SELECTED STUDIES ON

ELECTROSENSITIVITY (ES) AND

ELECTROMAGNETIC HYPER-SENSITIVITY (EHS)

4th edition (March 26th 2018)

with over 2,000 studies and references.

- *There are many thousands of peer-reviewed studies relevant to ES/EHS.*
- *This limited selection of over 2,000 studies and references aims to provide an indication of the wide range of studies and references 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.*
- *Some studies and references appear under two or more headings where these are relevant.*

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3. Summary: Some key findings, with dates first described

- *Electrosensitivity symptoms from man-made devices were recorded in the late 19th century.*
- *Electromagnetic hyper-sensitivity (EHS) symptoms were described in radio engineers in 1932.*
- *Skin changes in people with EHS were shown in 1994.*
- *Genetic variants were 9.7 times more likely in people with EHS (2014).*
- *Objective tests for diagnosing real physiological EHS were published in 2015.*
- *3d MRI scans showed brain differences in people with EHS in 2017.*

- *Various biological mechanisms and pathways for sensitivity to electromagnetic energy are becoming established. Three have been seen as especially significant.*
  (a) ERK cascade protein expression (2007), within two minutes of RF exposure, inducing transcription and phosphorylation leading to gene expression and long-term potentiation in the glial cells, which has been compared with potentiation in musicians' brains.
  (b) Magnesium (2012), an antioxidant and calcium-blocker, in the form of the isotope ^{25}Mg, has been proposed as having a magnetic effect through the radical pair mechanism or nuclear spin selectivity. Magnesium is linked with enzyme phosphorylation/ATP and downstream neurological effects such as depression and migraines. These consequences could also, however, be associated with electromagnetic effects on VGCCs.
  (c) VGCCs, or voltage-gated calcium channels (2013), are affected by environmental electromagnetic energy. Downstream consequences include excessive oxidative stress, leading to neurological effects, DNA breaks and cancer.
- *Other receptors, mechanisms and pathways include calcineurin, cryptochromes, gene expression, hydrogen bonds, magnetite, mast cell degranulation, melatonin, myelin, primary cilia, stochastic resonance and the sympathetic nervous system.*

- *EHS or 'El-allergy' was recognised in the ICD-10 code of 2000.*
- *Sweden recognised people with EHS as functionally impaired in 2000, later followed by other countries, along with awarding financial compensation for unemployment and disability.*
- *"Certain sensitive individuals" were recognised by WHO/ICNIRP in 2002 as needing long-term non-thermal safety guidelines, lower than ICNIRP's short-term heating-only guidelines.*
- *EUROPAEM 2016 biological guidelines specify safety levels for sensitive people from 2016.*

SUMMARY: ***Some key findings, with dates first described or established***	
Solar EM radiation variations: effects on plants[1]	1801
Solar EM radiation variations: effects on humans[2]	1860s
Solar EM radiation variations: effects on insects[3]	1881
Man-made electromagnetic fields: sensitivity effects on humans[4]	1889

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Non-thermal effects (20 kHz)[5]	1896
Man-made electromagnetic fields: sensitivity in fish[6]	1917
Electromagnetic Sensitivity, Electromagnetic Hyper-Sensitivity (EHS) in humans (RF)[7]	1932
Blood: pearl chain/rouleaux formation[8]	1946
Cataracts[9]	1948
Brain tumours, leukaemia (microwaves)[10]	1953
Solar and geomagnetic effects[11]	1960
Microwave hearing, tinnitus[12]	1961
Cardiovascular effects[13]	1962
Microwave hearing, tinnitus[14]	1962
Electromagnetic Sensitivity symptoms (ELF)[15]	1966
Bone tumours[16]	1968
Blood-brain barrier leakage[17]	1974
Calcium flux[18]	1974

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Non-linear effects, 'Windows' effects[19]	1977
Leukaemia, childhood (power lines)[20]	1979
Depression, suicide[21]	1979
Fetal damage (microwaves)[22]	1981
Melatonin reduced[23]	1981
Breast cancer, female (power lines)[24]	1982
Skin cancer (microwaves)[25]	1982
Leukaemia, adult[26]	1982
Leukaemia, acute myeloid[27]	1982
Cancer (microwaves)[28]	1984
DNA synthesis, from time-varying magnetic fields[29]	1984
Glutathione (antioxidant) reduced[30]	1985
Amyotrophic lateral sclerosis (ALS), Motor Neuron Disease, Lou Gehrig's disease[31]	1986
Behavioural changes, from non-thermal static and time-varying magnetic fields[32]	1986

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Breast cancer (male)[33]	1990
Brain tumours, glioblastoma[34]	1991
Calcium-dependent phosphorylation[35]	1991
Mast cell degranulation[36]	1994
DNA damage[37]	1994
DNA damage[38]	1995
Stochastic resonance, voltage-dependent ion channels[39]	1995
Grounding and earthing health effects[40]	2000
EHS: ICD-10 "El-Allergy"[41]; EHS: functional impairment (Sweden)	2000
Power frequency classified as 2B human carcinogen[42]	2001
"Certain sensitive individuals" recognised by WHO/ICNIRP[43]	2002
Magnesium-dependent phosphorylation in enzymes[44]	2004
ERK cascade of protein expression as signalling mechanism[45]	2007
Alzheimer's disease[46]	2009
Brain tumours, glioma etc., from mobile phones[47]	2009

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Radio frequency classified as 2B human carcinogen[48]	2011
Magnetic effects on enzymatic synthesis by magnesium nuclear spin, publicised[49]	2012
Safety levels for children (Bioinitiative, 2012)[50]	2012
VGCCs mechanism, accepted[51]	2013
Genetic variants associated with EHS[52]	2014
Oxidative stress mechanism, accepted[53]	2015
Objective tests for diagnosing EHS[54]	2015
Tumour promotion[55]	2015
Safety levels for sensitive people (EUROPAEM 2016)[56]	2016
Primary cilia sensitivity[57]	2017
3d fMRI scans show brain differences in people with EHS[58]	2017
Autoimmune disease affected by electrosmog; Vitamin-D receptors[59]	2017
Large study confirming RF (mobile phones) as a carcinogen[60]	2018

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Large study confirming RF (phone masts) as a carcinogen[61]	2018

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2. Some key studies and reviews

(useful introductory or general studies)*

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3. Specific ES/EHS symptoms and EM effects from man-made environmental radiation

- *Specific symptoms caused by intolerance of low-level electromagnetic exposure have been reported since the end of the 19th century. They have been confirmed as consistent since the discovery of the condition of hyper-sensitivity in 1932.*
- *These specific symptoms 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.*
- *These specific symptoms are present both among people in the general population, and among people who have been diagnosed with hyper-sensitivity.*
- *In most populations the proportion of people in the general population reporting specific symptoms associated with low-level electromagnetic exposure is often 30-40%.*
- *In most surveys the proportion of people with hyper-sensitivity reporting these specific symptoms associated with low-level electromagnetic exposure is about 3-4%.*

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4. Specific ES symptoms from, and sensitivity to, natural geomagnetic disturbances

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Websites providing geomagnetic and solar forecasts:

Aurora Forecast
Flarecast.eu
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5. Earthing and Grounding

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The practice of Earthing or Grounding is discouraged where the Earth has high electric fields and high frequency voltage transients caused by return currents. This is common in parts of Canada and the USA and can sometimes occur on the Earth of home wiring anywhere.

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6. Shielding (buildings and clothing) and Treatment

(a) Shielding: buildings

There has been much research into how buildings can be made protective against electromagnetic energy. This has particularly involved development of concrete with mixes of material materials to reduce the permittivity of cement mixtures. Materials tested include carbon black, carbon fibre, carbonaceous nano/micro inerts, chlorinated polyethylene/carbon nanofiber nanocomposites, ferrite–paraffin polymer composites, flexible graphite or submicron graphite particles, fly ash, graphene oxide/ferrofluid/cement composites, magnetite, Mn–Zn ferrite, multi-walled carbon nanotube cement composites, nano-titanium dioxide and nickel-coated carbon nanofiber, thermoplastic natural rubber filled magnetite nanocomposites, steel slag, and stainless steel fibers of diameter 8 μm and length 6 mm. The last, steel fibers, showed a shielding effectiveness of 70 dB at 1.5 GHz, while ferrite–paraffin polymer composites reached −46.60 dB at 10.5 GHz for an absorber thickness of 2 mm.

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(b) Shielding: clothing

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(c) Treatment

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7. Living with EHS: Functional impairment, socio-economic effects, human rights; Use of meters

Functional impairment, socio-economic effects, human rights:

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- Roda C et al.: "Mobile phone infrastructure regulation in Europe: Scientific challenges and human rights protection" *Environ Sci Policy.* (2014) Abstract. Article.
- 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.

Use of meters:

- Dieudonné M: "L'instrumentation profane. Sur l'usage d'instruments de mesure des champs électro-magnétiques par les personnes électro-hypersensibles" [Lay InstrumentationOn Electro-hypersensitive Persons' Use of Electromagnetic Field Measuring Devices] *Rev d'anthropologie des connaissances.* (2016) Abstract.
- Milham S: "An off-the-shelf meter for measuring body amperage: A new gold standard for epidemiologic studies?" *Electromagn Biol Med.* (2017) PMID: 28650676; pdf.

8. Legislation relevant to EHS:

European and International Resolutions
Global health
Nuremberg Code
UK early health retirement and DWP support allowances
UK disability and equality legislation
UK EMF legislation
UK health & safety legislation
United Nations
USA accommodation for people with EHS

European and International Resolutions:

- Council of Europe: Resolution 1815 (Parliamentary Assembly, 2011) Point 8.1.4:
  "Pay particular attention to 'electrosensitive' people who suffer from a syndrome of intolerance to electromagnetic fields and introduce special measures to protect them, including the creation of wave-free areas not covered by the wireless network."
- European Union: Parliamentary Resolution (2008/2211(INI)) (2009) Point 28:
  "Calls on Member States to follow the example of Sweden and to recognise persons that suffer from electrohypersensitivity as being disabled so as to grant them adequate protections as well as equal opportunities."
- European Union: PECCEM: (October 25 2016):
  "Open letter to the European Economic and Social Committee (EESC): to repair the damage caused by the conflicts of interest and procedural irregularities in its midst arising from the adoption of the counter-opinion on electromagnetic hypersensitivity (EHS)"
- International Justice Resource Centre: Committee on the Rights of Persons with Disabilities: Accessibility:
  "As long as goods, products and services are open or provided to the public, they must be accessible to all, regardless of whether they are owned and/or provided by a public authority or a private enterprise."
  "The strict application of universal design to all new goods, products, facilities, technologies and services should ensure full, equal and unrestricted access for all potential consumers, including persons with disabilities, in a way that takes full account of their inherent dignity and diversity."

Global Health:

- Hyland GJ: "Environmental Impact of Electrosmog" in: Clements-Croome D (ed.): "Electromagnetic Environments and Health in Buildings" Spon Press, Taylor & Francis (2004) p.162.
- Oberfeld G: "Precaution in Action - Global Public Health Advice Following BioInitiative 2007" *Bionitiative* (2012) pdf.

