



Electromagnetic Fields

2015 Update

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Context - An electromagnetic field (EMF) is a physical field produced by stationary, spinning or moving electrically charged particles. EMF are present in nature but are also a byproduct of electric devices and new technologies.

It is the omnipresence of these new technologies (including laptops, cell phones, induction cooktops and Wi-Fi) that has raised concerns about how EMF exposure might impact our health.

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The answers to these questions are a faithful summary of the scientific opinion produced in 2015 by the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR):
"Potential health effects of exposure to electromagnetic fields (EMF)"

The full publication is available at: <https://copublications.greenfacts.org/en/electromagnetic-fields/>
and at: <http://ec.europa.eu/health/opinions2/en/electromagnetic-fields/>



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- Each question is answered in Level 1 with a short summary.
- These answers are developed in more detail in Level 2.
- Level 3 consists of the Source document, the internationally recognised scientific opinion which is faithfully summarised in Level 2 and further in Level 1.

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and at: http://ec.europa.eu/health/scientific_committees/policy/opinions_plain_language/index_en.htm*

1. Introduction to electromagnetic fields

1.1 The term “electromagnetic field” (EMF) is frequently used as a generic term, however, it actually comprises quite different frequency ranges that differ considerably both with regard to physical and biological aspects. EMF comprise static magnetic (SMF) and static electric fields (SEF), extremely low frequency (ELF), 1Hz – 300Hz, and intermediate frequency (IF) electric (EF) and magnetic fields (MF), 300Hz – 100kHz, and radio frequency (RF) electromagnetic fields, 100kHz – 300GHz. Up to the RF range, electric and magnetic fields can be considered independently from each other, while in the RF range, they are tightly coupled together like the links of a chain.

In the ELF range, if strong enough, EF and MF are able to stimulate nerve and muscle cells, while in the RF range energy absorption (heating) is responsible for potential bioeffects. The IF range is characterised by the fact, that the mechanism of cellular stimulation becomes less and less effective while heating is not yet efficient. Static MF, SEF, oscillating EF, MF and EMF may be of natural origin such as the earth’s static magnetic field or friction-generated static electric fields (which may be encountered, for example, when producing microshocks during undressing). Lightning strokes generate broad-band electromagnetic fields extending from the LF to the RF range. A major natural source of RF EMF is solar activity. The technical use of electricity mainly causes sinusoidally alternating fields which may be generated in the LF range (e.g. railways, household appliances, power lines), IF range (e.g. energy saving lamps, electronic article surveillance systems) as well as in the RF range (e.g. broadcasting antennas, mobile telecommunication devices, microwave ovens).



Static magnetic fields of technical origin are generated by permanent magnets such as used in magnetic clasps or other closures in necklaces, underwear, handbags or holders or by direct electric currents such as in battery appliances. Extremely high magnetostatic fields are applied at some workplaces and in medical resonance imaging (MRI).

1.2 The present SCENIHR Opinion evaluated the most recent scientific studies to assess whether exposure to EMF may induce adverse health effects. It considers all scientific approaches from laboratory experiments carried out on human volunteers, animals (including life-long multigenerational exposure), tissues and cell cultures as well as epidemiologic studies on the population with daily life EMF exposure by comparing cases with controls (case-control study) or by analysing the health of population groups (cohort studies).

1.3 In the process of preparing their Opinion, SCENIHR conducted open public consultations by making the preliminary Opinion available on the internet from 4 February to 16 April 2014 for comments and contributions. In addition, a public hearing was held in Athens, on 27 March 2014 which was attended by 57 organisations. As a result of the public consultation 186 comments were submitted to different chapters of the Opinion and carefully considered in the revision of the draft Opinion.

2. What are the sources of exposure to radio frequency fields?

Radio frequency (RF) fields range from 100 kHz to 300 GHz. They have many applications in modern society. Familiar sources include radar, antennas for TV and radio broadcasting, various radio services and telecommunication as well as appliances such as microwave ovens or portable devices like mobile phones or tablets.



Since field strength falls rapidly with distance from source, body-near appliances such as a mobile phone are characterised by very inhomogeneous fields which expose only a local part of the body while fields from distant sources are almost homogeneous and, hence, lead to whole body exposure. Consequently, existing regulations limit both local and whole body exposure.

