EMF & CANCER: EPIDEMIOLOGIC EVIDENCE TO DATE

Dr Leeka I Kheifets
World Health Organization
Tel: +41 22 791 49 76, Fax: +41 22 791 4 1 23, Email: kheifetsl@who.int

✍✍ Abstract

The results of many years of epidemiologic studies concentrating on the possible health risks (particularly cancer risks) associated with exposure to electric and magnetic fields (EMF) have been equivocal. While some studies suggest that EMF could pose a health risk, the risk estimates are low, and their confidence intervals often include no effect. However, if real, even a small risk of a prevalent exposure could have major public health implications. In June 2001, an expert scientific working group of IARC reviewed studies related to the carcinogenicity of static and ELF electric and magnetic fields. Using the standard IARC classification that weighs human, animal and laboratory evidence, ELF magnetic fields were classified as possibly carcinogenic to humans based on epidemiological studies of childhood leukaemia. Evidence for all other cancers in children and adults, as well as other types of exposures (i.e. static fields and ELF electric fields) was considered not classifiable either due to insufficient or inconsistent scientific information.

Although there have been more than 200 epidemiologic studies in this area, many early studies of EMF were too limited in design and scope to do more than generate hypotheses. The number of epidemiologic studies with the methodologic wherewithal to test hypotheses is growing. Among the improvements in this new generation of studies are: *a priori* specification of hypotheses -- to better distinguish between chance occurrence and real association; examination of specific cancers, which should allow for the identification of agents specific to the etiology of a particular cancer; larger numbers of subjects to improve the precision of risk estimates; improved exposure assessment to reduce misclassification of exposure; and evaluation of a variety of potential confounders to minimize the possibility of a spurious association.

Unfortunately, the improvements in study quality have not led to a concomitant improvement in the clarity of our picture of the relationship between EMF and cancer risk. The discussion will include comments on what we have learned and why studying EMF exposure poses unique and substantial difficulties.

✍✍ Introduction

Electricity use has grown throughout the industrialized world since the first public power station began operation in London on 12 January 1882. Electricity is generated and usually transmitted as alternating current (ac) in North America at 60 or 60 Hertz (Hz) cycles per second. In the past, exposures to ambient EMF have been thought to be without biologic effects. The first suggestion that exposures might be detrimental to one's health arose from Soviet Union studies in the early 1960's (5). Since 1979 when epidemiological studies first raised a concern about exposures to power line frequency magnetic fields and childhood leukaemia, a large number of studies have been conducted to determine if measured ELF exposure can influence cancer development, especially in children.

Concern also continues about exposure to radiofrequency (RF) fields from sources used for mobile telecommunications, radars, radio and television broadcast, medical and industrial applications. Much of this concern arises because new technologies are introduced without provision of public information about their nature or discussion of the debate within the scientific community about possible health consequences. In the meantime, mobile phone use has increased dramatically with falling costs. Industry sources suggest that there will be over one billion users worldwide by 2005, far exceeding telephone use via fixed-lines.

Of particular concern to WHO is the fact that, if any adverse health effect is established from mobile phone use or use of electricity, it will be a global concern because developing countries are establishing this technology in preference to the more-expensive fixed line systems and the use of electricity is ubiquitous. Thus even a small impact on health could have a major public health consequence.

The health effects that have received the most attention are cancer, reproductive effects and neurobehavioral effects. The evidence linking cancer to EMF exposure is discussed below

✍✍ Long-term health effects of ELF

ELF fields are known to interact with tissues by inducing electric fields and currents in them. This is the only established mechanism of action of these fields. However, the electric currents induced by ELF fields commonly found in our environment are normally much lower than the strongest electric currents naturally occurring in the body such as those that control the beating of the heart.

There is no convincing evidence that exposure to ELF fields below currently accepted international exposure limits causes direct damage to biological molecules, including DNA. Since it seems unlikely that ELF fields

could initiate cancer, a large number of investigations have been conducted to determine if ELF exposure can influence cancer promotion or co-promotion. Results from animal studies used in the health risk assessments have been mostly negative.

However, two recent pooled analyses of epidemiological studies provide insight into the epidemiological evidence on childhood leukemia. These studies suggest that, in a population exposed to average magnetic fields in excess of 0.3 to 0.4 µT, twice as many children might develop leukaemia compared to a population with lower exposures. In spite of the large number data base, some uncertainty remains as to whether magnetic field exposure or some other factor(s) might have accounted for the increased leukaemia incidence.

Childhood leukaemia is a rare disease. Approximately, 4 out of 100,000 children between the age of 0 to 14 are diagnosed with childhood leukaemia every year. In addition, average magnetic field exposures above 0.3 or 0.4 µT in residences are rare.

Other studies of residential exposure from EMF are largely negative thus far, for a detailed review of residential studies, see Kheifets, 1997.

Over 80 occupational studies have examined magnetic fields as a potential risk factor for a variety of cancers. A few of these studies also considered electric fields as a risk factor, and one investigated the combination of electric and magnetic fields appearing together. These studies have varied widely in the design, types of study subjects, methods of exposure assessment, outcomes considered and quality.

Of the many cancers and exposures examined, a consistent small increase in the risk of leukemia and brain tumors in electrical workers is noted. Because of the large number of occupational studies of EMF and leukemia and brain cancers, specific study references which have been included in meta-analyses are omitted below. Please refer to Kheifets et al., 1995 and 1997 for a more detailed review of the literature.

The risks of leukemia associated with exposure to EMF are generally low; pooled analyses suggest an excess of all leukemias with a risk estimate of 1.18 (95 percent confidence interval (CI) 1.12-1.24) (11), with slightly higher risks for the various leukemia subtypes. Although most studies reported a small elevation in risk, the apparent lack of a clear pattern of exposure to EMF substantially detracts from the hypothesis that magnetic fields in the work environment are responsible for it. These findings were not sensitive to assumptions, influence of individual studies, weighting schemes, or modeling. Some evidence of publication bias was noted (12).

