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**Establishing the health risks of exposure to radiofrequency fields requires multidisciplinary research**

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## *Establishing the health risks of exposure to radiofrequency fields requires multidisciplinary research*

As a result of the worldwide expansion of the use of mobile telephones, radiofrequency (RF) field exposure has become ubiquitous, and the possible adverse effects of the fields emitted by cellular phones on the brain and nervous system have aroused considerable interest among both the scientific community and the general public. Accordingly, several international authorities have realized the necessity of expanding resources for RF radiation research in order to identify the gaps in scientific knowledge. For example, the World Health Organization (WHO) acknowledges that electromagnetic fields (EMF) represent one of the fastest growing environmental factors, spreading anxiety and speculation also among the working population. In order to provide independent scientific assessments of health effects from exposure to EMF, WHO launched the International EMF Project, which aims to form an umbrella for worldwide research coordination. To that end, WHO very recently published a comprehensive research agenda for RF fields to be used as a guide for studies that would have high value for RF health risk assessments.

Despite numerous studies carried out in a large number of research fields, such as epidemiology, cellular biology and toxicology, the picture of potential effects of low exposures on human health is far from distinct. Thermal effects caused by RF exposure are obvious and basically understood, whereas the principal scientific challenge is to reveal and understand the suspected or hypothesized nonthermal effects. Since the RF power emitted by cellular phones is too low to cause significant warming of absorbing tissues, the mechanism of temperature rise is unlikely to explain the alleged adverse health effects.

On the basis of comprehensive reviews of the available scientific literature, the International Commission on Non-ionizing Radiation Protection (ICNIRP) has issued guidelines on limits of exposure to time-varying EMF in the frequency range of up to 300 GHz (1). The system of protection developed by the ICNIRP aims at protecting against established the health effects of EMF (ie, effects indicated by high-quality, consistent, and reproducible research). All the effects that have been established so far by very extensive research are acute in their nature and only occur above given thresholds of exposure. In principle, however, various groups of the population may have differences in their ability to tolerate exposure to EMF. For instance, some persons in various countries claim to experience unpleasant feelings during or after exposure to RF fields. Typical subjective sensations and symptoms are described as headache, dizziness, fatigue, and nausea. Evidence to support these hypotheses has been sparse and never successfully replicated (2, 3).

In recent years, large resources have been dedicated to multinational large-scale epidemiologic studies (eg, the Interphone Study) that have focused on the association between exposure to RF fields emitted by mobile phones and the development of brain cancer or other forms of cancer. In this issue of the *Scandinavian Journal of Work, Environment & Health*, Lahkola et al (4) presents a meta-analysis of recent epidemiologic investigations on human exposure to mobile phone frequencies. While the epidemiologic evidence does not give consistent results that would indicate a causal role for RF exposure with respect to brain cancers, it does not establish the absence of any hazard either (5). The main limitation of previous studies is that none of them provide reliable information on individual levels of exposure, and hence expert assessments of RF exposure should be included in future epidemiologic investigations.

Similarly, significant research needs have been identified in the area of noncancer health effects on humans. Various immediate effects due to RF exposure have been observed in studies on cognitive

function and sleep physiology. They have been related to subtle changes regarding memory and reaction speed and an increase in the alpha power of sleep electroencephalography (EEG), suggesting an influence of RF fields on brain activity under certain circumstances (6, 7). However, when the studies have been replicated, most of the earlier findings have not been confirmed (8, 9). In addition, most human studies have examined healthy, young adults, a group not necessarily representing the most susceptible part of the population in terms of possible adverse effects. While no clear conclusions on the impact on human health can be drawn at present, future studies should cover a wide array of experiments focused on EEG activity, sleep physiology, cognition and performance, mood disturbances, hormone levels, and immune function.

The issue of whether children are especially sensitive to exposure to RF fields from mobile phones has also been brought to the forefront of the RF research agenda, based on the recommendations of the Independent Expert Group on Mobile Phones of the United Kingdom (10). According to the Group's report, children should avoid using cellular phones since they are being exposed to RF radiation from mobile phones from a younger age than adults. The report also states that "children will have a longer time in which to accumulate RF exposure over the course of their lives, and a longer time for any delayed effects of exposure to develop [p 117]." On the other hand, there is no convincing scientific data to indicate differences in the absorption of RF energy in the heads of children and adults, nor is it likely that the RF sensitivity of children's heads changes significantly after the first few years of life. Hence, in contrast to the scientific evidence-based conclusions with respect to adults, the aforementioned approach applied to children is based only on a precautionary principle.

Finally, to emphasize the importance of the multidisciplinary efforts in the area of RF biomedical research, interesting and worth mentioning is the recently published Global Risks Report 2006, which summarizes by stating that EMF risks that are associated with an increasing number of electronic devices, such as mobile phones, need to be clarified and better managed (11). The report concluded that "if it were to transpire that EMF had widespread harmful health effects at relatively low exposure levels, this would have huge societal and economic impacts, and may develop into the headline risks of tomorrow [p 5]".

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