

The Possible Harmful Biological Effects of Low-level Electromagnetic Fields of Frequencies up to 300 GHz

IEE Position Statement - May 2004

Summary

The Institution of Electrical Engineers Policy Advisory Group on the Biological Effects of low-level Electromagnetic Fields (the “Group”) has concluded that the balance of scientific evidence does not indicate that harmful effects occur in humans due to low-level electromagnetic field exposure. This conclusion is the same as that reached in its previous position statements, the last being in May 2002 and has not been changed by the peer-reviewed literature of the past two years.

At low frequencies, the cumulative evidence from the large body of literature built up from intensive research over the past 20 years suggests that the existence of harmful health effects in general is unlikely. No generally accepted exemplar of any biological effect of such fields has been established. However, pooled analysis of epidemiological studies have suggested an association between higher magnetic field levels and childhood leukaemia. Whilst the raised risk is statistically significant it is relatively low, and this finding warrants further analysis and research.

At higher frequencies the existing data do not suggest any harmful effects exist. However, the Group is of the opinion that further research, both epidemiological and laboratory based, should be supported. This view is consistent with the conclusions of major reviews published elsewhere, and is based on public concern and the ubiquitous nature of our exposure to such fields rather than a likelihood that harmful effects exist. The UK Mobile Telecommunications and Health Research (MTHR) Programme goes some way to addressing this need with 18 research projects starting in 2002/3 (http://www.mthr.org.uk/research_projects/funded_projects.htm). These studies are still underway, with most expected to report their findings in 2004/5

The Group regards the replication of studies as essential in order to assess and improve the robustness of the existing literature at both low and high frequencies. In view of the difficulties encountered in past replication studies it continues to recommend that isolated reports of biological effects or epidemiological findings should be treated with caution until confirmed by independent groups. In this context, confirmation by researchers of their own earlier results is not viewed by the Group as constituting replication.

The failure of recent attempts to replicate high profile studies, such as the effects of radiofrequency fields on mouse tumours, and on reaction time and blood pressure in volunteers, is of concern to the Group and indicates the likely fragility of much of the literature. These replication attempts have taken several years and considerable scientific effort and funding. It would now appear that the original studies heightened public concern erroneously. The Group is of the view that scientists have an over-riding responsibility to ensure that their findings are robust before publication.

The Group detected a moderation of the trend for study results to be published in the media before they appear in the peer reviewed scientific literature. It continues to support

the ‘Guidelines on Science and Health Communication’ produced by the Social Issues Research Centre in partnership with the Royal Society and the Royal Institution (http://www.sirc.org/publik/revised_guidelines.shtml). These recommend that the journalist should indicate if the work has not been peer reviewed and, in these cases, that the study methodology should be carefully checked, and advice sought from an independent expert, before being reported.

In summary, the absence of any new and robust evidence of harmful effects in the past two years is reassuring. The Group is of the opinion that this should be taken into account by policy makers when considering both the implementation of a precautionary approach to public exposure and also during the development of exposure standards.

Introduction

The Institution of Electrical Engineers (the “IEE”) created the Group in November 1992 to consider the possible harmful effects of low-level, low frequency electromagnetic fields, primarily at power frequencies. The Group first reported in June 1994, and then approximately every two years since that date. Its reports form the basis of the IEE’s position on these matters. In January 1998 the terms of reference of the Group were extended to include frequencies up to 300 GHz to reflect public concern over possible health effects of radiofrequency (RF) fields, especially from mobile communications systems. The Group has produced a FactFile that introduces the subject area and discusses some of the key public concerns (<http://www.iee.org/Policy/Areas/BioEffects/emfhealth.pdf>).

The Group uses refereed full papers as its source material, retrieved from a broad literature search of a range of electronic databases. The methodology and sources used are described in the attached Appendix.

The literature searches retrieved a total of 810 relevant refereed full papers in 2002 and 2003 combined, a figure largely unchanged from the previous two years. Of these 58% (previously 65%) covered static and low frequencies, primarily relating to 50/60Hz fields associated with power generation and distribution. 34% (previously 28%) of the papers dealt with radiofrequencies, of which 43% (previously 35%) were specifically related to mobile phone frequencies (equivalent to 15% (previously 10%) of the total relevant literature). These figures show the continuing trend for EMF research to refocus from power frequencies towards mobile phone frequencies.