Nuremberg Code:

For the general public, (i) the absence of definitive findings about the long-term health effects of exposure to EM energy, and (ii) the absence of knowledge and voluntary consent about enforced irradiation with EM exposure, suggest that governments are indulging in a massive health experiment without voluntary and informed consent, contravening the Nuremberg Code of 1947.
Ten principles of the Nuremberg Code:

1. Required is the voluntary, well-informed, understanding consent of the human subject in a full legal capacity.
2. The experiment should aim at positive results for society that cannot be procured in some other way.
3. It should be based on previous knowledge (e.g., an expectation derived from animal experiments) that justifies the experiment.
4. The experiment should be set up in a way that avoids unnecessary physical and mental suffering and injuries.

5. It should not be conducted when there is any reason to believe that it implies a risk of death or disabling injury.
6. The risks of the experiment should be in proportion to (that is, not exceed) the expected humanitarian benefits.
7. Preparations and facilities must be provided that adequately protect the subjects against the experiment's risks.
8. The staff who conduct or take part in the experiment must be fully trained and scientifically qualified.
9. The human subjects must be free to immediately quit the experiment at any point when they feel physically or mentally unable to go on.
10. Likewise, the medical staff must stop the experiment at any point when they observe that continuation would be dangerous.

The Nuremberg Code

UK allowances and health retirement:

The following have been awarded in the UK since 2012 to people with EHS, including Department of Work (DWP) and Pensions allowances:

- Early retirement on health grounds
- ESA (Employment and Support Allowance)
- JSA (Job Seeker's Allowance) exemptions
- PIP (Personal Independence Payment)

see ES-UK Newsletters

UK disability and equality legislation:

- Equality Act 2010
- Equality Act: Recruitment
- Flexible Working Regulations (2014)

UK EMF legislation:

- HSE: "Electromagnetic Fields at Work: A guide to the Control of EMFs at Work Regulations: 2016",

UK health & safety legislation:

- Health and Safety at Work Act 1974

United Nations:

Basic human rights, such as choosing where to live and work, are often denied for people with EHS.

- United Nations: "Convention on the Rights of Persons with Disabilities" (2006)
- United Nations: "The Standard Rules on the Equalization of Opportunities for Persons with Disabilities" (1993)
- United Nations: "The Universal Declaration of Human Rights" (1948)

USA accommodation for people with EHS:

- USA's Department of Labor: Job Accommodation Network (JAN)

9. Diagnostic markers

Physiological objective markers for EHS are becoming well established and now include:

- *3d fMRI brain scans showing changes in blood flow*
- *cerebral blood perfusion scans*
- *genetic variants up to 10 times more common*
- *markers such as heat shock protein, melatonin, saliva alpha amylase*

- Andrianome S et al.: "Increasing levels of saliva alpha amylase in electrohypersensitive (EHS) patients" *Int J Radiat Biol.* (2017) PMID: 28466664.
- 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; pdf.
- De Luca C et al: "Metabolic and genetic screening of electromagnetic hypersensitivity subjects as a feasible tool for diagnostics and intervention" *Mediators Inflamm.* (2014) PMID: 24812443; pdf.
- Heuser G et al.: "Functional brain MRI in patients complaining of electrohypersensitivity after long term exposure to electromagnetic fields" *Rev Environ Health.* (2017) PMID: 28678737; pdf. Heuser G et al.: "Corrigendum" *Rev Environ Health.* (2017) PMID: 29206645.
- Heuser G: Testing Protocol.
- 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.

10. Biological safety guidelines; criticism of heating-only guidelines; actual levels

(a) Necessity of biological safety guidelines for sensitive people
(b) Biological safety guidelines
(c) Objective biological safety guidelines
(i) Radiofrequency safety guideline markers
(ii) Power line safety guideline markers
(d) Criticism of heating safety guidelines: FCC, WHO and ICNIRP
(e) Appeal to UN and WHO for biological safety guidelines
(f) Biological long-term safety guidelines
(g) Heating short-term guidelines (6 minutes)
(h) Natural levels
(i) Typical exposure levels
(j) Risk assessment for EHS and related EM effects
(k) Utilitarian 'cost' argument; difference between:
(i) Stochastic cancer death risk from ionising radiation, and
(ii) Deterministic EHS 'living death' risk from non-ionising radiation
(l) Subservience of WHO to IAEA on radiation
(m) UK's switch from AGNIR to COMARE
(n) Radio frequency radiation safety guidelines (chart)

(a) Necessity if biological safety guidelines for sensitive people

Biological guidelines 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 instructed governments that they need to adopt non-thermal guidelines to protect such people, and especially "certain sensitive individuals". The UK says that it follows ICNIRP but it has not followed this advice yet.

- 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."
"Some guidelines may still not provide adequate protection for certain sensitive individuals nor for normal individuals exposed concomitantly to other agents, which may exacerbate the effect of the NIR exposure, an example being individuals with photosensitivity."

- 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:
"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 guidelines.
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)."*
- Gandhi OP et al.: "Exposure limits: the underestimation of absorbed cell phone radiation, especially in children" *Electromagn Biol Med.* (2012) PMID: 21999884. Article.

(b) Biological safety guidelines

Biological guidelines 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 guidelines

Safety guidelines should be based on objective biological measures, such as DNA fragmentation, cell hydration, miRNA effects, oogenesis, VGCC effects and nitric oxide (NO). Some are especially suited to either radiofrequency or ELF.

The outdated and invalidated heating hypothesis by Schwan of 1953 with its modelling of tissue heating qualities (SAR: Specific Absorption Rate) is irrelevant to most health outcomes, such as cancers, cardiovascular effects, DNA damage, EHS, fertility impairment and neurological effects.

(i) Radiofrequency safety guideline markers

- Ayrapetyan S et al: "Cell hydration as a biomarker for estimation of biological effects of nonionizing radiation on cells and organisms" *Scientific World Journal.* (2014) PMID: 25587574.
- Belyaev IY: "Dependence of non-thermal biological effects of microwaves on physical and biological variables: implications for reproducibility and safety standards" *Eur J Oncol Library.* (2010) article.
- Belyaev I: "Non-thermal biological effects of microwaves" *Mikrotalasna revija. [Microwave Rev.]* (2005) article.
- 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.
- Pall ML: "How to Approach the Challenge of Minimizing Non-Thermal Health Effects of Microwave Radiation from Electrical Devices" *Int J Innovat Res Engin Management (IJIREM).* (2015) pdf.

(ii) Power line safety guideline markers

- Ayrapetyan S et al: "Cell hydration as a biomarker for estimation of biological effects of nonionizing radiation on cells and organisms" *Scientific World Journal.* (2014) PMID: 25587574.
- Blank M et al.: "Electromagnetic fields and health: DNA-based dosimetry" *Electromagn Biol Med.* (2012) PMID: 22676645.
- Li H et al.: "Exosomal Small RNA Sequencing Uncovers the microRNA Dose Markers for Power Frequency Electromagnetic Field Exposure" *Biomarkers.* (2018) PMID: 29297241.
- Liu Y et al.: "Overexpression of miR-26b-5p regulates the cell cycle by targeting CCND2 in GC-2 cells under exposure to extremely low frequency electromagnetic fields" *Cell Cycle.* (2016) PMID: 26637059. PMC4943694.

(d) Criticism of heating safety guidelines: FCC, WHO and ICNIRP

The ICNIRP 1998 Guidelines are for short-term 6-minute heating effects only and not long-term non-thermal effects:
"These guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns … and elevated tissue temperatures resulting from absorption of energy during exposure to EMF"
and they do not protect against *"potential long-term effects of exposure, such as an increased risk of cancer".*
(ICNIRP: Guidelines, 1998)
The Guidelines are for short-term measurements averaged over 0.1 hour (6 minutes). This was established in the USA in 1966, for 10 mW/cm^2 [100,000,000 μW/m^2] for frequencies 10 MHz to 100 GHz, the heating limit suggested by Herman Schwan in 1953.

- ANSI (American National Standards Institute) C95.1-1966: "Safety Level of Electromagnetic Radiation With Respect to Personnel"

The heating metric SAR was introduced in 1982 in the USA in response to Schwan's mistaken heating hypothesis of 1953.

- ANSI C95.1-1982: "American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 300 kHz to 100 GHz" Standard.

In 1991 in the USA the IEEE adopted 0.08 W/kg for whole body exposure and 1.6 W/kg for a 1cm cube of tissue.

- ANSI/IEEE C95.1-1991: "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 KHz to 300 GHz" Standard.
- IEEE C95.1–2005: "Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz" Standard.

In comparison, in 1970 the USSR limits were:

0.1 W/m^2 [100,000 μW/m^2] up to 8 hours,
10 W/m2 [10,000,000 μW/m^2] up to 20 minutes, but 0.1 W/m^2 must not be exceeded at any other time during the day.

In comparison, in 2012 the Bioinitiative guidelines were:

6 μW/m^2 for the general population
3 μW/m^2 for children and sensitive people within the general population.

The ICNIRP Guidelines, like the FCC's in the USA, do not protect against any effects of EM energy except acute heating of one degree within 6 minutes:

"The FCC's current exposure guidelines, as well as those of the Institute of Electrical and Electronics Engineers (IEEE) and the International Commission on Non-ionizing Radiation Protection, are thermally based, and do not apply to chronic, nonthermal exposure situations. They are believed to protect against injury that may be caused by acute exposures that result in tissue heating or electric shock and burn. The FCC's exposure guideline is considered protective of effects arising from a thermal mechanism but not from all possible mechanisms. Therefore, the generalization by many that the guidelines protect human beings from harm by any or all mechanisms is not justified." (US, EPA: Norbert Hankin: Letter to Janet Newton, July 6 2002)

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 five common misconceptions about heating-only guidelines:

(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 guidelines, 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 guidelines 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.

(iv) 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. This makes these biological effects different from common dose-response models used in many areas of toxicology, since the body relies on its own EM signalling pathways which can be influenced by exogenous radiation.

(v) Heating-only proponents, like ICNIRP, accept that "certain sensitive people" need biological safety guidelines below ICNIRP's heating-only guidelines. See above Section 4(a).

