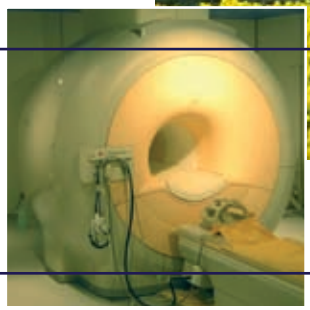
HEALTH EFFECTS OF ELECTROMAGNETIC FIELDS



Department of Communications,
Marine and Natural Resources

An Roinn Cumarsáide,
Mara agus Acmhainní Nádúrtha

Contents

Executive Summary

This report was compiled by a group of experts on electromagnetic fields (EMF). The Expert Group was established and funded by the Department of Communications, Marine and Natural Resources with the following terms of reference:

1) The Expert Group will focus on issues of public exposure, rather than examining occupational exposure.

2) The report produced by the Expert Group will be aimed at the Government and the public, rather than the scientific community.

3) The Expert Group will consult with Industry, recognised national and international experts and the wider community in order to complete its report.

4) In future, the Expert Group may be requested to take part in some ongoing monitoring; in order to update the Irish Government's position in light of new scientific publications or reports.

Members of the Expert Group were:

Dr Michael Repacholi (Chair), former Coordinator, Radiation and Environmental Health Unit, World Health Organisation;

Dr Eric van Rongen, Scientific Secretary, Health Council of the Netherlands;

Dr Anthony Staines, Senior Lecturer, University College Dublin;

Dr Tom McManus, former Chief Technical Adviser to the Department of Communications, Marine and Natural Resources;

Details of the membership of the Expert Group can be found in Annex 1.

This report provides science-based information on non-ionising radiation with particular reference to EMF, and includes responses to frequently asked questions as well as a brief review of the scientific literature that supports the conclusions and recommendations. Recommendations to Government on how best to deal with the EMF and planning issues are also included.

Responses to the following frequently asked questions are given in this report:

1. Are there any harmful health effects from living near base stations or using mobile phones?

2. Are there any harmful health effects from living near power lines and using electrical appliances?

3. How can safety be assured when new technologies are introduced before their health effects can be assessed?

4. Is it safe for children to use mobile phones and should phone masts be located near places where children gather?

5. Is electromagnetic hypersensitivity (EHS) caused by exposure to electromagnetic fields?

6. Why do reports of scientific studies often appear to reach different conclusions on EMF health effects?

7. The ICNIRP guidelines apply only to short-term exposure. How can they protect against long-term exposure?

8. Should precautionary measures be adopted in relation to EMF exposure?

9. How do the Planning Laws concerning phone masts have regard to public health and safety regarding EMF exposure?

The science review chapter includes a summary of the biological and health consequences of exposure to:

1. Radiofrequency (RF) fields produced mainly by radio, television and telecommunications systems;

2. Extremely low frequency (ELF) electric and magnetic fields from any device using electricity; and

3. Static fields generated mainly by magnetic resonance imaging used in medicine and transportation systems that operate from DC power supplies.

Conclusions

The conclusions of the Expert Group are consistent with those of similar reviews conducted by authoritative national and international agencies.

Radiofrequency Fields

Traffic accidents: The only established adverse health effect associated with mobile phone use, (both hand-held and hands-free) is an increase in traffic accidents when they are used while driving.

RF fields act on the human body by heating tissue. Health effects from RF are limited by international guidelines on exposure limits. RF fields normally found in our environment do not produce any significant heating. While non-thermal mechanisms of action have been observed, none have been found to have any health consequence.

So far **no adverse short or long-term health effects** have been found from exposure to the RF signals produced by mobile phones and base station transmitters. RF signals have not been found to cause cancer. However research is underway to investigate whether there are likely to be any subtle, non-cancer effects on children and adolescents. The results of this research will need to be considered in due course.

Siting of masts: When siting masts the maximum RF intensity always occurs at some distance from the antennas. While there have been suggestions to locate phone masts away from places where children gather, or away from hospitals, it should be understood that for mobile phone networks to operate efficiently, a minimum level of signal strength is needed. This applies irrespective of the location of the phone mast. If phone masts are located in suboptimal positions, this results in higher RF signals from both the mast and mobile phones to compensate for this. The net result can be that people are subjected to higher RF exposures in these areas, although the levels are still safe. A recent fact sheet issued by WHO indicates that the RF signals from base stations and wireless technologies are much too low to affect health (Annex 2).

Mobile phone use by children: There are no data available to suggest that the use of mobile phones by children is a health hazard. However, in Sweden and the UK, the authorities recommend a precautionary approach to either minimise use (essential calls only) or minimise exposure (by using a hands-free kit). In the Netherlands the use of mobile phones by children is not considered a problem. No research has found any adverse health effects from children using mobile phones, but more research on this issue has been recommended by WHO.

Extremely low frequency (ELF) fields

ELF fields induce electric fields and currents in tissues that can result in involuntary nerve and muscle stimulation, but only at very high field strengths. These acute effects form the basis of international guidelines that limit exposure. However, fields found in our environment are so low that no acute effects result from them, except for small electric shocks that can occur from touching large conductive objects charged by these fields. No adverse health effects have been established below the limits suggested by international guidelines.

Cancer: There is limited scientific evidence of an association between ELF magnetic fields and childhood leukaemia. This does not mean that ELF magnetic fields cause cancer, but the possibility cannot be excluded. However considerable research carried out in laboratories has not supported this possibility, and overall the evidence is considered weak, suggesting it is unlikely that ELF magnetic fields cause leukaemia in children. Nevertheless the evidence should not be discounted and so no or low cost precautionary measures to lower people's exposure to these fields have been suggested.

Siting of power lines: As a precautionary measure future power lines and power installations should be sited away from heavily populated areas to keep exposures to people low. The evidence for 50 Hz magnetic fields causing childhood leukaemia is too weak to require re-routing of existing lines, and so these measures should only apply to new lines. An example of how the Netherlands has dealt with this is available at:

www.vrom.nl/get.asp?file=/docs/20051004_letter_to_municipalities.pdf

www.vrom.nl/get.asp?file=/docs/20051004_elaboration.pdf

www.vrom.nl/get.asp?file=/docs/20051004_guideline.pdf

Static fields

Neither static magnetic nor static electric fields, at the levels members of the public are normally exposed to in the environment, are a short-term or a long-term health hazard. However, micro-shocks caused by the discharge of electrostatic fields can cause accidents if the person affected falls or drops something being carried.

Electromagnetic hypersensitivity (EHS)

EHS is a collection of subjective symptoms, such as headaches, sleeplessness, depression, skin and eye complaints, that sufferers attribute to EMF exposure. Symptoms suffered by EHS individuals are real and can be debilitating and require appropriate treatment. Research has not established any link between EMF exposure and the occurrence of EHS symptoms. A recent WHO fact sheet on this provides more details and a copy is in Annex 3.

Are children and the elderly more sensitive to EMF?

Currently there is no scientific evidence that children, diseased adults or the elderly are any more sensitive to EMF exposure than healthy adults. However, the ICNIRP international guidelines have included an additional safety factor of 5 into their exposure limits to take account of this possibility. At a recent WHO workshop convened to determine whether children were more sensitive than adults, it was concluded that they do not appear to be more sensitive than adults after about 2 years of age, and that the current ICNIRP guidelines seem to provided sufficient protection for children from EMF exposure.

Risk perception

Many factors can influence a person's perception of a risk and their decision to take or reject that risk. However, one very important factor is whether exposure to the risk is voluntary or involuntary. A WHO report published in 2002 gives more details on how people perceive risks, how to communicate better on EMF issues and ways to manage these issues.

Recommendations

International Guidelines

There should be strict compliance with ICNIRP guidelines: The ICNIRP guidelines on exposure limits have been recommended by the European Commission to its Member States, and they provide science-based exposure limits that are applicable to both public and occupational exposure from RF and ELF fields. They also provide sound guidance on limiting

exposure from mobile phones and masts, as well as for power line fields. The ICNIRP guidelines provides adequate protection for the public from any EMF sources. While the guidelines were published in 1998, they are constantly under review and still have appropriately protective limits. The guidelines are based on a weight of evidence review from all peer-reviewed scientific literature and not on the conclusions of any single scientific paper.

