

**SELECTED STUDIES ON
ELECTROSENSITIVITY (ES) AND
ELECTROMAGNETIC HYPER-SENSITIVITY (EHS)**

- *There are many thousands of peer-reviewed studies relevant to ES/EHS.*
- *This very limited selection of about 200 studies and references aims to provide an indication of the wide range of studies available.*
- *This selection does not attempt to give the earliest or most recent studies on any topic.*
- *This selection concentrates on positive studies which indicate the range of relevant evidence.*

CONTENTS	
1	<ul style="list-style-type: none"> (a) <i>General, reviews</i> (b) <i>Historical evidence</i>
2	<p><i>Specific ES/EHS symptoms from man-made environmental radiation</i></p> <ul style="list-style-type: none"> (a) <i>Base Stations, Mobile Phone/Radio/TV Masts</i> (b) <i>Computers, TVs</i> (c) <i>Mobile Phones</i> (d) <i>MRI Scanners</i> (e) <i>Photosensitivity, Blue Light effects</i> (f) <i>Power Lines, high frequency voltage transients</i> (g) <i>Pre-natal Exposure</i> (h) <i>Provocation Tests</i> (i) <i>Smart Meters</i> (j) <i>WiFi</i>
3	<p><i>Other effects and mechanisms of non-thermal EM exposure</i></p> <ul style="list-style-type: none"> (a) <i>Amyotrophic lateral sclerosis (ALS)</i> (b) <i>Antibiotic resistance in bacteria</i> (c) <i>ADHD (Attention Deficit Hyperactivity Disorder), Autism</i> (d) <i>Auto-immune effects</i> (e) <i>Blood-brain barrier leakage</i> (f) <i>Calcium flux, cell membrane permeability, phospholipids</i> (g) <i>Cancers, immunodeficiency</i> (h) <i>Cardiovascular changes</i> (i) <i>Chemical sensitivities and pollution</i> (j) <i>Fertility reduced: (i) Female (ii) Male births (iii) Male</i> (k) <i>Gender differences</i> (l) <i>Gene expression</i> (m) <i>Genetic variants</i> (n) <i>Genomic instability, DNA damage, micronuclei</i> (o) <i>Glucose metabolism, diabetes</i> (p) <i>Heavy metals, mercury in dental amalgam restorations</i>

	<ul style="list-style-type: none"> (q) Magneto-reception (r) Mast cells (s) Melatonin reduction, circadian effects (t) Mitochondrial dysfunction, leading to ROS (u) Myelin, Multiple Sclerosis (MS) (v) Neurological effects, anxiety, EEG, learning, memory, sleep (w) Nitric oxide (x) Non-linear effects, 'windows' (y) Non-thermal effects, including radio frequency hyperthermia (z) Oxidative stress, redox state (aa) Polarisation (bb) Protein expression (cc) Reactive oxygen species (ROS), Heat shock proteins (HSP) (dd) Resonance signalling, ion cyclotron resonance (ee) Skin effects (ff) Stem cells, osteoblasts (gg) Sympathetic nervous system (hh) Tinnitus (ii) Therapeutic uses (jj) Thyroid hormones and cancer (kk) Tumour promotion, tumour-specific frequencies (ll) Vagus nerve
4	Biological safety limits; criticism of heating-only limits
5	Living with EHS (functional impairment, socio-economic effects)
6	Proposed diagnostic markers
7	Differences between EHS and Electrophobia/Nocebo
8	Electromagnetic warfare
9	Sensitivity to natural geomagnetic disturbances
10	Sensitivity of plants and animals to electromagnetic exposure
11	Further information

1. (a) General, reviews (* useful introductory or general studies)

- *Belyaev I et al.: "EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses" *Rev Environ Health*. (2016) [pdf](#).
- *Buchner K et al.: "Changes of Clinically Important Neurotransmitters under the Influence of Modulated RF Fields - A Long-term Study under Real-life Conditions" *Um-Med-Ges* (2011) [pdf](#).
- *Carpenter D (ed.): "[Idiopathic environmental intolerance](#)" *Rev Environ Health*. (2015).
- Choy RYS et al.: "Electrical Sensitivities in Allergy Patients" *Clin Ecol*. (1987) [pdf](#).
- Dahmen N et al.: "Blood laboratory findings in patients suffering from self-perceived electromagnetic hypersensitivity (EHS)" *Bioelectromagnetics*. (2009) [PMID: 19259984](#).
- *De Luca C et al: "[Metabolic and genetic screening of electromagnetic hypersensitivity subjects as a feasible tool for diagnostics and intervention](#)" *Mediators Inflamm*. (2014) [PHID: 24812443](#).
- Eger H: ["Causal, Legally Recognized Proof of the Damage Potential of Technical Highfrequency Fields - a Case Report"] *Um-Med-Ges* (2014) [abs](#), [trans](#).
- *Eger H et al.: "Specific Health Symptoms and Cell Phone Radiation in Selbitz, Bavaria, Germany: Evidence of a Dose-Response Relationship" *Um Medizin Gesellschaft* (2010) [trans](#).
- *Genuis SJ et al.: "Electromagnetic hypersensitivity: fact or fiction?" *Sci Tot Env*. (2012) [PMID: 22153604](#); [article](#).
- Griesz-Brisson M: "Electrosensitivity from a neurological point of view" *Neuroepidemiology* (2013) [41: 275, no.227](#) (page 275).
- *Havas M et al.: "Dirty electricity and electromagnetic hypersensitivity: five case studies" *World Health Organization Workshop on Electrical Hypersensitivity, Prague* (2004) [pdf](#).
- *Healer J: "Review of studies of people occupationally exposed to radio-frequency radiations" (in: Cleary SF "Biological Effects ... of Microwave Radiation" (1969) [BRH/DBE 70-02: 90-97](#)).
- *Hedendahl L et al.: "Electromagnetic hypersensitivity - an increasing challenge to the medical profession" *Rev Environ Health* (2015) [PMID: 26372109](#).
- Hocking B "Preliminary report: symptoms associated with mobile phone use" *Occup Med (Lond)*. (1998) [PMID: 10024730](#); [pdf](#).
- *Hocking B: "Microwave sickness: a reappraisal" *Occ Med (Lond)*. (2001) [PMID: 11235831](#); [pdf](#).
- *Johansson O: "Electrohypersensitivity: a functional impairment due to an inaccessible environment" *Rev Environ Health* (2015) [PMID: 26613327](#); [pdf](#).
- *Kaszuba-Zwolińska J et al.: "Electromagnetic field induced biological effects in humans" *Przegł Lek*. (2015) Review. [PMID: 27012122](#); [pdf](#).
- *Levallois P et al.: "Study of self-reported hypersensitivity to electromagnetic fields in California" *Environ Health Perspect*. (2002) [PMID: 12194896](#); [article](#).
- Mueller CH et al.: "Project NEMESIS: perception of a 50 Hz electric and magnetic field at low intensities (laboratory experiment)" *Bioelectromagnetics*. (2002) [PMID: 11793403](#).
- *Navarro E et al.: "The Microwave Syndrome: A preliminary study in Spain" *Electromagn Biol Med*. (2003); [article](#).
- *Oberfeld G et al.: "[The Microwave Syndrome: Further Aspects of a Spanish Study](#)" (2002).
- Pall ML: "Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression" *J Chem Neuroanat*. (2015) [PMID: 26300312](#).
- Redmayne M et al: "Radiofrequency exposure in young and old: different sensitivities in light of age-relevant natural differences" *Rev Environ Health* (2015) [PMID: 26613328](#).
- Saravanamuttu S et al.: "A Survey on the Impact of RF-EMF from Wireless Devices on Information Technology Professionals" *Europ J Exper Biol*. (2016) [pdf](#).
- *Schilling CJ: "Effects of acute exposure to ultrahigh radiofrequency radiation on three antenna engineers" *Occup Environ Med*. (1997) [PMID: 9166136](#); [pdf](#).
- Smith CW: "Nursing the electrically-sensitive patient" *Com Ther Nurs Midw*. (1997) [9439262](#).
- Tresidder A et al.: "Electrosensitivity: Sources, Symptoms, and Solutions" in Rosch PJ (ed.) [Bioelectromagnetic and Subtle Energy Medicine](#); CRC Press, (2014) 2nd ed.: 567-585.
- *Tuengler A et al.: "Hypothesis on how to measure electromagnetic hypersensitivity" *Electromagn. Biol. Med*. (2013) [PMID: 23301924](#); [article](#).