- Bailey WH ET AL.: "Accounting for human variability and sensitivity in setting standards for electromagnetic fields" *Health Phys.* (2007) PMID: 17495668.
- Bandara P et al.: "Letter to the Editor [Wifi exposure in Australian schools]" *Rad Prot Dosimetry* (2017) doi.org/10.1093/rpd/ncx108; pdf.
- Bandara P et al.: "Cardiovascular disease: Time to identify emerging environmental risk factors" *Eur J Prev Cardiol.* (2017) PMID: 28969497; pdf.
- Frey AH: "Is a toxicology model appropriate as a guide for biological research with electromagnetic fields?" *J Bioelect.* (1990) pdf.
- Frey AH: "Biological function as influenced by low power modulated RF energy" *IEEE Trans Microwave Theory and Techniques.* (1971) pdf.
- Grigoriev Y: "Methodology of Standards Development for EMF RF in Russia and by International Commissions: Distinctions in Approaches" in Markov M (ed.) (2017) *Dosimetry in Bioelectromagnetics* (2017) ISBN: 978-1498774130; pdf.
- Hardell L et al.: "Biological effects from electromagnetic field exposure and public exposure standards" *Biomed Pharmacother.* (2008) PMID: 18242044.
- Hardell L: "World Health Organization, radiofrequency radiation and health – a hard nut to crack (Review)" *Int J Oncology.* (2017) PMID: 28656257. PMC5504984.
- Hensinger P et al.: "Wireless communication technologies: New study findings confirm risks of nonionizing radiation" *umwelt-medizin-gesellschaft.* (2016) pdf.
- Iakimenko IL et al.: [Metabolic changes in cells under electromagnetic radiation of mobile communication systems] *Ukr Biokhim Zh (1999).* (2011) PMID: 21851043.
- 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.
- Lan JQ et al.: "On the effects of glasses on the SAR in human head resulting from wireless eyewear devices at phone call state" *Prog Biophys Mol Biol.* (2018) PMID: 29428220.
- Leszczynski D ET AL.: "Mobile phone radiation health risk controversy: the reliability and sufficiency of science behind the safety standards" *Health Res Policy Syst.* (2010) PMID: 20205835; pdf.
- Marino AA et al.: "Trigeminal neurons detect cellphone radiation: Thermal or nonthermal is not the question" *Electromagn Biol Med.* (2017) PMID: 27419655.
- Markov M et al.: "Protect children from EMF" *Electromagn Biol Med.* (2015) PMID: 26444201.
- Markovà E et al.: "Microwaves from GSM mobile telephones affect 53BP1 and gamma-H2AX foci in human lymphocytes from hypersensitive and healthy persons" *Environ Health Perspect.* (2005) PMID: 16140623. PMC1280397.
- 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.

- Rubtsova N et al.: "Intensity-time dependence dosing criterion in the EMF exposure guidelines in Russia" *Electromagn Biol Med.* (2018) PMID: 29493302.
- 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.
- Sarkar S et al.: "Effect of low power microwave on the mouse genome: a direct DNA analysis" *Mutat Res.* (1994) PMID: 7506381.
- Starkey SJ: "Inaccurate official assessment of radiofrequency safety by the Advisory Group on Non-ionising Radiation" *Rev Environ Health.* (2016) PMID: 27902455; pdf.
- Steneck NH et al.: "The origins of U.S. safety standards for microwave radiation" *Science.* (1980) PMID: 6990492.
- Webster PC: "Federal Wi-Fi safety report is deeply flawed, say experts" *CMAJ.*(2014) PMID: 24756628; pdf.
- Yakymenko I et al.: "Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems" *Exp Oncol.* (2011) PMID: 21716201.

(e) Appeal to UN and WHO for biological safety guidelines

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 guidelines, 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) Biological long-term safety guidelines

EUROPAEM EMF Guideline 2016: international biological safety guidelines:
for EHS and sensitive people:
0.1 uW/m2 = 0.006 V/m *for: WiFi 2.45 GHz WiFi 5.6 GHz, DAB+ (10 Hz pulsing)*
1 uW/m2 = 0.019 V/m *for: DECT cordless phones, GMS (2G), UMTS (3G), LTE (4G):*
EUROPAEM 2016 international safety guidelines: Table 3; Table 4.

- *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. Article.

Bioinitiative 2012 international biological safety guidelines:
3 uW/m2 *for: sensitive population*
6 uW/m2 *for: general population* Bioinitiative 2012

Seletun Scientific Panel (2010)

- Fragopoulou A et al.: "Scientific panel on electromagnetic field health risks: consensus points, recommendations, and rationales" *Rev Environ Health.* (2010) PMID: 21268443; pdf.

The guidelines below are for the general population, not people sensitive to EM exposure.

New buildings:	ELF:	100 nT
Environment:	RF:	0.000033 W/kg whole body
	RF:	170 uW/m2 (precautionary)

International Institute for Building-Biology and Ecology (2008)

"Building Biology Evaluation Guidelines for Sleeping Areas" 7th edition (2008):

No concern:	ELF:	<20 nT	
	RF:	<0.006 V/m	
	RF:	<0.1 uW/m2	BB Guidelines (2008), (website)

Salzburg, new (2002):

Outdoors:	RF:	10 uW/m2	
Indoors:	RF:	1.0 uW/m2	"Precautionary limits"; list

(g) Heating short-term guidelines (6 minutes)

The WHO/ICNIRP short-term heating guidelines are to prevent a temperature rise of one degree in six minutes:

200,000 nT (50 Hz), 400,000,000 nT (static)
4.0 W/kg (limbs); 2.0 W/kg (head); 0.08 W/kg (average whole body)
4,500,00 uW/m2 (900 MHz); 9,200,000 (1,800 MHz)
61 V/m (1,952 V/m peaks allowed) ICNIRP 1998

(h) Natural levels

0.0013 nT
<0.00002 W/kg
0.00000 uW/m2
0.00002 V/m

(i) Typical exposure levels

- Bhatt CR et al.: "Radiofrequency-electromagnetic field exposures in kindergarten children" *J Expo Sci Environ Epidemiol.* (2016) PMID: 27759027.
  In 20 ***kindergartens,*** *over 16 frequency bands between 88 MHz and 5.8 GHz,*
  the median environmental exposure was 0.179 V/m
  and the median personal exposure of children was 0.081 V/m.

- 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.
  In a ***railway station*** *there was*
  a mean of 921 uW/m2 with outliers up to 95,500 uW/m2
  and mean total for walkabouts of 2,800 to 4,900 uW/m2.

- Hedendahl LK at al.: "Measurements of Radiofrequency Radiation with a Body-Borne Exposimeter in Swedish Schools with Wi-Fi" *Front Public Health.* (2017) PMID: 29214149. PMC5703119.

Among 18 teachers from 7 ***schools*** *for RF:*
mean: 1.1 to 66.1 μW/m²
highest mean: 397 μW/m² (during 5 min when students watched YouTube videos)
maximum peaks, from mobile phone uplink: 82,857 μW/m².

- Kurnaz C et al.: "Monitoring of RF/Microwave field strength at schools in a pilot district in Samsun/Turkey" *IEEE 16th Mediterranean Microwave Symposium (MMS),* (2016) abstract.
  In 92 ***schools***
  the maximum electric fields were 5.39 V/m and 3.04 V/m,
  while the maximum averages were 2.22 and 2.25 V/m.

- Mamrot P et al.: "Electromagnetic fields in the vicinity of DECT cordless telephones and mobile phones" *Med Pr.* (2015) PMID: 26674167.
  DECT cordless phone handsets:
  0.26-2.30 V/m (at 0.05 m); 0.18-0.26 V/m (at 1 m).
  DECT cordless telephones base units:
  1.78-5.44 V/m (at 0.05 m); 0.19-0.41 V/m (at 1 m).
  Mobile phones (GSM with voice):
  2.34-9.14 V/m (at 0.05 m); 0.18-0.47 V/m (at 1 m).
  Mobile phones (WCDMA):
  0.22-1.83 V/m (at 0.05 m); 0.18-0.20 V/m (at 1 m).

- Peyman A et al.: "Exposure to electromagnetic fields from smart utility meters in GB; part I) laboratory measurements" *Bioelectromagnetics.* (2017) PMID: 28324620.
  Smart Meters:
  15,000 uWm2 (max.) (at ≥0.5m);
  one outlier: 91,000 uWm2 (max.).

- Sagar S et al.: "Radiofrequency electromagnetic field exposure in everyday microenvironments in Europe: A systematic literature review" *J Expo Sci Environ Epidemiol.* (2018) PMID: 28766560.
  21 studies on the everyday microenvironments in Europe, 2000-2015:
  Mean total RF-EMF spot measurements: Homes: 0.29 V/m; Outdoor: 0.54 V/m
  Personal (trained researchers): Home: 0.24 V/m; Outdoor: 0.76 V/m.
  Personal (volunteers): Homes: 0.16 V/m; Outdoor: 0.20 V/m
  Transportation: highest mean total:
  1.96 V/m trains (Belgium 2007, >95% of exposure from uplink)

- Sagar S et al.: "Comparison of radiofrequency electromagnetic field exposure levels in different everyday microenvironments in an international context" *Envir Intern.* (2018) Abstract.
  RF-EMF exposure in 94 outdoor worldwide microenvironments and 18 public transport vehicles. Taken either by walking with a backpack for 30 min, or driving a car with roof-mounted for 15–20 min, with a sampling rate of once every 4 s (ExpoM-RF) and 5 s (EME Spy 201).
  Mean total RF-EMF exposure:
  Outdoors:
  from 0.23 V/m (non-central residential, Switzerland) to 1.85 V/m (university, Australia),
  Public transport:
  from 0.32 V/m (bus, rural, Switzerland) to 0.86 V/m (auto rickshaw, urban, Nepal).
  In most outdoor areas: major contribution: mobile phone base stations.
  Otherwise: broadcasting dominant.
  Mobile phone uplink generally very small, except in Swiss trains and some Swiss buses.

- Urbinello D et al.: "Radio-frequency electromagnetic field (RF-EMF) exposure levels in different European outdoor urban environments in comparison with regulatory limits" *Environ Int.* (2014) PMID: 24704639.

  In 2011-12, on 12 different days, every 4s for 15-30 min per area, repeated 12 times over 1 year:

  Basel, Switzerland (limit: 4-6 V/m):

  outdoor areas for mobile phone base stations: 0.22 V/m (mean)

  Amsterdam, Netherlands (limit: 41-61 V/m):

  outdoor areas for mobile phone base stations: 0.41 V/m (mean)

- Verloock L et al.: "Assessment of radio frequency exposures in schools, homes, and public places in Belgium" *Health Phys.* (2014) PMID: 25353235.

Schools:	*0.2 V/m average; 3.2 V/m maximal (WiFi).*
Homes:	*0.1 V/m average; 1.1 V/m maximal (telecommunication).*
Public places:	*0.6 V/m average; 2.4 V/m maximal (telecommunication).*
Offices:	*0.9 V/m average; 3.3 V/m maximal (telecommunication).*

(j) Risk assessment for EHS and related EM effects

- Aalam N: "Radio frequency radiation exposure, health hazards and risk assessment strategies" IEEExplore (2017) abstract.

(k) Utilitarian 'cost' argument: difference between:
(i) Stochastic cancer death risk from ionising radiation, and
(ii) Deterministic EHS 'living death' risk from non-ionising radiation

Governments typically consider potential lifetime excess cancer risks, as from nuclear plants, of between 1 and 10 per million as "acceptable" for non-occupational exposures. EHS, however, is not essentially a cancer condition but can result in a 'living death' for the persons affected. Since there is up to 100% certainty of EM exposure causing this 'living death' for those affected, it is inappropriate to consider as similar (i) stochastic cancer death risks from ionising radiation, and (ii) deterministic EHS 'living death' risks from non-ionising radiation.