Because of the relatively clear distinction between low and high frequency studies, coupled with the different types of sources involved and the likelihood that any mechanisms of interaction are different, the Group has divided its assessment of the literature into these two frequency bands without attempting to define them rigidly.

The literature has been further divided into five areas: epidemiology, human studies, animal studies, cellular studies, and mechanisms of interaction. An additional, and increasing, area of activity is that of reviews by panels of scientists, reporting to governments or other political agencies, and the conclusions of these have also been considered. The points below summarise the views of the Group on the latest literature in all these areas, and on which the conclusions in this statement are based.

Epidemiology

- A number of investigations of the potential health risks of exposure to low frequency electromagnetic fields, either at home or at work, have been published over the last 2 years. Conditions studied include testicular cancer, breast cancer and birth defects following parental or in-utero exposure. These studies do not suggest a link between exposure and adverse health effects.
- The UK Childhood Cancer Study, a unique large-scale project including over 3,000 children diagnosed with leukaemia and cancer, has now published three key papers on the risk of exposures to low frequency electromagnetic fields. No increased risks were present from directly measured domestic exposure, residence near overhead power lines or domestic electrical fields. A further paper showed no associations for prenatal occupational exposures of mothers or fathers.
- An international combined analysis of nine earlier childhood leukaemia studies suggested a two fold raised risk of childhood leukaemia associated with households where the average low frequency magnetic fields were greater than 400nT. This association does not necessarily imply a causal link and further investigations of this finding, particularly in relation to selection bias, are in progress.
- Epidemiological studies of occupational exposure to radiofrequency fields from various sources have been published over a span of many years. No studies have been able to satisfactorily deal with dosimetry issues. None of the studies are readily interpretable and although some suggest risks, they are low and generally not repeatable.
- Studies on residential proximity to radio antennas and the risk of cancer are generally weak and have methodological deficiencies.
- Mobile phone base stations remain a cause of considerable public concern. The MTHR programme has funded an epidemiological study to investigate this issue with respect to cancer in children under five years of age but dosimetry remains a major challenge.
- Results from seven studies of the use of mobile phone handsets and the risk of brain cancer and acoustic neuromas have been published over the last few years. Overall no convincing evidence is present to suggest that the use of mobile phones increases the risk of these tumours in adults.
- An international collaborative study of 13 countries, investigating the risk of brain tumours and acoustic neuromas and mobile phone use is underway – the INTERPHONE study. Results from individual countries are expected in 2004/5 and the overall combined analysis of all countries is anticipated in 2005.

Human studies

- Recent laboratory studies with volunteers provide little evidence to suggest that exposures to electromagnetic fields are capable of causing consistent and

reproducible biological effects. Where field-dependent effects have been reported, their potential impact on health remains unclear. The few instances of attempted replication have not confirmed the original observations.

- At power frequencies, relatively few studies with volunteers have been undertaken, and no consistent reports of field-dependent effects have emerged. In particular, experimental studies have failed to corroborate short-term effects on cardiac function, and on melatonin levels with night-time exposure to magnetic fields.
- At frequencies associated with mobile phones, research with volunteers has centred on investigating subtle physiological effects on the brain, especially changes in cognitive function and EEG activity. However, the results of these studies are largely inconsistent: both negative and positive results have been reported, with no clear pattern to those studies reporting field-dependent effects. Of particular note was the failure of a Finnish group (using improved methodology) to confirm their earlier study showing field-dependent effects of GSM fields on reaction time.
- The possibility that blood pressure is affected by exposure to GSM fields now seems less likely. An attempt by the same group to confirm and extend their original observations failed to detect field-related effects.
- A Dutch study reported that exposure to 3G signals, but not GSM signals, may decrease scores of subjective well-being. The possibility that such exposure, at levels commonly found in the environment from base stations, may affect subjective symptoms requires further careful investigation: the existing data are too limited to draw any firm conclusions.
- In summary, recent studies with volunteers exposed to electromagnetic fields at all frequencies have failed to demonstrate any clear pattern of biological responses. In addition, inconsistencies in those studies reporting positive results question, but cannot rule out completely, the existence of any field-dependent effect. But overall, the results of recent studies make the possibility of adverse health effects following acute exposure seem less likely.

