.* 2012;88(6):449-456. <https://doi.org/10.3109/09553002.2012.682192>. PMID: 22489926.
- [75] Belpomme D, Hardell L, Belyaev I, Burgio E, Carpenter DO. Thermal and non-thermal health effects of low intensity non-ionizing radiation: An international perspective. *Environ Pollut.* 2018;242(Pt A):643-658. <https://doi.org/10.1016/j.envpol.2018.07.019>. PMID: 30025338.
- [76] 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. <https://doi.org/10.1515/reveh-2015-0027>. PMID: 26613326.
- [77] Carpenter DO. The microwave syndrome or electro-hypersensitivity: historical background. *Rev Environ Health*. 2015;30(4):217-222. <https://doi.org/10.1515/reveh-2015-0016>. PMID: 26556835.
- [78] Dieudonné M. Does electromagnetic hypersensitivity originate from placebo responses? Indications from a qualitative study. *Bioelectromagnetics*. 2016;37(1):14-24. <https://doi.org/10.1002/bem.21937>. PMID: 26369906.
- [79] Belpomme D, Carlo GL, Irigaray P, Carpenter DO, Hardell L, Kundi M, et al. The critical importance of molecular biomarkers and imaging in the study of electrosensitivity. A scientific consensus international report. *Int J Mol Sci*. 2021;22(14):7321. <https://doi.org/10.3390/ijms22147321>. PMID: 34298941.
- [80] Stein Y, Udasin IG. Electromagnetic hypersensitivity (EHS, microwave syndrome) - Review of mechanisms. *Environ Res*. 2020;186:109445. <https://doi.org/10.1016/j.envres.2020.109445>. PMID: 32289567.
- [81] McCarty DE, Carrubba S, Chesson AL, Frilot C, Gonzalez-Toledo E, Marino AA. Electromagnetic hypersensitivity: evidence for a novel neurological syndrome. *Int J Neurosci*. 2011;121(12):670-676. <https://doi.org/10.3109/00207454.2011.608139>. PMID: 21793784.
- [82] Johansson O. Electrosensitivity: a functional impairment due to an inaccessible environment. *Rev Environ Health*. 2015;30(4):311-321. <https://doi.org/10.1515/reveh-2015-0018>. PMID: 26613327.
- [83] De Luca C, Thai JC, Raskovic D, Cesario E, Caccamo D, Trukhanov A, et al. Metabolic and genetic screening of electromagnetic hypersensitive subjects as a feasible tool for diagnostics and intervention. *Mediators Inflamm*. 2014;2014:924184. <https://doi.org/10.1155/2014/924184>. PMID: 24812443.
- [84] Piras C, Pibiri M, Conte S, Ferranti G, Leoni VP, Liggi S, et al. Metabolomics analysis of plasma samples of patients with fibromyalgia and electromagnetic sensitivity using GC-MS technique. *Sci Rep*. 2022;12(1):21923. <https://doi.org/10.1038/s41598-022-25588-2>. PMID: 36535959.
- [85] Heuser G, Heuser SA. Functional brain MRI in patients complaining of electrosensitivity after long term exposure to electromagnetic fields. *Rev Environ Health*. 2017;32(3):291-299. <https://doi.org/10.1515/reveh-2017-0014>. PMID: 28678737.
- [86] Hedendahl L, Carlberg M, Hardell L. Electromagnetic hypersensitivity--an increasing challenge to the medical profession. *Rev Environ Health*. 2015;30(4):209-215. <https://doi.org/10.1515/reveh-2015-0012>. PMID: 26372109.
- [87] Sonzogni L, Al-Chobq J, Combemale P, Massardier-Pilonchery A, Bouchet A, May P, et al. Skin fibroblasts from individuals self-diagnosed as electrosensitive reveal two distinct subsets with delayed nucleoschuttling of the ATM protein in common. *Int J Mol Sci*. 2025;26(10):4792. <https://doi.org/10.3390/ijms26104792>. PMID: 40429933.
- [88] Kjellqvist A, Palmquist E, Nordin S. Psychological symptoms and health-related quality of life in idiopathic environmental intolerance attributed to electromagnetic fields. *J Psychosom Res*. 2016;84:8-12. <https://doi.org/10.1016/j.jpsychores.2016.03.006>. PMID: 27095153.
- [89] Hallberg O, Oberfeld G. Letter to the editor: will we all become electrosensitive?. *Electromagn Biol Med*. 2006;25(3):189-191. <https://doi.org/10.1080/15368370600873377>. PMID: 16954121.