2.1 Among the multiple sources, transmitters in close vicinity to or on the body have become the main sources of exposure for the general population. In particular for brain tissues, the mobile phone used at the ear remains the main source of exposure. However, since the first generation of mobile telephony, the technology aimed at reducing the emitted power of mobile handsets by various means. In addition, hands-free kits drastically reduce the energy absorbed by the head.

2.2 For **handheld mobile phones**, the exposure to RF is mostly restricted to the region closest to the phone's antenna. **Cordless phones** also emit radio waves, but since the base stations are closer to the handsets, they are much less powerful. The same applies to **wireless computer networks (WLAN)**.

2.3 Antennas of **mobile phone base stations** and **broadcasting towers** transmit by characteristic spatial patterns to provide their service efficiently. Consequently, the distance measured near the antennas is an inadequate surrogate for exposure.

2.4 **In medicine**, applied EMF are dedicated to be strong enough to induce stimulatory or heating effects for therapy and diagnosis.

The European Union has recommended safety limits also on exposure to RF fields. For handheld mobile phones, these limits are given in terms of the specific energy absorption rate both for local and whole body exposure. Phones today have power output much lower than the recommended safety limit. Other wireless devices used in close quarters, like cordless phones and wireless computer networks, also generate radio waves but exposure from these sources is generally lower than from mobile phones. Regarding antennas that transmit radio signals, because the field strength decreases rapidly with distance, most people are exposed only to a very small fraction of the recommended limit.

3. Can mobile phones cause cancer?

3.1 In recent years many studies with different scientific approaches have investigated whether radio frequency (RF) fields, particularly those of mobile phones, could cause cancer.

Epidemiological studies on mobile phone users have focused on cancers of the head and neck region because these tissues are primarily exposed to the RF fields emitted by hand-sets. To date, most studies available do not show an increased risk of brain tumours. Furthermore, they also do not indicate an increased risk for other cancers of the head and neck region.



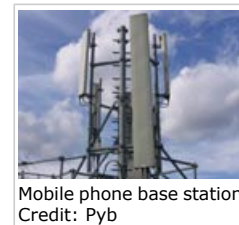
Some few studies raised questions regarding an increased risk of some specific tumours (glioma and acoustic neuroma) in heavy users of mobile phones. Other recent epidemiological studies did not confirm this association. Furthermore, data derived from cancer registries in some countries; do also not indicate an increase of these brain tumours since the introduction and massive use of mobile phones and challenge this hypothesis. Epidemiological studies do not indicate increased risk for other malignant diseases including childhood cancer.

3.2 Further evidence for the absence of a carcinogenic effect was provided by a considerable number of well-performed experimental studies that investigated whether RF fields could induce cancer.

3.3 Studies assessing the potential of RF fields to cause genetic damage have not shown such effect. Other potential endpoints were also investigated, such as cell death, expression of genes, of cell proliferation, and most of the studies did not find any effect.

4. Can mobile phones or base stations trigger headaches or other health effects?

4.1 Some people attribute non-specific health symptoms such as headache, fatigue and dizziness to radio frequency (RF) fields. Such complaints have raised concern that certain individuals may be critically more sensitive than others to electromagnetic fields, a phenomenon that has been coined as “electromagnetic hypersensitivity”. Studies conducted since the previous Opinion in 2009 add additional weight to the former conclusion that there is no evidence that EMF exposure from mobile phones may be causally linked to these symptoms.



Mobile phone base station
Credit: Pyb

Instead, present evidence suggests a “nocebo” effect (a negative placebo effect), which means that effects may be caused by the pure belief that something is harmful rather than by the suspected cause itself. Actually, there is no scientific evidence that humans - be it so-called sensitive groups or healthy control groups - can perceive radio frequency fields better than would be expected by chance.

4.2 Because mobile phones are used near the head, there have been concerns they could affect the brain. There is some evidence that RF exposure might have a subtle impact on brain activity, sleep, learning, memory or behaviour, but there is yet no evidence for health relevance. However, present results merit further research on this issue.