In 2007 the International Commission on Radiological Protection (ICRP) suggested that a death rate of one in 1 million exposed individuals may be considered acceptable to society. The ICRP defines 'justification' by whether

> *"… a planned activity involving radiation is, overall, beneficial, i.e. whether the benefits to individuals and to society … outweigh the harm (including radiation detriment) resulting from the activity … i.e., whether the benefits to individuals and to society (including the reduction in radiation detriment) from introducing or continuing the remedial action outweigh its cost and any harm or damage it causes."* ["The 2007 Recommendations of the International Commission on Radiological Protection" *ICRP Publication 103* (extract). p.25]

The UK's Health & Safety Executive allows an expected death rate of one in 1 million from environmental pollution such as atomic radiation:

> *"HSE's practice is to advise against homes being built in places where any individual's chance of receiving a dangerous dose [of chemicals] was greater than 1 in 10^5 (1 in 100 000) per year." [HSE, section 69] "the measures taken for nuclear installations mean that the risk borne on average by members of the public in the vicinity of a plant from its normal operation will generally be no more than 1 in 1 million (1 in 10^6) per annum."* [HSE 1992, section 174]

HSE: *"… does not advise against granting planning permission on safety grounds for developments where such individual risk is less than 1 in a million a year. (Somewhat different criteria are applied to sensitive developments where those exposed to the risk are more vulnerable, e.g. schools, hospitals or old peoples' homes, or to industrial or leisure developments, reflecting the different characteristics of the hypothetical person used to assess individual risk)."* [HSE 2001, paragraph 138]

- Busby C: "Child health and ionizing radiation: Science, Politics and European Law" *Pediatr Dimensions.* (2017) abstract; pdf.
- Health and Safety Executive: (2001) "Reducing risks, protecting people" HSE; pdf.
  Rimington JD (chair) et al: "The Tolerability of Risk from Nuclear Power Stations" HSE, 1988, rev.1992; pdf.
- Setton E et al.: "Risk-based indicators of Canadians' exposures to environmental carcinogens" *Environ Health.* (2013) PMID: 23398723; pdf.
- Valentin J: "The 2007 Recommendations of the International Commission on Radiological Protection" ICRP; no.103; pdf of extract.

(l) Subservience of WHO to IAEA:

Since 1959 the World Health Organization (WHO) has been subservient to the International Atomic Energy Agency (IAEA) on all matters to do with radiation:

- "Agreement Between the International Atomic Energy Agency and the World Health Organization" (1959) Agreement.

  "… it is recognized by the World Health Organization that the International Atomic Energy Agency has the primary responsibility for encouraging, assisting and co-ordinating research and development and practical application of atomic energy for peaceful uses throughout the world …"
  (Article 1.2)
  "Whenever either organization proposes to initiate a program or activity on a subject in which the other organization has or may have a substantial interest, the first party shall consult the other with a view to adjusting the matter by mutual agreement."
  (Article 1.3)

(m) UK's switch from AGNIR to COMARE:

In 1990 the UK government founded AGNIR (Advisory Group On Non-Ionising Radiation). This was an attempt to quash concerns about cancers and other adverse effects caused by non-ionising radiation, such as from power lines and wireless radio frequency from mobile phones. It was at first chaired by Sir Richard Doll, famous for linking smoking and cancer, but later notorious for switching sides and supporting industries and governments involved in environmental pollution.

In 2016 a peer-reviewed study showed that AGNIR's 2016 Radio Frequency Report, which was not peer-reviewed, was 'inaccurate' and 'unsafe'.

- Starkey SJ: "Inaccurate official assessment of radiofrequency safety by the Advisory Group on Non-ionising Radiation" *Rev Environ Health.* (2016) PMID: 27902455. Article.

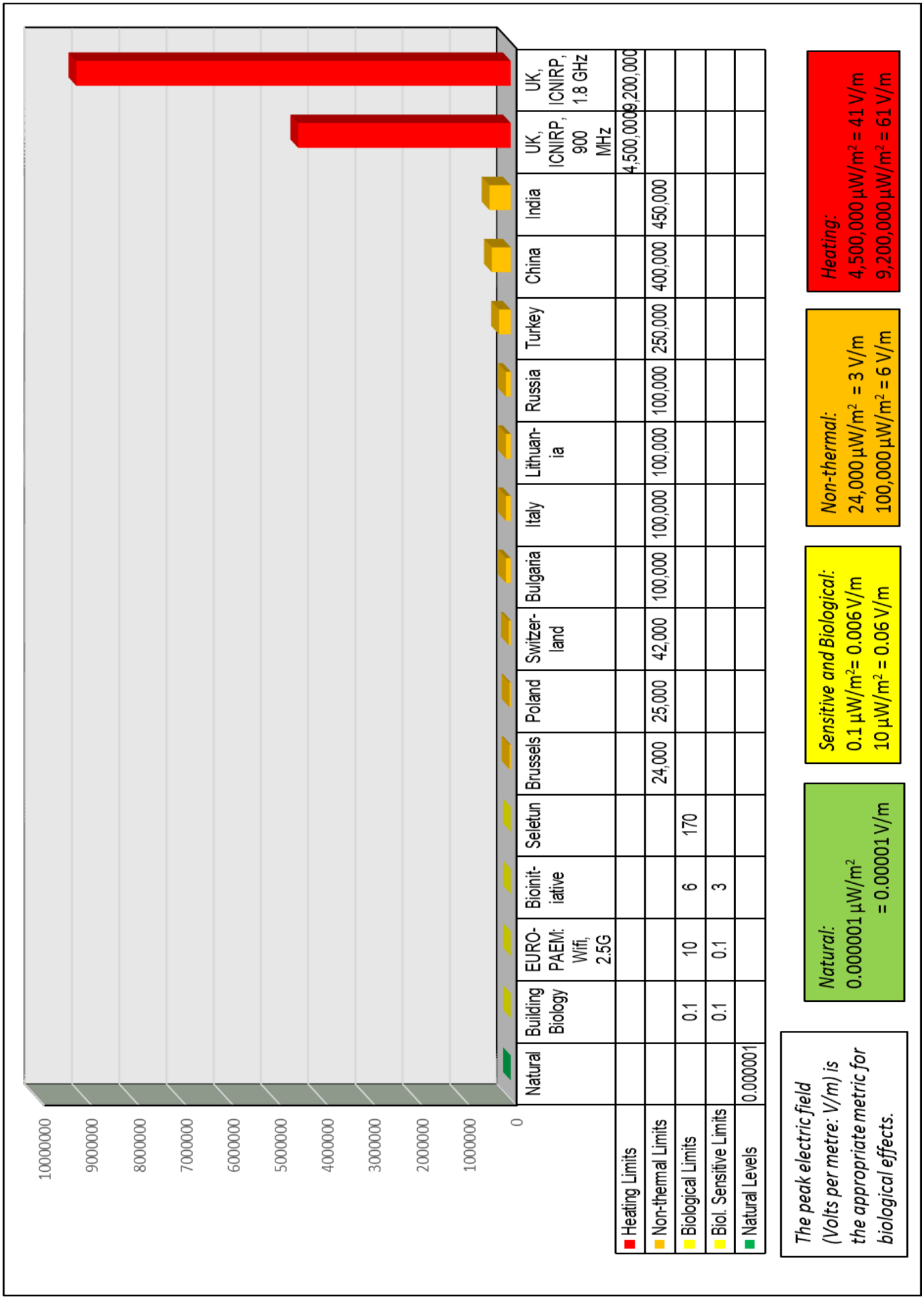
In 2017 the UK government disbanded AGNIR (Advisory Group On Non-Ionising Radiation) and transferred AGNIR's role in giving advice on non-ionising radiation to COMARE (Committee on Medical Aspects of Radiation in the Environment). This group was established in 1985 to quash concerns about

cancer clusters discovered near Sellafield and other nuclear plants with non-ionizing radiation. COMARE is a committee which accepts the utilitarian approach of ICRP (International Commission on Radiological Protection).

(n) Radio frequency radiation safety guidelines

Figure on next page: **RADIO FREQUENCY RADIATION SAFETY GUIDELINES**
for: Power Flux Density (a heating metric) – micro Watt per metre squared *($\mu W/m^2$)*
This shows:

Natural levels	0.000001 $\mu W/m^2$
Biological safety guidelines	0.1 $\mu W/m^2$ and 10 $\mu W/m^2$
UK 6-minute heating guidelines	4,500,000 $\mu W/m^2$ and 9,200,000 $\mu W/m^2$


10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
Natural
Building Biology
EURO-PAEM: Wifi, 2.5G
Bioinit-iative
Seletun
Brussels
Poland
Switzer-land
Bulgaria
Italy
Lithuan-ia
Russia
Turkey
China
India
UK, ICNIRP, 900 MHz
UK, ICNIRP, 1.8 GHz
Heating Limits
4,500,000
9,200,000
Non-thermal Limits
0.000001
24,000
25,000
42,000
100,000
100,000
100,000
100,000
250,000
400,000
450,000
Biological Limits
0.1
10
6
170
Biol. Sensitive Limits
0.1
0.1
3
Natural Levels
0.000001
The peak electric field (Volts per metre: V/m) is the appropriate metric for biological effects.
Natural:
0.000001 µW/m²
= 0.00001 V/m
Sensitive and Biological:
0.1 µW/m²= 0.006 V/m
10 µW/m² = 0.06 V/m
Non-thermal:
24,000 µW/m² = 3 V/m
100,000 µW/m² = 6 V/m
Heating:
4,500,000 µW/m² = 41 V/m
9,200,000 µW/m² = 61 V/m

11. (a) Cancer Risks and (b) Cancer Classification (WHO/IARC)

(a) Cancer Risks

Cancer is the second leading cause of death worldwide. It accounts for 15% of deaths. There are some 200 different types of cancer, some of which are rare.

There are many risks for cancers, both intrinsic and external, with many estimates, including diet and obesity (30-35%), smoking (25-30%), infections (15-20%), environmental pollution and stress (5-25%), and genetics (5-10%) (e.g. Anand P et al., 2008; Wu S et al., 2016). Another study found 38% of cancers can be attributed to known risk factors, with the two highest modifiable risk factors at 15% for smoking and 6% for obesity (Brown KF et al., 2018)

The biophysical effects of electromagnetic exposure can be cumulative, so the duration is relevant as well as the intensity, frequency, modulation and amplitude of exposure. For most cancers it takes years for symptoms to appear.

Studies listed in this 'Selected Studies' show:

- *Living within about 500 metres of a phone mast has been show to increase the risk of genetic damage, immune damage and cancers, typically by up to 3 and sometimes by up to 5 times, compared with living further away. This also applies to radio and TV masts and was suspected in 1994 [62] and confirmed in 1996.*
  (e.g. Dode AC et al., 2010; Eger H et al., 2004; Gandhi G et al., 2015; Ghosh PM et al., 2015; Gulati S et al., 2018; Hocking B et al., 1996; Hocking B et al., 2003; Houshyari M et al., 2015; Khurana VG et al., 2010; Kundi M et al., 2009; Levitt BB et al., 2010; Taheri M et al., 2017; Wolf R et al., 2004; Zothansiama et al., 2017).

- *Living within about 600 metres of power lines has been known since 1979 to increase the risk of cancers, often by 1.3 to 1.5 or up to 3 times compared with living further away. In some countries and for some voltages the risk for children has been shown to be over 10 times.*
  (e.g. Sohrabi MR et al., 2010; see many more studies listed under, e.g., Leukaemia)

- *Use of a mobile phone and similar wireless devices has been linked with brain tumours since 1999 (analogue) and 2009 (digital). Since 1953 brain tumours have been associated with various electromagnetic exposures, especially for exposures of 10 years or more. Some cases, however, have been reported within 5 years of using a mobile phone or working with radar. Typically, heavy long-term mobile phone users have up to 3 times the risk of brain tumours compared with light users, and up to 5 times if starting aged under 20 years.*
  (e.g. Carlberg M et al., 2014; see many more studies listed under, e.g., Brain Tumours, Cancer, Glioma, etc.)

