



Powerline Frequency Electromagnetic Fields and Human Health - Is it the time to end further research?

An Overview of Three Recent Studies

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Abstract

On March 2nd of this year the results of a study by the Royal Adelaide Hospital were released which found "no evidence for cancer link with powerlines", and has been quoted as confirmation that it "should be of great peace of mind to the many thousands of people who live near or under powerlines".

On July 3rd 1997 the USA National Cancer Institute's Linet study was released which "found no evidence that magnetic fields (EMFs) in the home increase the risk for the most common form of childhood cancer".

On October 31st 1996 the USA National Academy of Sciences National Research Council issued a review of the EMF literature and concluded that "there is no conclusive and consistent evidence showing that exposure to residential electric and magnetic fields produces cancer, adverse neurobehavioral effects, or reproductive and developmental defects".

Largely on the basis of these three studies, there are calls in Australia and the USA to put an end to further research into the possible adverse biological effects from human exposure to powerline frequency EMFs.

However, a careful examination of the limitations of these three studies does not support this conclusion.

Introduction

One of the more contentious issues in the scientific community today is that of the biological effects of electromagnetic fields (EMFs) and whether or not they are adversely affecting our health. This issue has caused much concern and controversy, which largely dates from 1979 when epidemiologist Nancy Wertheimer *et al.* reported a link between powerline magnetic fields and childhood leukemia in Denver, Colorado. Many epidemiological studies since that time have reported a statistically significant connection with magnetic field exposure and cancer, while other studies do not report such a correlation.

Many people who have been following this issue for the last few years would have some justification in thinking that recent studies have 'concluded' that there are no health hazards associated with human exposure to electromagnetic fields generated from our use of electric power.

A brief examination of media reporting and press releases from several recent scientific studies would certainly indicate that the possible dangers from powerline EMF exposure have been overstated and perhaps it is time to direct research funding into other areas.

The Studies

The Royal Adelaide Hospital ELF Mice Study, Australia, 1998)

In March of 1998 the American scientific journal *Radiation Research*

published the results of the Royal Adelaide Hospital ELF (Extremely Low Frequency) mice study, titled: "A Test of Lymphoma Induction by Long-Term Exposure of Eu-Pim 1 Transgenic Mice to 50 Hz Magnetic Fields". In this study, which looked at 50 Hertz powerline frequency magnetic fields, five groups of approximately 120 mice per group were exposed to different levels of magnetic field strengths:

Zero milliGauss (mG) (Sham exposure group), 1, 100, 1,000, 10,000 and pulsed 10,000 milliGauss.¹

On March 2, 1998 the Centenary Institute of Cancer Medicine and Cell Biology issued a press release on the findings from the Royal Adelaide Hospital ELF mice study:

"No evidence for Cancer Link with Powerlines - No increase in incidence of a cancer of the immune system called lymphoma was detected in mice after prolonged exposure to magnetic fields of the type emitted by electric power lines and equipment."

Professor Tony Basten, Chairman of the research team, was quoted in an interview with the *Sydney Morning Herald*:

"In view of the earlier reports of a possible association between proximity to powerlines and incidence of childhood leukemia, a close relative of lymphoma, our clear cut negative results should be very reassuring," said Professor Basten, [it] "supports other carefully conducted studies showing no measurable increase in cancer risk and really should be of great peace of mind to the many thousands of people who live near or under powerlines."²

The NCI, Linet Study, USA, 1997

On Friday July 4th 1997, both *The Australian* and *The Sydney Morning Herald* featured articles about the National Cancer Institute's Linet study, which found that there was no evidence that powerline electromagnetic fields increase childhood leukemia risks. This study was published on July 3rd in the *New England Journal of Medicine*.³

The researchers compared magnetic field exposures of 638 children with leukemia and 620 children without leukemia who were similar in age and race.

To quote from the National Cancer Institute's press release, dated July 2nd, 1997:

"A comprehensive study by researchers from the National Cancer Institute (NCI) and the Children's Cancer Group (CCG) found no evidence that magnetic fields (EMFs) in the home increase the risk for the most common form of childhood cancer."

In this case-control study the researchers found that, in general, children who lived in homes with high measured magnetic fields were not significantly more likely to be diagnosed with acute lymphoblastic leukemia (ALL) than children living in homes with lower magnetic field levels. Nor was ALL found to be more likely among those whose homes were classified in high categories of 'wire-code,' a surrogate measure of magnetic fields that is based on the thickness, configuration, and distance from the home of nearby power lines."

