

4.8 Electromagnetic fields and health

Key messages:

- There are well-defined acute human effects of exposure to certain electromagnetic fields, including symptoms such as nerve and sensory organ stimulation and the heating of tissues.
- There is currently little scientifically established evidence of causal relationships between long-term exposure and reported symptoms, though in some cases there is certainly a clear need for further research.
- Given the limitations in the current evidence base and the expected increase in exposure of the European population to radio frequency electromagnetic fields following deployment of 5G, further research is needed regarding possible health effects.
- The World Health Organization is carrying out further research on electromagnetic fields exposure, to provide more comprehensive conclusions on the potential long-term health effects.

Electromagnetic fields (EMFs) are a combination of invisible electrical and magnetic fields of force. They are generated by natural phenomena, such as the Earth's magnetic field, but also by human activities, mainly the use of electricity (EC, 2009). EMFs are generated by many devices, such as mobile phones, televisions, power tools and electrical power lines. Certain applications deliberately use EMF, for example the use of static magnetic fields in magnetic resonance imaging for medical purposes.

There are two types of EMF: ionising and non-ionising radiation. Ionising radiation includes EMF of mid to high-frequency, such as ultraviolet rays, x-rays and gamma rays, the energy from which can damage human cells and cause cancer. Non-ionising EMFs are normally categorised based on the frequency of the field, typically:

- radio frequency (RF — 100 kHz to 300 GHz);
- intermediate frequency (IF — 300 Hz to 100 kHz);

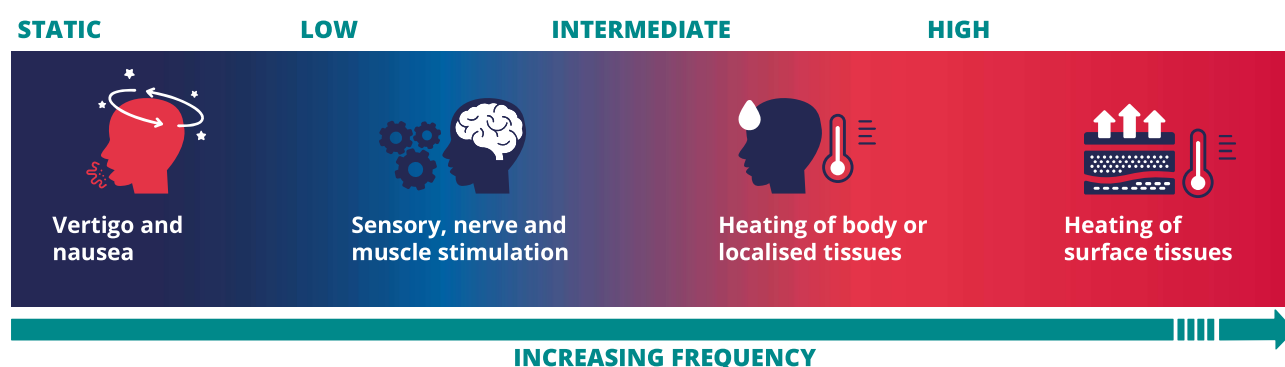
- extremely low frequency (ELF — 0 Hz to 300 Hz);
- static (0 Hz).

More recently, EMFs in the terahertz (THz) range have also become more widely used.

There are direct and indirect health effects of exposure to EMFs that are well understood. Direct effects at different frequency ranges are shown in Figure 4.18, and include non-thermal effects (such as the stimulation of nerves, muscles and sensory organs) and thermal effects (such as tissue heating). These effects are normally short term and transient and cease when the EMF is deactivated.

Indirect effects relate to situations in which the presence of an object within an EMF may cause a safety or health hazard (EC, 2015b). Indirect effects could include, for example, interference with implanted medical devices in the human body.

Figure 4.18 The effects of non-ionising EMFs in different frequencies



Note: Frequency intervals are not to scale.

Source: EC (2015b).

Box 4.29 Policies on EMF

In 1999, the Council of the European Union published a recommendation on the limitation of exposure of the general public to electromagnetic fields (EMFs) (Council of the European Union, 1999). This included recommended reference values for high voltage power lines of 5 kilovolts per metre for electric fields and 100 microteslas for magnetic fields. As this is a recommendation, it has not been applied in all EU Member States. Some countries have chosen to implement more stringent reference values. The different approaches taken by different Member States are illustrated in Map 4.9, which shows the variation in the limits for power frequency EMFs. There are also variations in the limits applied to radio frequency EMFs (not shown).

The EMF Directive was adopted in 2013 (EU, 2013b) to protect workers from both the direct and the indirect effects of EMFs in the workplace. The directive does not address the long-term effects of exposure to EMFs because of a lack of causal evidence of harm to health. If such evidence emerges, then the Commission will consider the necessary means for addressing such effects (EC, 2014).