In comparison, for lung cancer, which is caused by smoking in 85% of cases (NHS), typically, light smokers aged 35-49 have a 3 (males) to 5 (females) times higher risk of lung cancer than non-smokers. Heavy smokers are up to 13 (women) to 24 (men) times more likely to die from lung cancer than non-smokers (Schane RE et al., 2010; see also Taghizadeh N et al., Table 2, 2016). At age 60 a smoker has a 10% risk of lung cancer by age 75, compared with a 0.5% risk for a non-smoker (Netdoctor). Passive smoking accounts for about 20% of lung cancers in non-smokers (CRUK).

[62] Maskarinec G et al.: "Investigation of increased incidence in childhood leukemia near radio towers in Hawaii: preliminary observations" *J Environ Pathol Toxicol Oncol.* (1994) PMID: 7823291.

(b) Cancer Classification

(i) World Health Organization's International Agency for Research on Cancer WHO / IARC

Much of the Electromagnetic spectrum, including frequencies at (a) ELF (Extremely Low Frequency, MW (Microwave Frequency) and RF (Radio Frequency), (b) the visible spectrum, and (c) ionising frequencies, is now regarded as a possible, probable or certain human carcinogen.

These carcinogenic outcomes are non-thermal effects and thus outside the scope of ICNIRP's safety guidelines, which are based on Schwan's mistaken hypothesis of 1953 that heating is the only adverse effect of EM exposure. The ICNIRP heating limits prevent a rise in body temperature of one degree within 6 minutes, although the same temperature rise can be achieved through exercise but without the known consequences from EM exposure of cardiovascular, fertility and neurological harm and cancers.

(a) Electromagnetic energy (ELF, RF):

WHO/IARC:

- *Radio Frequency (RF):* *2B (possible) human carcinogen (2011)*
- *Extremely Low Frequency (ELF):* *2B (possible) human carcinogen (2002)*

The following studies confirm ELF and RF as a class 2B (possible) human carcinogen.

RF:

- Baan R et al.: "Carcinogenicity of radiofrequency electromagnetic fields" *Lancet Oncol.* (2011) PMID: 21845765. Article.
- International Agency for Research on Cancer (IARC), World Health Organization (WHO): "IARC Classifies radiofrequency electromagnetic fields as possibly carcinogenic to humans" Press Release no. 208 (2011). Article (2013).

ELF:

- International Agency for Research on Cancer (IARC), World Health Organization (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).
- Mild KH et al.: "Occupational carcinogens: ELF MFs" *Environ Health Perspect.* (2005) PMID: 16263490. PMC1310936.

See below at the end of this section for studies arguing that the evidence now requires that ELF and RF should be reclassified as a class 2A (probable) or class 1 (certain) human carcinogen.

(b) Electromagnetic energy: visible blue light (in visible light, the colour blue has the shortest wavelength and highest frequency) at night, as in shift-work, disrupts the body's circadian rhythm and reduces melatonin, a cancer suppressor.

WHO/IARC:

- *Visible blue light at night:* *2A (probable) human carcinogen (2007)*

- Brainard GC et al.: "Action spectrum for melatonin regulation in humans: evidence for a novel circadian photoreceptor" *J Neurosci.* (2001) PMID: 11487664.
- Canadian Union of Public Employees: "Shiftwork" Health & Safety Factsheet.
- Giachello CN et al.: "Magnetic Fields Modulate Blue-Light-Dependent Regulation of Neuronal Firing by Cryptochrome" *J Neurosci.* (2016) PMID: 27798129.
- International Agency for Research on Cancer (IARC), World Health Organization (WHO): "IARC Monographs Programme finds cancer hazards associated with shiftwork, painting and firefighting" Press Release no. 180 (2007);

- International Agency for Research on Cancer (IARC), World Health Organization (WHO): "Shiftwork"*IARC Monographs on the Evaluation of Carcinogenic Risks to Humans.* 98(2010).
- Portnov BA et al.: "Light at night and breast cancer incidence in Connecticut: An ecological study of age group effects" *Sci Total Environ.* (2016)PMID: 27531467.
- Sasseville A et al.: "Blue blocker glasses impede the capacity of bright light to suppress melatonin production" *J Pineal Res.*(2006) PMID: 16842544.
- Wright HR et al.: "Effect of light wavelength on suppression and phase delay of the melatonin rhythm" *Chronobiol Int.* (2001)PMID: 11763987.
- Yoshii T et al.: "Cryptochrome mediates light-dependent magnetosensitivity of Drosophila's circadian clock" *PLoS Biol.* (2009) PMID: 19355790.

(c) Electromagnetic ionising frequencies, as in x-rays and gamma (γ) rays

WHO/IARC:

- *X-rays and gamma rays: 1 (certain) human carcinogen (1999)*

- International Agency for Research on Cancer (IARC), World Health Organization (WHO): "Ionizing Radiation, Part 1: X- and Gamma (γ)-Radiation and Neutrons" *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans.*75(2000).
- IARC: "5. Summary of Data Reported and Evaluation" (2000).

(ii) WHO/IARC: System of cancer classification:

The IARC classifies human and animal evidence as one of the following four categories:

- no evidence
- inadequate
- limited
- sufficient

WHO/IARC CLASS		*Level of evidence required*
Group 2		(i) Humans: almost sufficient evidence or (ii) no Human data but Animal: sufficient evidence. (The terms 'probably' and 'possibly' have no quantitative significance; they are descriptors of different levels of Human evidence, higher or lower.)
	Class 2B (possible) human carcinogen	based on 3 possible combinations: (i) Humans: limited evidence + Animals: insufficient evidence or (ii) Humans: inadequate evidence + Animals: sufficient evidence or (iii) Humans: inadequate evidence + Animals: insufficient evidence + Mechanistic evidence etc.
	Class 2A (probable) human carcinogen	based on 2 possible combinations: (i) Humans: limited evidence + Animals: sufficient evidence or (ii) Humans: inadequate evidence + Animals: sufficient evidence + Mechanistic evidence etc. (or as member of class of agents in 1/2A)
Group / Class 1		Humans: sufficient evidence.

(iii) WHO/IARC: Current classification and current evidence requiring reclassification:

WHO/IARC Class 2B (possible):
In 2002 IARC classified ELF as a 2B (possible) human carcinogen,[63]
and in 2011 IARC classified RF as 2B (possible) human carcinogen,
from "limited" evidence in humans and animals.[64]
2B: *"'Limited evidence of carcinogenicity': A positive association has been observed between exposure to the agent and cancer for which a causal interpretation is considered by the Working Group to be credible, but chance, bias or confounding could not be ruled out with reasonable confidence."* [65]

WHO/IARC Class 2A (probable): adequate animal evidence?
IARC's requirements for 2A (probable): [66] *(i) two species of animals*
(ii) reproducibility.
These now seem fulfilled. There are numerous studies, including:
RF as a carcinogen:
1980-82: $4.5 USAF: 0.15-0.4 W/kg at 2.45 GHz (OR=4.27 primary malignancies).[67]
1993-99: $28.5m WTR
1999-2018: $25m National Toxicology Program:
significantly increased glioma (brain) and schwannoma (heart) in rats from mobile phone radiation under heating limits.[68]
2001-18: €5m Ramazzini Institute:
significantly increased schwannoma (heart) in rats from phone mast radiation under heating limits.[69]
Comparison of NTP and RI studies: EHT, 2018.
2016: Confirmation of RF as a tumour-promoter.[70]
ELF as a co-carcinogen or tumour-promoter:
2016: Sinusoidal-50 Hz prenatal to death and acute 0.1 Gy γ radiation at 6 weeks:
carcinogenic effects for the mammary gland, and increased malignant schwannomas of the heart (female and male rats);
increased lymphomas / leukemias (male rats).[71]
2016: Sinusoidal-50 Hz MF and formaldehyde in drinking water from 6 weeks:
increased malignant tumours, thyroid C-cell carcinomas and hemolymphoreticular neoplasias (male rats).[72]

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[63] 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).

[64] Baan R et al.: "Carcinogenicity of radiofrequency electromagnetic fields" *Lancet Oncol.* (2011) PMID: 21845765.

[65] IARC Mongraphs on the Evaulation of Carcinogenic Risks to Humans: Preamble (2006).

[66] IARC Mongraphs on the Evaulation of Carcinogenic Risks to Humans: Preamble (2006).

[67] Chou CK et al.: "Long-term, low-level microwave irradiation of rats" *Bioelectromagnetics.* (1992) PMID: 1482413. Article.
[Guy AW (1984) Study Findings (presented by Chou CK, Kunz L at the Bioelectromagnetics Society (BEMS) Conference, Atlanta, July 1984) Bioelectromagnetics Research Laboratory, University of Washington School of Medicine, Seattle; sponsored by the U.S. Air Force. "Microwaves Promote Cancer" *Microwave News*, July/August 1984, iv(6): 1, 4-5.].

[68] Lin JC: "Potential Game Changer for Mobile-Phone Radio-Frequency Radiation Carcinogenesis" *Rad Sci Bull. IEEE.* (2016); pdf.
Hardell L et al.: "Comment on NTP study" (2018) Article.

[69] Falcioni L et al.: "Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission" *Environ Res.* (2018) PMID: 29530389. Article.

[70] Lerchl A et al: "Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans" *Biochem Biophys Res Commun.* (2015) PMID: 25749340.

[71] 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.

[72] Soffritti M et al.: "Synergism between sinusoidal-50 Hz magnetic field and formaldehyde in triggering carcinogenic effects in male Sprague-Dawley rats" *Am J Ind Med.* (2016) PMID: 27219869.

WHO/IARC Class 1 (certain): adequate human evidence?
WHO/IARC's requirements for class 1 (certain) are sufficient (reproducible) human evidence. These now seem fulfilled. There are numerous studies, including the following.
[OR=Odds Ratio]

RF as a carcinogen:

1953: Hughes Aircraft Corporation:
internal bleeding (75-100 cases out of 6,000 workers), brain tumours (2 out of 5), and leukaemia (2 out of 600) from EM microwave exposure.[73]

1969-82: Maryland, USA:
951 brain tumour cases: OR=2.15 glioma and astrocytoma for definite EM exposure.[74]

1971-85: Poland:
3,700 EM exposed out of 128,000 non-exposed: OR=2.0 all cancers; OR=3.19-3.24 alimentary tract; OR=1.91 brain tumours; OR=6.31 haemopoietic and lymphatic (OR=13.9 chronic myelocytic leukaemia, OR=8.62 acute myeloblastic leukaemia, OR=5.82 non-Hodgkin lymphomas).[75]

1972-1990: Australia:
Within a radius of <4km compared with >12 km for 3 TV towers:
all ages: OR= 1.24 for leukaemia;
children: OR=1.58 for leukaemia, OR=1.55 for childhood lymphatic leukaemia.[76]

1974-1986: UK:
TV and FM radio masts: OR=1.83 for adult leukemia <2 km.[77]

1977: brain tumours: 2 cases of astrocytoma (glioma) in 18 radar EM exposed.[78]

1999- Nordic countries:
ipsilateral mobile phone: OR=2.4 acoustic neuroma and OR=2.0 (1.2 to 3.4) glioma ≥10 years;[79]
for 1,251 glioma astrocytoma: OR=2.7 mobile phone >10 year and OR=1.8 cordless phone >10 year; astrocytoma 1st use wireless phone <age 20: OR=4.9 mobile phone and OR=3.9 cordless phone;[80]
of 593 analogue mobile: OR=1.8 and >25 years OR=3.3; 2G OR=1.6 and >15-20 years OR=2.1; cordless phones OR=1.7 and 15-20 years OR=2.1.[81]

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[73] McLaughlin JT: "A Study of Possible Health Hazards from Exposure to Microwave Radiation" *Hughes Aircraft Copr., Culver City, Calif.* (1953) MS.