4.3 On the basis of the most recent human and animal studies, the new SCENIHR Opinion concluded that there are no adverse effects on reproduction and development from RF fields at non-thermal exposure levels.

4.4 The one epidemiologic study which addressed mobile phone use and brain tumours in children and adolescents showed no association.

There are still no substantiated indications of any other health effects.

5. Conclusions on mobile phones and radio frequency fields

Extensive research has been conducted in recent years on how RF fields generated by mobile phones might affect health by a variety of scientific approaches such as, laboratory studies on cells, tissues, animals and human volunteers, and epidemiologic studies on the general population.



Few studies have looked at effects on children

Overall, the epidemiological studies on mobile phone RF EMF exposure did not show an increased risk of brain tumours. Furthermore, they do not indicate an increased risk for other cancers of the head and neck region, neither in adults nor in children. Research has found no evidence that exposure to RF fields at levels below existing safety limits could cause self-reported non-specific symptoms such as headache and dizziness. Present evidence suggests rather a “nocebo” effect (a negative placebo effect), which means that effects may be caused by the pure belief that something is harmful rather than by the suspected cause itself.

Some studies have looked at potential health effects in children, to account for the growing popularity of mobile phones among the young and for concerns that children might be more vulnerable to EMF.

There were no adverse or substantiated effects found on reproduction and development.

6. Intermediate frequency (IF) fields like those from induction ovens

6.1 “Intermediate frequencies” range from 300 Hz to 100 kHz. These are lower than radio frequencies and higher than extremely low frequencies such as from electric energy supply. The name IF range stems from the fact that it lies at the borderline of the ranges of two well established interaction mechanisms. It is characterised by the fact, that the mechanism of cellular stimulation becomes less and less effective while heating is not yet efficient. Technologies generating intermediate frequency (IF) fields have increased in recent years, including induction ovens or inductive chargers. Intermediate fields are also used by medical devices and are generated by industrial processes such as welding.

6.2 Established biological effects in the IF range are nerve stimulation at the lower end and energy absorption at the upper end of the range. Few data are available on the exposure of individuals to IF fields. There are only few specific studies available. No epidemiological studies have been conducted. In view of the expected increase of occupational exposure to IF, SCENIHR recommends more experimental studies on biomarkers and health outcomes in workers.

7. Extremely low frequency fields (ELF) like those from power lines and household appliances

7.1 Extremely low frequency (ELF) MF and EF are those below 300 Hz. ELF magnetic fields are for instance generated by the alternating current (AC) used in power lines, wiring and household appliances. Other important sources of ELF MF are transformers, welding machines and trains.

ELF electric fields are particularly strong below high voltage overhead power lines. The field strengths of both ELF MF and EF fall rapidly with distance from source which means that body-near appliances cause inhomogeneous fields and, hence, partial body exposure, while distant sources such as overhead lines cause almost homogeneous fields and, hence, whole body exposure.

7.2 In the areas that are accessible to the public, exposure to ELF fields is below the existing limits. For instance, directly below a high voltage power line, the EF level may be close to, though still within safety limits while MF fields are further below limits. At home, both EF and MF fields are strongest close to electric appliances; highest MF may be encountered near appliances such as food processors or drills.

7.3 Recent studies confirm the previous finding of a statistical association between leukaemia in children and MF such as from high voltage power lines. However, it remains difficult to interpret these reports since no mechanisms have been identified that could explain these findings nor is the epidemiologic evidence supported by other scientific approaches such as laboratory studies *in vivo* or *in vitro*.

The association with childhood leukemia remains an isolated finding since epidemiologic studies on other childhood cancers or adult cancers show no consistent association with any other type of cancer.

7.4 As in the case of RF Fields, “electromagnetic hypersensitivity” is an issue that also arises in the case of ELF field exposure. Overall, the existing studies do not provide convincing evidence for a causal relationship between ELF MF exposure and the self-reported non-specific symptoms.

Only a few new epidemiological studies on neurodegenerative diseases have emerged since the previous Opinion was published. They do not provide support for the previous conclusion that ELF magnetic field exposure could increase the risk for Alzheimer's disease or any other neurodegenerative diseases including dementia.

