

**Interagency
Advisory
Committee
on the
Health Effects
of
Electromagnetic
Fields:
Report
to
Ministers**

November 2004

Preface

In accordance with the Terms of Reference for the Interagency Committee on the Health Effects of Non-Ionising Fields, I present to you for consideration a report that summarises the principal outcomes of the Committee relating to its activities in recent years.

I am pleased to advise that the Committee considers that no new research has been reported which would cause it to change previous advice to Ministers, and that prevailing health and environmental policies are consistent with worldwide scientific and technical standards.

In particular, the Committee continues to endorse policies and standards based upon the application of exposure guidelines published by the International Commission on Non-Ionizing Radiation Protection.

The Committee notes that health and environmental concerns regarding electromagnetic fields continue to be of concern to populations within New Zealand and overseas. The Committee and its individual members appreciate these societal concerns and confirms that its considerations are focussed upon ensuring that New Zealand has a robust system of assessment in place so that these concerns can be appropriately handled.

As Chairperson, I take this opportunity of thanking the individual Committee members for their dedication and diligence in contributing to the outcomes of this report and commend the Committee's work to Ministers for consideration.

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1 Executive summary

A number of reviews into health effects of low and radio frequency electric and magnetic fields (ELF and RF fields) have been published since the previous report to Ministers by the Interagency committeeⁱ. Much of the research carried out since that report has been aimed at consolidating existing knowledge and resolving unanswered research questions, rather than investigating completely new avenues of research. The exception is in the area of low frequency fields, where there has been increased research carried out investigating neurodegenerative diseases (Alzheimer's disease, amyotrophic lateral sclerosis (ALS) etc) and cardiovascular disease.

Although questions still remain over the reason for a weak association between exposure to relatively high levels of low frequency magnetic fields and childhood leukemia, there is no good reason to believe that there is a cause and effect relationship between the two, or to reformulate exposure limits based on these findings. If the association represents a truly causal link, it has been estimated that in worst case magnetic fields would be responsible for less than 0.5% of cases of childhood leukemia. A New Zealand study found that none of the cases of childhood leukemia reported over a four year period was associated with exposure to high levels of magnetic fields. Indeed, it has been questioned whether there is anything to be gained from further epidemiological studies of the type which have been conducted to date. While there is some evidence of an association between employment in electrical occupations and ALS, it is felt that this is more likely to be due to risk of electric shocks, rather than extremely low frequency (ELF) fields.

While research into effects of radiofrequency (RF) fields is perhaps slightly less mature than for ELF fields, the findings to date have not given reason to believe that current exposure guidelines are inadequate to protect health. There are some major research programmes still under way, notably a multi-country (including New Zealand) study investigating whether use of cellphones is associated with incidence of brain tumours. The combined results of these studies will not be available for several years, but initial results have been reported from individual countries and have not shown a link between cellphone use and cancer.

Overall, the Committee considers that no new research has been reported which would cause it to change its previous advice to Ministers, and the Committee continues to endorse the application in New Zealand of exposure guidelines published by the International Commission on Non-Ionizing Radiation Protectionⁱⁱ.

2 Introduction

In March 2001 the Terms of Reference and membership of an existing interagency committee formed in 1989 to review possible health effects of exposures to extremely low frequency (ELF) electric and magnetic fields were extended to include consideration of radiofrequency (RF) fields.

The new Terms of Reference and committee membership are presented in an appendix.

The predecessor committee last prepared a review paper in 1998. This current paper summarises the findings of significant national and international reviews of research into possible effects of exposure to extremely low frequency fields published since then. The publications considered are mostly narrative reviews or commentaries, where the reviewers have reviewed all or part of the literature base and drawn conclusions based on their assessment of the studies considered. One publication, by Ahlbohm *et al*, is a meta-analysis, where data from several studies with very similar methodologies were combined in order to produce an analytical result of greater precision than the individual studies. In addition, relevant studies carried out in New Zealand have been highlighted.

Radiofrequency (RF) fields were included in the scope of the Committee's work as a result of the consultation process which led to the publication of the Ministry for the Environment's *National guidelines for managing the effects of radiofrequency transmitters* in December 2000. It was felt that there was a need for continuing government review of research into the possible effects of exposure to RF fields on health to ensure that government guidelines did not become outdated. This review picks up consideration of research from the point where the Guidelines were finalised in late 2000.

Current guidance from the Ministry of Health is to comply with exposure guidelines published in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP is an international scientific body which is recognised by the World Health Organisation for its expertise in this field. The ICNIRP guidelines have been widely adopted around the world, and have been incorporated into the New Zealand RF field exposure Standard New Zealand Standard 2772.1:1999 *Radiofrequency Fields Part 1: - Maximum exposure levels 3 kHz – 300 GHz*.

The ICNIRP guidelines set *basic restrictions* on fundamental dosimetric quantities. The dosimetric quantity used depends on the type of interaction between the electric and magnetic fields and the body which occur over different ranges of frequencies. For example, at frequencies below 10 MHz there is a basic restriction on the density of current induced in the body by exposure to a time varying electric or magnetic field. At frequencies greater than 100 kHz, there is also a restriction on the rate at which radiofrequency power is absorbed in the body. Protection from established health effects requires compliance with the basic restrictions.

