Journal of Environmental and Occupational Science
www.jenvos.com
DOI: 10.5455/jeos.20170609094703

Letter to the Editor

Mobile phones: Carcinogenic and other potential risks

Dear Editor,

The article by Lee *at al.* [1] contains no direct statements on the harm from radio-frequency electromagnetic fields (RF-EMF). However, certain phrases may create an impression that the harm is probable, e.g., "Extensive use of mobile phones, even among children, has incited public concern regarding the possible negative effects on human health resulting from exposure to the RF-EMF radiation emitted by such devices" or in the conclusion section: "The issue of whether children are more sensitive to RF-EMF emitted from mobile phones has been a hot topic among many researchers over the past two decades [1]." These statements can be understood so as if "sensitivity" or "negative effects" would have been known facts. It should be commented that there is no consistent evidence that RF-EMF enhances cancer risk. The only recognized biological effect is heating, which for cell phones are negligible [2,3]. According to the International Agency for Research on Cancer (IARC), there is limited evidence for the carcinogenicity of RF-EMF, although there was a minority opinion in the IARC that the evidence in humans is inadequate [4,5]. Indeed, several epidemiological studies reported associations between RF-EMF and glioma, acoustic neuroma and other tumors [6-17]. Other studies did not confirm such associations [18-21] or even identified a reduced risk of brain tumors among mobile phone users (which the authors identified as probably due to selection bias and thus did not report a protective effect), although odds ratios for glioma tended to be greater in subjects who reported usual phone use on the same side of the head as their tumor than on the opposite side [18,20]. However, the ipsilateral effect found in low exposure groups suggested that cases might have over-reported the use on the side of the tumor [18]. According to the Scientific Committee on Emerging Newly Identified Health Risks, the epidemiological studies on mobile phone RF-EMF exposure do not show an overall increased risk of brain tumors [22]. A considerable number of well-performed *in vivo* studies have been negative [22]. Numerous *in vitro* studies have been negative as well, whereas the more research quality criteria were satisfied, the less cellular responses were observed [23]. Furthermore, a publication bias has been noticed, i.e. preferred publication of positive results [22]. The existing data were found to be not sufficiently strong to suggest that RF-EMF is directly genotoxic, while some of the reported "adverse effects" may be attributed to hyperthermia [4]. Biases are known to occur in the epidemiologic research (dose-dependent self-selection, recall bias, etc.,), for ionizing radiation discussed in Jargin's study [24]. To confirm a cause-effect relationship, verification by reliable methods and understanding of the mode of action are needed [25]. No experimental findings can provide an explanation for supposed carcinogenicity of RF-EMF, thus no established biological or biophysical mechanisms of action exist so far [3,23,26]. Large-scale animal experiments could provide more information, for example, this study being conducted by the National Toxicology Program in the US.

Reported risks are from anthropogenic RF-EMF of non-thermal intensity. At the same time, ultra high frequency (UHF)-therapy of thermal intensity (diathermy) has been widely used and officially recommended in the former Soviet Union for the treatment of tonsillitis and rhinosinusitis in children and adults since the early 1960s [27,28]. The extremely high-frequency fields have also been used for respiratory and allergic conditions in children, where absence of contraindications was pointed out [29]. Associations with cancer have never been reported, although overexposure of tissues such as eye lenses and brain can occur in patients receiving shortwave diathermy if certain output power levels are exceeded [22,30]. Considering anatomical proximity of tonsils and neural structures especially in children, there have been concerns about such use of microwaves. A singular case of behavioral changes, transitory strabismus and slight but persistent dysphagia in a child, started at the time of the UHF-therapy for allergic rhinitis and tonsillitis at the age of 4-6 years, is known [31]. Experiments with large animals, e.g., calves imitating UHF-therapy might be helpful to clarify the matter, including the imprecise focusing and excessive exposures that may occur in the therapeutic practice. A search for brain damage using magnetic resonance imaging might be helpful in this connection. Admittedly, the UHF-therapy (several procedures pro course 10-15 min each) can be regarded as an acute exposure, while accumulated doses (absorbed energy) in mobile phone users or people residing near RF-EMF emitters may be higher. However, in view of the lack of verification of any proposed non-thermal interaction mechanism, established knowledge does not suggest RF-EMF effects accumulating with time [22]. In particular, no correlations between exposure duration and cellular responses *in vitro* were found [23]. People using mobile phones the longest (>10 years) and accumulating the highest lifetime call hours might be expected to have the highest risk. This has been demonstrated neither for glioma nor for meningioma [18]. However, in other studies, the risk of glioma increased with increasing time since the first mobile phone use or with increasing cumulative call time [8,10,11]. Considering potential biases in epidemiological research, cumulative effects should be verified in experiments.