Government

There should be a new focus for Government to address EMF issues: Currently the Government has divided responsibility for EMF among a number of agencies. This has lead to a lack of focus and coordination on EMF issues. In addition there appears to be a conflict of interest since the Department of Communications, Marine and Natural Resources has responsibility for both promotion and development of mobile communications, as well as provision of health advice. The following recommendations are directed at the Central Government:

Central government, its policy makers and regulators, should take a **more proactive role** in providing health advice in relation to EMF and managing this issue through a single agency. This agency should be established and properly resourced with a mandate to cover both ionising and non-ionising radiations. The non-ionising radiations should include electromagnetic fields in the frequency range 0-300 GHz, infra-red, visible light, ultraviolet, lasers and ultrasound.

Ideally this agency should:

1. Have a mandate to cover all radiations and fields in the electromagnetic spectrum and ultrasound

2. Provide advice to local and central government, and other public bodies, on all appropriate radiation issues. This includes advice on regulations and standards for the safe use of ionising and non-ionising radiations

3. Provide information to the general public and the media on health and safety aspects of radiation

4. Monitor radiation exposures to the public

5. Conduct or manage research on radiation health and safety issues

The rationale for having a single agency responsible for all radiation health and safety issues is as follows:

- The skills required are similar for addressing all radiations and fields in the electromagnetic spectrum.

- While it would be possible to establish several agencies to deal with the radiation health and safety issues, the costs of this would be substantial. A single agency would provide value for money.

- This agency can act as a ‘one stop shop’ for the public.

- In many developed countries national authorities have established a single agency to provide this service (e.g. some Nordic countries, Australia, New Zealand, Singapore, Malaysia, Germany)

- There are many health concerns with various radiations that are not currently being adequately addressed by government. No government agency is responsible for the control of UV exposure; for example from sun beds or lasers used by the public or in industry and medicine. No government agency has a regulatory role for public exposure to static magnetic fields or ELF fields.

- Similar regulatory issues and public concerns arise for both ionising and non-ionising radiations.

- This agency would eliminate the current conflict of interest within the Department of Communications, Marine and Natural Resources.

While this agency should have employees with the knowledge and experience to manage radiation issues, it should also include:

- **A Scientific Advisory Committee.** This independent scientific committee should be appointed to review, from the Irish perspective, the published scientific data. It should be serviced by the agency, drawing on skills in the Civil Service, HSE, Irish universities, and international bodies, and be modelled on the UK Ad hoc Group on Non Ionising Radiation (AGNIR)

- **An EMF Safety Users Group.** Consultation with stakeholders on EMF issues is an important part of the process towards equitable solutions We propose that the agency and the Irish Scientific Advisory Committee should organise regular meetings and consultations with stakeholders on topical issues. This would be especially important when major new EMF or other radiation emitting facilities were to be established, such as major power line corridors.

- **A Policy Coordination Committee on Health Effects of EMF.** On this Committee there should be representatives from relevant government departments and state agencies having responsibility for EMF related issues and should be overseen by the relevant Government authority.

Mobile telephony

To ensure that readers understand what is being discussed, it is important to define the terms used in this report. Antennas are the RF radiating elements, masts are the structures supporting the antennas, and the base stations include all the antennas and their support structures as well as the communication electronics and their housing structure.

Siting of masts. This issue has been one of the main reasons why there has been so much concern expressed about base stations. Inputs provided to the Expert Group, through the public submissions process, suggest that the

planning guidelines for siting base stations are seen as lacking transparency and lacking any input from stakeholders (especially the public), and that insufficient information is provided to local authorities to make informed decisions for approval of new base stations. This has lead to a perception of health risks from the RF signals emitted from the antennas that is out of proportion with the scientific evidence.

While the scientific evidence does not indicate any health effects from exposure to the RF fields emitted by base stations, there has been a high level of frustration and anxiety about the lack of transparency in the approval process for new base stations. Part of the problem seems to be with the exemption process that applies to the construction of replacement masts and the placement of antennas and base stations on existing buildings. In addition many local authorities have adopted their own planning guidelines for the approval of new base stations, with different requirements on their location.

It is strongly recommended that national guidelines be agreed on the planning and approval process for new antennas on existing masts and future base stations through a public consultative process. Once agreement has been reached it should be implemented uniformly throughout Ireland. Examples of National Agreements in UK and the Netherlands are available at:

www.communities.gov.uk/index.asp?id=1144926

and

www.antennebureau.nl/index.php?id=185

respectively.

Results of emission monitoring on website. The results of measurements made near over 400 antennas are published on the Comreg website (www.askcomreg.ie), and we recommend that they be made available in a more user-friendly form, to facilitate comparison with similar measurements made in other countries, and comparison between sites. These data should be linked with the index of mast sites maintained by ComReg. If the recommended single agency takes responsibility for monitoring public exposures they should maintain this database and website.

Mobile phones

SAR notification on mobile phones is a voluntary requirement. A full explanation of SAR is given in the response to question 1. However manufacturers have accepted that the public needs this information and makes it available at the point of sale of mobile phones. These data are also available on the Mobile Manufacturers' Forum website at http://www.mmfai.org. All phones supplied in the European Union have a CE mark, which indicates, among other things, that they comply with the ICNIRP guidelines.

Certification. This is in place through the National Standards Authority and their certification process that complies with the EU regulations in this area.

Power lines

Siting of power lines: Where possible new power lines should be sited away from heavily populated areas so as to minimise 50 Hz field exposure. Where major new power lines are to be constructed, there should be stakeholder input on the routing. This could take the form of open public hearings or meetings with interested parties. The involvement of the EMF Safety Users Group mentioned above would be appropriate for this process.

General Issues

Use precautionary measures. Precautionary measures are recommended. WHO is drafting a framework for developing precautionary measures that could be appropriate for Ireland. It is important to note that lowering the limits in international guidelines as a precautionary measure is not recommended by WHO.

Treatment of EHS individuals. While symptoms suffered by EHS individuals are not directly related to EMF exposure, treatments have been developed in a number of countries. An example is given in Annex 4 (Swedish treatment regime). It is recommended that GPs in Ireland be provided information about the appropriate treatment for EHS symptoms and be informed that the symptoms are not due to EMF exposure.

EMF research in Ireland

The Group recommends that sufficient funds be made available in Ireland for scientific research on the health effects of exposure to EMF. A requirement for this should be that the research is performed with expertise available in Ireland – the principal investigators should be Irish scientists – but international collaboration should be encouraged and in some cases is a necessity. Research should address topics in the Research Agendas of the WHO International EMF Project, since these provide the most comprehensive and up-to-date list of gaps in knowledge.

The research program should:

- be managed through an established agency. This body would scientifically and administratively manage the program, and function as a buffer between the financing bodies and the researchers, so as to guarantee the scientific independence of the research.
- run for at least 5 years with a budget co-funded by government and the industry (e.g. mobile telecom operators, electricity companies).

There are a number of benefits to this. It will

- increase global knowledge about EMF effects
- expand the expertise on this subject in Ireland
- be better accepted by people as they generally place a higher value on results from national research than from other countries.

The following are some research topics the Expert Group considers to be feasible and needed in Ireland:

- A survey of EMF exposure of the population. Both ELF (50 Hz) and RF exposure (a range of frequencies) needs to be conducted at a variety of locations, both urban and rural.
- A pilot study on the use of mobile telephones by children to determine patterns of use (texting, messaging, calling) and the associated EMF exposures.
- The effect of mobile phone use on traffic safety. Non-hands-free use of a mobile telephone while driving has recently been prohibited in Ireland. However, there is some scientific evidence that road safety is not only negatively influenced by using a phone while driving, but also by diminished concentration on the traffic environment when making a mobile telephone call. It could be investigated whether the recent measures have improved road safety in Ireland.