1. (b) Historical evidence

- Thompson SP: "A physiological effect of an alternating magnetic field" *Proc Roy Soc.* (1910) [CrossRef](#): *"I have, however, recently succeeded in demonstrating a real physiological effect due to magnetism ... I observed a faint visual effect when my forehead was placed close to the magnet ... I have found a means of producing the visual effect (which is physiological and subjective) in a way that succeeds with every person on whom it has yet been tried ... it has been noted by several observers that a sensation of taste in the mouth is excited after exposing the head for two or three minutes to the action of the alternating magnetic field."*
- Schliephake E: "Arbeitsgebiete auf dem Kurzwellengebiet" ["Fields of the Short-wave region"] *Dtsch Med Wochenschr.* (1932): [\[trans.\]](#) *"The symptoms of people working close to a short-wave radio station / mast were: first tiredness in day time and restless sleep in night time. Thereafter a feeling of "pull/pressure" on forehead and on top of head, developing to headaches, even intolerable ones. Eventually, depression and un-normal excitability / nervousness. Here, too, in our experience the wavelength is of a significant influence."*
- Likhberman BV et al.: "Terapevticheskoy primenenii korotkikh voln" ["On the Therapeutic Application of Short Waves"] Sevastopol (1936), in Kholodov YuA "Vliyaniye elektromagnitnykh i magnitnykh poley na tsentral'nyuyu nervnyuyu sistemu" ["The Effect of Electromagnetic and Magnetic Fields on the Central Nervous System"] Academy of Sciences USSR, Moscow, (1966). Trans.: [NASA TT F-465](#): *"People subjected to the systematic influence of a UHF field complained of somnolence, headaches, fatigability and irascibility ... the reactions to a UHF field ... depend on the individual characteristics of the organism and upon the initial functional state."*
- Letavet AA, Gordon ZV (eds) "O biologicheskoy vozdeistviy sverchvysokich tchastot." *Izd.Akad. Med. Nauk., SSSR, Moscow* (1960) vol.1. ["The biological action of ultrahigh frequencies" (1962) Office of Technical Services, US Department of Commerce, JPRS-1271; summarized in: NIOSH 210-76-0145; "Radiofrequency /Microwave Radiation Biological Effects and Safety Standards: A Review" RL-TE-94-53; [pdf](#), p.9] *"The researchers reported that several CNS related disorders were discovered among 525 workers exposed to RF/MW radiation. The symptoms were listed as: hypotension, slower than normal heart rates, an increase in the histamine content of the blood, an increase in the activity of the thyroid gland, disruption of the endocrine-hormonal process, alterations in the sensitivity to smell, headaches, irritability, and increased fatigue. Other researchers have acknowledged similar biological responses."*
- Marha K: "Biologicheskiye ucinky elektromagnitnykh voln o vysoke frekvenci" ["Biological effects of high-frequency electromagnetic waves"] *Prac Lek.* (1963) [PMID: 14108751](#); [ATDRep. trans.:](#) *"about 1,000 studies have been published on this subject up to the present time [1963] ... Low-intensity EM waves cause difficulties ... These include headaches, pain in the eyes, tiredness and general weakness, dizziness after standing for a period of time, fitful sleep at night, sleepiness in the daytime, changing moods, irritability, hypochondriacal attitudes, fear, depressions, reduced intellectual capacity, and reduced memory. With longer exposure, laziness and an inability to make decisions result. Complaints are voiced regarding sensations of tension in the skin, head, and forehead, loss of hair, muscle aches, and pain around the heart ... Such people experience slight eyelid, tongue, and finger tremors accompanied by increased perspiration. During work in a higher field a marked reduction in blood pressure has been observed which leads to collapse ... women in general are more susceptible to such influence than men."*
- Carpenter DO: "The microwave syndrome or electro-hypersensitivity: historical background" *Rev Environ Health* (2015) [PMID: 26556835](#).

2. Specific ES/EHS symptoms from man-made environmental radiation

EHS's specific symptoms have been confirmed as consistent since the discovery of the condition in 1932. They are caused by a wide range of EM exposures. Most modern radiation devices like mobile phones and WiFi have both low and microwave frequencies, each producing symptoms.

- Carpenter DO: "Excessive exposure to radiofrequency electromagnetic fields may cause the development of electrohypersensitivity" *Altern Ther Health Med.* (2014) [Research Gate](#); [PMID: 25478802](#).

(a) Base Stations, Mobile Phone/Radio/TV Masts

- Abdel-Rassoul G et al.: "Neurobehavioral effects among inhabitants around mobile phone base stations" *Neurotoxicology* (2007) [PMID: 16962663](#).
- Blettner N et al.: "Mobile phone base stations and adverse health effects: phase 1 of a population-based, cross-sectional study in Germany" *Occup Environ Med.* (2009) [PMID: 19017702](#).
- Borkiewicz A et al.: "Subjective symptoms reported by people living in the vicinity of cellular phone base stations: review" (Polish) *Med Pr.* (2004) [PMID: 15620045](#).
- Buchner K et al.: "Changes of Clinically Important Neurotransmitters under the Influence of Modulated RF Fields - A Long-term Study under Real-life Conditions" *Umwelt-Medizin-Gesellschaft* (2011) ([copy](#)).
- Eger H, Jahn M: "Specific Health Symptoms and Cell Phone Radiation in Selbitz, Bavaria, Germany - Evidence of a Dose-Response Relationship" *Umwelt Medizin Gesellschaft* (2010) [article in trans](#).
- Gomez-Perretta C et al: "[Subjective symptoms related to GSM radiation from mobile phone base stations: a cross-sectional study](#)" *BMJ Open* (2013) [PMID: 24381254](#).
- Hutter H et al.: "Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations" *Occup Environ Med.* (2006) [PMID: 16621850](#).
- Huttunen P et al.: "Involuntary human hand movements due to FM radio waves in a moving van" *Acta Physiol Hung.* (2011) [PMID: 21616774](#).
- Khurana VG et al: "Epidemiological evidence for a health risk from mobile phone base stations" *Int J Occup Environ Health* (2010) [PMID: 20662418](#).
- Kolodynski AA, Kolodynska W: "Motor and psychological functions of school children living in the area of the Skrunđa Radio Location Station in Latvia" *Sci Total Environ.* (1996) [PMID: 8717320](#).
- Santini R et al.: "Survey study of people living in the vicinity of cellular phone base stations" *Electromagn Biol Med.* (2003) [article](#).
- Santini R et al.: "Investigation on the health of people living near mobile telephone relay stations: I. Incidence according to distance and sex" *Pathol Biol. (Paris)* (2002) [PMID: 12168254](#).
- Santini R et al.: "Symptoms experienced by people in the vicinity of base stations: II. Incidence of age, duration of exposure, location of subjects in relation to the antennas and other electromagnetic factors" *Pathol Biol. (Paris)* (2003) [PMID: 12948762](#).
- Shahbazi-Gahrouei D et al.: "Health effects of living near mobile phone base transceiver station (BTS) antennae: a report from Isfahan, Iran" *Electromagn Biol Med.* (2014) [PMID: 23781985](#).
- Shinjyo T: [Signifikanter Rückgang klinischer Symptome nach Senderabbau – eine Interventionsstudie] "Significant Decrease of Clinical Symptoms after Mobile Phone Base Station Removal – An Intervention Study" *Umwelt-Medizin-Gesellschaft.* 27(4): (2014) [copy](#).

(b) Computers, TVs

- Eriksson N et al.: "The psychosocial work environment and skin symptoms among visual display terminal workers: a case referent study" *Int J Epidemiol.* (1997) [PMID: 9447405](#).

- Johansson O et al: "Cutaneous mast cells are altered in normal health volunteers sitting in front of ordinary TVs/PCs - results from open-field provocation experiments" *J Cut Pathol.* (2001) [PMID: 11737520](#).