While useful as fundamental quantities, the *basic restrictions* are generally impractical to measure in order to assess compliance. For this reason, ICNIRP also specifies *reference levels* in quantities more amenable to measurement, generally in terms of electric and magnetic field strengths. Compliance with the reference levels ensures compliance with the basic restrictions, and in most situations can be effectively regarded as “exposure limits” (although this term is not used as such in the guidelines). If exposures exceed the reference levels, this does not necessarily mean that the basic restriction is also exceeded. However, a more careful analysis is required in order to assess compliance with the basic restriction.

Different limits are set for persons exposed occupationally and for the general public. ICNIRP’s reasoning for this is that the occupationally exposed population consists of adults exposed under controlled conditions, who should receive training to inform them of potential risks, and precautions they should be taking. Occupational exposures are limited to the duration of the working day and over the working lifetime. The general public, on the other hand, includes individuals of all ages in all states of health, who will not normally be aware of the exposure they are receiving. They can be exposed for twenty-four hours per day, and over a whole lifetime, and should not be expected to accept any effects which may have no health consequences but nevertheless cause some annoyance or discomfort.

In addition to compliance with the ICNIRP guidelines, the Ministry of Health also recommends that where possible, low-cost or no-cost interventions should be voluntarily applied in order to avoid or reduce exposures. This is consistent with Ministry recommendations with regard to exposures from other agents, and recognises the impossibility of proving any agent absolutely safe, and the fact that there are still some areas where further research is being undertaken to complete our understanding of how electric and magnetic fields interact with the body. This approach is consistent with a requirement in the RF field exposure Standard to “Minimise, as appropriate, RF exposure which is unnecessary or incidental to achievement of service objectives or process requirements, provided this can be readily achieved at modest expense”. This approach is similar to that taken by the Ministry of Health for other agents.

3 ELF research and reviews

Research into the effects of ELF fields has largely been a consolidation and synthesis of previous work, with comparatively few major studies reported into possible effects on cancer induction or progression. Interest has started to broaden from the original concentration on cancer studies, to investigate whether there may be other effects such as on the cardiovascular system, and on the nervous system.

3.1 National Institute of Environmental Health Sciences

The final part of the EMF-RAPID programme (a five year programme coordinated by the US National Institute of Environmental Health Sciences (NIEHS) and Department of Energy (DOE)) was the publication of a report to Congress by the NIEHS. This report was based on the findings of a 1998 workshop review panelⁱⁱⁱ, which was discussed in the 1998 report from the Interagency group. In summary, the findings of the 1998 workshop review panel were:

- Based on studies suggesting associations between childhood leukaemias and residential exposures, and chronic lymphocytic leukaemia and occupational exposures, ELF fields should be regarded as a “possible carcinogen”.
- Evidence supporting this conclusion was limited, and could not be used for a definitive evaluation. For example, there is questionable identification of the exposure, bias may have played a small role in the findings, confounders were not ruled out, an observed effect was small, and there was little information on a dose-response relationship. Animal and other laboratory studies did not support or refute the conclusion.
- There is inadequate evidence for an association between carcinogenicity in adults and residential exposures, and associations with childhood cancers other than leukaemia.
- There is inadequate evidence for links to non-cancer diseases such as Alzheimer’s, depression and birth defects.

The NIEHS report to Congress^{iv}, published in May 1999, drew on the findings of this and other workshops, and on the results from research funded through the EMF-RAPID programme. The principal conclusions in that report were that:

- The scientific evidence suggesting that ELF exposures pose any health risk is weak.
- There is some indication from epidemiological studies of a possible increased risk of leukaemia in children from residential exposures, and chronic lymphocytic leukaemia in adults from occupational exposures. Such associations are weak, however, and are not supported by laboratory data.
- Other cancers or non-cancer health outcomes do not provide sufficient evidence of a risk to warrant concern.
- Laboratory studies do not suggest that everyday exposures to ELF fields cause health effects.

- Under the US National Toxicology Program, ELF fields would not be listed as an agent “reasonably anticipated to be a human carcinogen”.
- Exposure to ELF fields cannot be recognised as entirely safe, but aggressive regulatory action is not warranted.

The NIEHS suggested that their conclusions justified only passive regulatory actions, such as educating the public and the electricity industry on means to reduce exposures. The industry should continue its current practice of siting power lines to reduce exposures, and continue to explore methods to achieve such reductions without increasing other risks. Areas meriting further research were also highlighted.

As part of its own educational programme, the NIEHS published a comprehensive information booklet *Questions and answers about EMF*. The booklet discusses the nature and origin of ELF fields, results of health effects research, and exposure Standards. This, and the other publications resulting from the EMF-Rapid programme, is available for download at www.niehs.nih.gov/emfrapid.

3.2 New Zealand childhood cancer study

Results from a nationwide study in New Zealand were published in *Cancer Causes and Control (1998)^v* and *the Lancet (1999^{vi})*. The work was conducted by John Dockerty and colleagues from the University of Otago Medical School in Dunedin. The study included a total of 303 children diagnosed with cancer between 1990 and 1993, and another 303 comparison children without cancer. Parents were interviewed about the use of household electrical appliances, and measurements of electric and magnetic fields were taken in the children’s homes (for those with leukaemias and their controls).

