

HEALTH EFFECTS FROM POWER FREQUENCY ELECTRIC AND MAGNETIC FIELDS: RECENT FINDINGS

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Abstract: *This paper summarises the findings of a recent review conducted by the National Institute of Environmental Health Sciences on the possible health effects of power frequency electric and magnetic fields (EMF). The review group suggested that EMF should be regarded as a 'possible carcinogen'. The paper further places this finding in perspective with similar and other classifications of carcinogens and stresses the importance of communicating these perspectives to the lay person.*

Keywords: Electric, Magnetic, Field, EMF, and Health, Review

1. BACKGROUND

Much debate was centred around possible health effects of power frequency electric and magnetic fields (EMF) over the past three decades. The National Institute of Environmental Health Sciences (NIEHS) was charged in 1992 by the US Congress to prepare and submit *an evaluation of the potential human health effects from exposure to extremely low frequency (ELF) EMF*. This work was carried out under the (US\$60 million, 5 year) EMF Risk Assessment and Public Information Dissemination (RAPID) Programme funded by the US Department of Energy that came to an end in 1997/8¹.

2. EVALUATION PROCESS¹

To evaluate the quality of the science and the strength of the evidence on EMF, NIEHS organised three symposia (covering epidemiology, *in vivo* studies and *in vitro* studies) with special breakaway sessions to discuss the EMF research findings. In addition, a Working Group (WG) Meeting was held with the Group members comprising scientists both within and outside EMF research and representing a wide range of disciplines, including: engineering, epidemiology, cellular and molecular biology, medicine, mathematics, neurobiology, pathology, physics, statistics and toxicology. The objective of the WG was to perform a critical review and evaluation of the research data on ELF EMF exposure and potential biological and / or health effects.

The WG issued a report in August 1998. Comments on the report, both public and scientific were invited for submission by October 1998. A condensed Working

Group report was submitted to the US Congress in June 1999².

Only peer-reviewed literature, published in acknowledged scientific journals was used in the evaluation.

The process of evaluating the carcinogenic risk of EMF was based on a programme, accepted and used by the International Agency for Research on Cancer (IARC) to evaluate the carcinogenic risk of chemicals to humans since 1971. The objective with this programme is to prepare, with the help of International Working Groups of Experts, and to publish in the form of monographs, critical reviews and evaluation of evidence on the carcinogenicity of a wide range of human exposures.

The IARC monographs are recognised as an authoritative source of information on the carcinogenicity of a wide range of human exposures. These monographs may assist national and international authorities in making risk assessments and in formulating decisions concerning any necessary preventative measures. They also provide evaluations based on scientific qualitative judgements about evidence for or against carcinogenicity from the available data. These evaluations represent only one part of the body of information on which regulatory measures may be based. Other components of regulatory decisions may vary from one situation to another and from country to country responding to different socio-economic and national priorities. Therefore, no recommendation is given with regard to regulation or legislation, which is the responsibility of individual governments and/or other international organisations.

Evaluations of the strength of the evidence for carcinogenicity were made based on the following:

2.1 Degrees of evidence for carcinogenicity in humans and in experimental animals and supporting evidence

(These categories refer only to the strength of evidence that an exposure is carcinogenic and not to the extent of its carcinogenic potency nor to the mechanisms involved).

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i) *Carcinogenicity in humans, classified according to the following categories¹:*

- a) *Sufficient evidence of carcinogenicity* – the WG considers that a causal relationship has been established between exposure and agent, ie, a positive relationship has been observed between exposure and cancer in studies in which chance, bias and confounding could be ruled out with reasonable confidence.
 - b) *Limited evidence of carcinogenicity* – a positive association has been observed between exposure and agent and cancer for which a causal interpretation is considered by the WG to be credible, but chance, bias or confounding could not be ruled out with reasonable confidence.
 - c) *Inadequate evidence of carcinogenicity* – 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.
 - d) *Evidence suggests 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 to the agent and any studied cancer at any observed level of exposure.
- ii) *Carcinogenicity in animals, classified according to the following categories*¹:
- a) *Sufficient evidence of carcinogenicity* – the WG considers that a causal relationship has been established between agent and an increased incidence of malignant neoplasms or of an appropriate combination of benign and malignant neoplasms in (a) two or more species of animals or (b) in two or more independent studies in one species carried out at different times or in different laboratories or under different protocols.
 - b) *Limited evidence of carcinogenicity* – the data suggest a carcinogenic effect but are limited for making a definitive evaluation because (a) evidence of carcinogenicity is limited to a single experiment, (b) there are unresolved questions regarding the adequacy of the design, conduct or interpretation of the study.
 - c) *Inadequate evidence of carcinogenicity* – Studies cannot be interpreted as showing either the presence or absence of a carcinogenic effect because of major qualitative or quantitative limitations.
 - d) *Evidence suggest lack of carcinogenicity* – Adequate studies involving at least two species are available which show that, within the limits of the tests used, the agent is not carcinogenic. A conclusion of evidence suggesting lack of

carcinogenicity is inevitably limited to species, tumour sites and levels of exposure studied.

2.2 Other data relevant to the evaluation of carcinogenicity and its mechanisms¹

The strength of the evidence that any carcinogenic effect observed is due to a particular mechanism is assessed using terms such as weak, moderate or strong.