Animal studies

- Recent laboratory studies with animals exposed to low-level electromagnetic fields provide very limited evidence in support of field-dependent biological effects. Where effects have been reported, their potential impact on health remains unclear. The few instances of attempted replication of positive results have failed to confirm the original observations.
- At power frequencies, animal studies continue to suggest that low-level exposure to magnetic fields does not cause or affect the development of various cancers. Similarly, studies with rats provide largely inconsistent evidence for field-dependent changes in melatonin function.

- Studies of the effects of low-level magnetic fields on the brain and behaviour have also continued, and the possibility of subtle effects still exists. For example, recognition memory in rodents was reported to be unaffected by acute exposure in one study, but impaired by chronic exposure in another study.
- At frequencies associated with mobile phones, a number of studies using well-established animal models of cancer have reported a lack of effect of exposure on survival or on the incidence of spontaneous and chemically induced tumours. Most noteworthy, an Australian study (using improved methodology) failed to replicate an earlier study which reported that long-term, intermittent exposure to GSM signals increased lymphoma incidence in transgenic mice.
- One study suggested acute, low-level exposure increased the permeability of the blood-brain barrier and caused long lasting neuronal damage. However this study has severe methodological and other shortcomings which make its results unreliable. These particular findings are also incompatible with the results of other studies.
- Studies of possible effects of radiofrequency fields on the brain and behaviour have continued to produce sporadic positive results, although some of these may reflect compensatory thermoregulatory changes. However, worthy of particular mention are three studies which all reported a lack of any field-dependent effect of mobile phone frequencies on spatial memory processes in rodents following an earlier positive finding.
- In summary, as with the studies using volunteers, recent studies with animals have failed to demonstrate any obvious pattern of field-induced biological responses, and inconsistencies exist within the studies reporting positive results. Overall, the recent literature suggests that the possibility of increased risk of cancer or other adverse health effects from the fields associated with wireless telecommunications systems seem less likely, although subtle effects on brain function remain a possibility.

Cellular studies

- Cellular research at low frequencies is dominated by pulsed EMF studies, mainly medical in nature. Most show potentially beneficial effects over a wide range of clinical conditions, but predominantly bone or cartilage related. Some of the claimed effects are small and may not be clinically relevant even if confirmed; importantly there are few independent replications of these findings, however there are an increasing number of double-blind control studies being undertaken.
- At power frequencies (50 or 60 Hz) there is little convincing evidence that EMF exposure causes cancer, the energy is too low to break chemical bonds in DNA and data supporting its role as a co-promoter is too inconsistent to conclude that the effects are real. Other claimed effects of EMF exposure such as the reduction of cell-cell communication and induction of stress proteins are also too variable to show an emerging pattern. Independent replication studies generally do not support the claimed effects.

- At radiofrequencies, including those used by mobile phones and TETRA, there is no convincing evidence of a direct carcinogenic effect; most of the studies into DNA damage are negative. The results of studies into the induction of stress proteins are interesting, but show no cohesive pattern of response or sensitivity. Calcium studies, including those investigating the modulation frequencies, have not shown cause for concern.
- In general there remains doubt about the validity of most claimed effects of EMF exposure at the cellular level as there is a poor record of reproducibility of findings; the results do not appear to form part of any pattern in terms of exposure or biological response; there is no known mechanism of action and an almost complete absence of dose response effect.

Mechanisms

- There have been no major developments in the study of mechanisms at power frequencies. Work has continued in several areas, notably on the detailed behaviour of aerosols and the effect of power lines on them; on the effect magnetic fields have on free radicals; and on the extent to which the factors which produce magnetic fields also produce contact voltages in water pipes in homes, which may produce significant currents in people when touched.
- However the conclusion remains that there are currently no established plausible power frequency mechanisms for health effects, a fact that on its own is certainly not conclusive but which does reduce the plausibility of epidemiological findings which report small effects.
- Similarly, no plausible mechanism has yet to emerge by which high frequency electromagnetic fields can have biological effects at levels below those that cause heating. Free radical reactions continue to be investigated, but experimental evidence to support this mechanism in biological systems has yet to be found.
- The hypothesis that localized regions of high power deposition may occur at a sub-cellular level is being studied using microdosimetry modelling.

