

What is Radiofrequency (RF) Electromagnetic Fields (EMF)?

Radiofrequency EMFs consist of oscillating electric and magnetic fields; the number of oscillations per second is referred to as “frequency,” and is described in units of hertz (Hz). Radiofrequency electromagnetic radiation ranges from 30 kilohertz (30 kHz, or 30,000 Hz) to 300 gigahertz (300 GHz, or 300 billion Hz). As the field propagates away from a source, it transfers power from its source, described in units of watt (W), which is equivalent to joule (J, a measure of energy) per unit of time (sec). When the electromagnetic field impacts upon material, including biological tissue, it interacts with the atoms and molecules in that material.

The human body absorbs energy from devices that emit radiofrequency electromagnetic radiation. The dose of the absorbed energy is estimated using a measure called the specific absorption rate (SAR), which is expressed in watts per kilogram of body weight.

SAR depends on the power of the source, time of exposure and distance from the source.

What are the sources of RF EMF?

The most common sources of radiofrequency radiation are wireless telecommunication devices and equipment, including cell phones, radars, satellite stations, radio and TV signals, smart electric and gas meters, and portable wireless devices, such as tablets and laptop computers. In the United States, cell phones currently operate in a frequency range of about 1.8 to 2.2 GHz.

Are there adverse effects of the RF EMF on human health?

The most obvious effect of the EMF interaction with human body is heating. This effect is relatively easy to detect, and its mechanism is well understood and described. Most EMF regulations and guidelines are based on limiting thermal effect to 1°C of body temperature rise. For example, International Commission on Non-Ionizing Radiation Protection (ICNIRP) in its latest Guidelines (1) set basic restrictions for SAR for general public at 0.08 W/kg. For the frequency range 2-300 GHz this level of SAR is produced by the incident field with power density of 10 W/cm².

What about cancer and other non-thermal health effects of the cell phone use? Are these effects being studied?

Because cell phones usually are held near the head when a person is on a call, the main concern has been whether the phones might cause or contribute to tumors in this area, including malignant (cancerous) brain tumors, such as gliomas, non-cancerous tumors of the brain, such as meningiomas, non-cancerous tumors of the nerve connecting the brain to the ear (vestibular schwannomas, also known as acoustic neuromas), tumors of the salivary glands. A few studies have also looked at possible links to other types of cancer.

These studies were performed in the lab, using lab animals or cell cultures and with the groups of cell phone users. Some of the largest lab studies performed were by the US National Toxicology Program (NTP) published in 2018 (4) and by the Ramazzini Institute in Italy (5).

While both studies had strengths, they also had limitations that make it hard to know how they might apply to humans being exposed to RF waves from cell phones. A 2019 review of these two studies by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (1, Appendix B) determined that the limitations of the studies didn't allow conclusions to be drawn regarding the ability of RF energy to cause cancer.

Several dozen studies of cell phone users have looked at possible links between cell phone use and tumors. Most of these studies have focused on brain tumors. Many of these have been case-control studies, in which patients with brain tumors (cases) were compared to people who didn't have brain tumors (controls), in terms of their past cell phone use.

These studies have had mixed results. Some studies have found a possible link between cell phone use and brain tumors, while others have not. For example, several studies published by the same research group in Sweden have reported an increased risk of brain tumors in people using cell phones. However, there was no apparent overall increase in brain tumors in Sweden during the years that correspond to these reports.

The largest of the cell phone user studies were:

- **The INTERPHONE study** (6): the largest case-control study done to date, looked at cell phone use among more than 5,000 people who developed brain tumors (gliomas or meningiomas) and a similar group of people without tumors. Overall, the study found no link between brain tumor risk and the frequency of calls, longer call time, or cell phone use for 10 or more years.
- **The Danish cohort study** (7): A large, long-term study has been comparing all the people in Denmark who had a cell phone subscription between 1982 and 1995 (about 400,000 people) to those without a subscription to look for a possible increase in brain tumors. The most recent update of the study followed people through 2007. Cell phone use, even for more than 13 years, was not linked with an increased risk of brain tumors, salivary gland tumors, or cancer overall, nor was there a link with any brain tumor subtypes or with tumors in any location within the brain.
- **The Million Women Study** (8): A large prospective study of nearly 800,000 women in the UK examined the risk of developing brain tumors over a 7-year period in relation to self-reported cell phone use at the start of the study. This study found no link between cell phone use and brain tumors overall or several common brain tumor subtypes, but it did find a possible link between long-term cell phone use and acoustic neuromas. The authors of this study, however, did note the possibility that this link might have been due to more intensive medical investigation in long-term cell phone users because of media coverage at the time.

Several US and international governmental agencies and scientific organizations periodically review published studies and issue regulations, guidelines, recommendations and statements:

- US Federal Communications Commission (FCC) (9)
- US Food and Drug Administration (FDA) (10)
- National Toxicology Program (NTP) has not included RF radiation in its Report on Carcinogens, which lists exposures that are known to be or reasonably anticipated to be human carcinogens (11)
- US Occupational Safety and Health Administration (OSHA) (12)
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) (1)
- European Commission (13)
- The International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO) has classified RF radiation as "possibly carcinogenic to humans" (Group 2B) based on limited evidence of a possible increase in risk for brain tumors among cell phone users, and inadequate evidence for other types of cancer (14).

What about Wi-Fi?

FCC SAR limit for cell phones is set at 1.6 W/kg. For WiFi mobile and portable routers it is set to 250 mW (milliwatt = one one-thousandth of a watt). Clemson University uses routers with power of 25 mW. Considering that cell phones are being used much closer to the human's body than the WiFi source, exposure to the EM radiation emitted by the WiFi is significantly (orders of magnitude) lower than the exposure even to the very limited cell phone use. For example, assuming 2 cm distance from the cellphone with SAR of 1 W/kg and WiFi client emitting 25 mW from 2 meters (200 cm) away, 24 hour exposure to this WiFi will equal approximately 25 seconds of cellphone use, even if we conservatively assume linear power fall-off with distance.

In view of the widespread use of Wi-Fi in schools, the UK Health Protection Agency (now part of Public Health England) has conducted the largest and most comprehensive measurement studies to assess exposures of children to radiofrequency electromagnetic fields from wireless computer networks (15). This agency concluded that radiofrequency exposures were well below recommended maximum levels and that there was "no reason why Wi-Fi should not continue to be used in schools and in other places" (16).

I am concerned about cellphone exposure. How can I lower it?

Exposure to the cellphone emissions can be reduced by

- Limiting your phone use time
- Texting instead of talking (not while you are driving, of course!)
- Using speakerphone, hands-free device or earpiece increases distance from the phone to the head and other parts of the body
- Choosing phone with lower SAR (but this may impair its ability to connect to the network)

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