In the European Commission's 2016 communication on connectivity for a competitive digital single market, towards a European gigabit society (EC, 2016a), the deployment of very high capacity fifth generation telecommunications technologies (5G) across Europe by 2025 is identified as a critical building block of the digital economy and society. It sets 2025 connectivity targets for public service providers, transport hubs and major terrestrial transport routes, digital enterprises, and urban and rural households. Specifically, urban areas, major roads and railways should have uninterrupted 5G coverage. The 5G for Europe Action Plan (EC, 2016b) sets out measures for the timely and coordinated deployment of 5G across the EU. Adopted in 2018, the European Electronic Communications Code (EU, 2018) paves the way for the uptake of 5G across the EU. It recognises the need to ensure that citizens are not exposed to electromagnetic fields at levels harmful to public health, with Member States able to restrict the types of radio networks or wireless access technology to protect human health.

Current questions focus on the impact of rolling out the fifth generation of telecommunications technologies, known as 5G, intended to power the Internet of Things. Compared to previous generations of communications technology, 5G employs higher frequency radio waves that have shorter ranges, requiring a dense network of antennas and transmitters to deliver significantly improved connectivity. Such a dense network is predicted to result in constant exposure of the population to RF EMF, a form of non-ionising radiation, with some researchers expressing concerns regarding impacts on human health (Karaboytcheva, 2020).

Policies to address human exposure to EMF and to support the roll out of 5G in Europe are presented in Box 4.29.

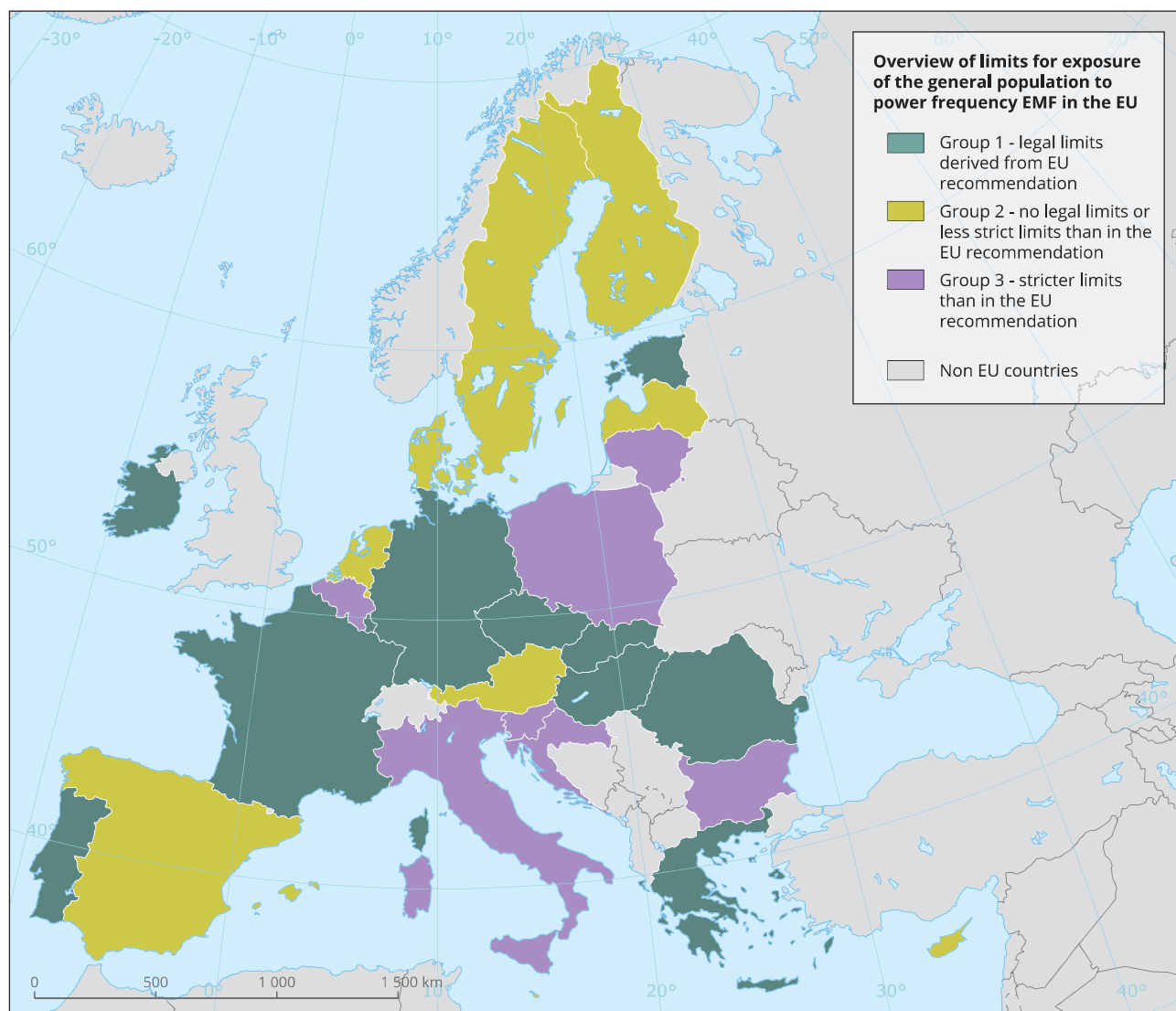
4.8.1 Longer term effects of exposure to EMFs