The results showed no link between childhood cancer and the use of most household appliances. Among the many appliances studied, the results for childhood leukaemia and the child’s use of an electric blanket were: odds ratio 2.2, 95 percent confidence interval 0.7–6.4 (Dockerty *et al* 1998). However, this non-significant result may have been a chance finding. There was a weak non-significant association between exposure to strong measured 50 Hz magnetic fields and childhood leukaemia (odds ratio 3.3, 95% confidence interval 0.5–23.7) (Dockerty *et al* 1999).

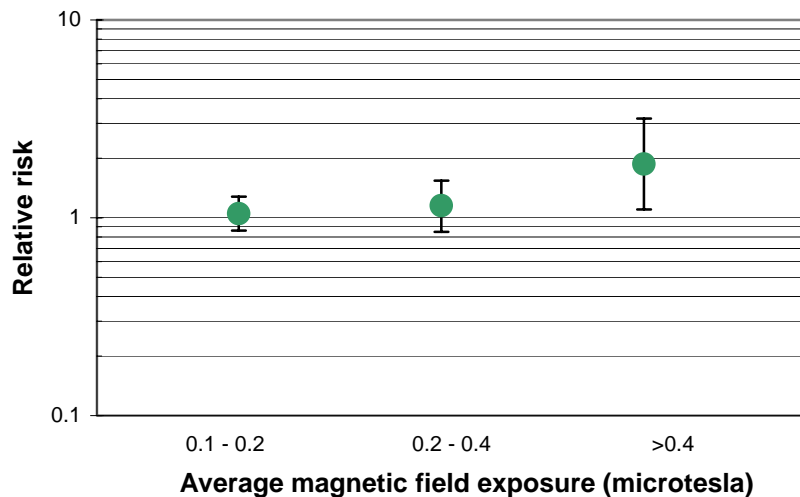
The investigators are continuing to work on other parts of their study, to investigate other possible risk factors for childhood cancers.

3.3 Ahlbom meta-analysis^{vii}

In the mid to late 1990s, several good quality epidemiological studies (including the New Zealand study) investigating the relationship between exposure to ELF magnetic fields and childhood leukaemia were published. In common with previous studies, these later ones suffered from considerable uncertainty in the results due to the relatively low number of study subjects in the highest exposure categories. By pooling the results in a meta-analysis, the study authors hoped to overcome

these limitations and reduce the statistical uncertainty inherent in the individual studies.

The meta-analysis took data from each of the contributing studies to evaluate the average exposure in the year preceding diagnosis of the leukaemia. Children were placed into one of four groups, depending on the level of their average exposure. Children in the lowest exposure group were used as a reference, and leukaemia incidence in the other groups was compared against that of the lowest exposure group. The results are plotted below.



The scale along the bottom of the graph shows the average magnetic field exposure, in units of microtesla. The scale up the side shows the relative risk of leukaemia in the three highest exposure groups, compared with the lowest exposure group. A relative risk of one would mean that there is no difference in incidence of leukaemia between the groups, a relative risk greater than one means that the incidence in the higher exposure group is greater than that in the lowest exposure group. Lines extending above and below each point show the margin of uncertainty (normally referred to as the confidence interval – CI) in the calculated relative risk. If the range of the uncertainty includes a relative risk of 1, the result is said to lack statistical significance – in other words, there is a high probability that the apparent increased risk arose through chance.

Although, on the face of it, the meta-analysis shows that there is an increased incidence of leukaemia associated with the highest exposures, and this is statistically significant (ie unlikely to have arisen by chance) the authors are very cautious in their interpretation of this result. They note that there is a reasonable likelihood that biases in the study designs may have accounted for some of the apparent increase, and also comment that “knowledge about risk factors for childhood leukaemia is very limited so one cannot exclude the possibility that adjustment for some other variable would have had an effect” (ie there was a possibility of confounding). Their final conclusion is that “The explanation for the increased risk is unknown, but selection bias may have accounted for some of the increase.”

Dr Mark Elwood, recently head of the Hugh Adam Cancer Epidemiology Unit at the Otago Medical School, and now head of the Australian National Cancer Control

Initiative, commented on the Ahlbom meta-analysis in the course of a report commissioned by the Ministry of Health. In addition to the caveats expressed by the study authors, he also pointed out that the choice of data used in the analysis also had a strong influence on the results. He cited the example of a Canadian study by McBride et al included in the meta-analysis. In the original study, magnetic field exposures were assessed by getting the children to wear a small backpack incorporating a magnetic field meter for 48 hours, placing the meter beside the bed at night time. In the Ahlbom meta analysis, however, this detailed information was not used: to provide consistency with the other studies, only in-house measurements from a fixed instrument were included. Whereas the original authors, using their more sophisticated exposure evaluation, found a relative risk of 0.44 (CI 0.11-1.80) for exposures between 0.4 and 0.5 microtesla (μT), and 0.89 (CI 0.24-3.36) for exposures greater than 0.5 μT , the result in the Ahlbom meta-analysis for the Canadian data showed a relative risk of 1.55 (CI 0.65-3.68). This example serves to illustrate the sensitivity of the results to the choice of measurement used in the analysis.

A table in the Ahlbom analysis shows that none of the childhood leukaemia cases in the New Zealand study fell into the highest exposure group. It is also worth emphasising that the exposure categories considered by Ahlbom are for *average* exposures. Whereas there are many everyday situations in which exposures may exceed 0.4 μT , measurement data shows that instances where average exposures exceed that value are quite rare.