[74] Lin RS et al.: "Occupational exposure to electromagnetic fields and the occurrence of brain tumors. An analysis of possible associations" *J Occup Med.* (1985) PMID: 4020499.

[75] Szmigielski S: "Cancer morbidity in subjects occupationally exposed to high frequency (radiofrequency and microwave) electromagnetic radiation" *Sci Total Environ.* (1996) PMID: 8717316.

[76] Hocking B et al.: "Cancer incidence and mortality and proximity to TV towers" *Med J Aust.* (1996) PMID: 8985435. Article.

[77] Dolk H et al.: "Cancer incidence near radio and television transmitters in Great Britain. I. Sutton Coldfield transmitter" *Am J Epidemiol.* (1997) PMID: 8982016.

[78] Zaret MM: "Potential hazards of hertzian radiation and tumors" *N Y State J Med.* (1977) PMID: 264612.

[79] E.g.: Hardell L et al.: "Long-term use of cellular phones and brain tumours: increased risk associated with use for > or =10 years" *Occup Environ Med.* (2007) PMID: 17409179. PMC2092574.

[80] Hardell L et al.: "Pooled analysis of case-control studies on malignant brain tumours and the use of mobile and cordless phones including living and deceased subjects" *Int J Oncol.* (2011) PMID: 21331446.

[81] Hardell L et al.: "Case-control study of the association between malignant brain tumours diagnosed between 2007 and 2009 and mobile and cordless phone use" *Int J Oncol.* (2013) PMID: 24064953. PMC3834325.

2000-12: Interphone:
OR 2.8 to 6.9 for gliomas in most exposed areas;[82]
OR=up to 1.8 for tumour distance from ear for all users.[83]

2004-14: France, CERENAT:
for 253 gliomas and 194 meningiomas: life-long cumulative duration ≥896 h, OR=2.89 gliomas, OR=2.57 meningiomas and OR=2.10 gliomas ≥18,360 calls.[84]

2018: Meta-analysis of CERENAT, Interphone and Nordic studies:
glioma ≥896 h/≥1,640 h OR=1.9 all, OR=2.54 ipsilateral;
meningioma ≥896 h/≥1,640 h OR=1.27 all, OR=1.49 ipsilateral.[85]

ELF as a carcinogen and/or co-carcinogen:

1979: USA:
childhood leukaemia in proximity to wiring (OR=2.35)[86]
and many subsequent studies (see under e.g. Leukaemia).

1986-1996: Norway:
Residential exposure and malignant melanoma for 0.05-0.2 and >0.2 compared with <0.05 microT: OR= 2.01 and OR=2.68 (women); OR=1.70and OR=1.37 (men) respectively.[87]

1986-1996: Norway:
Breast cancer in women with residential exposure OR=1.58.
Exposed women versus unexposed women with estrogen receptor (ER)-positive and ER-negative breast cancer OR=1.33 and OR=1.40 respectively.
Women with highest occupational exposure OR=1.13 compared with unexposed.[88]

1997-2009: Sweden:
ELF cumulative exposure: tumour promotion/progression: astrocytoma grade IV (glioblastoma multiforme) 1-14 years OR=1.9 p linear trend <0.001, and p linear trend 0.44 in highest exposure categories 2.75+ and 6.59+ μT years.[89]

2002: Canada:
ELF occupational exposure >0.6 microT glioblastoma multiforme: OR=5.36.[90]

2010: Iran:
300 children aged 1-18 years with acute lymphoblastic leukemia (ALL) living near overhead high voltage power lines during ≥past 2 years:
OR=2.61 for <600 meters from nearest lines against >600 meters,
OR=9.93 for 123 KV lines, OR=10.78 for 230 KV lines, OR=2.98 for 400 KV lines;
OR of ALL decreased 0.61 for every 600 meters from the nearest power line.[91]

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[82] Cardis E et al.: "Risk of brain tumours in relation to estimated RF dose from mobile phones: results from five Interphone countries" *Occup Environ Med.* (2011) PMID: 21659469. PMC3158328.

[83] Grell K et al.: "The Intercranial Distribution of Gliomas in Relation to Exposure From Mobile Phones: Analyses From the INTERPHONE Study" *Am J Epidemiol.* (2016) PMID: 27810856. PMC5152665.

[84] Coureau G et al.: "Mobile phone use and brain tumours in the CERENAT case-control study" *Occup Environ Med.* (2014) PMID: 24816517.

[85] Hardell L et al.: "Comment on NTP study" (2018) Article.

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

[87] Tynes T et la.: "Residential and occupational exposure to 50 Hz magnetic fields and malignant melanoma: a population based study" *Occup Environ Med.* (2003) PMID: 12709519. PMC1740536.

[88] Kliukiene J et al.: "Residential and occupational exposures to 50-Hz magnetic fields and breast cancer in women: a population-based study" *Am J Epidemiol.* (2004) PMID: 15105178.

[89] Carlberg M et al.: "Case-control study on occupational exposure to extremely low-frequency electromagnetic fields and glioma risk" *Am J Ind Med.* (2017) PMID: 28394434.

[90] Villeneuve PJ et al.: "Brain cancer and occupational exposure to magnetic fields among men: results from a Canadian population-based case-control study" *Int J Epidemiol.* (2002) PMID: 11914323.

[91] Sohrabi MR et al.: "Living near overhead high voltage transmission power lines as a risk factor for childhood acute lymphoblastic leukemia: a case-control study" *Asian Pac J Cancer Prev.* (2010) PMID: 20843128. Article.

2013: Pooled OR=1.32 increased risk of male breast cancer with EMF exposure.[92]
2014: Meta-analysis: non-menopausal women: OR(MH)=1.25.[93]
2016: Canada:
115 cases of breast cancer in men:
OR=1.80 exposed to ≥0.6 μT compared with <0.3 μT.
OR=2.77 for men exposed to occupational MF fields ≥30 years compared with background levels.[94]

Some studies which argue that recent evidence now requires reclassification by WHO/IARC of RF and ELF as class 2A (probable) or class 1 (certain) human carcinogens:

RF:

- Carlberg M et al.: "Decreased survival of glioma patients with astrocytoma grade IV (glioblastoma multiforme) associated with long-term use of mobile and cordless phones" *Int J Environ Res Public Health* (2014) PMID: 25325361.
- Carlberg M et al.: "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) PMID: 28401165. PMC5376454.
- Falcioni L et al.: "Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission" *Environ Res.* (2018) PMID: 29530389. Article.
- 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.
- Lin JC: "Potential Game Changer for Mobile-Phone Radio-Frequency Radiation Carcinogenesis" *Rad Sci Bull. IEEE.* (2016); pdf.
- Morgan LL et al: "Mobile phone radiation causes brain tumors and should be classified as a probable human carcinogen (2A) (review)" *Int J Onc.* (2015) PMID: 25738972.
- Peleg M et al.: "Radio frequency radiation-related cancer: assessing causation in the occupational/military setting" *Environ Res.* (2018) PMID: 29433020.

ELF

- Carlberg M et al.: "Case-control study on occupational exposure to extremely low-frequency electromagnetic fields and glioma risk" *Am J Ind Med.* (2017) PMID: 28394434.
- Soffritti 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.

[92] Sun JW et al.: "Electromagnetic field exposure and male breast cancer risk: a meta-analysis of 18 studies" *Asian Pac J Cancer Prev.* (2013) PMID: 23534787. Article.

[93] Zhao G et al.: "Relationship between exposure to extremely low-frequency electromagnetic fields and breast cancer risk: a meta-analysis" *Eur J Gynaecol Oncol.* (2014) PMID: 24984538.

[94] Grundy A et al.: "Occupational exposure to magnetic fields and breast cancer among Canadian men" *Cancer Med.* (2016) PMID: 26792203. PMC4799956.

12. Electrophobia, radiophobia, the nocebo effect and IEI-EMF

Electrophobia *and* ***radiophobia*** *are psychological fears, often described as the* ***nocebo effect****. At first, from 1903, electrophobia was known as radiophobia (see below under 'radiophobia'). When radiophobia became used exclusively for ionising radiation, the term electrophobia was used, from 1990, for fear of non-ionising radiation and was later identified with the nocebo effect, a term coined by Walter Kennedy in 1961. In 2004 the World Health Organization renamed electrophobia as* ***Idiopathic Environmental Intolerance attributed to Electromagnetic Fields****, stating that it was not caused by EM energy, to prevent it being confused with a real physical sensitivity, such as electromagnetic sensitivity and electromagnetic hyper-sensitivity. The condition has also been named the* ***environmental somatization syndrome****. This condition is most commonly studied by psychologists and not by physiological medical doctors or molecular biologists. The term IEI-EMF tends to be favoured by the wireless and electricity industries and by some regulators.*

- Anon.: "Electromagnetic fields and public health: Electromagnetic hypersensitivity" *World Health Organization* (2005) Backgrounder 296 [not peer-reviewed].
- Baliatsas C et al.: "Comparing non-specific physical symptoms in environmentally sensitive patients: prevalence, duration, functional status and illness behaviour" *J Psychosom Res.* (2014) PMID: 24745783.
- Baliatsas C et al.: "Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF): a systematic review of identifying criteria" *BMC Public Health.* (2012) PMID: 22883305. PMC3504528.
- Bonneux L: [Electromagnetic fields: damage to health due to the nocebo effect] *Ned Tijdschr Geneeskd.* (2007) PMID: 17520846.
- Boyd I et al.: "Taking refuge from modernity: 21st century hermits" *J R Soc Med.* (2012) PMID: 23288087.
- Dömötör Z et al.: "Dispositional aspects of body focus and idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF)" *Scand J Psychol.* (2016) PMID: 26861662.
- Dömötör Z et al: "Nature relatedness is connected with modern health worries and electromagnetic hypersensitivity" *J Health Psychol.* (2017) PMID: 28810440.
- Eltiti S et al.: "Aggregated data from two double-blind base station provocation studies comparing individuals with idiopathic environmental intolerance with attribution to electromagnetic fields and controls" *Bioelectromagnetics.* (2015) PMID: 25644455.
- Eltiti S et al.: "Does short-term exposure to mobile phone base station signals increase symptoms in individuals who report sensitivity to electromagnetic fields? A double-blind randomized provocation study" *Environ Health Perspect.* (2007) PMID: 18007992; pfd.
- Kjellqvist A et al.: "Psychological symptoms and health-related quality of life in idiopathic environmental intolerance attributed to electromagnetic fields" *J Psychosom Res.* (2016) PMID: 27095153.
- Nilsson CG et al.: [Environmental somatization syndrome. How to deal with the external milieu syndrome?] *Nord Med.* (1994) PMID: 8170802.
- Oftedal G et al.: "Mobile phone headache: a double blind, sham-controlled provocation study" *Cephalalgia.* (2007) PMID: 17359515.
- Rubin GJ et al.: "Are some people sensitive to mobile phone signals? Within participants double blind randomised provocation study" *BMJ.* (2006) PMID: 16520326.
- Rubin GJ et al.: "Electromagnetic hypersensitivity: a systematic review of provocation studies" *Psychosom Med.* (2005) PMID: 15784787.
- Rubin GJ et al.: "Do people with idiopathic environmental intolerance attributed to electromagnetic fields display physiological effects when exposed to electromagnetic fields? A systematic review of provocation studies" *Bioelectromagnetics.* (2011) PMID: 21769898.