The European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) published an opinion on the potential health effects of exposure to EMFs (EC, 2015c). The report examines available evidence of the impacts from different frequencies of EMFs, with the conclusions broadly establishing that there is little convincing evidence of causal relationships between exposure and reported symptoms, though in some cases there is a clear need for further research.

There are a limited number of studies investigating the effects of very high frequency EMFs — THz EMFs — but they do not provide evidence of specific health impacts. The SCENIHR recommends that, as a result of the expected increase in use of THz technology, further research on its effects is necessary.

RF EMFs are associated with mobile phone usage, as well as the deployment of 5G, and are of particular interest to the public in terms of the potential health effects. In 2011, the International Agency for Research on Cancer (IARC) classified RF EMF as a possible human carcinogen, based largely on limited evidence of increased risks of gliomas and acoustic neuromas among long-term users of cell phones (IARC, 2011). In contrast, the 2015 SCENIHR report indicates that studies on mobile phone exposure do not show an increased risk of brain tumours or other cancers in the neck and head region. However, there is evidence that RF EMF exposure can affect brain activity when a person is awake and also during sleep, though the potential impacts of this are not clear. The report found a lack of evidence linking RF EMF exposure to impaired cognitive function, neurological diseases or reproduction and developmental effects (EC, 2015c).

A Danish review of more than 28 000 children found that an elevated risk of behavioural problems was associated with both the mother's and the child's own mobile phone use (Divan, 2012). In this study,

Map 4.9 Overview of limits for exposure of the general population to power frequency EMFs in the EU

Source: RIVM (2018).

exposure to mobile phones was also associated with lower socio-economic status, maternal smoking and the younger age of mothers, which slightly weakened the strength of the association between exposure and the prevalence of behavioural problems.

More recently, in a 2018 statement on emerging environment and health risks, the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) highlighted the potential effects of increases in electromagnetic radiation on wildlife as a concern, noting that health and safety issues remain unknown and there is a lack of evidence to inform exposure guidelines for 5G (SCHEER, 2018). Some scientists have expressed concerns that children born today

will experience cradle-to-grave lifespan exposure to RF EMR, in a context where health impacts remain poorly understood (Russell, 2018). A 2018 review found evidence that RF-EMF exposure drives biomedical effects in animals, increasing oxidative stress, a condition involved in cancer onset, as well as in several acute and chronic diseases and in vascular homeostasis (Di Ciaula, 2018). In follow up, a report of the Swedish Radiation Safety Authority found that the association between exposure to EMF and oxidative stress was not conclusive (Swedish Radiation Safety Authority, 2019). In terms of current exposure levels, a recent review found that RF-EMF exposure levels were highest in public settings, including libraries, train and tram stations, followed by outdoor and private indoor environments. Everyday RF-EMF

exposure was not found to have increased since 2012, despite the increased use of wireless communication devices (Jalilian, et al., 2019).

Given the limitations in the current evidence base, coupled with the expected increase in exposure for the European population, further research regarding the possible long-term health effects of 5G deployment is important.

In relation to ELF fields, existing studies do not provide convincing evidence for a causal relationship between exposure and reported symptoms. A range of studies have found an increased risk of childhood leukaemia associated with exposure to ELF fields; however, no causal relationship can be identified, as no plausible mechanisms have been identified (EC, 2015c).

There are concerns that RF EMF may interact synergistically with other environmental stressors to affect health, with a recent study cautioning against possible systemic health effects (Kostoff, et al., 2020). The SCENIHR report also examined the potential impacts of co-exposure to EMFs and environmental stressors, with no definitive conclusions. The report recommends further research on the effects of co-exposure with other agents (EC, 2015c).

The WHO remains concerned about the potential health effects of EMF exposure, particularly regarding the knowledge gaps highlighted above. The WHO has an ongoing international EMF project assessing the health and environmental effects of electric and magnetic fields (WHO, 2018g).