7.5 For some other diseases, recent results do not show any effect of the ELF fields on the reproductive function in humans. Effects on cardiovascular diseases are considered unlikely.



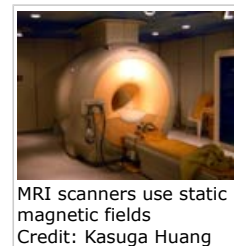
Power lines generate ELF fields Credit: Miguel Saavedra



See also our Digest on Power Lines [see <https://www.greenfacts.org/en/power-lines/index.htm>]

8. Static magnetic fields like those from battery devices and high voltage overhead DC power lines

8.1 Static magnetic fields such as those generated by permanent magnets do not oscillate and hence have no frequency (0 Hz). Man-made static magnetic fields are generated wherever electricity is used in the form of direct current (DC), for instance in some railways, trams, subway systems, but also in upcoming long-distance high voltage DC overhead power lines and DC operated (battery) appliances or they may stem from body worn magnets such as used for clasps in necklaces of underwear. Extremely high static MF are used in medical imaging by MRI (Magnetic Resonance Imaging) scanners.



8.2 In principle, static magnetic fields can induce forces on biological molecules and cellular components with magnetic properties such as haemoglobin. Rapid movements in extremely high static magnetic fields may cause induction of relevant intracorporal electric field strengths with subsequent acute effects such as dizziness or nausea. However, globally, there is no consistent evidence for sustained adverse health effects from short-term exposure up to several Teslas. Therefore, taken together, the new findings reported do not provide any reason for changing the risk assessment of static magnetic fields exposure which was already presented in the previous Opinion.

A number of new technologies, such as MRI equipment, are using combinations of different EMF, which merits further research.

9. Are there health effects from combined exposures to different EMFs or co-exposure with other agents?

The few available studies on **combined exposure** to different EMFs do not provide sufficient evidence for risk assessment. Regarding **co-exposure** to ELF or RF with several chemical or physical agents, inconsistent results of either an increase or decrease in the effects of some chemicals or physical agents have been observed in some cases. Further investigations are recommended to clarify the role of EMFs in such effects.

10. Conclusions on health effects of electromagnetic fields

10.1 Overall, the epidemiological studies on mobile phone **RF EMF** exposure do not show an increased risk of brain tumours. Furthermore, they do not indicate an increased risk for other cancers of the head and neck region.

There is no evidence that self-reported non-specific symptoms like headache or fatigue are linked to exposure to radio frequency fields.

10.2 Because data for the intermediate frequency (IF) fields are sparse, the assessment of health risks of short-term exposure to high levels of intermediate frequency fields is based on established biological effects at lower and higher frequencies. Proper assessment of possible health effects from long-term exposure is important because exposure to such fields is increasing, especially in certain workplaces.

10.3 The new epidemiological studies are consistent with earlier reports of an association of childhood leukaemia with exposure to magnetic fields such as from power lines. However, no mechanisms have been identified and there has been no support from other scientific

approaches such as experimental studies *in vivo* or *in vitro* that could explain these findings. Together with shortcomings of the epidemiological studies, this prevents a causal interpretation.

New epidemiological studies on neurodegenerative diseases published since the previous Opinion do not provide support for the previous conclusion that ELF magnetic field exposure could increase the risk for Alzheimer's disease or any other neurodegenerative diseases including dementia. Furthermore, they show no evidence for adverse pregnancy outcomes or any effect on the reproductive function in humans.

10.4 New applications of very strong static magnetic fields, used alone or in association with other fields, will require risk assessments of occupational exposure, as for instance in the vicinity of MRI scanners. Globally, there is no consistent evidence for sustained adverse health effects from short-term exposure up to several Teslas.

10.5 The few available studies on combined exposure to different EMFs do not provide sufficient evidence for risk assessment. Exposure to ELF or RF with several chemical or physical agents results in inconsistent results of either an increase or a decrease in their effect. Therefore, due to the small number of available investigations and the large variety of protocols adopted, it is not possible to draw definitive conclusions, in particular regarding their relevance to human carcinogenicity under real-life exposure conditions.

10.6 The Opinion identifies a number of areas where information regarding health effects is either sparse or insufficient, or is too discordant to allow assessment of hypothetical health effects.

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