Continue participation in International programmes: The Irish Government has been involved in international initiatives concerning the EMF-health issue over many years. It produced reviews on the topic in 1988 and 1992. In 1996 it was a founder member of the WHO International EMF Project and one of the project's first and continuing financial supporters. It has participated in all EU research initiatives and legislation concerning EMF exposure effects. In 1997 expert medical advice was provided to the EU investigation on the extent of EHS in Europe. Ireland was a founder member of the European Co-operation on Science and Technology (COST) Action 281, which sought a better understanding of the health effects of emerging communication and information technologies. Ireland also provided technical expertise to an EU Recommendation on limiting public exposure to EMF and to two occupational Directives dealing with limiting exposures to EMF and Optical Radiation.

Communication on EMF Risks

It is recommended that the public be provided with information about the risks of EMF exposure and kept informed of recent scientific developments. This can be achieved through a number of avenues:

- A central contact person within the proposed single agency should be appointed to provide to the public responses about EMF issues and to respond to questions from the media and other parties
- An active, informative and user-friendly website giving details of the health effects of EMF, what the government is doing to ensure compliance with EMF standards and other topical issues of concern.
- A brochure about EMF that can be provided to concerned citizens. The frequently asked question section of this report could be published and made available to interested parties.

Optical radiation

While this report deals mainly with lower frequency EMF, optical radiation (ultraviolet, light and infrared, including lasers) also form part of the non-ionising electromagnetic spectrum. There are important health issues related to exposure to optical radiation that should be addressed. Ultrasound emissions should be addressed within the same framework especially in the context of its safe use in industry and medicine.

Chapter 1
Introduction

Many people in Ireland have expressed concern that exposure to electromagnetic fields (EMF) from mobile phone base stations (generally referred to by people in Ireland as masts) and high voltage power lines may have adverse effects on their health. The Joint Oireachtas Committee on Communications, Marine and Natural Resources (Joint Oireachtas Committee), examined the issue of non-ionising radiation and published a report "Non-ionising radiation from mobile phone handsets and masts", in June, 2005. At the same time this issue was being dealt with by staff at the Department of Communications, Marine and Natural Resources. As a result an Inter-departmental Committee on Health Effects of Electromagnetic Fields (Inter-departmental Committee) was appointed by the Government in September 2005. This Inter-departmental Committee established an Expert Group on the Health Effects of EMF in November 2005 to provide conclusions and recommendations about EMF exposure under the terms of reference given in the Executive Summary.

The Expert Group identified questions requiring detailed consideration from four sources. These were the terms of reference, the recommendations of the Joint Oireachtas Committee, the public consultation process and the Inter-departmental Committee.

Questions arising from this process are given in Chapter 3.

Issues arising from the Expert Group's terms of reference included:

- Are the elderly and children more sensitive to EMF?
- How should the issue of locating new masts be addressed?
- Should power lines be located away from schools?
- What changes in Government structure should be made to better address EMF issues?
- What research should be conducted in Ireland to better address and understand local issues?
- How can we better communicate any risks from exposure to EMF?

Reviews were conducted of scientific reports on the health effects of exposure to: radiofrequency (RF) fields (frequencies from 300 Hz to 300 GHz), including those associated with mobile telecommunications, radio and television; extremely low frequency (ELF) fields (frequencies >0 to 300 Hz that exist where electricity is generated, distributed or used in electrical appliances; and static fields (frequency 0 Hz) associated with such devices such as Magnetic Resonance Imaging in medicine or direct current (DC) used for transportation systems. Brief reviews of the health effects of exposure to UV light and laser light were also prepared.

Consultations were held with representatives of central and local government, concerned citisens groups and industry. In addition, the draft report was subjected to an international panel of recognised scientific experts and reviewed by the Inter-departmental Committee. Membership of the Expert Group, the International Panel of experts, and those interested parties consulted by the Expert Group are listed in Annex 1.

This report provides the conclusions from the review of the scientific literature, addresses key topic of concern, and makes recommendations on:

- Adoption and compliance with international standards
- Participation in international programmes
- Appropriate government structures to best manage the EMF issues and to respond to public and local authority concerns
- Use of precautionary measures
- Planning for the location of new base stations
- Siting of new power lines
- Assistance for hypersensitive individuals
- EMF research that would be useful to Ireland

Chapter 2
What are Electromagnetic Fields?

Electromagnetic fields (EMF) are all around us. We need them to see, to listen to radio and watch television, to communicate using mobile phones, and we generate them every time we turn on a light switch or use an electric appliance.

Ionising versus non-ionising radiation

An electromagnetic field is a generic term for fields of force generated by electrical charges or magnetic fields. Under certain circumstances EMF can be considered as radiation when they radiate energy from the source of the fields. Electromagnetic waves periodically change between positive and negative. The speed of the changes, or the number of changes per second, is called the frequency and is expressed in hertz (1 Hz = 1 full cycle of change per second).

Often when people think of EMF, they think of radiation that is associated with X-rays, radioactivity or nuclear energy. What people consider as 'radiation' is ionising radiation that contains sufficient energy to cause ionisation; that is, they can dislodge orbiting electrons from atoms or break bonds that hold molecules together, producing ions or charged particles. Production of ions or ionisation in tissues may result in direct damage to cells causing health effects. These types of high-energy radiation, that include X-rays, gamma rays and cosmic rays, are called "ionising radiation".

But these are not the only types of radiation in the electromagnetic spectrum: there is a continuous spectrum of fields (see figure 2.1). All other types of radiation do not have enough energy to result in ionisation and so are referred to as "non-ionising radiation". This full spectrum of electromagnetic radiation and fields can be divided into discrete bands having different interactions on living organisms: ultraviolet radiation, visible light, infra-red radiation, microwaves, radiofrequency fields and low frequency fields (figure 2.1).

This report covers three main types of non-ionising EMFs – radiofrequency (RF) fields (defined as EMFs with frequencies in the range of 300 Hz to 300 GHz), extremely low frequency (ELF) fields (EMFs in the frequency range between 0 and 300 Hz), and static fields (electric and magnetic fields that are not varying with time and therefore have a frequency of 0 Hz).

Ultraviolet (UV) radiation, visible light, and infrared radiation are only briefly covered in this report, but it is important to emphasise that the main public health impacts of non-ionising radiation come from exposure to UV, from sun exposure and the use of tanning salons.

Units:

Hz	hertz, cycles per second
kHz	kilohertz, 10^3 Hz
MHz	megahertz, 10^6 Hz
GHz	gigahertz, 10^9 Hz
THz	terahertz, 10^{12} Hz
PHz	petahertz, 10^{15} Hz
V	volt, unit of potential
V/m	volt per metre, unit of electric field strength
A	ampere, unit of current
A/m^2	ampere per metre squared, unit of current density
W	watt, unit of power
W/m^2	watts per metre squared, unit of power density
W/kg	watts per kilogram, unit of specific absorption rate (SAR)

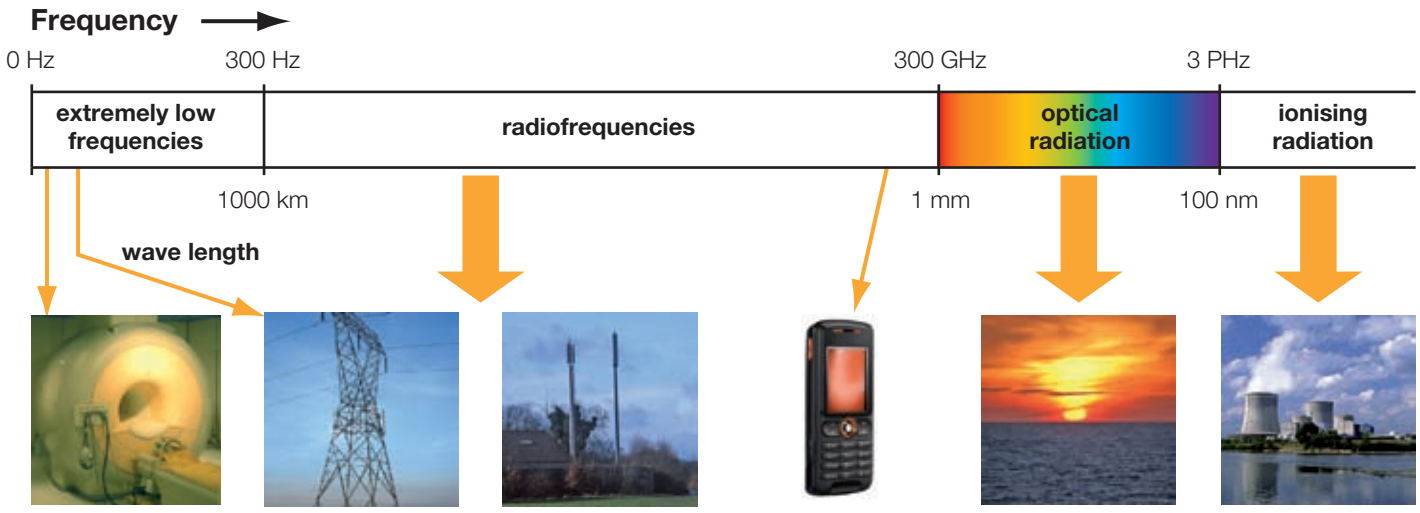


Figure 2.1 The Electromagnetic Spectrum

Chapter 3
Frequently Asked Questions

Introduction

The following nine questions reflect specific concerns expressed by individuals, groups and organisations that responded to the DCMNR's request for submissions to the Expert Group. The material used in the preparation of these responses is taken from the Science Review section of this report (Chapter 4) that gives a more detailed overview.