3.4 NRPB/AGNIR

The British National Radiological Protection Board (NRPB) set up an Advisory Group on Non-ionising Radiation (AGNIR) in 1990 to aid the development of NRPB advice on non-ionising radiation. The Advisory Group issued its first report on ELF fields and the risk of cancer in 1992^{viii}, with subsequent updates published in 1993^{ix} and 1994^x. A further report on ELF fields and cancer was released in 2001^{xi}.

The AGNIR noted the improvement in quality of the studies published since their previous reports. This improvement was seen in both residential and occupational studies. In spite of this, though, the Advisory Group found that the evidence from occupational studies was still inconsistent, with no clear evidence of an effect on either brain tumours or acute myeloid leukaemia – the two cancers noted in 1992 as possibly showing an association with ELF field exposure. They found no reason to believe that residential exposures to ELF fields were associated with adult cancers.

With regard to childhood leukaemias, the Advisory Group agreed with the finding in the Ahlbom meta-analysis that there was a statistically significant increase in leukaemia risk associated with average exposures of greater than 0.4 μT . They, too, commented that in part this finding may be due to biases in the study methods and hence the extent, if any, of a direct cause and effect relationship was difficult to judge. Using exposure data from a large childhood cancer study in the UK, the NRPB commented that if the association between ELF field exposure and childhood leukaemia were real, then two of the 500 hundred cases of childhood

leukaemia diagnosed in the UK every year could be attributed to the effects of ELF fields, and one case every two years to the ELF fields from power lines.

In summary, then, the AGNIR findings on cancer in their 2001 report were:

- The scientific evidence suggesting that exposure to ELF fields poses an increased risk of cancer is very weak.
- Laboratory studies provide no good evidence that ELF fields are capable of producing cancer.
- Some epidemiological evidence suggests that long term exposure to comparatively high fields is associated with a small risk of leukaemia in children, but such exposures are relatively rare in the UK.
- Epidemiological studies do not suggest a general cancer risk from ELF fields, and there is no clear evidence of a carcinogenic effect in adults.
- The epidemiological evidence is not strong enough to conclude that such fields cause leukaemia in children, although that remains a possibility.

A second, briefer, review published in 2001 by the AGNIR^{xii} looked at neurodegenerative diseases. The report noted that research to date was mostly from epidemiological studies, but no laboratory research had been initiated to investigate the possibility of effects of ELF fields on animals or cell cultures which might lead to neurodegenerative diseases. While studies on the effects of weak ELF fields on calcium movement in and out of cells may have some relevance, it was felt that the evidence was, at best, “thin”.

Epidemiological studies suggested no clear evidence of an association with Parkinson’s disease, and only very weak evidence of an association with Alzheimer’s disease. While there was stronger evidence of an association between work in electrical occupations and ALS, this was felt to be more due to an increased risk of electric shock rather than ELF field exposure.

The NRPB published a further, comprehensive review in 2004^{xiii}, along with revised guidance on exposure limits^{xiv}. While the review of the research did not identify any new results suggesting the need for major revision of existing exposure limits, NRPB recommended that the ICNIRP guidelines should be adopted in the UK to replace NRPB-formulated limits which had previously been recommended. (The NRPB limits had the same basis as the ICNIRP guidelines, but set different reference levels.) The NRPB also recommended that internal electric field strength was a more appropriate measure than induced current density as a fundamental dosimetric quantity for ELF fields.

3.5 IARC

The International Agency for Research on Cancer (IARC) reviewed ELF and static fields^{xv} as part of the WHO International EMF project (discussed below). The review followed the standard IARC procedure, where agents are classified into one of five categories (tabulated below) depending on the nature of the research evidence into their potential carcinogenicity.

Category	Usual nature of evidence	Examples
1 Carcinogenic	Strong evidence of carcinogenicity in humans	Asbestos Tobacco Gamma radiation
2A Probably carcinogenic	Limited evidence of carcinogenicity in humans and strong evidence of carcinogenicity in animals	Diesel exhaust Sun lamps PCBs
2B Possibly carcinogenic	Limited evidence of carcinogenicity in humans but no support from animal or other studies	Car exhaust Coffee Pickled vegetables
3 Unclassifiable	Data inadequate to permit evaluation of carcinogenic or non-carcinogenic effects	Fluoride in drinking water Glass wool insulation
4 Probably not carcinogenic	Evidence showing no carcinogenic effect in humans and animals.	Caprolactam (substance used in nylon manufacturing) No others

IARC considered that the epidemiological studies of leukaemia in children provided only limited evidence of a carcinogenic effect in humans (as effects due to bias could not be ruled out), and that there was no support from animal studies. They found no consistent relationships between exposures to ELF fields and any other cancers in adults or children. On this basis they classified ELF fields as Class 2B (possibly carcinogenic).

3.6 Health Council of the Netherlands

In March 2000^{xvi}, the Health Council of the Netherlands (HCN) published a report updating their 1992 report on health effects of ELF fields. Their findings are summarised below.