- [90] Rubin GJ, Hahn G, Everitt BS, Cleare AJ, Wessely S. Are some people sensitive to mobile phone signals? Within participants double blind randomised provocation study. *BMJ*. 2006;332(7546):886-891. <https://doi.org/10.1136/bmj.38765.519850.55>. PMID: 16520326.

- [91] Rubin GJ, Das Munshi J, Wessely S. Electromagnetic hypersensitivity: a systematic review of provocation studies. *Psychosom Med*. 2005;67(2):224-232. <https://doi.org/10.1097/01.psy.0000155664.13300.64>. PMID: 15784787.
- [92] International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF). Scientific evidence invalidates health assumptions underlying the FCC and ICNIRP exposure limit determinations for radiofrequency radiation: implications for 5G. *Environ Health*. 2022;21(1):92. <https://doi.org/10.1186/s12940-022-00900-9>. PMID: 36253855.
- [93] Yakymenko I, Tsybulin O, Sidorik E, Henshel D, Kyrylenko O, Kyrylenko S. Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation. *Electromagn Biol Med*. 2016;35(2):186-202. <https://doi.org/10.3109/15368378.2015.1043557>. PMID: 26151230.
- [94] Pall ML. Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. *J Cell Mol Med*. 2013;17(8):958-965. <https://doi.org/10.1111/jcmm.12088>. PMID: 23802593.
- [95] Panagopoulos DJ, Yakymenko I, De Iuliis GN, Chrousos GP. A comprehensive mechanism of biological and health effects of anthropogenic extremely low frequency and wireless communication electromagnetic fields. *Front Public Health*. 2025;13:1585441. <https://doi.org/10.3389/fpubh.2025.1585441>. PMID: 40547468.
- [96] Salford LG, Brun AE, Eberhardt JL, Malmgren L, Persson BR. Nerve cell damage in mammalian brain after exposure to microwaves from GSM mobile phones. *Environ Health Perspect*. 2003;111(7):881-883. <https://doi.org/10.1289/ehp.6039>. PMID: 12782486.
- [97] Papageorgiou CC, Hountala CD, Maganioti AE, Kyprianou MA, Rabavilas AD, Papadimitriou GN, et al. Effects of wi-fi signals on the p300 component of event-related potentials during an auditory listening task. *J Integr Neurosci*. 2011;10(2):189-202. <https://doi.org/10.1142/S0219635211002695>. PMID: 21714138.
- [98] Meo SA, Alsubaie Y, Almubarak Z, Almutawa H, AlQasem Y, Hasanato RM. Association of exposure to radio-frequency electromagnetic field radiation (RF-EMFR) generated by mobile phone base stations with glycated hemoglobin (HbA1c) and risk of type 2 diabetes mellitus. *Int J Environ Res Public Health*. 2015;12(11):14519-14528. <https://doi.org/10.3390/ijerph121114519>. PMID: 26580639.
- [99] Volkow ND, Tomasi D, Wang GJ, Vaska P, Fowler JS, Telang F, et al. Effects of cell phone radiofrequency signal exposure on brain glucose metabolism. *JAMA*. 2011;305(8):808-813. <https://doi.org/10.1001/jama.2011.186>. PMID: 21343580.
- [100] Foerster M, Thielens A, Joseph W, Eeftens M, Rösli M. A prospective cohort study of adolescents' memory performance and individual brain dose of microwave radiation from wireless communication. *Environ Health Perspect*. 2018;126(7):077007. <https://doi.org/10.1289/EHP2427>. PMID: 30044230.
- [101] Havas M, Marrongelle J. Replication of heart rate variability provocation study with 2.4-GHz cordless phone confirms original findings. *Electromagn Biol Med*. 2013;32(2):253-266. <https://doi.org/10.3109/15368378.2013.776437>. PMID: 23675629.
- [102] Lai H, Singh NP. Single- and double-strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromagnetic radiation. *Int J Radiat Biol*. 1996;69(4):513-521. <https://doi.org/10.1080/095530096145814>. PMID: 8627134.
- [103] Friedman J, Kraus S, Hauptman Y, Schiff Y, Seger R. Mechanism of short-term ERK activation by electromagnetic fields at mobile phone frequencies. *Biochem J*. 2007;405(3):559-568. <https://doi.org/10.1042/BJ20061653>. PMID: 17456048.

- [104] Deshmukh PS, Nasare N, Megha K, Banerjee BD, Ahmed RS, Singh D, et al. Cognitive impairment and neurogenotoxic effects in rats exposed to low-intensity microwave radiation. *Int J Toxicol*. 2015;34(3):284-290. <https://doi.org/10.1177/1091581815574348>. PMID: 25749756.