General background information on EMF is given in chapter 2 of this report. However it is very important to recognise that not all biological effects result in health consequences. While exposure to EMF may result in a detectable change in the exposed organism, this effect will only have an effect on the health of the organism if the effect is outside its compensatory mechanism. For example, a rise in temperature results from RF exposure. However, such a temperature increase will only have detrimental health consequences if the temperature rise exceeds about 2-3°C.

The following questions are discussed:

Question 1: Are there any harmful health effects from living near base stations or using mobile phones?

Question 2: Are there any harmful health effects from living near power lines and using electrical appliances?

Question 3: How can safety be assured when new technologies are introduced before their health effects can be assessed?

Question 4: Is it safe for children to use mobile phones and should phone masts be located near places where children gather?

Question 5: Is electromagnetic hypersensitivity (EHS) caused by exposure to EMF?

Question 6: Why do reports of scientific studies often appear to reach different conclusions on EMF health effects?

Question 7: The ICNIRP guidelines apply only to short-term exposure. How can they protect against long-term exposure?

Question 8: Should precautionary measures be adopted in relation to EMF exposure?

Question 9: How do the Planning Laws concerning phone masts have regard to public health and safety regarding EMF exposure?

Question 1: Are there any harmful health effects from living near base stations or using mobile phones?

Response: From all the evidence accumulated so far, no adverse short or long term health effects have been shown to occur from exposure to the signals produced by mobile phones and base station transmitters. However studies have mainly involved looking at cancer and cancer-related topics. Among other studies being planned are prospective cohort studies of children and adolescent mobile phone users and studies of health outcomes other than brain cancer including more general health outcomes such as cognitive effects and sleep quality.

The only established adverse health effect associated with mobile phones is with traffic accidents. Research has clearly demonstrated an increase in the risk of traffic accidents when mobile phones (either hand held or with a hands-free kit) are used while driving.

To function, a mobile phone must communicate by radio signals with a nearby base station. A mobile phone call from Ireland to a mobile phone in Australia is made up of two local wireless connections: a call to the nearest base station in Ireland plus a second call from the base station in Australia nearest to the other mobile phone. The worldwide communications network links the two base stations.

Each of the 4500 base stations in Ireland is at the centre of a cell. Each cell in turn can handle a limited number of concurrent phone calls. Adjoining cells use slightly different frequencies to prevent interference. However because there are only a limited number of frequencies available for mobile telephony they must be reused in other cells. To do this no immediately adjacent cells use the same frequencies. Because of the limited number of calls that can be handled by a base station at one time, the number of base stations in a given area has to be increased to accommodate greater mobile phone use. As a result, the signal strength from base stations and mobile phones will be reduced. Moreover, signals between the base station and the phone constantly adjust to the lowest level necessary for efficient operation.

Box 3.1 How a Mobile Phone Works

Mobile phone use

Mobile phones are now an integral part of modern telecommunications. In some parts of the world they are the only reliable phones available. In Ireland their popularity is due to the ease with which they provide continuous communication without inhibiting freedom of movement. Worldwide, the number of people using mobile phones is approaching two billion. In Ireland, over four million mobile phones are now in use. Without base stations these phones could not function.

Exposure characteristics: mobile phones

A person's exposure to a mobile phone is measured in terms of Specific Absorption Rate (SAR). This is a measure of the rate of energy deposition in a person's body during a call and is expressed in watts per kilogram (W/kg). The SAR varies depending on the distance to the nearest base station and whether there are RF signal absorbing obstacles between the caller and the base station, such as buildings, tunnels etc. The SAR exposure from the mobile phone will be highest when the base station is distant and/or the user is in a building or a stationary vehicle that impedes the phone signal. The phone will then operate with maximum signal strength. All phones are provided with details of the maximum SAR they will produce when operating under such conditions. The SAR values are all measured in exactly the same way in EU approved laboratories to ensure the values obtained are accurate and comparable.

SAR values for the most widely used phones range from 0.1 to 1.2 W/kg.

The maximum SAR levels for exposure of the general public recommended in the 1999 Recommendation of the EU Council of Health Ministers (EU, 1999) are compared to the typical mobile phone SARs in Box 3.2.

Frequency (MHz)	EU SAR limit (W/kg)	Typical phone SAR (range) (W/kg)
900	2.0	0.7 (0.2 – 1.2)
1800	2.0	0.7 (0.2 – 1.2)
1900	2.0	0.3 (0.1 – 0.5)

Box 3.2 Comparison of EU SAR limits and actual mobile phone handset SARs

Exposure characteristics: phone masts

Unlike mobile phones, where the user's exposure to RF fields is localised to that part of the body closest to the phone antenna, a person's whole body is exposed to the RF emissions from phone mast antennas (base station). Exposure to a mobile phone base station is measured in terms of power density. This is a measure of the rate at which RF energy is reaching a person from that base station. The unit of power density is 'watt per square metre' (W/m^2). The actual exposure of an individual depends on the height of the transmitting antennas on the mast, the power output and gain of the antennas, the direction of the beam, and the distance of the individual from the antennas.

On a typical phone mast the antennas are mounted at the top of a triangular metal lattice tower 20 to 30 metres in height. Antennas can also be found mounted on shorter platforms on the roofs of buildings. The power input to the antennas is of the order of 20 to 30 W. The antennas shape and emit the radio signals into a narrow beam that is directed downwards at an angle of between 5 and 10 degrees. The peak exposure at ground level is typically found 50 to 300 metres from the base of the tower, depending on its height, and whether the ground is flat and there are no intervening buildings or other barriers. Because there can be many obstacles to the beam, especially in urban areas, the calculation of public exposures to base stations is complex. It is usually simpler to determine the strength of the RF field from a phone mast by direct measurement, although several measurements are generally required before the highest field strength and its location are identified.

Public exposures in the vicinity of 400 phone masts in Ireland were measured in 2004 and 2005 (*ComReg*, 2004). Measurements rarely exceeded 0.01 W/m^2 and more often were around 0.001 W/m^2 or less. The maximum allowable public exposure levels (*EU*, 1999) are hundreds to thousands of times greater than this – 4.5 W/m^2 at 900 MHz. Only by approaching the phone mast antennas to within a few metres and within the main beam is it possible to exceed this limit. Such access should be prevented by barriers or other means.

Health concerns: mobile phones in general

Given the large number of phone users, even small adverse effects on health could have major public health implications. Although public exposure to RF fields from mobile phones are within the EU limits, these exposures are still much higher than those previously experienced by the general public. This has led public health authorities and the World Health Organisation to promote research into the possible adverse health effects of mobile phones. The INTERPHONE study (http://www.iarc.fr/ENG/Units/RCA4.php) is a leading example.

RF fields penetrate tissues to depths that depend on the frequency. At mobile phone frequencies the RF energy is absorbed to a depth in tissue of about one centimetre. RF energy absorbed by the body is converted into heat that is carried away by the body. All established adverse health effects are caused by heating. While RF energy can interact with tissues at levels that do not cause significant heating, there is no consistent evidence of adverse health effects at exposures below the international guideline limits.