(c) Mobile Phones

- Chiu CT et al: "Mobile phone use and health symptoms in children" *J Formos Med Assoc.* (2014) [PMID: 25115529](#).
- Eyvazlou M et al: "Association between overuse of mobile phones on quality of sleep and general health among occupational health and safety students" *Chronobiol Int.* (2016) [PMID: 26942630](#).
- Frey AH: "Headaches from cellular telephones: are they real and what are the implications?" *Environ Health Perspect.* (1998) [PMID: 9441959](#).
- Hocking B: "Preliminary report: symptoms associated with mobile phone use" *Occup Med (Lond).* (1998) [PMID: 10024730](#); [pdf](#).
- Ikeda K et al: "Association between mobile phone use and depressed mood in Japanese adolescents: a cross-sectional study" *Environ Health Prev Med.* (2014) [PMID: 24347468](#).
- Kim J et al.: "Association between Exposure to Smartphones and Ocular Health in Adolescents" *Ophthalmic Epidemiol.* (2016) [PMID: 27254040](#).
- Manjunatha N et al.: "Idiopathic environmental intolerance (electromagnetic hypersensitivity syndrome)" *Natl Med J India.* (2011) [PMID: 22680087](#); [pdf](#).
- Redmayne M et al: "The relationship between adolescents' well-being and their wireless phone use: a cross-sectional study" *Environ Health* (2013) [PMID: 24148357](#).
- Szyjkowska A et al: "The risk of subjective symptoms in mobile phone users in Poland - an epidemiological study" *Int J Occup Med Environ Health* (2014) [PMID: 24692074](#).
- Yogesh S et al.: "Mobile usage and sleep patterns among medical students" *Indian J Physiol Pharmacol.* (2014) [PMID: 25464686](#).

(d) MRI Scanners

The magnetic fields near MRI scanners, inducing electric currents in people moving through them, can cause specific ES/EHS symptoms. The Lorentz force of a magnetic field on the inner ear fluid's electrical currents may explain nystagmus or involuntary eye movements.

- Schaap K et al.: "Exposure to MRI-related magnetic fields and vertigo in MRI workers" *Occup Environ Med.* (2015) [PMID: 26561507](#).
- Schaap K et al: "Occupational exposure of healthcare and research staff to static magnetic stray fields from 1.5-7 Tesla MRI scanners is associated with reporting of transient symptoms" *Occup. Environ. Med.* (2014) [PMID: 24714654](#).
- van Nierop LE et al.: "Simultaneous exposure to MRI-related static and low-frequency movement-induced time-varying magnetic fields affects neurocognitive performance: A double-blind randomized crossover study" *Magn Reson Med.* (2014) [PMID: 25224577](#).
- Ward BK et al.: "Vestibular stimulation by magnetic fields" *Ann N Y Acad Sci.* (2015) [PMID: 25735662](#).

(e) Photosensitivity, Blue Light effects

- Bonmati-Carrion MA et al.: "Protecting the melatonin rhythm through circadian healthy light exposure" *Int J Mol Sci.* (2014) [PMID: 25526564](#).
- Chepesiuk R: "Missing the dark: health effects of light pollution" *Environ Health Perspect.* (2009) [PMID: 19165374](#); [pdf](#).
- Krishnan HC et al.: "Synchrony and desynchrony in circadian clocks: impacts on learning and memory" *Learn Mem.* (2015) [PMID: 26286653](#).
- Matynia A et al.: "Peripheral Sensory Neurons Expressing Melanopsin Respond to Light" *Front Neural Circuits.* (2016) [PMID: 27559310](#).
- Renard G et al.: "The dangers of blue light: True story!" *J Fr Ophtalmol.* (2016) French. [PMID: 27039979](#).

- van der Meijden WP et al.: "Individual Differences in Sleep Timing Relate to Melanopsin-Based Phototransduction in Healthy Adolescents and Young Adults" *Sleep*. (2016) [PMID: 27091519](#).

(f) Power Lines, high frequency voltage transients

Linesmen working on telephone cables in during the late 19th century showed some of the first specific symptoms associated with electromagnetic exposure. Recently, high frequency voltage transients, or 'dirty' electricity, have been associated with similar specific symptoms.

- Ghadamgahi M et al: "Memory loss risk assessment for the students nearby high-voltage power lines - a case study" *Environ Monit Assess*. (2016) [PMID: 27194231](#).
- Havas M (2008) "Dirty electricity elevates blood sugar among electrically sensitive diabetics and may explain brittle diabetes" *Electromagn Biol Med*. 27(2): 135-146; [PMID: 18568931](#).
- Havas M: "Electromagnetic Hypersensitivity: Biological Effects of Dirty Electricity with Emphasis on Diabetes and Multiple Sclerosis" *Electromagn Biol Med*. (2006) [PMID: 17178585](#).
- Havas M et al.: "Power quality affects teacher wellbeing and student behavior in three Minnesota Schools" *Sci Total Environ*. (2008) [PMID: 18556048](#).

(g) Pre-natal Exposure

- Divan HA et al: "Prenatal and postnatal exposure to cell phone use and behavioral problems in children" *Epidemiology* (2008) [PMID: 18467962](#).
- Sudan M et al: "Prenatal and postnatal Cell Phone Exposure and Headaches in Children" *Open Pediatr. Med. Journal* (2012) [PMID: 23750182](#).

(h) Provocation Tests

- Havas M: "Radiation from wireless technology affects the blood, the heart, and the autonomic nervous system" *Rev. Environ Health* (2013) [PMID: 24192494](#).
- Huttunen P et al.: "FM-radio and TV tower signals can cause spontaneous hand movements near moving RF reflector" *Pathophysiology* (2009) [PMID: 19268549](#).
- Huttunen P et al.: "Involuntary human hand movements due to FM radio waves in a moving van" *Acta Physiol Hung*. (2011) [PMID: 21616774](#).
- Köteles F et al: "Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) and electrosensitivity (ES) - are they connected?" *Int J Hyg Environ Health* (2013) [PMID: 22698789](#).
- Leitgeb N: "Electromagnetic hypersensitivity" in *Proceedings, International Workshop on Electromagnetic Fields and Non-Specific Health Symptoms, Graz, Austria*. (COST 244bis: Biomedical Effects of EMFs, WHO, ICNIRP) (1998) [pdf](#).
- Leitgeb N et al.: "Electrosensibility and electromagnetic hypersensitivity" *Bioelectromagnetics* (2003) [PMID: 12929157](#).
- McCarty DE et al.: "Electromagnetic hypersensitivity: evidence for a novel neurological syndrome" *Int J Neurosci*. (2011) [PMID: 21793784](#).
- Rea WJ et al.: "Electromagnetic field sensitivity" *J Bioelectricity* (1991) ([copy](#)).

(i) Smart Meters

- Lamech F: "Self-Reporting of Symptom Development From Exposure to Radiofrequency Fields of Wireless Smart Meters in Victoria, Australia: A Case Series" *Altern Ther Health Med*. (2014) [PMID: 25478801](#).

(j) WiFi

- Dasdag S et al.: "Effect of long-term exposure of 2.4 GHz radiofrequency radiation emitted from Wi-Fi equipment on testes functions" *Electromagn Biol Med*. (2015) [PMID: 24460421](#).
- Paknahad M et al.: "Effect of radiofrequency radiation from Wi-Fi devices on mercury release from amalgam restorations" *J Environ Health Sci Eng*. (2016) [PMID: 27418965](#).
- Saili L et al.: "Effects of acute exposure to WIFI signals (2.45GHz) on heart variability and blood pressure in Albinos rabbit" *Environ Toxicol Pharmacol*. (2015) [PMID: 26356390](#).

- Shahin S et al: "2.45 GHz Microwave Radiation Impairs Learning and Spatial Memory via Oxidative/Nitrosative Stress Induced p53 Dependent/Independent Hippocampal Apoptosis: Molecular Basis and Underlying Mechanism" *Toxicol Sci.* (2015) [PMID: 26396154](#).

3. Other effects and mechanisms of non-thermal EM exposure

Many studies show biological effects at non-thermal levels of EM exposure, many times lower than current heating limits. These effects do not necessarily produce immediate conscious symptoms, even for people with ES/EHS who may be more susceptible to such effects.

(a) Amyotrophic lateral sclerosis (ALS)

- Li CY et al.: "Association between occupational exposure to power frequency electromagnetic fields and amyotrophic lateral sclerosis: a review" *Am J Ind Med.* (2003) [PMID: 12541277](#).

(b) Antibiotic resistance in bacteria

- Soghomonyan D et al.: "Millimeter waves or extremely high frequency electromagnetic fields in the environment: what are their effects on bacteria?" *Appl Microbiol Biotechnol.* (2016) [PMID: 27087527](#).

(c) ADHD (Attention Deficit Hyperactivity Disorder), Autism

- Alsaeed I et al.: "Autism-relevant social abnormalities in mice exposed perinatally to extremely low frequency electromagnetic fields" *Int J Dev Neurosci.* (2014) [PMID: 24970316](#).
- Herbert MR et al.: "Autism and EMF? Plausibility of a pathophysiological link - Part I" *Pathophysiology.* (2013) [PMID: 24095003](#); Part II [PMID: 24113318](#).
- Milham S: (2011) "Attention deficit hyperactivity disorder and dirty electricity" *J Dev Behav Pediatr.* (2011) [PMID: 21904211](#); [copy](#).