- For the majority of the diseases and disorders that have been investigated, epidemiological research has not produced any evidence of a relationship with exposure to ELF fields at the relatively low field strengths that occur in the residential or working environment.
- Epidemiological research points to a reasonably consistent association between residence near overhead power lines and a slight increase in the risk of leukaemia in children. Were this association present in the Netherlands, less than about 0.5% of the cases of childhood leukaemia in the Netherlands could be explained by it. However, the data do not show that exposure to ELF fields is responsible for this association.
- Epidemiology also shows a weaker and less consistent association between occupational exposures and chronic lymphocytic leukaemia and possibly brain tumours. Here too, the data do not show that exposure to ELF fields is responsible for this association.

- Laboratory research has produced no evidence of a causal link between exposure to ELF fields and any form of cancer, nor has it suggested how ELF fields could cause cancer in humans. The cause of the associations that have been found in the epidemiological studies is unknown. It is conceivable that one or more factors other than ELF field exposure are responsible. There are no indications as to the nature of these factors.
- There is no reason to recommend measures to restrict residence near overhead power lines or working under circumstances involving increased ELF field exposure.

An update published in 2001^{xvii} considered more recent publications, including the meta-analysis by Ahlbom (discussed above) and another by Greenland et al^{xviii}. The HCN reaffirmed its earlier conclusion that the apparently positive association between magnetic field exposure and incidence of childhood leukaemia was not likely to be indicative of a causal relationship, on the grounds that the association was weak and without a reasonable biological explanation. Hence the HCN felt that adults and children living near power lines were not at risk.

The HCN Committee published a third update at the beginning of 2004^{xix}, which looked at the IARC assessment and a review carried out by the California Department of Health Services^{xx}. They felt that neither gave cause for the Committee to revise their conclusions. In addition, the Committee examined two 2002 studies into possible effects on risk of miscarriage. While both studies suggested a possible association between maximum magnetic field exposure and risk of miscarriage, they were also felt to have limitations which precluded any firm conclusions. It was felt that further research was needed.

3.7 ICNIRP

The 1998 exposure guidelines published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) were discussed in the 1998 report from the Interagency Committee. These guidelines were based on a review of the health effects research published to that time.

The ICNIRP Standing Committee on epidemiology published a further review in 2001^{xxi}, which examined numerous end points, including cancer, suicide and depression, reproductive outcomes, neurodegenerative diseases and cardiovascular disease.

The review devoted considerable discussion to the methodological issues which have arisen in this research, such as exposure assessment, and the potential for bias and confounding, as these were felt to be critical to the appraisal of the data. The authors confirmed the potential for selection bias to account for some of the apparent association between average exposure greater than 0.4 μT and childhood leukaemia, and found that the result was “difficult to interpret in the absence of a known biological mechanism or reproducible experimental support of carcinogenesis”.

With regard to adult cancers, the authors found that although the results were consistent with a relative risk of leukaemia in the most highly exposed groups of the

order of 1.1 – 1.3, at this level epidemiological methods may struggle to identify cause and effect relations, and overall the evidence supporting a role of ELF fields was weak. Similar conclusions were drawn for adult brain tumours.

Evidence for all the other outcomes considered was felt to be insufficient to draw any conclusions. Several studies have investigated incidence of ALS in electrical workers and these show an increase in mortality associated with ELF exposure. However, it was felt that some confirmatory studies, including consideration of possible confounding by, for example, electric shock, were needed before any firm conclusions could be drawn. The data on reproductive effects was considered to give very little encouragement for pursuing this line of research.

3.8 Conclusions of the Interagency Committee

There is a wide consensus that there is a weak but relatively consistent association between prolonged exposure to relatively strong magnetic fields and childhood leukaemia. There is no known mechanism which could explain this association, and hence there is considerable doubt over whether it is indicative of a cause and effect relationship. Evidence of links between exposures and adult cancers are, at most, very weak, and generally inconsistent. There is no good laboratory evidence suggesting an effect of ELF fields on the development of cancer. At most, the evidence merits only a passive regulatory response, if any. There are two large childhood leukaemia studies in progress in Japan and Italy, but results from these would need to show a very strong effect to cause a major change in these views.

Overall, these conclusions are very similar to those in the original 1993 review paper prepared for Ministers:

- Exposure to extremely low frequency (ELF) fields commonly encountered does not give rise to any established adverse associations with mental and physical performance, general health and reproductive outcomes.
- While there is some epidemiological evidence for a link between the incidence of some cancers and ELF exposure, no biological mechanism has been identified to explain the possible link and the evidence is very weak.

The ICNIRP review concluded that the most recent epidemiological studies investigating possible associations between ELF field and cancer were close to the limits of what could realistically be achieved, and that, especially for childhood leukaemia, there was little to be gained from further studies of the same type. Rather, there was a need to test specific hypotheses, such as the existence of biases, or aspects of exposure not previously captured. Perhaps the most useful line for further research is in the investigation of neuro-degenerative diseases. Occupational studies have shown a small but fairly consistent association with exposure to ELF fields. However, the evidence to date is too weak to conclude that there is a causal relationship.

4 RF reviews

Since publication of the joint *MfE/MoH National guidelines for managing the effects of radiofrequency transmitters*, there have been a few new reviews and other research initiatives investigating possible health effects of exposure to RF fields. Largely, these have concentrated on mobile phone technologies, as these, especially the handsets, are the source of the most widespread exposures and, to some people, concern.