- [105] Kim JH, Yu DH, Huh YH, Lee EH, Kim HG, Kim HR. Long-term exposure to 835 MHz RF-EMF induces hyperactivity, autophagy and demyelination in the cortical neurons of mice. *Sci Rep*. 2017;7:41129. <https://doi.org/10.1038/srep41129>. PMID: 28106136.
- [106] Kochnev A, Betzalel N, Ben Ishai P, Feldman Y. Human sweat ducts as helical antennas in the sub-THz frequency range – an overview. *Terahertz Sci Technol*. 2018;11(2):43-56. <http://www.tstnetwork.org/June2018/tst-v11n2-43Human.pdf>
- [107] Henshaw DL, Philips A. A mechanistic understanding of human magnetoreception validates the phenomenon of electromagnetic hypersensitivity (EHS). *Int J Radiat Biol*. 2025;101(2):186-204. <https://doi.org/10.1080/09553002.2024.2435329>. PMID: 39652433.
- [108] Aly AA, Cheema MI, Tambawala M, Laterza R, Zhou E, Rathnabharathi K, et al. Effects of 900-MHz radio frequencies on the chemotaxis of human neutrophils in vitro. *IEEE Trans Biomed Eng*. 2008;55(2 Pt 1):795-797. <https://doi.org/10.1109/TBME.2007.912636>. PMID: 18270019.
- [109] Yakymenko I, Sidorik E, Kyrlyenko S, Chekhun V. Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems. *Exp Oncol*. 2011;33(2):62-70. PMID: 21716201.
- [110] Roser K, Schoeni A, Struchen B, Zahner M, Eeftens M, Fröhlich J, et al. Personal radiofrequency electromagnetic field exposure measurements in Swiss adolescents. *Environ Int*. 2017;99:303-314. <https://doi.org/10.1016/j.envint.2016.12.008>. PMID: 28038972.
- [111] van Wel L, Liorni I, Huss A, Thielens A, Wiart J, Joseph W, et al. Radio-frequency electromagnetic field exposure and contribution of sources in the general population: an organ-specific integrative exposure assessment. *J Expo Sci Environ Epidemiol*. 2021;31(6):999-1007. <https://doi.org/10.1038/s41370-021-00287-8>. PMID: 33654268.
- [112] Frei P, Mohler E, Neubauer G, Theis G, Bürgi A, Fröhlich J, et al. Temporal and spatial variability of personal exposure to radio frequency electromagnetic fields. *Environ Res*. 2009;109(6):779-785. <https://doi.org/10.1016/j.envres.2009.04.015>. PMID: 19476932.
- [113] Levitt BB, Lai HC, Manville AM. Effects of non-ionizing electromagnetic fields on flora and fauna, part 1. Rising ambient EMF levels in the environment. *Rev Environ Health*. 2022;37(1):81-122. Published online 2021. <https://doi.org/10.1515/reveh-2021-0026>. PMID: 34047144.
- [114] Levitt BB, Lai HC, Manville AM. Effects of non-ionizing electromagnetic fields on flora and fauna, part 2 impacts: how species interact with natural and man-made EMF. *Rev Environ Health*. 2022;37(3):327-406. Published online 2021. <https://doi.org/10.1515/reveh-2021-0050>. PMID: 34243228.
- [115] Levitt BB, Lai HC, Manville AM. Effects of non-ionizing electromagnetic fields on flora and fauna, part 3. Exposure standards, public policy, laws, and future directions. *Rev Environ Health*. 2022;37(4):531-558. Published online 2021. <https://doi.org/10.1515/reveh-2021-0083>. PMID: 34563106.
- [116] Levitt BB, Lai HC, Manville AM. Low-level EMF effects on wildlife and plants: What research tells us about an ecosystem approach. *Front Public Health*. 2022;10:1000840. <https://doi.org/10.3389/fpubh.2022.1000840>. PMID: 36505009.
- [117] Levitt BB, Lai HC, Manville AM, Scarato T. Flora and fauna: how nonhuman species interact with natural and man-made EMF at ecosystem levels and public policy recommendations. *Front Public Health*. 2025;13:1693873. <https://doi.org/10.3389/fpubh.2025.1693873>. PMID: 41358243.

- [118] Halgamuge MN. Review: Weak radiofrequency radiation exposure from mobile phone radiation on plants. *Electromagn Biol Med*. 2017;36(2):213-235. <https://doi.org/10.1080/15368378.2016.1220389>. PMID: 27650031.
- [119] Waldmann-Selsam C, Balmori-de la Puente A, Breunig H, Balmori A. Radiofrequency radiation injures trees around mobile phone base stations. *Sci Total Environ*. 2016;572:554-569. <https://doi.org/10.1016/j.scitotenv.2016.08.045>. PMID: 27552133.
