

## **ELF-EMF exposure and childhood leukemia**

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### **Introduction**

In 1996, the World Health Organization (WHO) established the International Electromagnetic Fields (EMF) Project to address the health issues associated with exposure to EMF. This Project is intended to provide independent scientific assessment of health effects from exposure to EMF (0-300 GHz); identify gaps in knowledge requiring further research in order to improve health risk assessments; encourage focused, high quality research; and conduct formal WHO/IARC/ICNIRP health risk assessments after key research has been completed. The International EMF Project is currently reviewing research results and conducting risk assessments of exposure to static and extremely low frequency (ELF) electric and magnetic fields. WHO will be conducting an evaluation of all health effects from ELF field exposure during 2002-3.

This paper summarizes what is known about ELF exposure on childhood leukaemia, what the IARC classification means and how some national authorities have responded. In addition, WHO recommendations are given to provide guidance to national authorities wanting to protect their populations against EMF exposure.

### **ELF Fields**

Whenever electricity is conducted through transmission lines, distribution lines or is used in appliances, both electric and magnetic fields exist close to the lines or appliances. The power frequency used is 50 or 60 Hz. Use of electric power has become part of everyday life. However, questions have been raised as to whether these and other ELF fields are carcinogenic or can produce any other effects on health.

Recent reviews of the scientific literature on possible health effects from exposure to electric and magnetic fields in the frequency range  $>0$  to 300 Hz have been completed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998), the National Institute of Environmental Health Sciences (NIEHS, 1998), WHO (Repacholi and Greenebaum, 1999), the National Radiological Protection Board (AGNIR, 2001), the Health Council of the Netherlands (2001) and the International Agency for Research on Cancer (IARC, 2002). All reviews concluded that there were no established adverse health consequences from exposure to ELF field levels below the limits in the ICNIRP (1998) guidelines. However, these reviews indicated that there was some consistency in the epidemiological studies on childhood leukaemia which suggested that there might be an increasing risk of disease in children exposed to mean magnetic fields above about 0.3 - 0.4  $\mu\text{T}$ .

### **IARC classification**

The International Agency for Research on Cancer (IARC) – a specialized cancer research agency of WHO – has recently concluded the first step in WHO's health risk assessment process by classifying ELF fields with respect to the strength-of-the-evidence that they could cause cancer in humans (<http://monographs.iarc.fr>). In June 2001, an expert scientific working group of IARC reviewed studies related to the carcinogenicity of static and ELF electric and magnetic fields. Two pooled analyses of epidemiological studies provide insight into the epidemiological evidence that played a pivotal role in the IARC

evaluation (IARC, 2002). These analyses suggested that, in a population exposed to average magnetic fields in excess of 0.3 to 0.4  $\mu$ T, twice as many children might develop leukaemia compared to a population with lower exposures.

It is useful to know what other agents have been classified by IARC as possibly carcinogenic to humans. These are shown in table 1 below. Within this table is given the basis for the classification. For example, to reach a classification of "carcinogenic to humans" there has to be strong evidence from epidemiological studies that the agent does indeed cause cancer in humans. This classification is strengthened when it is consistent with the evidence from animal and laboratory studies.

To reach a classification of "probably carcinogenic to humans", the scientific evidence would be weaker, where the animal evidence can be strong, but the human data is less convincing or lacking altogether. Finally for a classification of "possibly carcinogenic to humans" the human data should be considered credible, but for which other explanations could not be ruled out. In the case of ELF magnetic fields the human studies had a consistency when the data were combined, but selection bias could not be ruled out. In addition, neither the animal or laboratory studies supported the human data. This further strengthens that there may be another explanation for the association between exposure to ELF magnetic fields and childhood leukaemia.

Table 1 gives examples of common physical and chemical agents classified for their carcinogenicity in humans by the International Agency for Research on Cancer (IARC). For more examples refer to the IARC web site (See: <http://monographs.iarc.fr>).