4.1 French Health Ministry

The French Health Ministry commissioned an Expert Group to review recent reports into possible health effects of mobile phone technology and comment on whether they justified adapting risk management regulations adopted by French and European authorities^{xxii}.

The Group concluded that while research data indicated that biological effects occurred at exposure levels too low to cause any heating effects (in other words, at exposure levels permitted by current Standards), it is not yet possible to say whether these present a health hazard, or to state definitively that there are no health risks. If however, future research were to demonstrate the existence of health hazards, the risk to individuals would be very low, but in view of the large number of mobile phone users, the overall public health risk could be substantial.

Nevertheless, there is no data available which would allow meaningful revision of existing exposure limits, so a precautionary approach to manage any potential risks is recommended instead. The general objective should be to “reduce average exposure of the public to the lowest possible level compatible with service quality”. The Group suggested several means by which this could be implemented, including:

- individuals should take simple steps to reduce exposures from phones
- “Sensitive” buildings (hospitals, day care centres, schools etc) located less than 100 metres from a cellsite should not be directly in the main transmission beam
- Cellsites should be dispersed, rather than several operators being grouped together at a single site
- Although research data do not suggest that children are at greater risk than adults, and they do not receive higher exposures from cellphones, their cumulative exposure will be greater than adults’ so parents should be advised to ensure that children make reasonable use of cellphones.
- Exposure information should be available with phones.
- The European Union recommendations (on adoption of the ICNIRP guidelines) should be implemented as soon as possible.

4.2 Health Council of the Netherlands

The Health Council of the Netherlands (HCN) has published three reports since 2000, two dealing specifically with mobile phone technologies (one on GSM¹ base stations^{xxiii}, the other with mobile phones^{xxiv}) and one considering frequencies up to 10 MHz. An update to cover new research up to the end of 2003 was published at the beginning of 2004.

Besides considering possible health effects of ELF fields (discussed above) the report on frequencies up to 10 MHz is largely concerned with recommending exposure limits at these frequencies. These are largely consistent with the ICNIRP 1998 guidelines.

The HCN reports on GSM base stations and mobile phones both endorsed earlier HCN recommendations on exposure limits. These use the same basic restrictions as ICNIRP, but the reference levels recommended by the HCN become progressively less restrictive than ICNIRP at frequencies greater than 300 MHz. The HCN found that the research data provided no reason to apply any form of precautionary principle.

The mobile phones report examined research data on a wide variety of end points, including cancer, cognitive functions, the blood brain barrier and the immune system. None of the data was felt to provide evidence suggestive of adverse health effects, but further research in some areas was recommended in order to fully resolve some of the questions raised. No particular restrictions on use of mobile phones by children were recommended.

In the 2003 update, the HCN Committee found that the research published since its previous reports did not change their previous conclusions. The Committee discussed the occurrence of “non-specific symptoms”, such as headaches, gastrointestinal symptoms, fatigue, inability to concentrate, difficulty sleeping etc, which are sometimes felt by sufferers to be caused by exposure to RF fields. The Committee concluded that there is no causal relationship between these symptoms and exposure.

The HCN has also evaluated a recent study^{xxv} (often referred to as the “TNO study”) into the effects of GSM and UMTS²-like electromagnetic fields on well-being and cognitive functions. This study, which exposed one group of subjects who considered they had health problems attributable to electromagnetic fields and a second group with no such symptoms, found that exposure to the UMTS-like signal had an adverse effect on well-being in both groups. These findings were of considerable public interest, especially in the Netherlands.

In its evaluation^{xxvi}, the HCN made the following observations:

¹ GSM – Global System for Mobile Communication, the predominant technology used for mobile phone systems in Europe. There is a GSM network in New Zealand.

² UMTS – Universal Mobile Telecommunications System, an updated technology for mobile phone systems, often referred to as “3G”

- The TNO study was of good quality, both in design and execution.
- The field levels used for the exposures were higher than would normally be found around operating UMTS antennas, so the results of the study cannot be used to assess whether, and to what extent, there will be any effects in practice.
- There is debate about the validity of the questionnaire used to assess well-being, to the extent that it is uncertain whether the answers reflect a real change in well-being.
- As little or no similar research had been carried out before the TNO study, it should be regarded as explorative (ie not as testing an *a priori* hypothesis, but as generating hypotheses for future research to test).

The HCN made several recommendations for further research to try and replicate aspects of the TNO study, and explore further some of the questions raised. Overall, they felt that the TNO study could not be used to determine whether there was a causal relationship between exposure to electromagnetic fields and decreased well-being.

4.3 COST 281

In order to coordinate research into possible effects of exposure to electromagnetic fields, the European Union has initiated a programme under its COST (European Cooperation in the Field of Scientific and Technical Research) framework. COST 281, the programme was established in 2001 and is supported by most of the EU member states. COST 281 does not fund research, but attempts to bring together researchers and disseminate results so that research across the EU is carried out in a coordinated fashion.

A secondary objective of the programme includes scientific evaluation of the research, and the first of these was published as a “Watchdog Report” at the end of 2002^{xxvii}. The review concluded that “there have been no major new studies that justify increased concern about adverse health effects below the recommended exposure limits”, but noted the continuing public concerns about cellsites nevertheless. For this reason cellsites were subject of a special workshop held in May 2003, which investigated them from the points of view of exposure assessment, health effects research, psychological effects and risk communication. The 2003 Watchdog report^{xxviii} noted that while the debate on the possibility of there being significant adverse effects from exposure to relatively weak RF fields had continued, there were no major new studies to justify concern.

