Childhood Leukaemia and 50Hz Magnetic Fields

Introduction

Acute Lymphoblastic Leukaemia (ALL) is the most common form of childhood cancer and accounts for more than one third of the cancers in the 0-14 year age bracket. It most commonly occurs in children aged 2 to 8 with a peak incidence at age 4. However it can affect all age groups. The survival rate with modern treatment now exceeds 70%.

Leukaemia occurs when the body begins to accumulate apparently abnormal white blood cells. In the process, the mature white blood cells decrease drastically in number and ability. Numbers of mature platelets and red blood cells are also reduced.
Children who have inherited certain genetic problems have a higher risk of developing leukaemia as do children who are receiving medical drugs to suppress their immune systems following organ transplant. Children who have received radiation or chemotherapy also have a higher risk.

Most leukaemias arise from non-inherited changes in genes of growing blood cells and these errors generally occur randomly. Currently there is no effective way to prevent most types of leukaemias.

In 1979 a paper was published that claimed that magnetic fields from high current installations such as power lines and substations in the proximity to residences were associated with increased risks of childhood cancer[1]. Since that time, at least twenty epidemiological studies have been conducted in this area worldwide. In 2002 the International Agency for Research on Cancer (IARC) classified 50 Hz magnetic fields as a possible carcinogen[2].

Types of Leukaemia

The four common types of leukaemia are:

- Acute Lymphoblastic Leukaemia (ALL) occurs when the leukaemia affects cells very early in cell life. This means that the cells remain immature and do not function it all. The patient with an acute form of leukaemia is therefore more likely to suffer from infection, bleeding, and anaemia, and almost always requires immediate treatment. ALL is most common in children, and it is the most common form of childhood cancer.

- Chronic Lymphocytic Leukaemia (CLL) occurs when the leukaemia affects more mature cells. Often these cells have much of their normal function, and anaemia, bleeding and infection are less likely. Patients do not always require immediate treatment as it is a slow progressing type of leukaemia. This disease usually occurs in older patients - it does not occur in children.

- Acute Myeloid Leukaemia (AML) affects the myeloid line of cells. The myeloid family consists of four types of blood cells: *granulocytes, monocytes, red blood cells and platelets.* The granulocytes are mainly affected in this type of leukaemia. Myeloid cells circulate in the blood. Their job is to search for infectious invaders in the blood and nearby tissue. This type of leukaemia may occur in children and adolescents but it usually affects adults.

PO Box 655
MIRANDA NSW 1490
Phone +612 9541 8333
Fax +612 9541 8314

E-mail: info@arpansa.gov.au **Web:** www.arpansa.gov.au
Freecall: 1800 022 333 (a free call from fixed phones in Australia)

619 Lower Plenty Road
YALLAMBIE VIC 3085
Phone +613 9433 2211
Fax +613 9432 1835

- Chronic Myeloid Leukaemia (CML) also affects the myeloid line of cells. The abnormal myeloid cells in CML are usually mature in appearance but they do not function properly. This leukaemia is associated with an abnormal marker in cells and usually affects younger patients rather than that of CLL. The disease can switch into an acute stage when it becomes exactly like an acute leukaemia.

Childhood Leukaemia Rates in Australia (AIHW, 2001)

Age range (years)	Leukaemia rate /100,000/year	
	Male	**Female**
0-4 5-9 10-14	9.6 4.8 3.8	7.5 4.6 3.9
Total childhood risk	91/100,000	80/100,000

The most recent data from the Australian Institute of Health and Welfare (AIHW) indicated that in 2001 there were 228 new cases of ALL in Australia.

Epidemiological Studies of Exposure to Electric and Magnetic Fields and Human Health

The Wertheimer and Leeper[1] study initiated a large number of epidemiological studies worldwide. However, one of the major problems with electric and magnetic fields (EMF) epidemiology is exposure assessment. Practically everyone is exposed to extremely low frequency (ELF) magnetic fields, there is a wide variety of sources and exposures vary greatly over short distances which makes it difficult for researchers to identify the appropriate determination of exposure. Several different approaches have been used. Wertheimer and Leeper[1] used a wire code configuration classification scheme, this has been refined in subsequent years[3-5]. The relation between wire code configuration and measured magnetic field levels may be influenced by residence electric wiring, grounding, electric appliances, and other sources of EMF in the home.

A different approach to exposure assessment has been used in Sweden and Norway. Feychting and Ahlbom[6] calculated historical magnetic field levels using data from various registries with long-term power line load data and specifications for power lines and associated structures obtained from the utility industry. The distance between power lines or other sources of high magnetic fields and residences has also been used in a number of studies[6-9].

It would be expected that measurement would prove to be the ideal exposure assessment method, however, difficulties arise because there is no agreement on what physical measurement should be made. In addition, retrospective measurements are inexact and the relevant exposure period is not known. However many studies using spot and/or 24-hour or longer magnetic field measurements have been reported.