As reported in the February 1998 issue of *EMF Update*, published by

the Electricity Supply Association of Australia:

“A major scientific study published in the 3 July edition (1997) of the *New England Journal of Medicine* reported no statistically significant correlation between magnetic field exposure in the home and the incidence of childhood leukemia.”

Don MacPhee from LaTrobe University's School of Microbiology was quoted in *The Australian* that the results of the NCI Study backed his claims that power lines did not emit enough energy to cause childhood cancer or any other form of cancer. MacPhee said that it was mostly the media, and scientists of “dubious quality”, that had perpetuated the myth that there was any link between power lines and cancer. “Its just absolute non-sense”, Dr. McPhee said.⁴

The NAS/NRC Report, USA, 1996

On October 31st, 1996, the USA National Academy of Sciences, National Research Council (NAS/NRC) issued a review of the EMF literature: “Possible Health Effects of Exposure to Residential Electric and Magnetic Fields”. The conclusions of this report are that “there is no conclusive and consistent evidence showing that exposure to residential electric and magnetic fields produces cancer, adverse neurobehavioral effects, or reproductive and developmental defects”.

Of significant importance are the words, “conclusive and consistent”. Like the more familiar phrase in law, ‘beyond reasonable doubt’, ‘conclusive and consistent’ implies a certain standard of evidence that warrants more serious action. Using that type of reasoning, the NRC Committee concluded that research results do not show that EMF exposure at a residential environmental level causes adverse health effects.⁵

According to the newsletter *EMF Health Report*, (Nov/Dec 1996) published by the USA-based Information Ventures: “The findings to date do not support claims that EMFs are harmful to a person's health,” said Dr. Charles Stevens of the Salk Institute, who was the chair of the NRC Committee which wrote the report.

The official NRC/NAS news release headline states: “No Adverse Health Effects Seen From Residential Exposure to Electromagnetic Fields.”

In the Electrical Supply Association of Australia's (ESAA) newsletter *EMF Update* of January 1997, it is reported:

“In an extensive review of the scientific literature relating to the possible health effects of exposure to residential electric and magnetic fields... the (NAS) concluded that ‘the current body of evidence does not show that exposure to these fields presents a human-health hazard...’ NAS appointed an expert committee of 16 scientists to review 17 years of research . . . in hundreds of studies on three continents. The present report is the result of that effort . . . It [the NAS report] is an important benchmark document in the history of the EMF scientific debate against which future research findings will need to be viewed.”

As a result of the ‘not guilty’ verdict from the National Academy of Sciences and the National Cancer Institute, the USA Department of Energy (DOE) is ending practically all bio-electromagnetic research in September 1998, and there is the likelihood that the USA House of Representatives and the Senate will drastically cut the budget for future research.

Acting on the press releases from both the NCI and NAS studies, the Victorian Radiation Advisory Committee, in its annual report to the Victorian Parliament for 1997 stated:

“. . . However, the weight of opinion as expressed in the USA National Academy of Sciences report and the negative results from the National Cancer Institute study (Linnet *et al.* 1997) would

seem to shift the balance of probability more towards there being no identifiable health risks.”⁶

Commentary on the Studies

Considering that the USA National Academy of Science, the USA National Cancer Institute and other organisations have made the above statements on the EMF health debate, it would seem quite reasonable to conclude that at long last we have settled this issue.

However, before any firm conclusions can be drawn, let us go back and carefully re-examine the three studies mentioned above to see if the press releases and media statements on safety are really reflected in the study findings themselves.

The Royal Adelaide Hospital ELF Mice Study (1998) - Limitations

One important admission of the authors of this study, and one which should have been mentioned in the press release, is the following:

“Perhaps the increased incidence of cancer, that in some epidemiological studies has been associated with residential proximity to high-current power-distribution wiring, results from exposure to high-frequency transients rather than the primary 50/60 Hz magnetic fields. Transients originate from the operation of devices such as light switches, electronic controllers and electric motors during start up. They are of short duration (<1 s) and have frequencies peaking in the megahertz range and intensities up to several microtesla [mT]. . .

In our study, the magnetic fields to which the mice were exposed were switched on and off in a manner that minimised the production of transients. Thus the possible carcinogenic consequences of exposure to transients have yet to be tested.”⁷

This statement is in conflict with the statement in the official press release where it is claimed: “No increase in incidence of a cancer of the immune system called lymphoma was detected in mice after prolonged exposure to magnetic fields of the type emitted by electric power lines and equipment”.

