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Correspondence

Exposure to radiofrequency electromagnetic fields and risk of cancer: Epidemiology is not enough!☆

Dear Editor,

The spread of radiofrequency electromagnetic fields (RF-EMF) is rising and health effects are still under investigation, with controversial evidence. This scenario generates public concerns, risk of misinformation and a relevant challenge for stakeholders involved in public health and for institutions responsible for regulating and monitoring possible health effects deriving from RF-EMF exposure.

A paper by Karipidis et al (Karipidis et al., 2024), recently published in *Environment International*, was aimed to explore if evidence provided by selected epidemiological studies are strength enough to support a possible causal association between the environmental exposure to radiofrequency electromagnetic fields (RF-EMF) and the risk of cancer. Authors concluded that they "did not observe an adverse effect of the exposure on the investigated outcomes, neither overall, nor among long term".

These reassuring conclusions, however, are based on epidemiological studies with a strength of evidence only ranging, according to authors, from low to moderate. Limitations are mainly due to possible selection biases, to sub-optimal assessment of individual exposure and/or to missing adjustment for individual confounders. According to authors, in particular, "residual confounding may not be a major issue because, except ionizing radiation, no strong risk factors for the investigated neoplasms are known". This assumption can generate a significant underestimation of available epidemiologic findings, since previous systematic reviews and meta-analyses documented how the risk for glioblastoma can be affected by factors as high body mass index, alcohol consumption (Yoshikawa et al., 2023) and dietary habits (Zhang et al., 2022). Similarly, the risk for acoustic neuroma has been linked with noise exposure (Abbasi et al., 2023). Thus, besides a precise evaluation of individual exposure, the role of individual confounders and, as a consequence, possible selection biases in case-control studies still remain a critical issue. This issue should not be underestimated in future analyses.

The authors considered a much larger dataset that that previously examined by the WHO International Agency for Research on Cancer (IARC) to classify, in the year 2011, RF-EMF as "possibly carcinogenic to humans" (Group 2B). However, at variance with the analysis from IARC, a comprehensive discussion at least mentioning previous evidence derived from animal and experimental studies is completely lacking. Although a translational analysis was not the aim of the study from Karipidis et al, possible implications in terms of practice and policy should adequately counterbalance the evident limitations in epidemiological studies with results deriving from experimental and animal studies.

Of note, subsequent to the IARC evaluation, experimental studies (Falcioni et al., 2018; Lerchl et al., 2015; NTP, 2018) strengthened the evidence underlying a causal relationship between exposure to high-frequency electromagnetic fields and the onset of cancer. Excluding the results of studies on animal carcinogenicity from the discussion on a health topic of primary social and regulatory relevance, as that of RF-EMF exposure, offers a very partial scenario and generates uncertainty. This approach reinforces the anti-ethical belief that epidemiological assessments simply based on the "count" of cancer cases in humans (even if approximate and conditioned by a number of possible confounders) would be a privileged way to demonstrate the carcinogenicity (or the lack of carcinogenicity) of widely diffused, potentially harmful environmental agents. This is an extremely dangerous assumption, as it is equivalent to accept that potentially detrimental effects can only be determined *a posteriori*, after the considered agent has had time to damage public health.

Another critical point is that, as also stated by authors, participants in the majority of the reviewed studies were mainly exposed to 1G-2G networks. Mobile phones using 3G-4G technology have substantially lower average output power. However, the introduction of smartphones and, more recently, the wide implementation of the 5G network changed, in the last years, the features of micro-environmental personal exposures to RF-EMF.

The "old" risks deriving from 1G-4G mobile phones are rapidly being added to those deriving from 5G technology and IoT ("Internet of Things"), with a number of scientific (Di Ciaula, 2018), monitoring (Korkmaz et al., 2024) and regulatory uncertainties. In last years, the trend of total individual exposure increased, mainly in terms of mobile downlink and in dense urban areas (Bhatt et al., 2024; Urbinello et al., 2014). In this scenario, possible short- and long-term health effects still need to be adequately determined, not only in terms of risk of cancer and, in particular, for exposure starting during childhood.

In this respect, although the only evidence that clearly emerges from the analysis of Karipidis et al is the lack of certainty about the relationship between exposure to RF-EMF and cancer, no effort has been made to propose how to use such uncertainties for primary prevention purposes, in particular in terms of public health policies and regulations.

A reasonable statement should be that of resorting to caution in the use of RF-EMF, at least until further and more solid epidemiological evidence became available, especially in the case of non-thermal effects and in more vulnerable subjects as children.

☆ **Letter to Editor regarding** "The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A systematic review of human observational studies – Part I: Most researched outcomes", published in. Environ Int. 2024;191:108983.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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Agostino Di Ciaula[a,b,*], Maria Grazia Petronio[b], Fausto Bersani[b], Fiorella Belpoggi[b]

[a] *Clinica Medica "A. Murri", AOUC Policlinico Bari - Department of Preventive and Regenerative Medicine and Ionian Area (DiMePrev-J), University of Bari Aldo Moro, Bari, Italy*

[b] *International Society of Doctors for Environment (ISDE), Arezzo, Italy*

[*] Corresponding author at: Clinica Medica "Augusto Murri" – AOUC Policlinico, Department of Precision and Regenerative Medicine and Ionian Area (DiMePre-J), Piazza Giulio Cesare 11, 70124 Bari, Italy.
E-mail address: agodiciaula@gmail.com (A. Di Ciaula).

Handling Editor: Paul Whaley