International Agency for Research on Cancer

World Health Organization

IARC Monographs on the Identification of Carcinogenic Hazards to Humans

Report of the Advisory Group to Recommend Priorities for the *IARC Monographs* during 2020–2024

Non-ionizing radiation (radiofrequency) and extremely low-frequency magnetic fields

Radiofrequency electromagnetic fields (RF-EMF) were evaluated by the *IARC Monographs* as *possibly carcinogenic to humans* (Group 2B) (IARC, 2013e), on the basis of limited evidence of an increased risk of glioma. Extremely low-frequency magnetic fields (ELF-MF) were evaluated as *possibly carcinogenic to humans* (Group 2B) (IARC, 2002), on the basis of *limited evidence* of an increased risk of childhood leukaemia.

Exposure Data

Human exposures to RF-EMF can occur from use of personal devices (e.g. cell phones, cordless phones, and Bluetooth) and from environmental sources such as cell phone base stations, broadcast antennas, and medical applications. More than 5 billion people now have access to cell phone devices, and the technology is constantly evolving. Use has also expanded rapidly in low- and middle-income countries, where more than 75% of adults now report owning a cell phone; in high-income countries, the proportion is 96% (Pew Research Center, 2018).

Cancer in Humans

Since the previous *IARC Monographs* evaluation, several new epidemiological studies have been published on the association between RF-EMF and cancer, although the evidence remains mixed. In the Million Women Study cohort, there was no evidence of increased risk of glioma or meningioma, even among long-term users. There was an increased risk of acoustic neuromas with long-term use and a significant dose–response relationship (Benson et al., 2013). Updated follow-up in the Danish nationwide subscribers study did not find increased risks of glioma, meningioma, or vestibular schwannoma, even among those with subscriptions of 10 years or longer (Frei et al., 2011; Schüz et al., 2011). New reports from case–control studies that assessed long-term use also found mixed results; for example, increased risks of glioma and acoustic neuroma were reported by Hardell & Carlberg (2015) and Hardell et al. (2013), but no evidence of increased risks for these tumours were reported by Yoon et al. (2015) and Pettersson et al. (2014). Röösli et al. (2019) recently reviewed these new data. Several large-scale studies are still in progress and should report results within the next few years. Mobi-Kids is a multicentre case–control study of brain tumours in those aged 10–24 years. Cohort Study of Mobile Phone Use and Health (COSMOS) is a new European cohort of adult cell phone users. There will also be updated results from the Million Women Study.

Cancer in Experimental Animals

New data in experimental animals for exposure to RF-EMF have been published since the previous *IARC Monographs* evaluation. The large study by the United States National Toxicology Program found an increased risk of malignant schwannomas of the heart in male rats with high exposure to radiofrequency radiation at frequencies used by cell phones, as well as possible increased risks of certain types of tumours in

the brain and adrenal glands, but no increased risks in mice or female rats (NTP, 2018a, b). Another study in experimental animals also found an increase in schwannomas of the heart in highly exposed male rats and a possible increase in gliomas in female rats (Falcioni et al., 2018).

Mechanistic Evidence

The previous IARC evaluation concluded that there was weak evidence that radiofrequency radiation was genotoxic but that there was no evidence for mutagenicity (IARC, 2013e). Although there have been many new publications from a wide variety of experiments, uncertainty remains about the mechanisms, and there are few systematic reviews of the new data (Kocaman et al., 2018).

Although a future evaluation could be broadened to consider exposure to all non-ionizing radiation (including ELF-MF), ELF-MF were evaluated by IARC as *possibly carcinogenic to humans* (Group 2B), and the Advisory Group did not recommend an update, because of a lack of new informative epidemiological findings, no toxicological evidence, and little supporting mechanistic evidence.

Key References

The following key references were also identified: Coureau et al. (2014); Carlberg & Hardell (2015); Pedersen et al. (2017).

Recommendation for non-ionizing radiation (radiofrequency): High priority (and ready for evaluation within 5 years)

Recommendation for extremely low-frequency magnetic fields: No evaluation

Nuclear industry work

Different types of ionizing radiation have been evaluated repeatedly by the *IARC Monographs* programme (IARC, 2000b, 2012f), and all types have been classified as *carcinogenic to humans* (Group 1); overall evaluations are based on different evidence streams, often including *sufficient evidence* in humans for several cancer sites. New research in recent years has confirmed increased risks per unit of exposure to ionizing radiation for cancer sites and groups of cancer sites that have already been linked with ionizing radiation. No specific evaluation has been made in respect of work in the nuclear industry, which represents a specific exposure condition for agents already classified as *carcinogenic to humans* (Group 1).

Key References

The following key references were identified: Lee et al. (2015c); Leuraud et al. (2015); Richardson et al. (2015); Schubauer-Berigan et al. (2015); Grellier et al. (2017).

Recommendation: No evaluation