Health concerns: mobile phones and cancer

Current scientific evidence indicates that exposure to RF fields emitted by mobile phones is unlikely to induce, progress or promote cancer. Several studies of animals exposed to RF fields similar to those emitted by mobile phones found no evidence that RF causes or promotes brain cancer.

The INTERPHONE study is a major epidemiological study to determine if there is any relationship between mobile phone use and tumours in the head. It is being co-ordinated by WHO's International Agency for Research on Cancer (IARC) and involves 14 studies conducted in 13 countries, all using an identical study protocol. Nothing untoward has emerged from the results published so far, although reports of an increased incidence of acoustic neuroma (a benign tumour of the acoustic nerve) among people who have been using mobile phones for more than ten years will require further investigation. However this results was not confirmed in a recent study conducted in Denmark.

An analysis of a set of Swedish studies conducted by the same investigators suggests an association between mobile phone use and brain tumours, but these studies have been criticised to the extent that the results they have produced are not convincing. Other recent epidemiological studies have found no convincing evidence of an increase in the risk of cancer or any other disease with use of mobile phones.

Health concerns: mobile phones and other health risks

Some scientists have reported other effects of using mobile phones including changes in brain activity, reaction times, sleep patterns and self-reported well-being. These effects are small and have no clear health significance. More studies are in progress to try to confirm these findings.

Driving while using a mobile phone is a proven cause of traffic accidents. The use of a hands-free kit does not significantly reduce the risk. (*IEGMP*, 2000)

When mobile phones are used close to some medical devices such as pacemakers, implanted defibrillators and certain kinds of hearing aid, there is a possibility of causing interference. There is also a possibility of such interference with aircraft guidance systems. These concerns are gradually being overcome with better design to stop this equipment being interfered with by RF signals.

Health concerns: phone masts in general

A concern among the public about base stations is that whole body exposure to the RF signals they emit may have long-term health effects. To date the only acute health effects from RF fields have been confined to occupational over-exposures in industrial situations. No public exposure falls into this category. Phone mast exposures are broadly similar to or below those from radio and television stations that have been broadcasting worldwide for over sixty years. (*WHO*, 2006)

Few studies have investigated general health effects in individuals exposed to RF fields from base stations because of the difficulty distinguishing their very low signals from other higher strength RF sources in the environment. Paging and other communications antennas such as those used by the fire, Gardaí, and emergency services operate at similar or higher power levels than base stations.

Some individuals report non-specific symptoms upon exposure to RF fields from base stations. As recognised in a recent WHO fact sheet (*WHO*, 2005), EMF has not been shown to cause such symptoms. Nonetheless it is important to recognise the plight of people suffering from them.

Health concerns: phone masts and cancer

There have been media reports of cancer clusters around base stations that have heightened public concern. Generally, cancers are distributed unevenly among any population (*National Cancer Registry*, 2005). Given the large number of base stations and their distribution around centres of population it can be predicted that some concentrations of cancer or other diseases will occur in the vicinity of a base station. This does not mean that the base station is the cause of the cancer cluster. Investigations of such clusters often show that there is a collection of different types of disease with no common characteristic or cause.

Over the past 15 years, several epidemiological studies have examined the potential relationship between RF transmitters and cancer (*NRPB*, 2004; *WHO*, 2005; *HCN*, 2005). These studies have as yet provided no evidence that RF exposure from the transmitters increases the risk of cancer. Likewise animal studies have not established an increased risk of cancer from exposure to RF fields, even at levels that are much higher than those produced by base stations.

Conclusions

It remains unclear to what extent the long-term use of a mobile phone is related to the occurrence of acoustic neuroma because one study has identified an association and another has not. Further, if the association is real, this appears to relate only to the use of the older analogue phones and not the currently used digital types such as GSM phones. There is some evidence from one series of studies of an association between brain tumours and mobile phone use but these studies have been the subject of considerable criticism. For both types of tumour the results of the INTERPHONE study and the pooled analysis of these results by IARC, which will be available in 2007, will provide a more reliable picture.

While there is no evidence that mobile phones are detrimental to health, the UK *NRPB* (2004) endorsed the recommendation of the Stewart report (*IEGMP*, 2000) that the use of mobile phones by children be limited. In the Netherlands, however, the Health Council saw no reason to recommend that mobile phone use by children over the age of two be restricted (*HCN*, 2002; 2005).

The question of whether living in the proximity of a base station is associated with an increased risk of developing an illness concerns many of the people who find themselves in this situation. However, considering the very low exposure levels and the scientific evidence available to date, it appears highly unlikely that the weak signals people are exposed to from base stations could cause cancer or any other adverse health effects (*WHO*, 2006)

Question 2: Are there any harmful health effects from living near power lines and using electrical appliances?

Response: Power lines and electrical appliances are sources of Extremely Low Frequency (ELF) fields. The International Agency for Research on Cancer (IARC) concluded, on the basis of limited evidence in humans that ELF magnetic fields are a possibly human carcinogen. This does not mean that ELF magnetic fields are actually carcinogenic, simply that there is that possibility. Evidence for the association between ELF magnetic field exposure and childhood leukaemia derives from epidemiological studies. These studies, taken individually or as collectively reviewed by expert groups, are insufficient either to make a conclusive judgement on causality or to quantify appropriate exposure restrictions. Apart from this there are no other identified harmful health effect from ELF exposure, where such exposures are below the international limits.

Exposure characteristics: power lines

Everyone in Ireland who uses electricity is exposed to 50 Hz electric and magnetic fields. These two types of field are associated with the transmission, distribution and use of electric power. The electric field is related to the voltage of the power supply and the magnetic field to the electric current flowing through the wires. The strength of the fields increase with increasing voltage and current respectively. However the fields fall off very rapidly with distance from source.

The maximum electric field strength directly under the mid-span of an ESB 220 kV transmission line is 5 kilovolts per metre (kV/m). The corresponding maximum magnetic field strength is about 7 microtesla (μT). At 30 metres distance from this point, the strength of the electric field falls fourteen-fold and the magnetic field ten-fold to 350 V/m and 0.7 μT respectively. While the walls of a house will shield the occupants from the electric field, the magnetic field is not impeded and passes through buildings with little attenuation.

Exposure characteristics: electrical appliances

The fields close to operating electrical appliances can be higher than those found near power lines; magnetic fields fall off at a rate inversely proportional to the cube of the distance from the appliance. For example, an electric can opener can produce fields of 20 μT, a hair dryer can expose the user to magnetic fields of 7 μT, cooking hotplates to 4 μT and a TV set to 2 μT. However even in a busy kitchen, the magnetic field in the centre of the room will rarely exceed 0.2 μT.

Magnetic field exposures last only for as long as the appliances remain switched on. Of the more common electrical appliances, electric (analogue) bedside clocks and electric over-blankets probably contribute most to an individual's overall average exposure to appliance fields. The user of an electric blanket will be exposed to fields of around 1 μT to 2.5 μT.

In many homes the level of magnetic field exposure will depend on the wiring configurations employed to supply the power sockets and lighting circuits. In the electrical supply to power sockets the live and neutral wires usually run together in the one cable and so the magnetic fields from the wires largely cancel one another. However, in many lighting systems the live and neutral wires are contained in separate cables and the magnetic fields are no longer cancelled but may be additive.