The researchers had understandable reasons for filtering out the possible effect of transients, as this could have been a possible confounder if a positive result was found. That is, if transients were not filtered out and an effect was found, they would not know if it was the 50 Hz magnetic field or the transients which were responsible. Therefore they decided to eliminate one of those for the purposes of the study. However, by doing so the relevance for real world exposures is severely limited, as the following indicates.

Transients

Quoted from the paper “How You Can Avoid or Eliminate Pulsing Electric or Magnetic Fields within Your Home and Bedroom” by James B. Beal, EMF Interface Consulting, 5500 Prytania, #406, New Orleans, LA 70115, USA:

“Repetitious transients and surges (pulse spikes) occur on power lines too, but the more influencing transients are created by factors in home and business wiring, water piping (poor grounding/balancing), appliances and equipment. This repetitious long-term exposure may provide a kind of irritation or suppression factor, posing potential hazards to our health. . . . Persons at risk would be those exposed for years in constant proximity to power line components (transformers, sub-stations), appliances (electric blankets, hair dryers), power tools, TVs and computer monitors, switching systems, and other sources of potential rapid transient (switching) EMFs.”⁸

The relevance of studies that only consider field magnitude, while excluding other factors such as transients, are now being questioned by some researchers. This issue was highlighted in a recent article by

Janet Raloff in *Science News*, Jan. 10th, 1998, "EMFs' Biological Influences - Electromagnetic fields exert effects on and through hormones"; in an interview with Charles Graham, an experimental physiologist at the Midwest Research Institute (MRI) in Kansas City, Missouri:

"What concerns me," Graham says, is that the public "tends to get so worried about the magnitude of a field. The bigger it is, the worse it's supposed to be." In fact, Loscher has found that very high fields, as well as those below a certain strength, have little impact on tumor growth. Only those across a relatively narrow range consistently foster tumors and other negative health effects.

"We've seen the same thing in our studies," Graham told *Science News*.

Moreover, he says, it's beginning to appear that a field's magnitude matters less than its intermittency or other features, such as power surges called electrical transients.

These surges can pack a big burst of energy into a short period of time. They occur whenever lights or other electric devices turn on [or off], when motors or compressors (such as those in refrigerators and air conditioners) cycle on, or when dimmer switches operate. "Being transient doesn't mean they're rare, just quick," Graham notes. "Transients are hard to avoid because they may stem from surges elsewhere - in a neighbor's house or even power lines up the street."⁹

The argument that powerline EMFs are too weak to possibly affect cellular processes does not necessarily apply to transients. Research by Dr. Antonio Sastre and colleagues indicates that when it comes to powerline EMF transients, the induced signal can rise above the background cellular noise.¹⁰

Considering that the Adelaide Hospital ELF mice study specifically filtered out the possible effect of transients, the results of this study cannot be used to justify any assurance of safety with real world exposures. It would be far more accurate to rewrite the press release from the Centenary Institute to state the following:

No Evidence for Cancer Link with Laboratory 50 Hz Magnetic Fields - no increase in incidence of a cancer of the immune system called lymphoma was detected in mice after prolonged exposure to magnetic fields of the type emitted by laboratory Helmholtz coils.

The NCI, Linet Study, 1997 - Limitations

It is unfortunate that the authors of the official NCI press release, which gives the impression that this study is convincing evidence that a risk does not exist from long term exposure to powerline electromagnetic fields, did not take the time to critically examine what the study actually found, and to examine the criteria which led to the NCI researchers' conclusions:

"The researchers actually acknowledge, in no less than four places, a statistically significant increase in acute lymphoblastic leukemia (ALL) in children exposed to powerline magnetic fields in excess of 3 milliGauss. This is a confirmation of many previous studies which have shown a similar level of association between childhood leukemia and magnetic fields from electricity."

The article in *The Australian* mentions that the researchers dismissed as a "statistical fluke" a 24% increase in leukemia risk for children exposed to what is termed "especially high magnetic fields".

The NCI researchers were able to dismiss this fact by arbitrarily setting a 2 mG level as a cut-off limit. Only by setting that artificial limitation could they conclude that there was no association. The fact is, that if they had used the 3 mG level as a cut-off point in their calculations, the conclusions would have been exactly the opposite -

that there is a statistically significant connection between powerline magnetic fields and childhood leukemia at levels over 3 mG.