There is a large body of research seeking to establish whether there is a connection between ELF exposure and adverse health effects including leukaemia and brain tumours in childhood and later in life. Other diseases and effects have been endpoints studied including breast cancer, cardiovascular disease and suicide. Overall the most consistent result indicating a positive association is for childhood leukaemia.

Wertheimer and Leeper[1] study found significantly elevated risks for total childhood cancer (relative risk =2.25), childhood leukaemia (RR=2.98), brain and nervous system tumours (RR=2.40), and lymphomas (RR=2.08). Over the subsequent twenty years or more a number of case-control childhood cancer studies have used the wire code method alone and sometimes in conjunction with measurements, both spot and 24 hour. The results have been mixed. There has been little support for a relationship with lymphoma and other studies have not found excess risks of brain and nervous system tumours associated with high residential wire code configurations[10,11]. The use of other exposure metrics, for example spot measurements[4], 24-48-hour residential magnetic field measurements[10,12] and calculated magnetic field levels[6-8], were not linked with increased risks of childhood brain and nervous system tumours.

It has been to childhood leukaemia that a lot of attention has been focussed. All of the exposure metrics described above have been used with the following outcomes:

- **wire codes:** elevated risks found in two studies[1,4] were not found in others[13-15].
- **distance:** elevated risks for children residing within 100 m of a power line have been reported[6,7] but no increase in risk was found in other studies[8,9]. Most of the reported studies were based on only a small number of cases. However, in a recent study[16] elevated risks for childhood cancer up to a distance of 600 m from high voltage power lines were reported;
- **calculation:** this approach was used in Scandinavian countries and for a small number of cases increased risk was found in three studies[6,17,18] but not in a fourth[8]; and
- **measurement:** elevated risk, although, in most cases, not statistically significant was found in a number of studies[4,12,14,15,19-24] with exposure generally ≥0.2μT .

Pooled studies

In an attempt to decrease the statistical uncertainty of the studies Ahlbom et al[25] have pooled data from what they considered to be the better of the published studies. They found no elevated risk among the 3,203 children with leukaemia and having residential magnetic field exposure < 0.4 μT. However, for exposures ≥ 0.4 μT a relative risk of 2.0 was found and this was statistically significant. For these exposures there were 44 leukaemia cases and the expected number of cases was 24.

Greenland et al.[26] also undertook a pooled analysis and found an a relative risk of 1.7 in association with residential magnetic fields, usually assessed as 24-hour time weighted average, of ≥ 0.3 μT. These two pooled analyses are the main reason why the IARC has classified magnetic fields as a possible carcinogen, despite the absence of supporting evidence from animal experiments or known mechanisms[2].

International Agency for Research on Cancer (IARC)

IARC is part of the World Health Organization and is responsible for coordinating and conducting research on the causes of human cancer and the mechanisms of carcinogenesis. It publishes expert assessments on the carcinogenic potential of chemical and physical agents.

In 2002 it published a monograph "Non-Ionizing Radiation, Part 1: Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields" (IARC, 2002) and found:

> "There is limited evidence[1] in humans for the carcinogenicity of extremely low-frequency magnetic fields in relation to childhood leukaemia";
>
> "There is inadequate evidence[2] in humans for the carcinogenicity of extremely low-frequency magnetic fields in relation to all other cancers"; and
>
> "There is inadequate evidence in experimental animals for the carcinogenicity of extremely low-frequency magnetic fields".

Overall IARC concluded:

> "Extremely low-frequency magnetic fields are possibly carcinogenic to humans (Group 2B)".

Implication of Childhood Leukaemia results

As discussed above there is some epidemiological evidence that prolonged exposure to power frequency magnetic fields at levels higher than what is normally encountered is associated with a small risk of leukaemia in children. There is no evidence from either cellular or animal studies that would suggest a causal link. Hence at this point in time the childhood leukaemia data can not directly influence the establishment of exposure limits. IARC, on the basis of the consistency of the data, has concluded that ELF magnetic fields are possibly carcinogenic to humans.

If the relationship was found to be causal it would be possible to estimate how many of the annual cases of childhood leukaemia are due to exposure to residential magnetic fields. A survey of 300 randomly selected houses currently underway in Melbourne would suggest that in 3-4% of houses the magnetic field in a child's bedroom exceeds 0.4 μT. If this percentage applied to all Australian houses and the pooled results were valid in Australia then it could be estimated that up to about 7 cases out of 225 annual cases of childhood leukaemia could be due to exposure to residential magnetic fields.

On the basis of the above information the standard recommends a precautionary approach (see Section 5 Protection - occupational and general public exposure). Precautionary policies and approaches are discussed in Annex 6 of the Standard..

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1 IARC meaning: data suggest a carcinogenic effect but are limited for making a definitive evaluation because of, for example, single experiment, questions re design, conduct or interpretation of study or agent increases incidence of benign lesions.

2 IARC meaning: the studies cannot be interpreted as showing either the presence or absence of a carcinogenic because of major qualitative or quantitative limitations, or no data on cancer in animals are available.

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