Health concerns: power lines

The origin of the concern over exposure to high voltage power lines is discussed in the Science Review, section 4.2. In 1979 this concern was centred on an apparent increased incidence of leukaemia observed among children living in residences close to overhead power lines and transformers carrying high currents. This led to further studies in the United States and in other countries, to determine if there was an association between childhood leukaemia and living near power lines. It also led to studies investigating whether other cancers and non-cancer health effects (Alzheimer's, Parkinson's disease, miscarriage) among various population groups (adults, electrical industry workers, workers using electrical machinery) was associated with exposure to electric and magnetic fields from various sources; power lines, electrical sub stations, electrical appliances, industrial

Types of transmission lines	Usage	Magnetic field (μT)				
		Maximum on Right-of-Way	Distance from lines			
			15m	30m	61m	91m
115 kV	Average	3	0.7	0.2	0.04	0.02
	Peak	6.3	1.4	0.4	0.09	0.04
230 kV	Average	5.8	2.0	0.7	0.18	0.08
	Peak	11.8	4.0	1.5	0.36	0.16
500 kV	Average	8.7	2.9	1.3	0.32	0.14
	Peak	18.3	6.2	2.7	0.67	0.30

Box 3.3 Electric and Magnetic Field Strengths in the vicinity of power lines (NRPB, 2001)

Appliance	Distance = 25 cm			Distance = 56 cm		
	95th percentile	5th percentile	Median	95th percentile	5th percentile	Median
Non-ceiling fan	9.2	0.03	0.3	1.6		0.04
Can opener	32.5	0.2	21.0	3.2	0.2	2.4
Clock-radio (digital)	0.3	0.1	0.1	0.1	0.01	0.02
Clock-radio (analog)	2.5	0.3	1.5	0.4	0.1	0.2
Ceiling fan	1.6	0.03	0.3	0.3	<0.01	0.1
Electric range	1.9	0.2	0.9	0.3	0.04	0.2
Microwave oven	6.7	1.7	3.7	1.7	0.5	1.0
Colour TV	1.2	0.4	0.7	0.3	0.1	0.2
Refrigerator	0.5	0.2	0.3	0.3	0.1	0.1

Box 3.4 Magnetic fields associated with the use of appliances (NIEHS, 1998)

machinery and electric transportation systems. In addition, studies were conducted on laboratory animals, mainly rats and mice, exposed for their lifetime to fields up to a thousand times stronger than those experienced by the general public.

There is therefore substantial knowledge now available on the health effects of ELF electric and magnetic fields. Health outcomes ranging from reproductive effects to cardiovascular and neurodegenerative diseases have been examined. However, the only consistent evidence to date concerns the association with childhood leukaemia. In 2001, an expert scientific group from IARC reviewed studies related to the carcinogenicity of static and ELF electric and magnetic fields. Using the standard IARC classification methodology that weighs human, animal and laboratory evidence, ELF magnetic fields were classified as possibly carcinogenic to humans. While support for this classification came from the epidemiological studies of childhood leukaemia animal studies did not provide any confirmatory support. The IARC classification system is summarised in the Science Review, section 4.2.

"Possibly carcinogenic to humans" is a classification used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals. Evidence for all other cancers in children and adults, as well as other types of exposure (i.e. static fields and ELF electric fields) was considered inadequate to classify either due to insufficient or inconsistent scientific information. Despite the classification of ELF magnetic fields as possibly carcinogenic to humans by IARC, for this classification it is possible that there are other explanations for the observed association. An example of a substance classified by IARC as 'possibly carcinogenic to humans' is coffee, which may increase the risk of kidney cancer.

The evidence is unconvincing that ELF is a cause of adverse birth outcomes in humans, nor a cause of Alzheimer's disease, motor neuron disease, suicide and depression, or cardiovascular disease. There is very weak evidence that maternal or paternal occupational exposure to ELF causes reproductive effects.

Conclusions on health effects

Acute effects, as discussed below, have been established for exposure to ELF electric and magnetic fields in the frequency range up to 100 kHz. Since these may lead to health hazards, exposure limits are needed. International guidelines (*ICNIRP*, 1998; *IEEE*, 2004) exist that have addressed this issue. Observing these guidelines provides adequate protection against established acute effects.

There is consistent epidemiological evidence suggesting that chronic low intensity ELF magnetic field exposure is associated with an increased risk for childhood leukaemia. However, laboratory studies do not provide convincing evidence for a causal relationship so the impact on public health is uncertain. Exposure limits based upon this epidemiological evidence are not recommended.

The health risk assessment carried out in the Science Review, section 4.2, concerning ELF health effects concluded that if, the association between increased childhood leukaemia and magnetic field exposure is causal, then, using the results of the UK childhood cancer study as a basis, approximately one case of childhood leukaemia in 150 might be due to magnetic fields. This would represent one additional case in Ireland every three to five years. However there is no known mechanism that would explain how exposure to ELF magnetic fields could lead to cancer. Apart from the childhood leukaemia issue there is no evidence that there are any adverse health effects associated with exposure to such fields at environmental levels.

There have been few extensive studies of the relationship between use of appliances and personal exposure to ELF magnetic fields. Sleeping on or under an electric blanket while it is switched on can be a major contributor to magnetic field exposure. At one time there was concern that women sleeping with an electric blanket switched on would be at higher risk from breast cancer and possible reproductive disorders. However, despite a number of research studies there is little or no evidence for an association between ELF magnetic field exposure and an increased risk for breast cancer (*IARC*, 2002).

IARC (2002) concluded that ELF electric fields are "not classifiable as to their carcinogenicity to humans". This means that there is no scientific evidence to support the hypothesis that electric fields might cause cancer.

Question 3: How can safety be assured when new technologies are introduced before their health effects can be assessed?

Response: There are a large number of novel technologies being developed using RF signals for various purposes. Examples include WiFi, Bluetooth, Ultra-wide Band, and others. All of these are assessed for safety by the strength and frequency of their RF emissions. These emissions are then compared with the limits allowed in the international standards. If the new technology emits fields less than these limits they are considered safe, and vice-versa. Thus the advantage of having adopted international exposure limits is that they provide information on safe levels of EMF exposure from any existing device or any device produced in the future, but also provides manufacturers with the exposure limits within which they must manufacture their devices. Within the European Union, devices having the "CE" mark are considered to be safe for their intended purpose.

The introduction of a new technology raises questions of a technical, legal, financial and moral nature:

- Is the technology new?
- Is the technology untested?
- What are the authorities doing to ensure people's health is protected?

These questions can be addressed to all the new wireless communication technologies discussed in the Science Review, section 4.4.

Is the technology new?

Mobile wireless communications have existed since 1910 when they first began to be used on ships. The sinking of Titanic in 1912 gave a huge boost to the Marconi company: without radio communication many more would have perished that April night. Police, the armed forces and the emergency services have been using mobile wireless telephony since the late 1930s. The technology at that time could never have had widespread application among the general public for many reasons: the limited availability of radio frequency bands, the weight of the transmitting and receiving equipment that had to be carried, and to avoid being overheard by others with radio receivers one needed to transmit messages in code.

Before the advent of the microchip, pocket sized mobile phones were a dream from the pages of science fiction. If one were to build a mobile phone with its present computing power using 1960s transistors one would need a large truck in which to carry it. The modern GSM phone transforms the user's speech into a series of encoded digital pulses. The code is changed every few seconds to prevent eavesdropping. The response from the party replying is sent in a similarly coded form on a carrier wave from the nearest phone base station with spare capacity. The use of digital radio transmission by GSM phones was the first time such technology had been employed in a commercial application. A concern that the pulse frequency might mimic some natural frequencies that occur in the body (e.g. brain signals) and so adversely affect some bodily functions has been discounted (*Foster and Repacholi*, 2004). There are no known decoding mechanisms that could affect the body using digital transmissions from mobile phones.

So, is the technology new? The mobile phone combines a powerful computer with a radio transmitter and receiver. The electric currents flowing in the phone are measured in milliamps –if higher currents were needed the phone would forever need recharging. The power of the RF signals from the phone is only a fraction of a watt – illustrating the efficiency of digital radio transmission. So, the technology is new in that never before has it been possible to communicate so much to so many with so little power.

The foregoing comments are equally applicable to the various new applications of wireless telephony discussed in the Science Review, section 4.4.

Is the technology untested?

No untested wireless technology can be placed on sale within the European Union. All such equipment must meet a battery of standards for electrical safety, electrical compatibility, electrical interference, performance and fitness for use.

The CE mark is applied to all tested electrical goods marketed within the EU. Mobile phones and other wireless hardware meets the Electromagnetic Compatibility Directive 89/336 EEC, the Low Voltage Directive 73/23 EEC, the CE (Mark) Directive 93/68 EEC and the R&TTE Directive 1999/ EC. In addition mobile phones are designed and manufactured not to exceed the limits for exposure to RF fields recommended by international guidelines. These guidelines were developed by ICNIRP, an independent scientific commission, through periodic and thorough evaluation of scientific studies. The exposure limits in the guidelines include a substantial safety margin designed to ensure the safety of all persons, regardless of age and health status.