(d) Auto-immune effects

- Marshall TG et al.: "Electrosmog and autoimmune disease" *Immunol Res.* (2016) [PMID: 27412293](#).

(e) Blood-brain barrier leakage

- Nittby H et al.: "Increased blood-brain barrier permeability in mammalian brain 7 days after exposure to the radiation from a GSM-900 mobile phone" *Pathophysiology.* (2009) [PMID: 19345073](#).

(f) Calcium flux, cell membrane permeability, phospholipids

- Pall ML: "Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects" *J Cell Mol Med.* (2013) [PMID: 23802593](#).
- Tolstykh GP et al.: "600ns pulse electric field-induced phosphatidylinositol4,5-bisphosphate depletion" *Bioelectrochemistry.* (2014) [PMID: 24530104](#).

(g) Cancers, immunodeficiency

- Dode A et al.: "Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil" *Sci Total Environ.* (2011) [PMID: 21741680](#).
- Eger H et al.: "Cancer incidence from residents within a mobile phone base station in Westphalia - interview-based pilot survey and risk assessment" *Umwelt Medizin Gesellschaft* (2009) [article \[German\]](#).
- Hardell L et al.: "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) [PMID: 24192496](#).

- IARC, WHO: "[Non-Ionizing Radiation, Part 1: Static and ELF Electric and Magnetic Fields](#)" *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*. 80 (2002).
- IARC, WHO: "[IARC Classifies radiofrequency electromagnetic fields as possibly carcinogenic to humans](#)" Press Release no. 208 (2011); [pdf](#) (2013).
- Johansson O: "Disturbance of the immune system by electromagnetic fields - A potentially underlying cause for cellular damage and tissue repair reduction which could lead to disease and impairment" *Pathophysiology*. (2009) [PMID: 19398310](#).
- Mangiacasale R et al.: "Normal and cancer-prone human cells respond differently to extremely low frequency magnetic fields" *FEBS Lett*. (2001) [PMID: 11163365](#).
- Milham S et al.: "A new electromagnetic exposure metric: high frequency voltage transients associated with increased cancer incidence in teachers in a California school" *Am J Ind Med*. (2008) [PMID: 18512243](#).
- West JG et al.: "Multifocal Breast Cancer in Young Women with Prolonged Contact between Their Breasts and Their Cellular Phones" *Case Rep Med*. (2013) [PMID: 24151509](#).
- Wolf R, Wolf D: "Increased incidence of cancer near a cell-phone transmitter station" *Int J Cancer Prev*. (2004) [article](#).

(h) Cardiovascular changes

- Hänninen O et al: "Cardiovascular Responses to Electromagnetic Radiation" *J. Afr. Ass. Physiol. Sci*. (2013) [pdf](#).
- Havas M: "Radiation from wireless technology affects the blood, the heart, and the autonomic nervous system" *Rev Environ Health*. (2013) [PMID: 24192494](#); [pdf](#).
- Shuvy M et al.: "Electromagnetic fields promote severe and unique vascular calcification in an animal model of ectopic calcification" *Exp Toxicol Pathol*. (2014) [PMID: 24882371](#).

(i) Chemical sensitivities and pollution

- Hardell L et al.: "Increased concentrations of certain persistent organic pollutants in subjects with self-reported electromagnetic hypersensitivity - a pilot study" *Electromagn Biol Med*. (2008) [PMID: 18568937](#).
- Rea WJ: "History of chemical sensitivity and diagnosis" *Rev Environ Health*. (2016) [PMID: 27383867](#); [pdf](#).

(j) Fertility reduced:

(i) Female fertility

- Ahmadi SS et al.: "Effect of non-ionizing electromagnetic field on the alteration of ovarian follicles in rats" *Electron Physician*. (2016) [PMID: 27123226](#).

(ii) Male births

- Baste V et al.: "Radiofrequency electromagnetic fields; male infertility and sex ratio of offspring" *Eur J Epidemiol*. (2008) [PMID: 18415687](#).

(iii) Male fertility

- Adams JA et al: "Effect of mobile telephones on sperm quality: a systematic review and meta-analysis" *Environ Int*. (2014) [PMID: 24927498](#).
- Zhang G et al.: "Effects of cell phone use on semen parameters: Results from the MARHCS cohort study in Chongqing, China" *Environ Int*. (2016) [PMID: 26949865](#).

(k) Gender differences

- Zhang Y et al.: "Effects of fetal microwave radiation exposure on offspring behavior in mice" *J Radiat Res*. (2015) [PMID: 25359903](#).

(l) Gene expression

- Zhao YL et al.: "The Screening of Genes Sensitive to Long-Term, Low-Level Microwave Exposure and Bioinformatic Analysis of Potential Correlations to Learning and Memory" *Biomed Environ Sci*. (2015) [PMID: 26383594](#).

(m) Genetic variants

- De Luca C et al: "[Metabolic and genetic screening of electromagnetic hypersensitivity subjects as a feasible tool for diagnostics and intervention](#)" *Mediators Inflamm.* (2014) [PHID: 24812443](#).

(n) Genomic instability, DNA damage, micronuclei

- Kesari KK et al: "Induction of micronuclei and superoxide production in neuroblastoma and glioma cell lines exposed to weak 50 Hz magnetic fields" *J R Soc Interface.* (2016) [PMID: 26791000](#).
- Luukkonen J et al: "Induction of genomic instability, oxidative processes, and mitochondrial activity by 50Hz magnetic fields in human SH-SY5Y neuroblastoma cells" *Mutat Res.* (2014) [PMID: 24374227](#).

(o) Glucose metabolism, diabetes

- Havas M: "Dirty electricity elevates blood sugar among electrically sensitive diabetics and may explain brittle diabetes" *Electromagn Biol Med.* (2008) [PMID: 18568931](#).
- Havas M: "Electromagnetic Hypersensitivity: Biological Effects of Dirty Electricity with Emphasis on Diabetes and Multiple Sclerosis" *Electromagn Biol Med.* (2006) [PMID: 17178585](#).
- Meo SA et al.: "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) [PMID: 26580639](#).
- Milham S: "Evidence that dirty electricity is causing the worldwide epidemics of obesity and diabetes" *Electromagn Biol Med.* (2014) [PMID: 23781992](#).
- Volkow ND et al.: (2011) "Effects of cell phone radiofrequency signal exposure on brain metabolism" *JAMA.* (2011) [PMID: 21343580](#).

(p) Heavy metals, mercury in dental amalgam restorations

- Byun YH et al.: "Mobile phone use, blood lead levels, and attention deficit hyperactivity symptoms in children: a longitudinal study" *PLoS One.* (2013) [PMID: 23555766](#).
- Paknahad M et al.: "Effect of radiofrequency radiation from Wi-Fi devices on mercury release from amalgam restorations" *J Environ Health Sci Eng.* (2016) [PMID: 27418965](#).

(q) Magneto-reception

- Foley LE et al: "Human cryptochrome exhibits light-dependent magnetosensitivity" *Nat Commun.* (2011) [PMID: 21694704](#).
- Qin S et al.: "A magnetic protein biocompass" *Nat Mater.* (2015) [PMID: 26569474](#).

(r) Mast cells

- Johansson O et al.: "Cutaneous mast cells are altered in normal healthy volunteers sitting in front of ordinary TVs/PCs - results from open-field provocation experiments" *J Cutan Pathol.* (2001) [PMID: 11737520](#).

(s) Melatonin reduction, circadian effects

- Reiter RJ: "Static and extremely low frequency electromagnetic field exposure: reported effects on the circadian production of melatonin" *J Cell Biochem.* (1993) [PMID: 8098713](#).
- Sokolovic D et al.: "The Effects of Melatonin on Oxidative Stress Parameters and DNA Fragmentation in Testicular Tissue of Rats Exposed to Microwave Radiation" *Adv Clin Exp Med.* (2015) [PMID: 26467130](#).

(t) Mitochondrial dysfunction, leading to ROS

- Houston B et al.: "The effects of radiofrequency electromagnetic radiation on sperm function" *Reproduction.* (2016) [PMID: 27601711](#).