On July 4th 1998 this writer [D. Maisch] contacted Professor Ross Adey, one of the best known bio-electromagnetic researchers in the world. Dr. Adey is the author of numerous books and research papers on the bio-effects of EMFs. He recently conducted a \$3 million research program for Motorola and was a committee chairman on the USA National Council on Radiation Protection and Measurements (NCRP). His comments on the NCI study are as follows:

"A number of us worked on the NCI paper through last weekend. Sam Milham, the Washington State epidemiologist and a pioneer in this field, points out that if they had included the 3 mg level in their cutoff, the conclusions would have been exactly the opposite - that there *is* a significant risk. And selection of 2 mG is quite arbitrary. David Savitz used 3 mG in some of his work. Obviously there is no steep threshold beyond which risks rise exponentially. At the recent Bologna International Symposium, Schuz from the University Mainz had a paper combining kids from Berlin and Southern Saxony in high exposure homes to give leukemia odds ratio of 6.8 for young kids (under 4 years). So the dismissive attitude of NCI is totally unrealistic."¹¹

Also contacted at the same time for comment on the NCI study was Alasdair Philips from Powerwatch Network in the UK. Mr. Philips was a principal researcher for the UK study "Measured Electric Fields in the Bed Places of Leukemic Children", published in the June 1997 issue of the *European Journal of Cancer Prevention*.

"Surprisingly, for a modern study, the NCI researchers only measured magnetic fields and did *not* include electric fields which are being increasingly implicated in cancer development and many other adverse health conditions. Both magnetic and electric fields are being measured in the landmark UK Childhood Cancer Study due out early next year, as UK researchers understand the potential importance of electric fields. In the 1996 Ontario Hydro adult worker study conducted by Dr. Anthony Miller of Toronto University in Canada, when they took both fields into account, the risk rose from 1.6 (magnetic fields only, and similar to the 1.79 in this study) to 11.2 (of the magnetic and electric fields considered) - it is likely to be a similar increase for children."¹²

It should also be noted that the magnetic field is not the equivalent of EMF. It is only one of the now 'five or six' known EMF metrics. Of these, the electric field may well be the most important, though the role of transients, harmonics, ground currents, radon daughters and the radio frequencies that 'ride' on power lines are also suspect. Any study which only considers one of these metrics cannot give any assurance of 'safety'.

Comments on the NCI Linet study by Allen H. Frey, author of *On the nature of electromagnetic field interactions with biological systems*, (RG Landes Co., Austen TX, USA, 1994):

"Are the conclusions of the Linet epidemiological study and associated editorial by Campion justified? I think not."

As is often the case in science, the fault is in assumptions made before the study began, assumptions upon which the study is based. If the assumptions can not be shown to be true, then the conclusions are not valid.

In their statistical study, it was assumed that the active agent in power line biological effects is the 60 Hz sinusoidal wave. But there is substantial data and biological theory to indicate that the primary active agent would be the transients that are found on power lines in varying forms to varying degrees in various places (Frey, 1994). A broad statistical study such as Linet *et al.* would tend to obscure such effects, since data from areas where there are effective transients would be submerged in the mass of data from areas where there are no

such transients.

Epidemiological studies, and statistical studies in general, are quite useful for hypothesis generation. But they are not appropriate for drawing conclusions. Causality can not be shown. There are just too many unknown and uncontrolled factors operating in a large statistical study, as compared to wet biological experiments. This is particularly the case with magnetic fields as an agent, for it is not yet clear what parameters of the agent are of importance biologically.

Is it appropriate to draw what may be life and death conclusions on the basis of one statistical study that is based on an assumption about what is the active agent, an assumption that can not be shown to be true? I doubt that many people would be willing to stake their life on one such study.”¹³

Comments on the NCI Linet study by A.R. Liboff, Professor of Physics, Oakland University, Rochester, MI, July 14, 1997

“Like Allan Frey, I too have doubts concerning the implications of the Linet study.

Frey points to the possibility of transients as the metric underlying the earlier correlations.

Another possibility is that the geomagnetic field may be a complementary factor, either because of cyclotron resonance or some other type of resonance interaction. In connection with this it appears that Denver was not one of the areas examined, which is puzzling considering the fact that data from the Denver vicinity was the impetus for such epidemiological studies.