If carcinogenic effects of RF-EMF from mobile phones were substantial, corresponding incidence rates would have been higher especially in more developed countries. No such data

are known, in particular, for glioma, whose incidence in the U.S. remained stable over the period 1992-2008 in spite of the tremendous increase in the mobile phone use [32,33]. Admittedly, there has been a different interpretation of statistics [8]. Other factors, such as an improved access to care, may have played a role [33]. It should be mentioned that modeled expected incidence rates based on the associations reported in [6,18] for heavy cell phone users were shown to be higher than the observed rates [32,34-36]. According to the IARC, there has been no substantial increase in brain tumor incidence rates since the advent of the mobile phone era [4]. The trend in the accumulating evidence is interpreted to be increasingly against the hypothesis that mobile phones cause brain tumors [26].

Influence is not the same as harm. RF-EMF may influence neural functions, where moving electrical charges participate. Transient effects on the brain function or retinal phosphenes are not considered to be adverse health effects, although they can be disturbing in some occupational settings and should generally be avoided [37]. There have been numerous reports from Russia (some of them could not be reproduced [38,39] on the influence of RF-EMF on neural and some other functions [40,41]. Safety regulations, stricter in Russia than in the U.S., are partly based on such reports. Note that RF-EMF is a component of the natural environment fluctuating with the solar activity [42]; they might influence living organisms like the weather does, not necessarily causing harm. In the electromagnetic spectrum, structural damage on the molecular or other levels per unit of absorbed energy tends to increase with the decreasing wavelength, which is evident not only for ultraviolet and ionizing radiation but also for the infrared and visible light absorbed in superficial tissue layers causing burns [43] at energies that would be harmless for RF-EMF heating the tissues more evenly. Accordingly, there are no prima facie reasons to expect more damage from RF-EMF than from infrared radiation, which is ubiquitous and harmless up to the thermal damage. As mentioned above, the only proven interaction mechanism within the frequencies and magnitudes relevant to mobile telecommunications is a thermal effect [2,3,44]. On the contrary to ionizing radiation, humans are protected from hyperthermia by the thermoreception. Apart from electromagnetic waves, a body can be heated by thermal conduction, e.g., from hot air or water. Absorbed energy being equal, a hot bath can theoretically cause more structural damage (if any) than a nearby radio transmitter: The heating by conduction means intensification of thermal or Brownian motion of all molecules including potentially vulnerable nucleic acids and proteins. On the contrary, the absorption of RF-EMF energy generates currents transferred into the motion primarily of charged particles and dipoles such as ions and water molecules [4,45]. However, there is no evidence in favor of molecular or other structural damage due to the heating by thermal conduction, infrared or radio-frequency radiation, in the absence of thermal damage. The topic needs more attention from physicists.

In conclusion, there is neither compelling evidence nor theoretic considerations that RF-EMF is more carcinogenic than infrared radiation, which is ubiquitous and harmless up to the thermal damage. If in doubt, it can be tested in large-scale animal experiments under controlled exposure conditions to exclude biases and conflicts of interest. The accurate control of the exposure and experimental procedures is crucial [23]. As for the regulations, strictly observed realistic safety norms are more helpful for the public health than excessive restrictions that would be disregarded.

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Received: May 13, 2017
Accepted: May 31, 2017
Published: July 01, 2017

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Source of Support: Nil, Conflict of Interest: None declared.