

> Low-frequency magnetic fields and cancer

*Assessment of scientific studies in the low dose range.
Status as of August 2008*

*Summary of the publication
«Niederfrequente Magnetfelder und Krebs»
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> Summary

In 2002, the International Agency for Research on Cancer (IARC) assessed low-frequency magnetic fields such as those that result from the production and use of electricity as “possibly carcinogenic to humans” (group 2B). In the graded evidence classification model of the IARC, it is the lowest level of assessment of a positive relationship, i.e. lower than “probably carcinogenic to humans” (group 2A) and much lower than “carcinogenic to humans” (group 1). This assessment was based on the findings of epidemiological studies, which indicated an approximately doubled risk of leukaemia for children exposed to average magnetic fields greater than 0.3 to 0.4 μT . Low-frequency magnetic fields were not classified higher in terms of carcinogenic potential because insufficient evidence of cancer induction or promotion has been obtained from laboratory tests on animals, and a biological mechanism that could explain a carcinogenic effect of these low-intensity magnetic fields has not been identified to date.

The exposure limit values specified in the Ordinance on Protection against Non-Ionising Radiation (ONIR) protect the population against scientifically established acute effects of strong electric and magnetic fields. For the public electricity supply, these are 5 kV/m for the electric field and 100 μT for the magnetic flux density. It is not yet clear whether there are other biological effects that occur at lower exposure and could be of relevance to human health or well-being. This includes the cited association with the risk of leukaemia. In view of this, installation limit values were also specified in the ONIR as a precautionary measure. These are intended to reduce the risk of suspected, but as yet not adequately established, effects of long-term exposure at low levels. For the public electricity supply, the installation limit value for the magnetic flux density is 1 μT at full load.

It is the responsibility of the Federal Office for the Environment (FOEN) to monitor the progress of scientific research in this area, and to submit to the Federal Council modifications of the exposure limit values specified in the ONIR, if new established findings indicate that this is necessary. This report presents and assesses the current status of research on the association between weak low-frequency magnetic fields and cancer risk. In order to assess health risks, studies on humans, as well as laboratory tests on animals and cell cultures have to be taken into account. On the one hand, the report provides information as to whether new scientifically established and recognised findings exist that would result in the need to amend the exposure limit values, and on the other hand it uses a graded evidence classification model to identify and qualitatively evaluate potential effects.

The starting point of this report is the monograph published by the World Health Organisation (WHO) in 2007 entitled “Extremely Low Frequency Fields”, which includes scientific studies conducted on humans, animals and cells up to 2005. In view of those findings, the WHO confirmed the classification of low-frequency magnetic

fields as “possibly carcinogenic to humans”. Since the publication of the above WHO monograph, a variety of studies on humans, animals and cells have been completed, which form the main focus of this report. The overall assessment addresses the question whether the status of scientific knowledge as of August 2008 is still compatible with the conclusions drawn by the WHO.

The studies conducted on human beings were summarised and evaluated by the ELMAR documentation centre of the Institute of Social and Preventive Medicine at the Swiss Tropical Institute in Basel. Please refer to the ELMAR database (which is available for public access) for further details relating to these studies (www.elmar.unibas.ch/index.html). The results of the experiments on animals and cells were collected and evaluated by the Department of Biomedicine at the University of Basel.

The procedure used for evaluation essentially corresponds to that used by the International Agency for Research on Cancer (IARC). The evidence pointing to the carcinogenicity of a substance, an agent or exposure is classified in accordance with a standardised evaluation method comprising several steps. Initially the results of studies on humans and animals are evaluated separately. For each outcome, the evidence for a causal relationship is assessed. A 4-level scale is used for this purpose. Different allocation criteria apply depending on the type of study, and the number of existing studies is also taken into account. For epidemiological studies on humans, for example, the criteria of the IARC are as follows:

- > **Sufficient evidence:** A positive relationship has been observed in studies in which chance, bias and confounding could be ruled out with reasonable confidence. For humans, a causal relationship between exposure and cancer is regarded as established.
- > **Limited evidence:** A causal interpretation of the observed association is credible, but chance, bias or confounding could not be ruled out with reasonable confidence.
- > **Inadequate evidence:** The available studies are of insufficient quality, consistency or statistical power to permit a conclusion regarding the presence or absence of a causal association, or no data on cancer in humans are available.
- > **Evidence suggesting lack of carcinogenicity:** There are several adequate studies covering the full range of levels of exposure that human beings are known to encounter, which are mutually consistent in not showing a positive association between exposure and cancer at all exposure levels. A conclusion of “evidence suggesting lack of carcinogenicity” is inevitably limited to the cancer sites, exposure conditions and length of observation covered by the available studies. In addition, the possibility of a very small risk at the levels of exposure studied can never be excluded.

The same evidence classifications (sufficient, limited, insufficient, lack) are also used for experiments on animals and cells, with modified criteria.