4.4 NRPB/AGNIR

An AGNIR report published in late 2003^{xxix} emphasised analysis of studies conducted since the UK Independent Expert Group on Mobile Phones (IEGMP) report^{xxx} (often referred to as the “Stewart Report”) of 2000. One of the findings in the IEGMP report was the suggestion of possible effects of RF exposure from cellphones on cognitive effects (reaction times etc). In their update, the AGNIR found that subsequent studies in this area had inconsistent results, with some studies finding effects and others none: and where effects had been found, results had been contradictory (for example, both speeding up and slowing down reaction

times). With regard to effects on calcium transport out of cells, however, the AGNIR found that none of the more recent studies supported the existence of an effect. The AGNIR also found no suggestion of an effect of exposure on cancer, and concluded that “In aggregate, the research published since the IEGMP report does not give cause for concern”. Nevertheless, the group also noted that mobile phones have only been in widespread use for a relatively short time, and that continued research was needed to resolve some of the limitations in the available data.

An NRPB review published at the beginning of 2004 drew essentially the same conclusions as the AGNIR report, and was used as the basis for a revision of NRPB exposure recommendations. These revised recommendations proposed adoption of the ICNIRP guidelines in the UK (to replace NRPB guidance, which had the same basis as the ICNIRP guidelines but different reference levels).

4.5 Swedish Radiation Protection Authority

The Swedish Radiation Protection Authority (SSI) commissioned a review^{xxxix} of epidemiological studies on brain tumours in cellphone users from Dr J Boice and Dr J McLaughlin of the International Epidemiology Institute. The authors reviewed nine such studies, plus two which investigated uveal melanoma.

While papers from one group of researchers suggested that there is an association between cellphone use (especially analogue phones) and brain tumours, the review commented that there were “serious methodological weaknesses with evidence of selection, response, and interviewer bias”. Overall, the review found that “the methodologically sound epidemiologic studies, both of cellular phone use and occupational RF exposures, are consistent in finding no evidence for excess brain tumours; there has not been a single reported dose-response relation based on any measure of phone use; the strength of the association, if it exists, is very weak and most studies rule out relative risks greater than 1.2 to 1.3; and there is no known biological mechanism that supports a causal relation and no evidence of adverse effects in laboratory animals.”

Subsequently, the SSI set up an independent expert group on electromagnetic fields, whose first report was published at the end of 2003^{xxxix}. The report considered RF fields of the type used for mobile phones, especially with regard to cancer, the blood-brain-barrier, heat shock proteins and a precautionary framework.

The group considered that there had been no breakthrough results providing firm conclusions one way or the other in any of the areas investigated, but further research was warranted. While the evidence on cancer risk in mobile phone users indicated no effects, follow-up periods were short and hence the findings were inconclusive. Animal studies generally provided no evidence of an effect on cancer. Some cellular studies suggested genotoxic effects at exposure levels higher than those caused by mobile phones, and further research was warranted in this area. However, there was no consistent evidence of any effect on cell proliferation.

Results of studies on heat shock proteins were also inconclusive and inconsistent, with no evidence of health effects. Investigations into effects on the blood-brain-barrier have been carried out over several decades, and while recent apparently positive results have rekindled interest, the group felt that “a careful analysis of the data does not indicate the existence of a health risk”.

4.6 Others

4.6.1 Australian RF Standard

Development of an RF field exposure Standard was passed by Standards Australia to the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) in 1999. The ARPANSA Standard was developed by a working group of the Radiation Health Committee, and published in 2002^{xxxiii}.

The Standard follows the ICNIRP guidelines quite closely. Like the New Zealand exposure Standard, it also includes a requirement for minimising exposures which are unnecessary or incidental to achievement of service objectives, provided that this can be achieved at reasonable expense. A number of annexes include useful background information on the basis for the Standard.

4.6.2 SSK RF Standard

The German Commission on Radiological Protection (SSK) approved *Limit values and precautionary measures to protect the public against electromagnetic fields* in September 2001^{xxxiv}. These limit values cover the ELF and RF ranges.

The review includes a summary analysis of the research. While acknowledging that there is evidence which has given rise to a suspicion of possible health effects from exposure to both ELF and RF fields, SSK concludes that the exposure limits recommended by the European Union (themselves based on the ICNIRP guidelines) are “suitable and flexible enough to protect against any adverse impact on health arising from general everyday exposure”. The SSK also recommend that as a precautionary measure, exposures should be minimised to the extent that this is technically and economically possible. They also recommend appropriate labelling of devices to indicate the exposures they cause, partly as a matter of general public information and partly to facilitate evaluation of situations where there is exposure from multiple sources.

4.6.3 New Zealand cellphone study

A research group headed by Professor Alistair Woodward of the Auckland Medical School is part of a worldwide study into cellphone use and brain tumours coordinated by the IARC³. A preliminary analysis comparing rates of cellphone use and incidence rates for tumours of the head and neck was published in 2003^{xxxv}. The authors found that while cellphone use in New Zealand had increased from zero in 1987 to the point where around one third of the population are regular users, there was no material change in incidence rates of tumours of the head and

³ For further information on the Interphone study see www.iarc.fr/pageroot/UNITS/RCA4.html

neck over this period. While this is reassuring, the authors cautioned that the study has severe limitations because of the design (an ecological survey looking at population trends, rather looking at individual experiences) and the limited follow-up period. A more detailed case-control study is in progress.