- Rubin GJ et al.: "Idiopathic environmental intolerance attributed to electromagnetic fields (formerly 'electromagnetic hypersensitivity'): An updated systematic review of provocation studies" *Bioelectromagnetics.* (2010) PMID: 19681059.
- Stovner LJ et al.: "Nocebo as headache trigger: evidence from a sham-controlled provocation study with RF fields" *Acta Neurol Scand Suppl.* (2008) PMID: 18439225.
- Szemerszky R et al.: "Attribution-Based Nocebo Effects. Perceived Effects of a Placebo Pill and a Sham Magnetic Field on Cognitive Performance and Somatic Symptoms" *Int J Behav Med.* (2016) PMID: 26420517.
- van Rongen E et al.: "Effects of radiofrequency electromagnetic fields on the human nervous system" *J Toxicol Environ Health B Crit Rev.* (2009) PMID: 20183535.
- Verrender A et al.: "IEI-EMF provocation case studies: A novel approach to testing sensitive individuals" *Bioelectromagnetics.* (2018) PMID: 29125197.
- Wallace D et al.: "Cognitive and physiological responses in humans exposed to a TETRA base station signal in relation to perceived electromagnetic hypersensitivity" *Bioelectromagnetics.* (2012) PMID: 21647932.
- Wallace D et al.: "Do TETRA (Airwave) base station signals have a short-term impact on health and well-being? A randomized double-blind provocation study" *Environ Health Perspect.* (2010) PMID: 20075020. PMC2898847.

***Prevalence of electophobia, IEI-EMF or the nocebo effect**, and not real physiological EHS, may reflect media reports on electrophobia and real EHS. These studies typically did not screen subjects for whether they suffered, in addition to electrophobia or the nocebo effect, from real physiological EHS. Hospitals and centres specialising in diagnosing real physiological EHS estimate that about 1% of people suffering real physiological EHS also suffer from electrophia or the nocebo effect.*

- Bräscher AK et al.: "Are media reports able to cause somatic symptoms attributed to WiFi radiation? An experimental test of the negative expectation hypothesis" *Environ Res.* (2017) PMID: 28371755.
- Huang PC et al.: "Association between media coverage and prevalence of idiopathic environmental intolerance attributed to electromagnetic field in Taiwan" *Environ Res.* (2018) PMID: 29182909.
- Huang PC et al.: "Representative survey on idiopathic environmental intolerance attributed to electromagnetic fields in Taiwan and comparison with the international literature" *Environ Health.* (2018) PMID: 29334987. PMC5769530.
- Witthöft M et al.: "Are media warnings about the adverse health effects of modern life self-fulfilling? An experimental study on idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF)" *J Psychosom Res.* (2013) PMID: 23438710.
- Witthöft M et al.: "On the origin of worries about modern health hazards: Experimental evidence for a conjoint influence of media reports and personality traits" *Psychol Health.* (2017) PMID: 28758796.

***Radiophobia:** At first, rather than 'electrophobia', the term 'radiophobia' was first used for fear of non-ionising radiation. This began in 1903, in a paper by Dr Albert Soiland at a conference on June 2 1903 in Los Angeles, California, USA at a meeting of the Southern California Electro-Medical Society.[95] From 1951 radiophobia was used to describe fear of, or opposition to, nuclear radiation, soon after the development of nuclear radiation weapons and reactors, with the Chernobyl Syndrome sometimes used as a synonym since 1986. Radiophilia is the opposite attitude. Like electrophobia, radiophobia depends on prior cognitive conditioning.*

[95] Anon.: "Medicos Meet: Doctors Have Banquet, Speak About Electricity and Show up Their Theories by Various Machines" Los Angeles Times, (California, USA), June 3 1903, p.11.

- Abdollahi H et al.: "Radiophilia: A Common Case of Excessive Radiation Exposure in Healthcare" *OMICS J Radiol.* (2016) abstract; pdf.
- Ment de J: "Radiophobia; a new psychological syndrome" *West J Surg Obstet Gynecol.* (1951) PMID: 14877113.
- Novikau A: "What is "Chernobyl Syndrome?" The Use of Radiophobia in Nuclear Communications" *Env Comm.* (2017) Abstract.
- Pastel RH: "Collective behaviors: mass panic and outbreaks of multiple unexplained symptoms" *Mil Med.* (2002) PMID: 11778431.
- Pastel RH: "Radiophobia: long-term psychological consequences of Chernobyl" *Mil Med.* (2002) PMID: 11873498.
- Ropeik D: "The dangers of radiophobia" *Bull Atom Scientist.* (2016) abstract.
- Sacks B et al.: "Preserving the Anti-Scientific Linear No-Threshold Myth: Authority, Agnosticism, Transparency, and the Standard of Care" *Dose Response.* (2017) PMID: 28814947; pdf.
- Stawkowski ME: "Radiophobia had to be reinvented" *Culture, Theory and Critique*. (2017) abstract.

In contrast to psychological electrophobia, ***real Electromagnetic Hypersensitivity (EHS)****, also called Electrosensitivity, Electrical Sensitivity or Intolerance, El-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 has been accepted in the west by international groups since 2000. There are now studies on hundreds of people with real EHS as diagnosed using objective and environmental markers, including genetic tests, 3d MRI scans, blood perfusion measurements, blood and cardiovascular markers. Some degree of electromagnetic sensitivity has been identified in up to 40% of the population, as confirmed by environmental surveys and geomagnetic surveys, with a much smaller proportion having electromagnetic hyper-sensitivity.*

Studies show that real EHS can be distinguished from Electrophobia or a nocebo effect.

- Augner C et al.: "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.
- Chevalier G: "The effect of grounding the human body on mood" *Psychol Rep.* (2015) PMID: 25748085.
- Dieudonne M: "Does electromagnetic hypersensitivity originate from nocebo responses? Indications from a qualitative study" *Bioelectromagnetics* (2016) PMID: 26369906.

- Leszczynski D: "Open Letter on the Electromagnetic Hyper-Sensitivity Research" (BRHP, February 4 2018) [not peer-reviewed]

Confusion over EHS and electrophobia or IEI-EMF by WHO, ICNIRP, AGNIR, etc.
There is still a confusion in the literature of some regulators over these two different conditions of EHS and electrophia or IEI-EMF. Since about 2004, the World Health Organization (in its Backgrounder 296 of 2005), ICNIRP and related groups, such as the UK's AGNIR, Public Health England, the Royal Society of Canada's Report on Health Canada's Safety Code 6 and SCENIHR, all composed of a small clique of pro-wireless activists, tried to identify EM sensitivity with electrophobia or IEI-EMF, which they then defined as psychological and not caused by EM energy. Confusion over these two different conditions is apparent in that, since 2002, groups like ICNIRP have accepted that some members of the general population are especially sensitive to environmental EM energy, while simultaneously, since 2004, also stating that such sensitivity

is in fact a result of psychological cognitive conditioning, although the WHO also says that EHS is not a known psychological condition.

Cognitive conditioning, however, cannot include children, unaware adults and animals, all of which can show hyper-sensitivity to EM energy, so these three groups cannot suffer psychological IEI-EMF but only real EHS.
Cognitive conditioning cannot explain established human sensitivity among the general population to low-level EM sferics and other solar and geomagnetic phenomena.
Congitive conditioning cannot explain therapeutic uses of low-level EM energy among the general population.
Congitive conditioning cannot explain uses of EM energy in electromagnetic warfare.
Congitive conditioning cannot explain the established link between low-level EM energy and cancers and neurological illnesses.

Some Electrophobia studies using conscious provocation tests have identified people with conscious Electrophobia, but so far (i) they have failed to replicate this with young children, unaware or unconditioned adults and animals, and (ii) they have not explained the specific ES symptoms caused by environmental exposure in unaware adults. Many conscious provocation tests claiming the power to identify real EHS as well as Electrophobia have been invalidated (a) by not screening the subjects beforehand as to whether they have real EHS, and (b) by averaging the results, when real EHS is known to be an idiopathic response which varies between individuals, (c) by testing under 1,000 subjetcs, if hyper-sensitive individuals count for 0.1% of the general population and the study does not screen subjects for being EHS beforehand (to find ten EHS subjects from an unsceened population, at least 10,000 subjects would be needed), and (d) by assuming that only immediated conscious symptoms reveal EHS, whereas molecular, MRI and genetic tests show that there can be many long term outcomes from sensitivity including neurological damage and cancers.

- Hardell L: "World Health Organization, radiofrequency radiation and health – a hard nut to crack (Review)" *Int J Oncology.* (2017) PMID: 28656257. Article.
- 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.
- Starkey SJ: "Inaccurate official assessment of radiofrequency safety by the Advisory Group on Non-ionising Radiation" *Rev Environ Health.* (2016) PMID: 27902455. Article.
- Webster PC: "Federal Wi-Fi safety report is deeply flawed, say experts" *CMAJ.*(2014) PMID: 24756628. Article.

Doctors' attitudes *to patients linking symptoms to EM exposures: surveys showed that in 2009 29-58% of doctors in Germany accepted that EM exposure could cause ill health and 54% in Switzerland in 2006.*

- Huss A et al.: "Consultations in primary care for symptoms attributed to electromagnetic fields - a survey among general practitioners" *BMC Public Health.* (2006) PMID: 17074080.
- Kowall B et al.: "German wide cross-sectional survey on health impacts of electromagnetic fields in the view of general practitioners" *Int J Public Health.* (2010) PMID: 20020175.
- Kowall B et al.: "General practitioners using complementary and alternative medicine differ from general practitioners using conventional medicine in their view of the risks of electromagnetic fields: a postal survey from Germany" *J Prim Care Community Health.* (2015) PMID: 25142575.

13. Some historical evidence (1873 on)

- T. Springle, August 26 1873; in: Snape J: *Electro-dentistry: facts and observations*; London Simpson Marshall (c. 1874); pdf:
  "The difference of feeling expressed in the ten different statements submitted in your treatise, arises from the fact that electricity acts differently upon different individuals, or is differently expressed by them. I have watched people grasp the handles of a small electric battery such as yours, and some will laugh and stand it quite a while and say, "How nice!" Others will let the handles drop and say, 'How very unpleasant, it is a dreadful sensation."