What are the Irish authorities doing?

Although no research on the health effects of EMF has taken place in Ireland, the Irish authorities have been active participants in the EMF-health issue for many years. In 1988. concern over power line magnetic fields led the Minister for Energy to stop the energising of a newly constructed 220 kV line from Arklow to Carrickmines. Following an investigation (*McManus*, 1988) the line was energised. However a commitment was made to closely monitor all scientific and technical developments concerning EMF exposure and

participate in international forums dealing with the issue. A further review of the science was completed and published by the Government in 1992 (*McManus*, 1992).

In response to growing public concern over possible adverse health effects from an increasing number and diversity of EMF sources, the World Health Organisation launched its International EMF Project in 1996. Ireland was a founder member of the Project, provided a significant financial contribution to the Project and provided the first Chairman of the Project's International Advisory Committee. Ireland continues to provide financial support to the Project and to participate in numerous working groups and committees set up by the Project.

The International EMF Project brings together the current knowledge and available resources of key international and national agencies and scientific institutions in order to assess the health and environmental effects of exposure to static and time-varying electric and magnetic fields in the frequency range 0 – 300 GHz. The Project has been designed to follow a logical progression of activities and produce a series of outputs that allow improved health risk assessments to be made. The Project has produced numerous WHO Fact Sheets dealing with many sources and aspects of EMF, including several dealing with mobile wireless telephony. In 2006 an Environmental Health Criteria monograph on static fields was published (WHO 2006). Further Environmental Health Criteria handbooks on the health effects of ELF and RF fields are scheduled to be published by 2007 and 2009, respectively.

No scientific research into possible health effects of mobile phone technology has yet been carried out in Ireland. However, Ireland participated in expert groups involved in three major EU initiatives relating to the protection of the public and workers from the adverse health effects of exposure to non-ionising radiation. These were the Council Recommendation on limiting exposure of the public to electromagnetic fields (*EU*, 1999), and the two Physical Agents Directive dealing with limiting occupational exposure to electromagnetic fields (*EU*, 2004) and optical radiation (*EU*, 2006). Ireland also contributed medical expertise to an EU sponsored investigation of self-reported electrical hypersensitivity in Europe (*Bergqvist*, 1997).

COST is the acronym for "European Co-operation in the Field of Scientific and Technological Research". It provides a framework for international research and scientific co-operation, facilitating the co-ordination of national research at the European level. COST does not fund research but was established and is financially supported by the European Commission to co-ordinate joint research projects, in areas of importance to the EU Member States and other European countries. COST Action 281, in which Ireland participated as a founder member and as an Executive Committee member, was an action within the COST-Telecommunication Information Science and Technology. The main objective of COST 281, which ran from September 2001 to September 2006, was to obtain a better understanding of possible health impacts of emerging technologies, especially those related to communication and information technologies that may result in exposures to EMF. Ireland hosted a major COST 281 conference on mobile phones and base stations at Dublin Castle in 2003. The results of the work undertaken by COST 281 and details of its many research initiatives can be found on the website www.cost281.org.

The "400 Sites" survey of mobile phone base stations conducted by ComReg to measure public exposures from this source was completed in 2004. It was then the largest survey of its kind undertaken in Europe. In 2005 Ireland hosted the annual meeting of the International Committee on Electromagnetic Safety at Dublin Castle.

The lead role in addressing these issues is currently being taken by the Department of Communications, Marine and Natural Resources. At this time responsibilities are spread over a number of Government Departments. It is felt that the situation could be improved by having an existing or new agency take overall responsibility for providing scientific and policy advice. This report is one element of that initiative.

What are other authorities doing?

One of the most important research initiatives is that being undertaken by WHO through IARC. IARC is co-ordinating the INTERPHONE study. This is a multi-centre study to determine whether tumours of the brain, acoustic nerve, and parotid gland are associated with RF emitted by mobile phones. The study involves epidemiologists in 13 countries studying the association of these diseases with mobile phone use, under a common research protocol. The project is one of the largest ever undertaken on any topic and the first results are now being published. Seven reports are now available on the IARC website www.iarc.fr/ENG/Units/RCA4.php. Ireland is not a participant in INTERPHONE.

A large number of countries have contributed to major research projects on many aspects of wireless telephony. Major research projects are underway in the United States, Canada, UK, Sweden, Denmark, Finland, Norway, Russia, Germany, Poland, Hungary, Austria, Switzerland, Slovenia, the Czech Republic, the Netherlands, Belgium, France, Spain, Australia, Japan, China and Korea.

Question 4: Is it safe for children to use mobile phones and should phone masts be located near places where children gather?

Response: There is no data available to suggest that the use of mobile phones by children is a health hazard. The time in children's development that might make them particularly vulnerable to RF exposures to the head is when they are aged two years and younger. In the UK and Sweden the authorities recommend a precautionary approach to either minimise use (essential calls only) or minimise exposure (use a hands-free kit). In the Netherlands the use of mobile phones by children is not considered a problem.

There is no established scientific basis or evidence of adverse health effects affecting children or adults as a result of their exposure to mobile phone base stations. This applies irrespective of the location of the phone mast.

Children and mobile phones

The question concerning health hazards that might be faced by children using mobile phones was first raised in the UK by the Stewart report (*IEGMP*, 2000).

While the Stewart report concluded that the balance of evidence suggested that exposure to RF below the international guidance levels does not cause adverse health effects in the general population, it did recommend that the widespread use of mobile phones by children for non essential calls should be discouraged. The reason given for this recommendation was put in these terms:

> *"If there are currently unrecognised adverse health effects from the use of mobile phones, children may be more vulnerable because of their developing nervous system, the greater absorption of energy in the tissues of the head and a longer time of exposure."*

The UK Government accepted this recommendation and directed its Chief Medical Officer to liaise with the Stewart Committee to determine how best to achieve its aim.

The publicity surrounding publication of the Stewart report, and particularly its recommendation concerning children's use of mobile phones, led to investigations of the various assumptions implicit in the rationale for the Stewart report recommendation quoted above. The key questions were:

- Are there unrecognised adverse health effects from the use of mobile phones?
- Does the development of children's nervous systems at the ages when they might begin to use mobile phones make them more vulnerable than adults?
- Does a child's head absorb a greater proportion of the RF energy from mobile phones than an adult head?

There was also the concern that if there were long term health effects, the earlier one starts using a mobile phone, the longer will be the lifetime exposure to its fields, and so the greater the opportunity for harm.

Since the publication of the Stewart report in May 2000, a substantial amount of research work relevant to children's exposure to RF sources has been completed and more is ongoing. Among the organisations that have devoted considerable effort to appraise and interpret this work, are the Swedish Radiation Protection Institute (SSI), the Health Council of the Netherlands (HCN), the National Radiological Protection Board (NRPB) and WHO.

The most recent Swedish review (*SSI*, 2006) concluded that work on cognitive functions in volunteers (including children) exposed to RF fields had been negative; but methodological limitations in the studies prevented firm conclusions being drawn. However they were able to conclude that there was enough evidence to show that exposure to GSM mobile phones did not affect hearing.

The results of two epidemiological studies from the INTERPHONE project suggested that there was no increased risk of brain tumours from either short term or long term use of mobile phones, although data on long term use was sparse. However, there was a concern over the association of acoustic neuroma, a benign tumour of the acoustic nerve, with long term use.