The media has characterized this study as the largest yet. For some time, I have had the feeling that funding for such studies would continue until the funders got the answer they wanted. Never mind the original objections to the Wertheimer and Savitz results - that epidemiological studies were ‘innately non-scientific’ and did not prove anything. Now that the results are more in line with what is desired, we are subjected to newspaper and TV reports saying that this report is the final word.

Nowhere does the media awaken the public to the fact that, since Wertheimer’s original 1979 results, there has arisen a wealth of (laboratory) evidence showing that ELF magnetic fields can have profound effects on living things. What in 1979 seemed inconceivable no longer appears improbable.

Perhaps now that we have had, in the words of the media, the ‘final word’, the rest of us can get on with the science underlying these ELF interactions and, through the science, determine the consequences for human health.”¹⁴

With this in mind, the only thing the NCI study indicates is that children with magnetic field exposures at, or under, 2 mG are not at apparent increased risk of developing leukemia from their EMF exposure. Rather than exonerating EMFs, the NCI study gives further support for the 1995 draft guidelines from the USA National Council of Radiation Protection and Measurements. (NCRP). These guidelines generally endorse a 2 mG exposure limit.

The NCRP Draft Guideline conclusions:

“In arriving at the proposed guidelines, the committee has considered available laboratory studies on bioeffects and epidemiological reports of health hazards from electric and magnetic field exposure. . . In key areas of bioelectromagnetic research, findings are sufficiently consistent and form a sufficiently coherent picture to suggest plausible connections between Extremely Low Frequency (ELF) EMF exposures and disruption of normal biological processes, in ways meriting detailed examination of potential implications in human health.”¹⁵

The NAS/NRC Report, 1996 - Limitations

As mentioned earlier, this report found that there is no “conclusive and consistent evidence showing that exposure to residential electric and magnetic fields produces cancer, adverse neurobehavioral effects, or reproductive and developmental defects”. Using their criteria for admissible evidence, the NRC Committee concluded that research results do not show that EMF exposure at a residential environmental level causes adverse health effects.

Is the NAS/NRC report a conclusive vindication for EMFs in the health issue? The answer to that question depends upon your viewpoint. If you take a narrow legalistic interpretation, the ‘not guilty’ verdict may seem appropriate, especially if you take into account only the evidence considered by the NRC Committee.

However if you take a scientific interpretation and consider all the available evidence, the conclusion is inescapable. So many scientific studies were excluded from the ‘extensive’ NAS/NRC report, that its conclusions cannot be considered a proper review of current scientific findings.

- In its review of the literature, the NRC Committee restricted itself to considering only studies published in peer-reviewed journals up to mid-1995, when the report was drafted. The NRC press release states: “To date, they have found no evidence to show that EMFs can alter the functions of cells at levels of exposure common in residential settings. Only at levels between 1,000 and 100,000 times stronger than residential fields have cells shown any reaction at all to EMF exposure... In fact, exposure may actually help the body in some subtle ways, for example by speeding up the healing process after a bone is broken.”

“To date” means the cut off date of early 1995 for peer reviewed and published research, a process which can take years, thereby omitting many studies which had results opposed to the NAS/NRC report’s own findings.

In fact the NAS/NRC Committee only considered approximately half the evidence which was available to it. Dr. Kjell Hansson Mild of the National Institute for Working Life in Sweden, asked Dr Stevens, chair of the NRC Committee, how “the report turned out to be so biased in its selection of papers”. Mild, past president of the Bioelectromagnetics Society, noted that the report mainly included papers that showed no effect and omitted those that found a biological response.¹⁶

- Excluded from the NAS/NRC findings was the extensive body of occupational studies, such as the Ontario Hydro worker study, which found that workers exposed to high levels of magnetic and electric fields had leukemia rates that were up to 11 times greater than expected.¹⁷ In fact the committee acknowledged that workplace studies “have increased rather than diminished the likelihood of an association between occupational exposure to [EMFs] and cancer”. The NAS committee only did what has been called a “superficial overview” of this literature because (the official reason) it was not directly relevant to the committee’s assignment.¹⁸

- Excluded from the findings was the entire body of research into the effect of environmental low level EMF exposure on melatonin, known as the melatonin hypothesis (low level magnetic field exposures may reduce the pineal gland’s production of cancer-inhibiting melatonin and the ability of melatonin to suppress breast cancer cells). This hypothesis is supported by five *in vitro* studies, from three major laboratories, as well as some human exposure studies finding a reduction in melatonin levels in workers exposed to EMFs. The body of this research implicates prolonged powerline frequency magnetic field exposure in the order of 12 mG with possible hormone disruption. Besides melatonin being affected, levels of the stress hormone ACTH may be increased as a consequence.¹⁹