- O'Neill JJ: *Prodigal Genius: The Life of Nikola Tesla* (1944) pdf.
  Nikola Tesla, 1856-1943, is sometimes regarded as one of the first people to suffer from electromagnetic hyper-sensitivity when he was aged 25, in 1881:

  "The peculiar malady that now affected him was never diagnosed by the doctors who attended him. It was, however, an experience that nearly cost him his life. To doctors he appeared at death's door. The strange manifestations he exhibited attracted the attention of a renowned physician, who declared that medical science could do nothing to aid him.
  One of the symptoms of the illness was an acute sensitivity of all the sense organs. His senses had always been extremely keen, but this sensitivity was now so tremendously exaggerated that the effects were a form of torture. The ticking of a watch three rooms away sounded like the beat of hammers on an anvil. The vibration of ordinary city traffic, when transmitted through a chair or bench, pounded through his body. It was necessary to place the legs of his bed on rubber pads to eliminate the vibrations. Ordinary speech sounded like thunderous pandemonium. The slightest touch had the mental effect of a tremendous blow. A beam of sunlight shining on him produced the effect of an internal explosion. In the dark he could sense an object at a distance of a dozen feet by a peculiar creepy sensation in his forehead. His whole body was constantly wracked by twitches and tremors. His pulse, he said, would vary from a few feeble throbs per minute to more than a hundred and fifty. Throughout this mysterious illness he was fighting with a powerful desire to recover his normal condition."

- Anon. "The telephone as a cause of ear troubles" *BMJ.* (1889). JSTOR:
  "M. Gellé has observed, not in women only, but in strong-minded and able-bodied men, symptoms of what we may call " aural overpressure" … In some cases, also, the ear seemed to be irritated … into a state of over-sensitiveness which made it intolerant of sound … The patients suffered … with buzzing noises in the ear, giddiness, and neuralgic pains … M. Gellé in some cases found objective lesions, such as a subinflammatory condition of the membrana tympani. … the victims of " telephone tinnitus"."

- 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."

- Audiat J: "Action des ondes hertziennes sur l'excitabilite e1ectrique des nerfs," (andes amorties, entretenus, counrtes) *Rev. d'actionol.* 8: 227. (1932).
  This study showed that, because excitability of the nerve-muscle preparation diminished under the action of RF waves, it had to be a "specific" effect, since heating supposedly would have an opposite effect.

- Reiter T: *Ann. d'Inst Actinologie.* 7: 195-198. (1932)
  This study showed that biological effects could occur as a result of the wavelength or frequency and not from heating.

- Likhterman BV et al.: "Terapevticheskom primenenil korotkikh voln" ["On the Therapeutic Application of Short Waves"] Sevastopol (1936), in Kholodov YuA: "Vliyaniye elektromagnitnykh i magnitnykh poley na tsentral'nuyu nervnuyu 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."

- McLaughlin JT "Tissue destruction and death from microwave radiation (radar)" *Calif. Med.* (1957) Article.
  [Unusual thermal or athermal effects in the abdomen]

- Letavet AA, Gordon ZV (eds) "O biologitcheskom vozdeistvii 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: "Biologicke ucinky elektromagnetickyeh vln 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."

- Mohr GC et al.: "Effects of low frequency and infrasonic noise on man" *Aerosp Med.* (1965) PMID: 14332329. [Bridges JE, 1975: p.157-158]
  "In the very low infrasonic frequency range, chest wall vibration, gag sensations and respiratory changes were regularly observed. In the 50 to 100 Hz range responses included headaches, choking, coughing, visual blurring, and fatigue."

- Asanova TP et al.: "Health Conditions of Workers Exposed to an Electrical Field of 400-500 Kilovolt Open Distributing Installations" *Soviet Biotechnology and Bioastronautics.* (1966) Translation (1969). [Bridges JE, 1975, p.32]
  "41 of the 45 subjects suffered some discomfort as a result of exposure to electric fields. Most prevalent among subjective complaints were headache, fatigability, weakness, and drowsiness (37 subjects). Other complaints included disruption GI tract or cardiovascular activity. Neurological disruptions were unstable and usually most noticeable during the working day. As an example, headache intensity corresponded to the duration of exposure. In general, nervous system pathology was diagnosed in 28 subjects. In 26 of these, CNS disorders primarily took the form of autonomic dysfunction characterized by dermographism, pulse and arterial pressure lability, hyperhydrosis, and hand tremors."

- Bridges JE: "Biological Effects of High Voltage Electric Fields: Bibliography and Survey of Ongoing Work" (1975) *Electric Power Research Institute*. 313 pages. Copy.

- Sudokov KV: "A modulated electromagnetic field as a factor of selective influence upon the mechanisms of goal-orientated behaviour in animals" *Zhurnal Vysshey Nervnoy Deyatel'Nosti, Moscow.* (1976) Declassified 2012/05/10. CIA-RPD88B01125R000300120008-3.

- Faytel'berg-Blank VR et al.: "Selective action of decimetre waves on central structures of the brain" *Fiziologichekiy Zhurnal SSR, Leningrad.* (1977) Declassified in Part 2012/05/10. CIA-RPD88B01125R000300120006-5. In "Translations on USSR Science and Technology Biomedical and Behavioral Sciences (GUO 38/77) Effects of NonIonizing Electromagnetic Radiation" *General CIA Records*.

- Marino AA et al.: "Biological effects of extremely low frequency electric and magnetic fields: a review" *Physiol Chem Phys.* (1977) PMID: 414240. Article.
  "With few exceptions, ELF field research did not exist prior to about 1967."
  "as early as 1970 the Soviet literature contained more than 100 reports of the influence of ELF electric fields on biological systems"
  Yu I et al.: "Radio frequencies and microwaves; magnetic and electrical fields," in "Foundations of Space Biology and Medicine" 2(1) Academy of Sciences, USSR, Moscow, 1970. National Aeronautics and Space Administration, Washington, D. C., Technical Translation TT F-14, 021, (1971).

- Sudakov KV: "Hypnogenic effects of a modulated electromagnetic field" *Byulleten' Eskperimental'noy Biologii I Meditsiny, Moscow.* (1977) Declassified in Part 2012/05/10. CIA-RPD88B01125R000300120006-5. In "Translations on USSR Science and Technology Biomedical and Behavioral Sciences (GUO 38/77) Effects of NonIonizing Electromagnetic Radiation" *General CIA Records*.

- Justesen DR: "Behavioral and psychological effects of microwave radiation" *Bull N Y Acad Med.* (1979) PMID: 120208. PMC1807730.

- McRee DI: "Review of Soviet/Eastern European research on health aspects of microwave radiation" *Bull N Y Acad Med.* (1979) PMID: 295246. PMC1807746.

- Kinn JB. Postow E: "Index Of Publications On Biological Effects Of Electromagnetic Radiation (0-100 GHz)" US Environmental Protection Agency. (1981) copy. pdf. 3,627 references; 574 pages.

- Michaelson SM: "Health implications of exposure to radiofrequency/microwave energies" *Br J Ind Med.* (1982) PMID: 7039662. PMC1008955.
  Other reports *"implicate non-thermal or "specific" effects at the molecular and cellular level". "Clinical and laboratory studies of workers in the Soviet Union and other Eastern European countries employed in the operation, testing, maintenance, and manufacture of microwave-generating equipment are reported to have shown central nervous and cardiovascular reactions to MW/RF exposure. Functional disturbances of the central nervous system have been described as "radiowave sickness" - the neurasthenic or asthenic syndrome. The symptoms and signs include headache, fatigability, irritability, loss of appetite, sleepiness, sweating, thyroid gland enlargement, difficulties in concentration or memory, depression, and emotional instability. The clinical syndrome is generally reversible if exposure is discontinued. Another frequently described manifestation is a set of labile functional cardiovascular changes including bradycardia (or occasional tachycardia), arterial hypertension (or hypotension), and changes in cardiac conduction. This form of neurocirculatory asthenia is also attributed to nervous system influence. Effects indicated by hypotonus, bradycardia, delayed auricular and ventricular conduction, decreased blood pressure, ECG alterations in workers in RF or microwave fields have been reported."*

Reviews of the history of EM research:

- Bonnell JA: "Effects of electric fields near power-transmission plant" *J R Soc Med.* (1982) PMID: 6757432. PMC1438464.
- Carpenter DO: "The microwave syndrome or electro-hypersensitivity: historical background" *Rev Environ Health* (2015) PMID: 26556835. Article.
- Cook HJ et al.: "Early research on the biological effects of microwave radiation: 1940-1960" *Ann Sci.* (1980) PMID: 11610730. Article.

14. Mechanisms, pathways and other effects of low-level EM exposure

Many studies show biological effects at low-level or non-thermal levels of EM exposure, many times lower than current ICNIRP heating guidelines. Some of these effects produce immediate conscious symptoms, but others do not, even for people with ES/EHS who may be more susceptible to such effects.

(1) Acute myeloid leukemia, chronic myeloid leukemia

- Feychting M et al.: "Magnetic fields, leukemia, and central nervous system tumors in Swedish adults residing near high-voltage power lines" *Epidemiology.* (1994) PMID: 7986864.

(2) Adaptive response

- He Q et al.: "Adaptive response in mouse bone marrow stromal cells exposed to 900MHz radiofrequency fields: Impact of poly (ADP-ribose) polymerase (PARP)" *Mutat Res.* (2017) PMID: 28676262.
- Vijayalaxmi et al.: "Adaptive response in mammalian cells exposed to non-ionizing radiofrequency fields: A review and gaps in knowledge" *Mutat Res Rev Mutat Res.* (2014) PMID: 24548818.

(3) Adrenaline, adrenal system, norepinephrine, epinephrine

- Aboul Ezz HS et al.: "The effect of pulsed electromagnetic radiation from mobile phone on the levels of monoamine neurotransmitters in four different areas of rat brain" *Eur Rev Med Pharmacol Sci.* (2013) PMID: 23852905. Article.
- Laszlo AM et al.: "Effects of extremely low frequency electromagnetic fields on turkeys" *Poult Sci.* (2017) PMID: 29077912.
- Mahdavi SM et al.: "Effects of electromagnetic radiation exposure on stress-related behaviors and stress hormones in male wistar rats" *Biomol Ther (Seoul).* (2014) PMID: 25489427; pdf.
- Megha K et al.: "Effect of Low-Intensity Microwave Radiation on Monoamine Neurotransmitters and Their Key Regulating Enzymes in Rat Brain" *Cell Biochem Biophys.* (2015) PMID: 25672490.
- Singh S et al.: "Occupational EMF exposure from radar at X and Ku frequency band and plasma catecholamine levels" *Bioelectromagnetics.* (2015) PMID: 26058851.
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16. 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. It is now said to be used by several governments against some unaware civilian targets. Understandably, there are few peer-reviewed medical studies on this topic, although it inspired much of the EM research in the USSR and USA.
More recently the TASER electronic stun gun has also been widely deployed against civilian targets, with some reports of serious adverse consequences.

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17. Further information

Bias in studies according to sources of funding:

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Pressure on scientists to deny effects has been reported:

- *"The U.S. Air Force School of Aerospace Medicine has consistently suggested to us that there are no effects of low-level microwave exposure despite evidence to the contrary presented in the peer-reviewed literature."*
- *"pressure was applied [by Brooks officials] ... that we not report significant biological effects of low-power microwave irradiation."*
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