(u) Myelin, Multiple Sclerosis (MS)

- Havas M: "Electromagnetic Hypersensitivity: Biological Effects of Dirty Electricity with Emphasis on Diabetes and Multiple Sclerosis" *Electromagn Biol Med.* (2006) [PMID: 17178585](#).
- Johansson O et al: "Exacerbation of demyelinating syndrome after exposure to wireless modem with public hotspot" *Electromagn Biol Med.* (2016) [PMID: 27355805](#).
- Kudo M: "Environmental Pathology: SY09-2 Multiple Sclerosis (MS) and neurodegeneration: cause and pathogenesis in relation to EMFs" *Pathology.* (2014) [abstract](#).
- Redmayne M et al: "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) [PMID: 25205214](#).

(v) Neurological effects, anxiety, EEG, learning, memory, sleep

- Augner C et al.: "Effects of exposure to GSM mobile phone base station signals on salivary cortisol, alpha-amylase, and immunoglobulin A" *Biomed Environ Sci.* (2010) [PMID: 20708499](#).
- Buchner K et al.: "Changes of Clinically Important Neurotransmitters under the Influence of Modulated RF Fields - A Long-term Study under Real-life Conditions" *Umwelt-Medizin-Gesellschaft* (2011) ([copy](#)).
- Deshmukh PS et al.: (2015) "Cognitive Impairment and Neurogenotoxic Effects in Rats Exposed to Low-Intensity Microwave Radiation" *Int J Toxicol.* (2015) [PMID: 25749756](#).
- Lustenberger C et al.: "Inter-individual and intra-individual variation of the effects of pulsed RF EMF exposure on the human sleep EEG" *Bioelectromagnetics.* (2015) [PMID: 25690404](#).
- Milham S et al.: "Dirty electricity, chronic stress, neurotransmitters and disease" *Electromagn Biol Med.* (2103) Erratum in (2014) [PMID: 23323864](#).
- Papageorgiou CC et al.: "Effects of wi-fi signals on the p300 component of event-related potentials during an auditory hayling task" *J Integr Neurosci.* (2011) [PMID: 21714138](#).
- Roggeveen S et al.: "EEG Changes Due to Experimentally Induced 3G Mobile Phone Radiation" *PLoS One.* (2015) [PMID: 26053854](#).
- Saikhedkar N et al.: "Effects of mobile phone radiation (900 MHz radiofrequency) on structure and functions of rat brain" *Neurol Res.* (2014) [PMID: 24861496](#).
- Schneider J et al.: "Nonthermal Effects of Lifelong High-Frequency Electromagnetic Field Exposure on Social Memory Performance in Rats" *Behav Neurosci.* (2014) [PMID: 24999587](#).
- Wang H et al.: "The relationship between NMDA receptors and microwave induced learning and memory impairment: a long term observation on Wistar rats" *Int J Radiat Biol.* (2014) [PMID: 25426698](#).
- Zhao YL et al.: "The Screening of Genes Sensitive to Long-Term, Low-Level Microwave Exposure and Bioinformatic Analysis of Potential Correlations to Learning and Memory" *Biomed Environ Sci.* (2015) [PMID: 26383594](#).
- Zuo H et al.: "Neural Cell Apoptosis Induced by Microwave Exposure Through Mitochondria-dependent Caspase-3 Pathway" *Int J Med Sci.* (2014) [PMID: 24688304](#).

(w) Nitric oxide

- Pilla AA: "Electromagnetic fields instantaneously modulate nitric oxide signaling in challenged biological systems" *Biochem Biophys Res Commun.* (2012) [PMID: 22940137](#).
- Salunke BP et al.: "Experimental evidence for involvement of nitric oxide in low frequency magnetic field induced obsessive compulsive disorder-like behaviour" *Pharmacol Biochem Behav.* (2014) [PMID: 24780504](#).

(x) Non-linear effects, 'windows'

- Bawin SM et al.: "Possible mechanisms of weak electromagnetic field coupling in brain tissue", pages 75-86; in Taylor LS et al.: *The Physical Basis of Electromagnetic Interactions with Biological Systems* (The Office of Naval Research) (1977) [pdf](#).
- Carrubba S et al.: "Magnetosensory evoked potentials: consistent nonlinear phenomena" *Neurosci Res.* (2008) [PMID: 18036693](#).

(y) Non-thermal effects, including radio frequency hyperthermia

- Creixell M et al.: "EGFR-targeted magnetic nanoparticle heaters kill cancer cells without a perceptible temperature rise" *ACS Nano*. (2011) [PMID: 21838221](#).
- Giuliani L et al.: "Non-Thermal Effects and Mechanisms of Interaction Between Electromagnetic Fields and Living Matter" *Europ J Oncol*. (2010) [part I](#), [part II](#).
- Pilla AA: "Nonthermal electromagnetic fields: from first messenger to therapeutic applications" *Electromagn Biol Med*. (2013) [PMID: 23675615](#).
- Yang KL et al.: "In vitro comparison of conventional hyperthermia and modulated electro-hyperthermia" *Oncotarget*. (2016) [PMID: 2755650](#).

(z) Oxidative stress, redox state

- Abu Khadra KM et al.: "Evaluation of selected biochemical parameters in the saliva of young males using mobile phones" *Electromagn Biol Med*. (2015) [PMID: 24499288](#).
- Çelik Ö et al.: "Oxidative stress of brain and liver is increased by Wi-Fi (2.45GHz) exposure of rats during pregnancy and the development of newborns" *J Chem Neuroanat*. (2015) [PMID: 26520617](#).
- Mattsson M et al.: "Grouping of experimental conditions as an approach to evaluate effects of extremely low frequency magnetic fields on oxidative response in in vitro studies" *Front. Public Health*. (2014) [pdf](#); [PMID: 25229055](#).
- Megha K et al.: "Microwave radiation induced oxidative stress, cognitive impairment and inflammation in brain of Fischer rats" *Indian J Exp Biol*. (2012) [PMID: 23986973](#).
- Odacı E et al.: "Pathological effects of prenatal exposure to a 900 MHz electromagnetic field on the 21-day-old male rat kidney" *Biotech Histochem*. (2014) [PMID: 25158858](#).
- Rakhmanin YA et al.: "[Relationship between the prevalence of chronic noninfectious diseases and electrophysical state of the environment]" *Gig Sanit*. (2015) Russian. [PMID: 26856159](#).
- Simkó M: "Cell type specific redox status is responsible for diverse electromagnetic field effects" *Curr Med Chem*. (2007) [PMID: 17456027](#).
- Terzi M et al.: "The role of electromagnetic fields in neurological disorders" *J Chem Neuroanat*. (2016) [PMID: 27083321](#).
- Tök L: "Effects of melatonin on Wi-Fi-induced oxidative stress in lens of rats" *Indian J Ophthalmol*. (2014) [PMID: 24492496](#).
- Türedi S et al.: "The effects of prenatal exposure to a 900-MHz electromagnetic field on the 21-day-old male rat heart" *Electromagn Biol Med*. (2014) [PMID: 25166431](#).
- Yakymenko I et al.: "Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation" *Electromagn Biol Med*. (2015) [PMID: 26151230](#).

(aa) Polarisation

- Panagopoulos DJ et al.: "Polarization: A Key Difference between Man-made and Natural Electromagnetic Fields, in regard to Biological Activity" *Sci Rep*. (2015) [PMID: 26456585](#).

(bb) Protein expression

- Luo Q et al.: "Proteomic analysis on the alteration of protein expression in the early-stage placental villous tissue of electromagnetic fields associated with cell phone exposure" *Reprod Sci*. (2013) [PMID: 23420827](#).

(cc) Reactive oxygen species (ROS), Heat shock proteins (HSP) [see: Oxidative Stress]

- Friedman J et al.: (2007) "Mechanism of short-term ERK activation by electromagnetic fields at mobile phone frequencies" *Biochem J*. (2007) [PMID: 17456048](#).
- Kesari KK et al.: "Cell phone radiation exposure on brain and associated biological systems" *Indian J Exp Biol*. (2013) [PMID: 23678539](#).
- Ni S et al.: "Study of oxidative stress in human lens epithelial cells exposed to 1.8 GHz radiofrequency fields" *PLoS One*. (2013) [PMID: 23991100](#).

- Usselman RJ et al.: "Spin Biochemistry Modulates Reactive Oxygen Species (ROS) Production by Radio Frequency Magnetic Fields" *PLoS One*. (2014) [PMID: 24681944](#).

(dd) Resonance signalling, ion cyclotron resonance

- Foletti A et al.: "Bioelectromagnetic medicine: The role of resonance signaling" *Electromagn Biol Med*. (2013) [PMID: 23323834](#).
- Liboff AR: "Electric polarization and the viability of living systems: ion cyclotron resonance-like interactions" *Electromagn Biol Med*. (2009) [PMID: 19811395](#).