- [120] Tkalec M, Malarić K, Pevallek-Kozlina B. Influence of 400, 900, and 1900 MHz electromagnetic fields on *Lemna minor* growth and peroxidase activity. *Bioelectromagnetics*. 2005;26(3):185-193. <https://doi.org/10.1002/bem.20104>. PMID: 15768427.
- [121] Tkalec M, Malarić K, Pevallek-Kozlina B. Exposure to radiofrequency radiation induces oxidative stress in duckweed *Lemna minor* L. *Sci Total Environ*. 2007;388(1-3):78-89. <https://doi.org/10.1016/j.scitotenv.2007.07.052>. PMID: 17825879.
- [122] Monselise EB, Levkovitz A, Gottlieb HE, Kost D. Bioassay for assessing cell stress in the vicinity of radio-frequency irradiating antennas. *J Environ Monit*. 2011;13(7):1890-1896. <https://doi.org/10.1039/c1em10031a>. PMID: 21655615.
- [123] Balmori A. Electromagnetic radiation as an emerging driver factor for the decline of insects. *Sci Total Environ*. 2021;767:144913. <https://doi.org/10.1016/j.scitotenv.2020.144913>. PMID: 33636787.
- [124] Thill A, Cammaerts MC, Balmori A. Biological effects of electromagnetic fields on insects: a systematic review and meta-analysis. *Rev Environ Health*. 2024;39(4):853-869. Published online 2023. <https://doi.org/10.1515/reveh-2023-0072>. PMID: 37990587.
- [125] Engels S, Schneider NL, Lefeldt N, Hein CM, Zapka M, Michalik A, et al. Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird. *Nature*. 2014;509(7500):353-356. <https://doi.org/10.1038/nature13290>. PMID: 24805233.
- [126] Favre D. Mobile phone-induced honeybee worker piping. *Apidologie*. 2011;42(3):270-279. <https://doi.org/10.1007/s13592-011-0016-x>.
- [127] Odemer R, Odemer F. Effects of radiofrequency electromagnetic radiation (RF-EMF) on honey bee queen development and mating success. *Sci Total Environ*. 2019;661:553-562. <https://doi.org/10.1016/j.scitotenv.2019.01.154>. PMID: 30682608.
- [128] Treder M, Müller M, Fellner L, Traynor K, Rosenkranz P. Defined exposure of honey bee colonies to simulated radiofrequency electromagnetic fields (RF-EMF): Negative effects on the homing ability, but not on brood development or longevity. *Sci Total Environ*. 2023;896:165211. <https://doi.org/10.1016/j.scitotenv.2023.165211>. PMID: 37391156.
- [129] Shepherd S, Lima MAP, Oliveira EE, Sharkh SM, Jackson CW, Newland PL. Extremely low frequency electromagnetic fields impair the cognitive and motor abilities of honey bees. *Sci Rep*. 2018;8(1):7932. <https://doi.org/10.1038/s41598-018-26185-y>. PMID: 29785039.
- [130] Molina-Montenegro MA, Acuña-Rodríguez IS, Ballesteros GI, Baldelomar M, Torres-Díaz C, Broitman BR, et al. Electromagnetic fields disrupt the pollination service by honeybees. *Sci Adv*. 2023;9(19):eadh1455. <https://doi.org/10.1126/sciadv.adh1455>. PMID: 37172085.
- [131] Hässig M, Jud F, Naegeli H, Kupper J, Spiess BM. Prevalence of nuclear cataract in Swiss veal calves and its possible association with mobile telephone antenna base stations. *Schweiz Arch Tierheilkd*. 2009;151(10):471-478. <https://doi.org/10.1024/0036-7281.151.10.471>. PMID: 19780007.
- [132] Hässig M, Wullschleger M, Naegeli H, Kupper J, Spiess B, Kuster N, et al. Influence of non ionizing radiation of base stations on the activity of redox proteins in bovines. *BMC Vet Res*. 2014;10:136. <https://doi.org/10.1186/1746-6148-10-136>. PMID: 24946856.

- [133] Hutchison ZL, Gill AB, Sigray P, He H, King JW. Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom-dwelling marine species. *Sci Rep.* 2020;10(1):4219.
<https://doi.org/10.1038/s41598-020-60793-x>. PMID: 32144341.
- [134] Bormusov E, Andley UP, Sharon N, Schächter L, Lahav A, Dovrat A. Non-thermal electromagnetic radiation damage to lens epithelium. *Open Ophthalmol J.* 2008;2:102-106.
<https://doi.org/10.2174/1874364100802010102>. PMID: 19517034.