This body of research featured greatly at the *Second World Congress for Electricity and Magnetism in Biology and Medicine*, held in Bologna,

Italy in June of 1997, where over 600 scientific papers on many topics were presented, it was mentioned in the official program bulletin:

“A number of experimental studies have been conducted to test the [melatonin] hypothesis. Although the literature is still evolving and consensus is being built, it is fair to say, a) there exists credible scientific support for the hypothesis and, importantly, b) this support encompasses *in vitro*, *in vivo*, and epidemiological research. The melatonin hypothesis thus currently represents one of the more well documented/tested interactions in the field of bioelectromagnetics.”

The NAS press release states: “The committee also called for more research into the relationship between high exposures to EMFs and breast cancer in animals already exposed to other carcinogens, and on reasons why electromagnetic fields seem to affect the levels of the hormone melatonin in animals, an effect not reproduced in humans.” This statement gives the impression that there is no evidence that low level EMFs affect melatonin in humans.

The NAS can only state this by ignoring the melatonin hypothesis research because it did not meet the committee’s strict criteria for admissible evidence.

To be fair to the NAS/NRC report, the meta-analysis of 11 residential epidemiological studies was one of the most thorough to date. What it did find is that there is a reliable statistical association between childhood leukemia and power line proximity, as classified by wire codes.

However, because the committee was looking for conclusive evidence of a connection with EMFs, it was able to dismiss all data which failed to meet this criterion and therefore could not conclude EMFs were to blame. Epidemiology looks for increases in risk factors, it does not deal with conclusive proof. By setting such an impossible standard, the National Academy of Science was able to dismiss the EMF link with childhood cancer and announce to the world that there was nothing to worry about.

So rather than being an “important benchmark document in the history of the EMF scientific debate against which future research findings will need to be viewed” the NAS/NRC study appears to be designed, by its limitations, to give an assurance of safety, when the evidence does not warrant that conclusion.

Published Guidelines

NCRP draft report guidelines (1995)

The USA National Council on Radiation Protection and Measurements (NCRP), a congressionally chartered organisation, was contracted by the Environmental Protection Agency (EPA) in 1983 to conduct a review of the biological effects of Extremely Low Frequency (ELF) EMFs. Work was discontinued in 1986 due to funding cuts at the EPA, but resumed in 1991. In early 1995 the draft of the 800 page NCRP report was leaked to the New York based publication *Microwave News*, which published the report’s findings in August 1995. The final report was supposed to be publicly available in early 1996, but has received such intense industry opposition to its findings that its final outcome remains uncertain.

The Committee’s membership was described by chairman Dr. Ross Adey as “carefully selected to cover the great majority of societal interests on this scientific problem, including power industry engineers, epidemiologists, public health specialists as well as molecular and cellular biologists”. The draft report generally endorses a 2 mG exposure limit. It would immediately affect new day-care centres, schools and playgrounds, as well as having implications for new transmission lines near existing housing.

A somewhat more flexible policy would be applied to new housing and offices. For existing facilities, the committee recommended a more gradual approach, with stronger restrictions phased in over time if the evidence of a health risk continues to grow.

From the Committee’s conclusions:

“In arriving at the proposed guidelines, the committee has considered available laboratory studies on bioeffects and epidemiological reports of health hazards from electric and magnetic field exposure... In key areas of bioelectro-magnetic research, findings are sufficiently consistent and form a sufficiently coherent picture to suggest plausible connections between ELF EMF exposures and disruption of normal biological processes, in ways meriting detailed examination of potential implications in human health.”

From studies on humans the committee cites evidence for a link between EMFs and:

1. childhood and adult cancer, including leukemia and brain cancer;
2. teratological effects and other reproductive anomalies;
3. neuroendocrine and autonomic responses which, separately or collectively, may have pathophysiological implications;
4. neurochemical, physiological, behavioural and chronobiological responses with implications for development of the nervous system.

From laboratory studies the committee notes that EMFs:

1. affect cell growth regulation in animal and tissue models in a manner consistent with tumour formation;
2. increase tumour incidence and decrease tumour latencies in animals;
3. alter gene transcriptional processes, the natural defence response of T-lymphocytes and other cellular processes related to the development and control of cancers;
4. affect neuroendocrine and psychosexual responses.