(ee) Skin effects

- Gangi S et al.: "Skin changes in "screen dermatitis" versus classical UV - and ionizing irradiation-related damage - similarities and differences" *Exp Dermatol*. (1997) [PMID: 9412815](#).
- Johansson O et al.: "Skin changes in patients claiming to suffer from "screen dermatitis": a two-case open-field provocation study" *Exp Dermatol*. (1994) [PMID: 7881769](#).

(ff) Stem cells, osteoblasts

- Chen C et al.: "Exposure to 1800 MHz radiofrequency radiation impairs neurite outgrowth of embryonic neural stem cells" *Sci Rep*. (2014) [PMID: 24869783](#).
- Zhou J et al.: "Different electromagnetic field waveforms have different effects on proliferation, differentiation and mineralization of osteoblasts in vitro" *Bioelectromagnetics*. (2014) [PMID: 23775573](#).

(gg) Sympathetic nervous system effects

- Hänninen O et al.: "Cardiovascular Responses to Electromagnetic Radiation" *J. Afr. Ass. Physiol. Sci*. (2013) [pdf](#).

(hh) Tinnitus:

- Medeiros LN et al.: "Tinnitus and cell phones: the role of electromagnetic radiofrequency radiation" *Braz J Otorhinolaryngol*. (2016) [PMID: 26602000](#).

(ii) Therapeutic uses

- Hannemann PF et al: "The effects of low-intensity pulsed ultrasound and pulsed electromagnetic fields bone growth stimulation in acute fractures: a systematic review and meta-analysis of randomized controlled trials" *Arch Orthop Trauma Surg*. (2014) [PMID: 24895156](#).
- Ross CL et al.: "The effect of low-frequency electromagnetic field on human bone marrow stem/progenitor cell differentiation" *Stem Cell Res*. (2015) [PMID: 26042793](#).
- Tang A et al: "Repetitive Transcranial Magnetic Stimulation of the Brain: Mechanisms from Animal and Experimental Models" *Neuroscientist* (2015) [PMID: 26643579](#).

(jj) Thyroid hormones and cancer

- Carlberg M et al: "Increasing incidence of thyroid cancer in the Nordic countries with main focus on Swedish data" *BMC Cancer* (2016) [PMID: 27388603](#).
- Mortavazi S et al: "Alterations in TSH and Thyroid Hormones following Mobile Phone Use" *Oman Med J*. (2009) [PMID: 22216380](#).

(kk) Tumour promotion, tumour-specific frequencies

- Lerchl A et al: "Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans" *Biochem Biophys Res Commun*. (2015) [PMID: 25749340](#).
- Milham S et al.: "Tumor-specific frequencies and ocular melanoma" *Electromagn Biol Med*. (2016) [PMID: 27552371](#).
- Sofftitti M et al: "Life-span exposure to sinusoidal-50 Hz magnetic field and acute low-dose γ radiation induce carcinogenic effects in Sprague-Dawley rats" *Int J Radiat Biol*. (2016) [PMID: 26894944](#).

(II) Vagus nerve

- Burgess AP et al: "Acute Exposure to Terrestrial Trunked Radio (TETRA) has effects on the electroencephalogram and electrocardiogram, consistent with vagal nerve stimulation" *Environ Res.* (2016) [PMID: 27419367](#).

SUMMARY:			
<i>EM non-thermal exposure: key biological outcomes and date established</i>			
Electrosensitivity, EHS ¹	1932	Depression, suicide ²	1979
Microwave hearing, tinnitus ³	1962	Alzheimer's disease ⁴	2009
Blood-brain barrier leakage ⁵	1974	Brain tumours, glioma etc. ⁶	2009
Childhood leukaemia ⁷	1979	Tumour promotion ⁸	2015

4. Biological safety limits; criticism of heating-only limits

(a) Biological safety limits necessary for vulnerable and sensitive people

Biological limits for electromagnetic exposure need to cover particularly vulnerable members of the general public, such as children, the ill, the elderly and those sensitive or intolerant to such EM exposure. The WHO's private group ICNIRP has told governments that they need to adopt non-thermal limits to protect such people.

- ICNIRP: "General approach to protection against non-ionizing radiation" *Health Phys.* (2002) [PMID: 11906144](#).
"Different groups in a population may have differences in their ability to tolerate a particular Non-Ionizing Radiation (NIR) exposure. For example, children, the elderly, and some chronically ill people might have a lower tolerance for one or more forms of NIR exposure than the rest of the population. Under such circumstances, it may be useful or necessary to develop separate guideline levels for different groups within the general population, but it may be more effective to adjust the guidelines for the general population to include such groups."
- UK's Health & Safety Executive's Guide : [Control of Electromagnetic Fields at Work Regulations 2016](#):
 'Employees at particular risk': sections 49-61; pages 17-22:

¹ Schliephake E: "Arbeitsgebiete auf dem Kurzwellengebiet" ["Fields of the Short-wave region"] *Dtsch Med Wochenschr.* (1932); Czernski P et al: "Przypadek 'choroby mikrofalowej'" [A case of 'Microwave Sickness'] *Medycyna Pracy* (1964), etc.

² Reichmanis M et al: "Relation between suicide and the electromagnetic field of overhead power lines" *Physiol Chem Phys.* (1979) [PMID: 542502](#).

³ Frey AH: "Human auditory system response to modulated electromagnetic energy" *J Appl Physiol* (1962) [PMID: 13895081](#).

⁴ Huss A et al: "Residence near power lines and mortality from neurodegenerative diseases: longitudinal study of the Swiss population" *Am J Epidemiol.* (2009) [PMID: 18990717](#).

⁵ Frey AH: "Differential biologic effects of pulsed and continuous electromagnetic fields and mechanisms of effect" *Ann N Y Acad Sci.* (1974) [PMID: 4613239](#).

⁶ Hardell L et al: "Epidemiological evidence for an association between use of wireless phones and tumor diseases" *Pathophysiology* (2009) [PMID: 19268551](#).

⁷ Wertheimer N et al: "Electrical wiring configurations and childhood cancer" *Am J Epidemiol.* (1979) [PMID: 453167](#).

⁸ Lerchl A et al: "Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans" *Biochem Biophys Res Commun.* (2015) [PMID: 25749340](#); Sofftitti M et al: "Life-span exposure to sinusoidal-50 Hz magnetic field and acute low-dose γ radiation induce carcinogenic effects in Sprague-Dawley rats" *Int J Radiat Biol* (2016) [PMID: 26894944](#).

"You must give special consideration to the safety of employees at particular risk (even if you are in compliance with the exposure limits)." (section 49, page 17)

Risks for employees at particular risk can be at non-thermal levels, including WiFi, Bluetooth, mobile phones and cordless phones, for pregnant women and those with active or passive medical implants, even when the employer has provided an environment in compliance with the ICNIRP heating-only limits.

Employees intolerant of electromagnetic exposures are likely to be "at particular risk". Employers, once notified, have to undertake a risk assessment and then take special consideration of such employees.

- Statutory Instruments (2016): No. 588 HEALTH AND SAFETY: [The Control of Electromagnetic Fields at Work Regulations 2016](#).
 (Non-thermal electromagnetic sensitivity symptoms:
 Part 1: "employee at particular risk" means: (a) "an employee who has declared to his or her employer a condition which may lead to a higher susceptibility to the potential effects of exposure to electromagnetic fields." (p.2)
 Part 1: 2 (b) "non-thermal effects, related to the stimulation of nerves or sensory organs due to the presence of electromagnetic fields." (p.8)
 Part 2: Direct biophysical effects of exposure Action levels – non-thermal effects (p.9)
 Exposure limit values: non-thermal effects: Table ELV1: (b) "protection measures have been adopted which minimise, so far as is reasonably practicable, the sensory effects related to movement in static magnetic fields, including nausea and vertigo." (p.11)
- [Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents \(electromagnetic fields\)](#):
 Electromagnetic intolerance symptoms:
 Article 2(b) (ii) "Non-thermal effects, such as the stimulation of muscles, nerves or sensory organs. These effects might have a detrimental effect on the mental and physical health of exposed workers. Moreover, the stimulation of sensory organs may lead to transient symptoms, such as vertigo or phosphenes. These effects might create temporary annoyance or affect cognition or other brain or muscle functions, and may thereby affect the ability of a worker to work safely (i.e. safety risks)."

(b) Biological safety limits

Biological limits are provided by the expert groups in this field, such as Bioinitiative, Building Biology, EUROPAEM, Seletun, Salzburg, etc.