Reviews by scientific bodies

- In the past two years several national and international bodies have reviewed the scientific evidence on the biological effects of electromagnetic fields.
- The most recent of these (late 2003) is the report of the U.K. NRPB Independent Advisory Group on Non-Ionising Radiation entitled 'Health effects from radiofrequency electromagnetic fields':
http://www.nrpb.org/publications/documents_of_nrpb/abstracts/absd14-2.htm
 This extensive critique of the literature concludes that the research published since the IEGMP report (2000) does not give cause for concern. It states that the weight of evidence currently available does not suggest that there are adverse health effects, but draws attention to limitations of the existing research and recommends that research should continue. Mobile phone base stations are said to be unlikely to pose a risk to health.

- The Electromagnetic Fields committee of the Health Council of the Netherlands has published its 2003 update: <http://www.gr.nl/pdf.php?ID=886%20> . They conclude that the latest research does not indicate that exposure standards should be reduced. They discuss the application of the Precautionary Principle to electromagnetic field exposure and conclude that their recommended program of further research, coupled with the monitoring of other scientific developments, constitutes the appropriate application of the Principle until such time as scientific knowledge is on the verge of indicating health effects.
- The Swedish Radiation Protection Agency Independent Expert Group on Electromagnetic fields has presented its first annual report: http://www.ssi.se/english/EMF_exp_Eng_2003.pdf . Focusing on cancer, blood-brain barrier damage and heat shock proteins it concludes that no results have been obtained from which firm conclusions can be drawn and that the overall scientific assessment of possible health effects has not changed since the publication of the IEGMP report in 2000. It views replication of studies as essential before new results become accepted.
- A separate review of epidemiological studies of cellular phones and cancer, commissioned by the Swedish Radiation Protection Agency: http://www.ssi.se/ssi_rapporter/pdf/ssi_rapp_2002_16.pdf , concludes that they provide no evidence of a cancer risk. It reiterates that cell phones cannot directly damage DNA and hence are unlikely to be initiators of cancer. Cancer promotion is deemed unlikely because it would have been detected by existing studies. However the review recommends, as do all the reviews to date, that it would be prudent to carry out studies of long-term usage to provide further data.

Appendix

Search Criteria

The Policy Advisory Group concentrates on peer-reviewed literature retrieved by broad category, computerised, monthly searches of three major databases: INSPEC, MEDLINE, and BIOSIS.

INSPEC is a database maintained by the Institution of Electrical Engineers (IEE). Coverage is centred on four main subject areas: physics; electrical engineering; electronics and communications; computers, computing and information technology.

MEDLINE is the database maintained by the US National Library of Medicine (NLM). It provides access to articles published in more than 3,900 biomedical journals published around the world.

BIOSIS is an American 'not-for-profit organisation' that publishes biological abstracts and zoological records. It provides access to 6000 periodicals covering biological and biomedical sciences.

Group Reports

1. 'The Possible Biological Effects of Low-frequency Electromagnetic Fields' (Public Affairs Board Report No 10 - July 1991)
2. 'The Possible Biological Effects of Low-frequency Electromagnetic Fields' (Supplement to PAB Report No 10 - June 1994)
3. 'Possible Harmful Biological Effects of Low-level, Low-frequency, Electromagnetic Fields' (IEE Position Statement - November 1996)
4. 'Possible Harmful Biological Effects of Low-level, Low-frequency, Electromagnetic fields' (IEE Position Statement – May 1998)
5. 'The Possible Harmful Biological Effects of Low-level Electromagnetic Fields of Frequencies up to 300 GHz' (IEE Position Statement – May 2000)
6. 'The Possible Harmful Biological Effects of Low-level Electromagnetic Fields of Frequencies up to 300 GHz' (IEE Position Statement – May 2002)

Group Membership

Professor Anthony T Barker (Chairman)
Dr Leslie A Coulton
Dr Camelia Gabriel
Dr Patricia A McKinney
Dr Zenon J Sienkiewicz
Dr John Swanson