<b>Classification</b>	<b>Examples of Agents</b>
<b>Carcinogenic to humans</b> (usually based on strong evidence of carcinogenicity in humans)	Asbestos Alcoholic beverages Benzene Mustard gas Radon gas Solar radiation Tobacco (smoked and smokeless) X-rays and Gamma radiation
<b>Probably carcinogenic to humans</b> (usually based on strong evidence of carcinogenicity in animals)	Creosotes Diesel engine exhaust Formaldehyde Polychlorinated biphenyls (PCBs)
<b>Possibly carcinogenic to humans</b> (usually based on evidence in humans which is considered credible, but for which other explanations could not be ruled out)	Coffee ELF magnetic fields Gasoline engine exhaust Glass wool Pickled vegetables Styrene

### **What other evidence exists for ELF fields causing cancer?**

There is no consistent evidence that exposure to ELF fields experienced in our living environment 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 conducted so far suggest that ELF fields do not initiate or promote cancer (IARC, 2002).

**If the epidemiological studies are correct: what is the disease burden?**

Childhood leukaemia is a rare disease with approximately 4 out of 100,000 children between the age of 0 to 14 diagnosed every year. Also average magnetic field exposures above 0.3 or 0.4  $\mu\text{T}$  in residences are rare. It can be estimated from the epidemiological study results that less than 1% of populations using 240 volt power supplies are exposed to these levels, although this may be higher in countries using 120 volt supplies.

To respond to this, it is reasonable to use data from the AGNIR (2001) review where the effect on incidence rates were calculated for England and Wales. According to the AGNIR (2001) report: "The nature of an association with increasing exposure is unclear, notably whether there is any such increase, and if there is, whether there may be a linear or quadratic relationship. This lack of clarity is augmented by the effect of regression dilution [an underestimate of the strength of the relationship] resulting from the absence of accurate exposure measurement at the relevant time before diagnosis. About 430 cases of leukaemia (all types) are registered each year in England and Wales in those aged under 15 years (1999 UK Office of National Statistics). The UK childhood cancer study (UKCCS) indicates that 0.4% of children are exposed to 0.4  $\mu\text{T}$  or more and, assuming a doubling of risk at this level some two cases would occur anyway and a further two cases annually might be attributable to electromagnetic field exposure. If regression dilution were concealing a relative risk of 1.5 for those exposed to between 0.2-0.4  $\mu\text{T}$ , then the annual number of attributable cases might be six or seven. These estimates assume that any excess risk is confined to a very small number of children exposed to high electromagnetic field levels. If there is a linear exposure-response effect, the attributable numbers could be somewhat larger."

Thus if the epidemiological studies are revealing a real risk, then the increased number of childhood leukaemia cases is about an extra 2 in each year for a country with a population and exposure similar to the size of England and Wales combined. It is notable that, in the experience of the UKCCS, less than half the children receiving exposures of 0.4  $\mu\text{T}$  or more did not live in proximity to power lines. These exposures were received from the electricity supply within the homes either from the way the power wiring was connected or from electric appliance use.

**National and international responses**

In response to increasing public concern over health effects from EMF exposure, several countries have established their own scientific reviews prior to the IARC evaluation. The US National Institute of Environmental Health Sciences (NIEHS, 1998) classified ELF magnetic fields as possibly carcinogenic to humans and recommended "passive regulatory action", described as continued information and education of the public and encouraging power utilities to voluntarily reduce exposure to people where possible.

In the United Kingdom, an Advisory Group on Non-Ionising Radiation (AGNIR, 2001) concluded that while the evidence is currently not strong enough to justify a firm conclusion that EMF fields cause leukaemia in children, the possibility remains that

intense and prolonged exposures to magnetic fields can increase the risk of leukaemia in children.

Following the classification by IARC, the ICNIRP issued a statement indicating that the evidence for ELF magnetic fields causing leukaemia in children is insufficiently strong to recommend any change to their guidelines (ICNIRP, 2001). Also following the IARC classification, an EC committee recommended continuing use of the ICNIRP guidelines (EC, 2001).

### **WHO response**

In response to the IARC classification, WHO issued a fact sheet (WHO, 2001). While the classification of ELF magnetic fields as possibly carcinogenic to humans has been made, it remains possible that there are other explanations for the observed association between exposure to ELF magnetic fields and childhood leukaemia. WHO therefore recommends a follow-up, focused research programme to provide more definitive information. Some of these studies are currently being undertaken and results are expected over the next 2-3 years. See ([www.who.int/peh-emf](http://www.who.int/peh-emf)).

### **References**

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