Typical values for sensitive people are: 10 nanoTesla (magnetic fields, 50 Hz), 0.006 Volts/metre (peak electric fields, microwave frequencies), 1 Volt/metre (electric fields, 50 Hz). Power Flux Density and SAR are heating metrics, not directly relevant to non-thermal ES/EHS.

- [BioInitiative Report](#): "A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Fields (ELF and RF)" (2012).
- Building Biology: [Guidelines](#) (2008).
- [EUROPAEM EMF Guidelines](#) (ELF and RF) (2016).
- Fragopoulou A et al.: "Scientific panel on electromagnetic field health risks: consensus points, recommendations, and rationales" *Rev Environ Health*. (2010) [PMID: 21268443](#).
- Salzburg: "[Precautionary limits](#)" (2002).

(c) Objective biological safety limits

Safety limits should be based on objective biological measures, such as DNA fragmentation, cell hydration and oogenesis, not on a heating hypothesis and modelling of tissue heating qualities which are irrelevant to EHS.

- Ayrapetyan S et al: "Cell hydration as a biomarker for estimation of biological effects of nonionizing radiation on cells and organisms" *ScientificWorldJournal*. (2014) [PMID: 25587574](#).

- Blank M et al.: "Electromagnetic fields and health: DNA-based dosimetry" *Electromagn Biol Med.* (2012) [PMID: 22676645](#).
- Margaritis LH et al: "Drosophila oogenesis as a bio-marker responding to EMF sources" *Electromagn Biol Med.* (2014) [PMID: 23915130](#).

(d) *Criticism of heating-only safety limits*

The long invalidated heating-only hypothesis, used by the small clique of regulators adopting this minority viewpoint, has been frequently criticised by the leading experts, now that non-thermal effects are well established.

There are also four common misconceptions:

(i) Heating-only proponents, like ICNIRP, accept adverse non-thermal affects at ELF; since WiFi and mobile phones emit ELF as well as RF, this means that ICNIRP should also accept that WiFi and mobile phones can have adverse non-thermal effects.

(ii) Some heating-only proponents claim that ICNIRP's heating limits, defined by SAR or temperature rise, relate also to homeostasis or thermoregulation. Homeostasis or thermoregulation, however, where there is no significant temperature rise, are biological processes which are different from a rise in temperature. ICNIRP limits do not aim to prevent these biological processes, but only a rise in temperature.

(iii) Many biological processes produce much greater temperature rises in the body than the one degree rise which is used as the maximum permissible by ICNIRP's heating hypothesis. If ICNIRP's heating hypothesis is correct, ICNIRP would also need to ban all human exercise which produces a temperature rise of more than one degree averaged over 6 minutes.

(iii) Established non-thermal biological processes are non-linear, unlike the heating hypothesis using SAR and power density. Thus biological effects depend on frequency, modulation and temporal exposure pattern, not necessarily on a dose-dependent or linear response.

- Hardell L et al.: "Biological effects from electromagnetic field exposure and public exposure standards" *Biomed Pharmacother.* (2008) [PMID: 18242044](#).
- Johansson O: "Disturbance of the immune system by electromagnetic fields - A potentially underlying cause for cellular damage and tissue repair reduction which could lead to disease and impairment" *Pathophysiology.* (2009) [PMID: 19398310](#).
- Pall ML: "Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action" *Rev Environ Health.* (2015) [PMID: 25879308](#).
- Panagopoulos DJ et al.: "Evaluation of specific absorption rate as a dosimetric quantity for electromagnetic fields bioeffects" *PLoS One.* (2013) [PMID: 23750202](#).
- Redmayne M: "International policy and advisory response regarding children's exposure to radio frequency electromagnetic fields (RF-EMF)" *Electromagn Biol Med.* (2015) [PMID: 26091083](#).
- Sage C et al.: "Comments on SCENIHR: Opinion on potential health effects of exposure to electromagnetic fields, bioelectromagnetics 36:480-484 (2015)" *Bioelectromagnetics.* (2015) [PMID: 26688202](#); [RG](#).
- Sagioglou NE et al: "Apoptotic cell death during Drosophila oogenesis is differentially increased by electromagnetic radiation depending on modulation, intensity and duration of exposure" *Electromagn Biol Med.* (2016) [PMID: 25333897](#).
- Webster PC: "Federal Wi-Fi safety report is deeply flawed, say experts" *CMAJ.* (2014) [PMID: 24756628](#); [pdf](#).

(e) Appeal for Biological safety limits

The EMF Scientist Appeal, to the Secretary-General of the United Nations and the Director-General of the WHO, is now signed by over 200 experts in this field who accept the majority non-thermal viewpoint. It shows how urgently governments should adopt biological limits, like the USSR and a growing number of other countries since the 1950s, and not align with minority viewpoint represented by ICNIRP and a small clique of industry and pro-wireless activists.

- [The International Electromagnetic Field Scientist Appeal](#), submitted on May 11 2015 to His Excellency Ban Ki-moon, Secretary-General of the United Nations; Honorable Dr. Margaret Chan, Director-General of the World Health Organization; Honorable Achim Steiner, Executive Director of the U.N. Environmental Programme; U.N. Member Nations.

(f) Typical exposure levels

There are few recent surveys of total electromagnetic exposure in common situations. A survey at a railway station published in 2016 showed a mean of 921 $\mu\text{W}/\text{m}^2$ with outliers up to 95,500 $\mu\text{W}/\text{m}^2$ and mean total for walkabouts of 2,800 to 4,900 $\mu\text{W}/\text{m}^2$, compared with precautionary safety limits of 3 or 6 $\mu\text{W}/\text{m}^2$ (BioInitiative 2012).

- Hardell L et al: "Radiofrequency radiation at Stockholm Central Railway Station in Sweden and some medical aspects on public exposure to RF fields" *Int J Oncol.* (2016) [PMID: 27633090](#).

5. Living with EHS (functional impairment, socio-economic effects, disability and equality legislation)

- Budzinski BI et al: "White zones", free from mobile phone coverage – unrealistic or required by law?" *Neue Zeitschrift für Verwaltungsrecht* (2015) [trans](#).
- Gibson PR et al.: "Unmet health care needs for persons with environmental sensitivity" *J Multidiscip Healthc.* (2015) [PMID: 25670904](#).
- Johansson O: "Electrohypersensitivity: a functional impairment due to an inaccessible environment" *Rev Environ Health* (2015) [PMID: 26613327](#); [pdf](#).
- Johansson O.: "[Electrohypersensitivity; State-of-the-Art of a Functional Impairment](#)" *El Biol & Med.* (2006) [PMID: 17178584](#).
- Kato Y et al.: "Reported functional impairments of electrohypersensitive Japanese: A questionnaire survey" *Pathophysiology.* (2012) [PMID: 22458999](#).
- Massey KA: "The Challenge of Nonionizing Radiation: A Proposal for Legislation" *Duke Law J.* (1979) [pdf](#).
- Stenberg B et al.: "Medical and social prognosis for patients with perceived hypersensitivity to electricity and skin symptoms related to the use of visual display terminals" *Scand J Work Environ Health* (2002) [PMID: 12432989](#); [pdf](#).

6. Proposed diagnostic markers

- Austrian Medical Association: "Guideline of the Austrian Medical Association for the diagnosis and treatment of EMF related health problems and illnesses (EMF syndrome)" (2012) [pdf](#).
- Belpomme D et al: "Reliable disease biomarkers characterizing and identifying electrohypersensitivity and multiple chemical sensitivity as two etiopathogenic aspects of a unique pathological disorder" *Rev Environ Health* (2015) [PMID: 26613326](#); [pdf](#).
- Belyaev I et al.: "[EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses](#)" *Rev Environ Health* (2016) [PMID: 27454111](#).
- De Luca C et al: "[Metabolic and genetic screening of electromagnetic hypersensitivity subjects as a feasible tool for diagnostics and intervention](#)" *Mediators Inflamm.* (2014) [PHID: 24812443](#).
- Nordic Council of Ministers: "The Nordic Adaptation of Classification of Occupationally Related Disorders (Diseases and Symptoms) to ICD-10" (2000) [pdf](#); p.33 (ICD-10.R68.8), p.55.

7. Differences between EHS and Electrophobia/Nocebo

Electromagnetic Hypersensitivity (EHS) (also called *Electrosensitivity, Electrical Sensitivity or Intolerance, EI-Allergy, Microwave Sickness, Radio Wave Sickness*) was first described in 1932 in Germany. It was confirmed as a real physical condition in the USSR and Poland in the 1960s and accepted in the west by an international governmental group in 2000.