Similarly, there is a small but significant increase in brain cancer risk associated with estimates of potential workplace magnetic field exposure RR = 1.21 (CI 1.11-1.33) (13). While most studies reported a small elevation in risk, there was considerable heterogeneity in the results. The findings of this meta-analysis were not affected by inclusion of unpublished data, influence of individual studies, weighting schemes, or model specification.

Despite the large number of studies published, several endpoints have not been rigorously examined in a sufficient number of studies. As the methodology of studies improved, the estimates of risk have become lower, making it unlikely that a large risk is being missed. Nevertheless, a sufficient uncertainty remains as to the potential of EMF involvement in cancer etiology. Even a small risk associated with a ubiquitous exposure could have important public health consequences.

In June 2001, an expert scientific working group of IARC reviewed studies related to the carcinogenicity of static and ELF electric and magnetic fields. Using the standard IARC classification that weighs human, animal and laboratory evidence, ELF magnetic fields were classified as possibly carcinogenic to humans based on epidemiological studies of childhood leukaemia. Evidence for all other cancers in children and adults, as well as other types of exposures (i.e. static fields and ELF electric fields) was considered not classifiable either due to insufficient or inconsistent scientific information.

"Possibly carcinogenic to humans " is a classification used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals.

The IARC review addresses the issue of whether it is feasible that ELF-EMF pose a cancer risk. The next step in the process is to estimate the likelihood of cancers in the general population from the usual exposures and to evaluate evidence for other (non-cancer) diseases. This part of the risk assessment should be finished in the next 18 months.

Recent increased use of wireless communications has brought forth new concerns about biological effects of radiofrequency (RF) radiation. While it is well established that at higher power levels RF energy can produce deleterious effects, today's wireless communication systems employ a low power modulated form of RF radiation, the effects of which are still uncertain (Lin JC. Health effects of radiofrequency radiation from wireless communication technology, Advances in Electromagnetic Fields in Living Systems, vol. 2, 1997:129-164.)

In their review of cancer studies, the IEGMP (2000) concluded that: Some individual experimental studies have suggested that RF radiation can initiate tumour formation, enhance the effects of known carcinogens or promote the growth of transplanted tumours. However, in some of these the intensity was high enough to

produce thermal effects. The balance of evidence, from both in vitro and in vivo experiments, indicates that neither acute nor chronic exposure to RF fields increases mutation or chromosomal aberration frequencies when temperatures are maintained within physiological limits (UNEP/WHO/IRPA, 1993). This suggests that RF exposure is unlikely to act as a tumour initiator. Further, a variety of cancer studies using animals have sought evidence of an effect of RF exposure on spontaneous or natural cancer rates, the enhancement of the effects of known carcinogens or effects on the growth of implanted tumours. However, they have provided equivocal evidence for an effect on tumour incidence (ICNIRP, 1998; Repacholi, 1998; Moulder et al, 1999; Royal Society of Canada, 1999).

By far the greatest public concern has been that exposure to low-level RF fields may cause cancer. Of the epidemiological studies addressing possible links between RF exposure and excess risk of cancer, some positive findings were reported for leukaemia and brain tumours. Overall, the results are inconclusive and do not support the hypothesis that exposure to RF fields causes or influences cancer.

Review groups evaluating possible links between RF exposure and excess risk of cancer have concluded that there is no consistent evidence of a carcinogenic hazard. In some studies there are significant difficulties in assessing disease incidence with respect to RF exposure and with potential confounding factors such as ELF and chemical exposure. Overall the epidemiological studies suffer from inadequate assessment of exposure and insufficient latency, since mobile phones have not been in use for long enough to allow comprehensive epidemiological assessment of their impact on health. In addition, rapidly changing technology makes epidemiologic studies in this area particularly difficult.

✍✍ References

Ahlbom A, Day N, Feychting M, et al, A pooled analysis of magnetic fields and childhood leukaemia. Br J Cancer 83:692-8, 2000.

Greenland S, Sheppard AR, Kaune WT, et al, A pooled analysis of magnetic fields, wire codes, and childhood leukemia. Childhood Leukemia-EMF Study Group. Epidemiology 11:624-34, 2000.

Asanova T P, Rakov A I, The state of health of persons working in the electric field of outdoor 400 and 500 kV switchyards. Study in the USSR of medical effects of electric fields on electric power systems. 78 CH01020-7-PWR. New York: The Institute of Electrical and Electronics Engineers, 1978. {Gig Tr Prof Zabol 10:50-2 (in Russian)}.

Wertheimer N, Leeper E, Electrical wiring configurations and childhood cancer. Am J Epidemiol;109:273-84, 1979.

Kheifets L I, Kavet R, Sussman S S, Wire codes, magnetic fields, and childhood cancer. Bioelectromagnetics 18:99-110, 1997.

Kheifets L I, Afifi A A, Buffler P A, Zhang Z W, Occupational electric and magnetic field exposure and brain cancer: a meta-analysis. J Occup Environ Med 35:1327-41, 1995.

Kheifets L I, Afifi A A, Buffler P A, Zhang Z W, Matkin C C, Occupational electric and magnetic field exposure and leukemia: a meta-analysis. J Occup Environ Med 1997.

dimethylbenz[a]anthracene in rats. Bioelectromagnetics 14:131-43, 1993.

IEGMP, 2000, Mobile Phones and Health. Report of an Independent Expert Group on Mobile Phones established by the UK Minster of Public Health. Report available from the National Radiological Protection Board, Chilton, Didcot, Oxon OX11 0RQ, UK.