2.3 Overall evaluation¹

The body of evidence is considered as a whole in order to reach an overall evaluation. The agent or exposure circumstance is described according to the working of one of the following categories:

Group 1: *The agent is carcinogenic to humans:* sufficient evidence of carcinogenicity in humans or evidence in humans is less than sufficient but there is sufficient evidence of carcinogenicity in experimental animals and strong evidence in exposed humans that the agent acts through a relevant mechanism of carcinogenicity.

Group 2A: *The agent is probably carcinogenic:* limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals or inadequate evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals and strong evidence that carcinogenesis is mediated by a mechanism that also operates in humans.

Group 2B: *The agent is possibly carcinogenic:* limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals; inadequate evidence of carcinogenesis in humans but sufficient evidence of carcinogenicity in experimental animals; inadequate evidence of carcinogenicity in humans but limited evidence of carcinogenicity in experimental animals.

Group 3: *The agent is not classifiable as to its carcinogenicity to humans:* evidence of carcinogenicity is inadequate in humans and inadequate in experimental animals.

Group 4: *The agent is probably not carcinogenic:* evidence suggesting lack of carcinogenicity in humans and in experimental animals.

3 SUMMARY OF EVALUATION¹

3.1 Carcinogenicity in humans:

Of the 29 WG members, 19 voted that EMF are possibly carcinogenic to humans (Group 2B). One member abstained and the remaining members voted EMF to be either a Group 3 or Group 4 carcinogen.

- The above decision was driven by the results of childhood leukemia in residential environments and

of chronic lymphocytic leukemia (CLL) in adults in occupational settings.

- *In vitro* and mechanistic data provide, at best, marginal support for the conclusion that ELF EMF are possibly carcinogenic to humans.
- While ELF magnetic field fields at intensities greater than 100µT provide moderate support for effects *in vitro*, there was little evidence of effects at intensities below this limit.

3.2 Non-Cancer Health Effects:

The WG draw the following conclusions related to non-cancer health effects:

- Adverse birth outcomes from maternal occupational exposure – inadequate evidence.
- Reproductive effects from paternal exposure – inadequate evidence.
- Alzheimer’s disease – inadequate evidence.
- Amyotrophic lateral sclerosis – inadequate evidence.
- Suicide and depression – inadequate evidence.
- Adverse effects on pregnancy outcome or depression – inadequate evidence.
- Effects on immune system in experimental animals – no evidence.
- Cardiovascular disease – inadequate evidence.
- Effects on hematological parameters in rodents – no evidence.
- Neurobehavioral, neuropharmacological, neurophysiological and neurochemical effects in experimental animals – weak evidence.
- Reproductive or developmental effects from exposure to sinusoidal magnetic fields in experimental animals – no evidence.
- Affects bone repair and adaptation – strong evidence (for complex clinical exposures to pulsed electromagnetic fields).
- Affect nervous system and non-bone connective tissue repair and adaptation in vertebrates – no conclusion reached.
- Short term exposure and heart rate variability – weak evidence.
- Short term exposure and changes in sleep disturbance – weak evidence.
- Short term exposure and suppression of melatonin – weak evidence.
- Alters the levels of melatonin in rodents – weak evidence.
- Alters the levels of melatonin in sheep and baboons – no evidence.
- Effects on hematological system in experimental animals – no evidence.
- Electric fields can be perceived – strong evidence.

4 OVERALL EVALUATION¹

- The WG concluded that classification of ELF EMF as possibly carcinogenic (Group 2B) is a conservative, public health decision based on limited evidence of an increased risk for childhood leukemia with residential exposure and an increased occurrence of CLL associated with occupational exposure.
- For these cancers, the results of *in vivo*, *in vitro* and mechanistic studies do not confirm or refute the findings of epidemiological studies.
- Overall body of evidence has laid a foundation for furthering the understanding of the biological effects, mechanisms and exposure circumstances that may be related to the possible carcinogenicity and other adverse human health effects of exposure to ELF EMF.

5 IN PERSPECTIVE

This paper reflects the findings presented in the NIEHS WG Report. Further, the following comments are those of the author and not of Eskom in particular: The table below indicates examples of several well known carcinogenic agents, the categories they fall in and the number of carcinogens per category.

Category	Examples	No in Category
Group 1	Asbestos, benzene, tobacco smoking	75
Group 2A	Formaldehyde, ultraviolet radiation	59
Group 2B	Chloroform, saccharin, coffee, gasoline, welding fumes, (EMF)	225
Group 3	Coal dust, selenium, toluene	474
Group 4	Caprolactam	1

Suggestions to treat EMF as a Group 2B carcinogen may be alarmist and of concern to the lay person. However, being informed that coffee and saccharin (well known consumables by choice) fit the same carcinogenic profile as EMF, may largely alleviate such alarm or concern. It is therefore imperative that EMF information of this nature, be accurately communicated and conveyed in perspective to the person, less versed on the topic.

6 REFERENCES

- 6.1 Assessment of Health Effects from Exposure to Power Line Frequency Electric and Magnetic Fields, NIEHS Working Group Report, Aug 1998 (<http://www.niehs.nih.gov>).
- 6.2 NIEHS Report on Health Effects from Exposure to Power Line Frequency Electric and Magnetic Fields, NIH Publication No 99-4493, 4 May 1999.