Electrophobia, a psychological fear or Nocebo effect, was first applied to man-made electromagnetic exposure in the 1990s. It depends on prior cognitive conditioning and therefore cannot include children, animals or unaware adults, although all can suffer EHS, and cannot explain established human, animal and plant sensitivity to natural geomagnetism. The World Health Organization's [Backgrounder 296](#) on EHS, dated 2005, confuses EHS with Electrophobia.

- Augner C, Hacker GW: "Are people living next to mobile phone base stations more strained? Relationship of health concerns, self-estimated distance to base station, and psychological parameters" *Indian J Occup Environ Med.* (2009) [PMID: 20442833](#).
- Dieudonne M: "Does electromagnetic hypersensitivity originate from nocebo responses? Indications from a qualitative study" *Bioelectromagnetics* (2016) [PMID: 26369906](#).

8. Electromagnetic warfare

Non-thermal electromagnetic warfare, utilising ES/EHS specific symptoms, began in 1953 with microwave irradiation of the USA Embassy in Moscow. It was used against peace protestors at the USAF airbase, Greenham Common, Newbury, UK, in 1983 and in many recent conflicts in the Middle East. Understandably, there are few peer-reviewed medical studies on this topic, although it inspired much of the EM research in the USSR and USA.

- Bealy K: "[Electromagnetic Pollution: A Little Known Health Hazard, A New Means of Control?](#)" *Preliminary Report, Greenham Common Women's Peace Camp* (1984).
- Guthrie LB "Legal Implications of the Soviet Microwave Bombardment of the U.S. Embassy" *Boston Coll Internat Compar Law Rev.* (1977) [pdf](#).
- Guyatt D: "[Some aspects of anti-personnel electromagnetic weapons](#)" Synopsis for the Internat. Com. of the Red Cross Symposium: "The Medical Profession and the Effects of Weapons" (1996)
- Johnson Liakouris AG: "Radiofrequency (RF) Sickness in the Lillienfield Study: an effect of modulated microwaves?" *Arch Environ Health.* (1998) [PMID: 9814721](#); [pdf](#).

9. Sensitivity to natural geomagnetic disturbances

Most life on Earth depends on solar radiation. Solar and other fluctuations cause geo-magnetic disturbances which can cause biological effects in plants and some animals.

- Acheson ED et al.: "Some comments on the relationship of the distribution of multiple sclerosis to latitude, solar radiation, and other variables" *Acta Psychiatrica Scand.* (1960) [PMID: 13681205](#).
- Bevington M: "Lunar biological effects and the magnetosphere" *Pathophysiology* (2015) [PMID: 26462435](#).
- Martínez-Bretón JL et al.: "Artificial reproduction of magnetic fields produced by a natural geomagnetic storm increases systolic blood pressure in rats" *Int J Biometeorol.* (2016) [PMID: 27094916](#).
- Mo WC et al.: "Shielding of the Geomagnetic Field Alters Actin Assembly and Inhibits Cell Motility in Human Neuroblastoma Cells" *Sci Rep.* (2016) [PMID: 27029216](#).
- Rozhkov VN et al.: ["Psychophysiological and cardiohemodynamic effects of solar, geomagnetic and meteorological factors in man living in Arctic area"] *Fiziol Cheloveka.* (2014) Russian. [PMID: 25707219](#).
- Shaposhnikov D et al.: "The influence of meteorological and geomagnetic factors on acute myocardial infarction and brain stroke in Moscow, Russia" *Int J Biometeorol.* (2014) [PMID: 23700198](#).
- Tada H: "Association of geomagnetic disturbances and suicides in Japan, 1999-2010" *Environ Health Prev Med.* (2014) [PMID: 24005993](#).
- Villorosi G et al: "[Myocardial infarct and geomagnetic disturbances: analysis of data on morbidity and mortality]" *Biofizika* (1998) [PMID: 9783069](#).

10. Sensitivity of plants and animals to electromagnetic exposure

The weight of evidence from many studies shows convincing and consistent evidence of sensitivity by plants and animals to non-thermal levels of electromagnetic exposure, both natural and man-made, as with human studies. Plants and animals cannot experience the electrophobia or Nocebo effect suggested for some human symptoms, providing additional support for real human electromagnetic sensitivity and hyper-sensitivity.

- Cammaerts MC et al: "Food collection and response to pheromones in an ant species exposed to electromagnetic radiation" *Electromagn Biol Med.* (2013) [PMID: 23320633](#).
- Cammaerts MC et al: "GSM 900 MHz radiation inhibits ants' association between food sites and encountered cues" *Electromagn Biol Med.* (2012) [PMID: 22268919](#).
- Grémiaux A et al: "Low-amplitude, high-frequency electromagnetic field exposure causes delayed and reduced growth in Rosa hybrid" *J Plant Physiol.* (2016) [PMID: 26643955](#).
- Haggerty K: "Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings: Preliminary Observations" *Int J Forestry Res.* (2010) <http://dx.doi.org/10.1155/2010/836278>.
- Liang CH et al: "Magnetic Sensing through the Abdomen of the Honey bee" *Sci Rep.* (2016) [PMID: 27005398](#).
- Margaritis LH et al: "Drosophila oogenesis as a bio-marker responding to EMF sources" *Electromagn Biol Med.* (2014) [PMID: 23915130](#).
- Mina D et al: "Immune responses of a wall lizard to whole-body exposure to radiofrequency electromagnetic radiation" *Int J Radiat Biol.* (2016) [PMID: 26853383](#).
- Soran ML et al: "Influence of microwave frequency electromagnetic radiation on terpene emission and content in aromatic plants" *J Plant Physiol.* (2014) [PMID: 25050479](#).

- Waldmann-Selsam C et al: "Tree damage in the vicinity of mobile phone base stations" *Umweltmedizin-gesellschaft*. (2013); (trans.) [pdf](#).
- Waldmann-Selsam C et al: "Radiofrequency radiation injures trees around mobile phone base stations" *Sci Total Environ*. (2016) [PMID: 27552133](#).
- Waldmann-Selsam C et al: "[Trees in Bamberg and Hallstadt in the radiation field of 65 mobile phone base stations: Examples from a documentation about 700 trees \(2006-2016\)](#)" *Sci Total Environ*. (2016).

11. Further information

Bias in studies according to sources of funding:

- Huss A et al: "Source of funding and results of studies of health effects of mobile phone use: systematic review of experimental studies" *Environ Health Perspect*. (2007) [PMID: 17366811](#).
- Ledford BW: "Cell Phones, Electromagnetic Radiation, and Cancer: A Study of Author Affiliation, Funding, Bias, and Results" *Proc Pol Stud Org*. (2010) [pdf](#).
- Levis AG et al: "Mobile phones and head tumours. The discrepancies in cause-effect relationships in the epidemiological studies - how do they arise?" *Environ Health*. (2011) [PMID: 21679472](#).

Books, reviews and websites on Electromagnetic Sensitivity and Electromagnetic Hypersensitivity:

- Bevington M: "Electromagnetic Sensitivity and Electromagnetic Hypersensitivity: A Summary" 2nd ed. (2013) ISBN: 9781872072210 (available from [ES-UK](#)) (112 pages; 1,800 refs).
- Bioinitiative (2007): [Bibliography](#) (119 pages)
- Bioinitiative (2012): [Section 24.F](#) (ES references)
- Bioinitiative (2012): [Henry Lai: ES/EHS abstracts](#)
- Dr Magda Havas: [Archive of 1960-70s US Navy medical researcher Dr ZR Glaser](#)
- Electrosensitivity.co: [Mechanisms and pathways](#)
- EMF Portal: [Studies](#) (23,100 refs; 5,600 summaries, as at 06.2016)
- EMF Safety: [Bibliographies](#)
- Emfwise.com: [Effects](#)
- Philips A & J: [The Powerwatch Handbook](#) (2009)
- Powerwatch: [Electrical Hypersensitivity](#) (8 articles)
- Prove-It: [Studies](#) (1,168 refs)
- SSITA: Goldsworthy A: "[The Biological Effects of Weak Electromagnetic Fields](#)" (2012)
- Switch2safe: [Studies](#)
- US Naval Medical Research Inst.: "[Bibliography of Reported Biological Phenomena and Clinical Manifestations attributed to Microwave and Radio-Frequency Radiation](#)" (1971) (2,308 refs)
- WiFi in Schools.com: "[136 Studies Showing Health Effects from WiFi Radio Frequency Radiation](#)"
- WiFi in Schools.org.uk: [Studies](#)