In relation to the effect of low level EMFs on melatonin (evidence which the NAS/NRC report excluded), the committee concluded:

“There has been a strong focus on ELF field actions in the pineal gland, relating to... the pineal hormone melatonin, and on a broad series of regulatory functions mediated by this hormone. Melatonin plays a key role in controlling the 24-hour daily biological rhythm. Disturbance of the normal diurnal melatonin rhythm is associated with altered estrogen receptor formation in the breast, a line of experimental evidence now under study, on possible links between ELF field exposure and human breast cancer.

“Further, melatonin has general properties as a free radical scavenger, with the possibility of a preventative role in oxidative stress, recognized as a basic factor in a broad spectrum of human degenerative disorders, including coronary artery disease, Parkinson’s and Alzheimer’s diseases, and aging.”

According to the committee, problematic sources of ELF EMF include local electrical distribution systems, as well as high voltage power transmission systems. Particular appliances, including electric blankets and VDTs also rate highly as problem sources, along with “various occupational environments”.

The committee states that the evidence points to human health hazards in common exposures to EMFs, particularly magnetic fields exceeding 0.2 mT (2 milli-Gauss) and electric fields at intensities in the range 10-100 V/m (volts per metre). (An electric blanket on setting II can expose the sleeper to a field of 12 mG.)

“..there is an implication that a significant proportion of the world’s population may be subjected to a low level of risk, but a risk factor with significant societal consequences, by reason of its pervasive

nature and the serious consequences for affected individuals.”

NCRP interim exposure guideline recommendations:

The committee concludes that “neither laboratory studies nor epidemiological findings... can yet establish well-defined thresholds for safety guidelines.” Still, it contends: “From available epidemiological and laboratory data, it appears both prudent and responsible to set limits on permissible future exposures”. Therefore it calls for “interim exposure guides”, measures that “fall short of establishing either a standard or guideline, but offer guidance to limit exposure”.

ALARA policy endorsed:

While the report notes that committee members were not unanimous, it recommends a policy in which exposures would be “As Low As Reasonably Achievable”, known as ALARA. Over a three year period, ambient exposures in existing homes, schools and offices would be reduced to 10 mG. After six years, there would be an option to establish a guideline of 5 mG.

Each of these decisions would be based on whatever epidemiological and laboratory studies were then available. After ten years, a goal of 2 mG would be considered. The report stipulates that mitigation of the existing EMF environment to this level should be adopted only after “a careful evaluation of its socio-economic impact, as well as its cost-effectiveness”.

With respect to future construction, the report recommends observing a 2 mG exposure limit for schools and for new transmission lines near existing housing, with somewhat less strict guidelines for new housing and offices.²⁰

Committee member Dr. David Carpenter, of the School of Public Health at the State University of New York, Albany, said:

“In almost any other type of environmental exposures, if the evidence were as strong as the association between EMFs and cancer, there would be extensive government regulation. The major reason that many members of the committee were unwilling to set more rigorous standards was that it would be horrendously expensive and unrealistic to enforce them.”²¹

It must be pointed out that the NCRP report is still in a draft form and as such it has no official standing at this time. Because of this, there are many who would prefer that this report be ignored, while the NAS/NRC and NCI studies be taken as the definitive evaluation on the health effects from exposure to EMFs. It will be a sad day for science if studies which can only arrive at their conclusions by ignoring a significant body of evidence, are accepted as the definitive statement on the issue.

Considering further studies, published since the 1995 NCRP draft guidelines, epidemiologist Nancy Wertheimer has proposed a 3 mG cut off-level as a benchmark. She wrote in the September/October 1997 issue of the Bioelectromagnetics Society Newsletter that:

“...taken as a whole, the accumulated evidence from all the studies appears to show quite consistent and significant evidence that increased cancer risk accompanies measured or carefully calculated fields at the very high end of the field range (over about 3 mG). The same studies show little evidence that fields in the 2 mG to 2.9 mG range are indicators of risk.”²²

Australian maximum exposure guidelines

(Relevance to cancer and other adverse health states)

When you take the 2 mG NCRP guideline or Nancy Wertheimer’s 3 mG benchmark, as a measure of protection from cancer, there is an apparent discrepancy between these levels and the current maximum exposure limits, as set by the National Health & Medical Research Council (NH&MRC). These limits are based on the guidelines set by the International Commission on Non-Ionizing Radiation Protection

(ICNIRP) in 1993: for residential exposures - 1,000 mG; for occupational exposures - 5,000 mG.