In its concluding overall assessment, the IARC combines the evidence from studies on humans and animals, and also includes the results obtained from cell experiments. Its

overall assessment results in allocating the involved substance or physical exposure to one of five categories of carcinogenicity to humans:

- > Group 1: Carcinogenic to humans
- > Group 2A: Probably carcinogenic to humans
- > Group 2B: Possibly carcinogenic to humans
- > Group 3: Not classifiable as to its carcinogenicity to humans
- > Group 4: Probably not carcinogenic to humans

Evaluation of studies on humans as of the end of August 2008:

A causal relationship with exposure to low-frequency magnetic fields has not been established for any of the studied cancerous diseases. Sufficient evidence

In line with the majority of earlier studies on leukaemia in children, in the new epidemiological studies carried out up to August 2008 occurrences of leukaemia were also observed more frequently among children exposed to residential magnetic fields greater than 0.3 to 0.4 μT (long-term average). Although the number of highly exposed children in the studies was low and some uncertainties exist with respect to classification of exposure, a causal relationship cannot be ruled out, and according to the IARC criteria this is classified as limited evidence. Limited evidence

With respect to leukaemia in children in association with other forms of magnetic field exposure originating from prenatal exposure, incubators and use of electrical appliances, the existing data are insufficient for drawing any conclusions for or against an increased risk. Insufficient evidence

As far as the risk of brain tumours in children is concerned, signs of a similar increase in risk associated with exposure to residential magnetic fields greater than 0.3 to 0.4 μT to that for leukaemia were observed, but the statistical uncertainty is considerably greater here due to the smaller number of cases. The evidence for an association is therefore currently classified as insufficient. The same applies with respect to other cancerous diseases in childhood.

From the results of the existing studies it cannot be determined whether the cancer risk is higher for adults exposed to magnetic fields at work. In its report (WHO 2007) the World Health Organisation considered a causal relationship for breast cancer as improbable. In view of the only very low number of existing studies, the difficulty of determining exposure levels and the inconsistent findings of more recent studies, this assessment appears to be somewhat premature. Thus in deviation from the WHO report, the evidence for breast cancer, too, has to be regarded as insufficient.

Evaluation of studies on animals and cells as of the end of August 2008

The findings obtained from studies on animals and cells do not yield sufficient evidence pointing to a relationship between exposure to low-frequency magnetic fields Sufficient evidence

and the induction or promotion of cancer or the occurrence of cancer-relevant cellular modifications.

By contrast, limited evidence has been obtained from cell studies for an increase in the genotoxic effect of certain chemical or physical mutagens by low-frequency magnetic fields, as well as for an influence on growth control in tumour cells.

Limited evidence

Some studies on animals indicate a promoting effect of a low-frequency magnetic field on chemically or physically induced tumours. But since these findings are isolated and no such effects were observed in the majority of earlier studies, the evidence has to be classified as insufficient.

Insufficient evidence

In cell studies, indications of a weak genotoxic/mutagenic effect of magnetic field exposure are increasing in certain cell types. But as in the past, the degree of replicability of these effects – and in particular DNA strand breaks – is not sufficient to permit a conclusive assessment, and the evidence for a genotoxic or mutagenic effect has to be classified as insufficient. The same applies to the influencing of growth control in healthy cells and to the deregulation of genes.

To date, studies on animals have not yielded any indications that a magnetic field can induce tumours.

Evidence suggesting lack of carcinogenicity

Overall assessment as of the end of August 2008

Although a variety of new studies have been carried out since the publication of the report by the World Health Organisation (WHO 2007), the overall picture has not changed. The most prominent finding from epidemiological studies on humans concerns limited evidence for an increased leukaemia risk among children due to magnetic fields from the power supply.

Studies on animals have yielded evidence that magnetic fields do not induce tumours, and insufficient evidence for the promotion of chemically or physically induced tumours. Limited evidence has been obtained from cell studies for an increase in the genotoxic effect of certain chemical or physical mutagens, and for the influencing of growth control in tumour cells. It has not yet been ascertained whether these cellular end points actually play a part in the formation and growth of tumours. For all other outcomes examined in cell studies, the evidence for effects caused by magnetic fields is insufficient.

Thus in view of the published findings up to the end of August 2008, the classification of low-frequency magnetic fields as “possibly carcinogenic to humans” (group 2B) by the IARC (IARC 2000) and the WHO (WHO 2007) is confirmed. This classification indicates a suspicion, but it does not substantiate carcinogenicity. Only a very small percentage of the population is exposed over lengthy periods to potentially harmful magnetic fields greater than 0.3 to 0.4 μT (cf. WHO 2007).

The scientific studies assessed in this report do not (either individually or collectively) provide a sufficient basis for adjusting the exposure limit values specified in the ONIR. However, since it is not possible to definitely judge whether these limits also offer sufficient protection against long-term harm, it is advisable to maintain the precautionary approach with regard to low-frequency magnetic fields.