4.6.4 Hypersensitivity

The possibility that some people may be unusually sensitive to electromagnetic fields has been investigated in numerous studies over the past twenty years, initially in relation to ELF fields, but more recently to RF fields (especially from cellphones) as well. While it is clear that hypersensitivity exists, it is not clear what causes the symptoms, as provocation tests have not shown any clear link between exposure to electromagnetic fields and occurrence of the symptoms (as was noted in the 2003 HCN report). There are parallels with multiple chemical sensitivity.

4.6.5 Children and RF

One of the conclusions of the IEGMP report was that if there are any effects caused by exposure to RF fields which comply with existing Standards, children may be more susceptible. Two reasons were proposed for this: that children, because of their slightly different size and tissue composition, appeared to absorb more RF power than adults, and the cumulative period over which they could be exposed would be greater than for adults. For this reason the IEGMP recommended that non-essential use of cellphones by under-16s should be discouraged.

Since publication of the IEGMP report, further work has been done in this area. The more recent results have tended to discount the possibility that children may absorb higher levels of RF power than adults, and have not indicated that there may be any effects which could be exacerbated by cumulative exposure. No other review group has considered that special precautions are necessary for children, and ICNIRP has confirmed that its guidelines are intended to protect all exposed individuals, including children, and that no special approach beyond their recommended limits is necessary.

4.7 Conclusions of the Interagency Committee

Overall, there is a wide acceptance of the 1998 ICNIRP guidance, and the principles on which these Guidelines are based. The main points of difference are whether some form of precautionary approach should be adopted. The SSK and French recommendations support an exposure minimisation approach (similar to that in the New Zealand and ARPANSA RF field exposure Standards, and supported by the Ministry of Health for ELF exposures as well), whereas the HCN found that no precautionary approach was necessary. This type of approach has been supported in the relatively small volume of research literature on the subject.

5 Current research

There are still several research programmes in progress to try and add to our understanding of how electric and magnetic fields interact with the body.

First and foremost is the WHO International EMF Project. This project was established in 1996 to coordinate research, identify areas where further research is needed, publish authoritative health risk assessments in the WHO's Environmental Health Risk Criteria (EHC) series, and facilitate the development of internationally acceptable exposure Standards. The Project also maintains a database of research results.

Current timetables see the publication of the EHC documents on ELF and RF fields in 2004 and 2006 respectively. The Project has already published a handbook on risk communication, and is also working on frameworks for the development of Standards, and precautionary approaches.

Further details are available on the Project's website www.who.int/emf.

Following publication of the IEGMP report, the UK government established the Link Mobile Telecommunications and Health Research Programme (MTHR), to look into the possible health impact of Mobile Telecommunications. Funded by both government and industry, the programme has so far funded 17 research projects in a variety of fields. Further information is available on www.mthr.org.uk.

The Australian government has also set up a research programme, co-ordinated by the Australian Centre for RF Bioeffects Research at the Royal Melbourne Institute of Technology University. The programme is funded by the National Health and Medical Research Council of Australia (partly through levies on radio licences), with in-kind contributions from other centres. Several projects are in progress, including work on heat-shock proteins, dosimetry, EEG effects and effects on the blood-brain-barrier.

Appendix Terms of Reference

The Interagency Committee on the Health Effects of Non-Ionising Fields (the Committee) will provide the Director General of Health with high quality, independent scientific and technical advice on any potential health effects from exposures to extremely low or radiofrequency fields including:

- the quality and completeness of information on which findings and recommendations have been made
- assessment and review of the impact of research and information published locally and overseas, on policies, guidelines and advice promulgated by the Ministry of Health, Ministry for the Environment or Ministry of Economic Development
- other technical, scientific and epidemiological matters in relation to the extremely low or radio frequency fields as may be required.

The Committee will report to the Director General of Health, with copies of meeting notes provided to the Chief Executives of the Ministry for the Environment and the Ministry for Economic Development. Should there be reasonable suspicion of health hazards, or other issues of significance, these will be brought to the attention of joint Ministers. Annual and/or occasional reports will also be provided to joint Ministers.

Composition of the Committee

The membership of the Committee will include representatives from the following agencies, organisations, and sectors:

- Ministry of Health (including the National Radiation Laboratory)
- Ministry of Economic Development (including Energy and Communications)
- Ministry for the Environment
- Occupational Safety and Health Service of the Department of Labour
- public health service
- local government (Local Government New Zealand)
- academics/scientists
- consumers
- electrical industry (transmission and supply): up to two representatives
- telecommunications industry: up to two representatives.

The Ministry of Health will provide the Chair and secretarial support for the Committee.

Media Policy

In carrying their functions as members of the Committee, no member shall make media statements of any kind on behalf of the Committee or about the proceedings

of the Committee unless requested to do so by the Director General of Health. If members wish to discuss media issues, they should contact the Ministry of Health's Corporate Communications Unit in the first instance (tel. 04 496 2008, pager 026 112 413).

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