The reason for this large difference in levels is because the ICNIRP (and Australian) guidelines specifically do not address the issue of chronic exposure to powerline frequency EMFs. This was admitted in 1991 by Dr. Keith Lokan, from the Australian Radiation Laboratory, in a conference paper published in *Radiation Protection in Australia*:

“One thing which we have done, though it has little direct bearing on the issue of chronic low level exposure, is to adopt the (above) recommendations on field limits. These limits represent plausible field values, below which immediate adverse health effects are unlikely, and as such serve a useful purpose. They are not intended to provide protection against possible cancer induction by continued exposure at the lower field levels implicated in the studies . . .”²³

The attention solely on proximity to powerlines and cancer in many of the studies may be an over-simplification. Fields generated inside homes due to house wiring, faulty earthing and electrical appliance use, can give greater cumulative exposures than fields emitted by nearby powerlines. School and occupational exposures are usually not taken into consideration. The overall affect of these additional exposures could act as a ‘confounder’ to reduce the significance of any study which only looks at one condition (cancer) and distance from powerlines.

Also the preoccupation solely with cancer and EMFs does not consider other adverse health states which may be implicated as well. The draft NCRP report mentions these in detail, but the majority of epidemiological studies to date mainly focus on cancer.

Evidence indicates that electromagnetic fields may play a role in a number of disease conditions apart from cancer, possibly acting as an immune system stressor. One recent New Zealand study which looked at homes near powerlines examined combined chronic health problems, not just cancer. They found significant increased risks for asthma, arthritis, type-II diabetes and other chronic health problems.

“Although numerous studies of animals and cell cultures indicate effects of power frequency magnetic fields on immune-system function, few studies have looked for evidence of an association between environmental power-frequency magnetic field exposure and immune-related illnesses in humans.

The results are consistent with a possible adverse effect of environmental magnetic field exposure on immune-related and other illnesses.”²⁴

Protective action or more research?

At what point does the weight of evidence warrant some form of protective action for both home and occupational exposures? This question was addressed by Les Dalton, author of *Radiation Exposures*, in a paper on ethics of radiation exposures:

“At some point a growing body of evidence of an association between a disease and a biologically active agent raises ethical as well as scientific questions. The ethical questioning becomes more pertinent if exposure is involuntary rather than voluntary. A genuine scientific urge to resolve uncertainties over association between an imposed exposure and an incidence of disease, in a study population, cannot be allowed to obscure the fact that continued exposure takes on some aspect of human experimentation. At some point we have to decide who should have the benefit of the doubt, those who are exposed to, or those who emit, the agent in question.”²⁵

Conclusions

As a direct result of the USA National Academy of Science/National Research Council's report in 1995, the USA National Cancer Institute's Linet study in 1996, and now in Australia the Royal Adelaide Hospital ELF mice study, we see calls for the ending of further research into possible adverse human health effects from exposure to powerline frequency electromagnetic fields. Upon careful examination of these three studies, this call is not justified.

When one considers the totality of evidence now available, there are indications that a risk may indeed exist. That risk may be small when compared to other risks in our modern society, but important due to its pervasive nature and possibility of serious consequences for affected individuals.

For medical practitioners who are dealing with patients on a daily basis, there is the possibility that some of their patients may be adversely affected by prolonged exposure to powerline magnetic fields in excess of 2 to 3 milliGauss (NCRP-Wertheimer). The extent of that possibility is uncertain. It may be that only a small subset of the population is affected by these fields. It may be that the 50-60 Hertz sinusoidal wave is not the active agent, but that transients riding on that wave may be the active agent. Most research has centred on the magnetic component of the electromagnetic field. It may be that in situations of exposure to the electric field, adverse effects may also occur.

For now, any conclusive answers to the question of the possible adverse effects of exposure to these fields must remain an uncertainty. However, it is the opinion of the authors that when the totality of existing scientific evidence is considered, a recommendation to patients (when there are indications of possible excessive EMF exposure), to avoid or lessen this exposure, is clearly warranted.

This could be considered a Precautionary Principle, which in this case could be stated as:

The precautionary principle should guide medical practitioners when confronted by potential threats to human health. The lack of full scientific certainty should not be used as a reason for postponing measures to prevent exposure to these potential threats. If measures generally reducing exposure can be taken at reasonable expense and with reasonable consequences in all other respects, an effort should be made to reduce exposures to a level below that which evidence indicates may be harmful to health.

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