The Swedish position, as reflected in the report of SSI's Independent Expert Group (*SSI*, 2004) is that widespread exposure of children to mobile phones is recent and that not enough is known about the potential sensitivity of children. The absence of an observed effect does not necessarily mean that exposure is harmless, especially when crucial studies focussing on children are yet to be done. The SSI therefore adopted a precautionary approach (*SSI*, 2004):

> *"The existing knowledge gaps and the prevailing scientific uncertainty justify a certain precautionary attitude regarding the use of handsets for mobile telephony. Due to the widespread use of mobile phones even a very small risk could have consequences for public health. Because of the lack of knowledge in certain fields of research the Nordic authorities find it wise to use, for instance, a hands-free kit that reduces exposure to the head significantly. This information should be addressed to adults, young people and children. It is important that parents inform young people and children about how to reduce the exposure from mobile phones."*

The Electromagnetic Fields Committee of the Health Council of the Netherlands publishes regular reviews and assessments of scientific literature relating to the EMF – health issue. In regard to children's exposure to mobile phones the most recent review (*HCN*, 2005) referred to its 2002 advisory report on "Mobile telephones: a health-based analysis" (*HCN*, 2002) where the Health Council had stated that there is no reason, based on the existing data concerning the development of the head and brain in children, to suppose that there are still significant differences in sensitivity compared with adults after two years of age. In that 2002 report, the Health Council concluded that it saw no reason to recommend that the use of mobile phones by children over two years of age should be limited on account of the available scientific evidence on possible health effects of exposure to electromagnetic fields. The Health Council continues to endorse this position.

The Board of the UK NRPB revisited the Stewart report in 2004 to review progress on implementing Stewart's recommendations and provide further advice to address public concerns about mobile phone technology (*NRPB*, 2004). The Board concluded that in the absence of new scientific

evidence, the recommendation in the Stewart report on limiting the use of mobile phones by children remains appropriate as a precautionary measure. They recommended that the use by children of phones for non-essential calls should be discouraged. Text messaging and hands-free kits were seen as good ways for children to reduce their exposure.

The main initiative of the WHO International EMF Project concerning children and EMF was the expert workshop held in Istanbul in June 2004 (*WHO*, 2004). This workshop dealt with the development of the embryo, foetus, and child, with particular attention to the development of the brain. It also examined childhood susceptibility to environmental agents and childhood diseases implicated in EMF studies, and their exposure to EMF. The main outputs of the workshop were the publication of the presentations (*BEMS*, 2005), a summary of its findings (*Kheifets et al*, 2005), and recommendations for an RF research programme specially addressed to children's exposure (*WHO*, 2005). It will be a few years before the results of this research become available.

Children and mobile phones: conclusion

Recent expert analysis has concluded that there are no major effects due to focussing of the RF field in the head or to other properties of a child's head that might result in higher absorption of RF energy (*Christ and Kuster*, 2005; *Keshvari and Lang*, 2005).

Even though children are using mobile phones at a younger and younger age there are few users under the school age of five. Children tend to use their phones for sending texts rather than voice calls; this reduces their exposure. The use of hands-free kits also reduces exposures but these are not popular among children.

Three expert groups have reviewed the question of whether there should be restrictions on children using mobile phones. Two have recommended that there should be some restrictions, while one has suggested that it would make no difference. Given this disagreement it seems prudent to suggest that mobile phone use should be limited in younger children. However, there is no specific scientific justification for this advice.

Children and base stations

It is common for the public to object to proposals to build phone masts in their neighbourhood. When the proposal involves the phone mast being located near a school or crèche or health centre or indeed anywhere children gather the number of objections will usually increase.

In Ireland there are 4500 base stations in an area of just over 70,000 km^2. If these masts were evenly distributed geographically no one would be more than 2.5 km from a mast. However because the distribution of masts reflects the distribution of the population, in urban areas no one is likely to be more than a kilometre from the nearest mast. This can be confirmed by accessing the Communications Regulator's website www.ComReg.ie. It is clear that it is no longer possible for anyone, including children, to live anywhere in Ireland and not be exposed to the RF fields emitted by phone masts. However it is equally the case that there is nowhere in Ireland where a child is not exposed to the RF fields produced by local, national and international radio and television broadcasting stations. Indeed there are now few adults who have not been exposed to radio broadcasts all of their lives. Furthermore the fields from TV and radio stations are usually stronger than those from mobile phone masts.

One reason for the absence of concern regarding radio and TV is that broadcasting transmitters are more powerful than base station phone masts, so fewer of them are required to cover an area. However over 500 transmitters are still required to provide national TV coverage. Another explanation is that radio and TV transmitters are generally located on high ground that is usually unpopulated; in the case of the most powerful transmitters exclusion areas are employed to restrict public access from the areas where the RF fields might exceed international guideline limits.

The levels of public exposure to phone masts are usually thousands and often tens of thousands times below the international limits. The highest exposures at ground level are found some 50 m to 300 m from the phone mast. Fields at ground level at the site and within 50 m of the mast are generally lower than those at 200 m to 300 m distance.

National and international health advisory authorities have concluded that exposure to base station phone masts is not associated with adverse health effects. The position is summarised in a conclusion of the Stewart report (*IEGMP*, 2000):

> *"The balance of evidence indicates that there is no general risk to the health of people living near to base stations on the basis that exposures are expected to be small fractions of guidelines."*

The fact that exposures are very small fractions of the internationally accepted guidelines of ICNIRP has been demonstrated by the Communications Regulator's "400 Site Survey" (*ComReg*, 2004). The WHO workshop on children's exposure to EMF (*WHO*, 2004) also concluded that from the low exposures and the scientific evidence collected to date, it appeared highly unlikely that the weak signals to which people are exposed from base stations could cause cancer or any other adverse health effects. This was explained in the WHO fact sheet on mobile phone base stations and wireless networks (*WHO*, 2006).

Children and base stations – conclusions

There is no scientific basis for, or evidence of, adverse health effects affecting either children or adults as a result of their exposure to RF fields from phone masts.

This applies irrespective of the location of the phone mast. While the maximum exposures from a phone mast will occur at some distance from the mast, and not in its immediate vicinity nor underneath it, the exposures are so low as to make it immaterial where masts are located with respect to schools, playgrounds, health centres or other places where children gather.

The foregoing statements are not in accord with the positions adopted by some members of the public over what are suitable and unsuitable places to locate phone masts. The public can have legitimate concerns over the physical appearance of such masts in their neighbourhood. It is also true that some will be worried about the possible effects the mast may have on the health of their family, but the scientific evidence does not support their concerns.

Question 5: Is electromagnetic hypersensitivity (EHS) caused by exposure to electromagnetic fields?

Response: The short answer to the question posed is essentially "No".

No studies have established that EMF exposure leads to the subjective symptoms reported by EHS individuals. Several studies have shown that while the symptoms reported by EHS sufferers are real, they are not linked to EMF exposure. EHS sufferers do not experience worse symptoms when exposed to EMF fields.

This response does little to help those suffering the symptoms they attribute to EMF.

Among the experts present at the WHO's 2004 Prague workshop on hypersensitivity were a number of clinicians who deal specifically with EHS patients in their medical practices. This group provided advice on the characterisation, diagnosis, management and treatment of EHS individuals (*Hillert et al*, 2004). Their advice is available to interested parties in Ireland.

In February 2006 the Expert Group met representatives of groups providing support and assistance to fellow sufferers from EHS. During the discussions that followed, two things became very clear. The first was that the affected individuals were not imagining their pain and suffering. The second was that all attributed their illness to exposure to EMF from one or more sources. Many of the people they represented had taken extraordinary measures to reduce their exposure to the particular fields they believed were the cause of their health problems. For some, a particular radio frequency, which they claimed to be able to detect, was identified as the causal agent.

The attribution of the illnesses to exposure to EMF has generated widespread international concern since the first cases began to receive media attention in 1987. The first major international study of electromagnetic hypersensitivity was commissioned by the EU and included Irish medical participation in the expert team (*Bergqvist et al*, 1997). The aim of this study was to determine the extent of EHS across Europe, to review the scientific literature on the subject, and provide advice on better health protection for affected individuals. The study was unable to establish a relationship between exposure to low frequency or high frequency EMF. In the absence of a common diagnosis for the condition it was difficult to compare the reported incidence of the illness across Europe – the estimate of severe cases provided by Irish self-aid groups, between 1000 and 10 000, was equalled only in Sweden. The study concluded that the limited number of seriously affected individuals and the absence of evidence for EMF as a causal factor did not justify public alarm but that substantial additional research was needed. And, indeed, the last ten years have seen a great deal of high quality research on EHS.

The scientific findings concerning a possible link between exposure to EMF and EHS have been examined recently by the Swedish Radiation Protection Institute (*SSI*, 2004), the Health Council of the Netherlands (*HCN*, 2005), and by WHO at a Prague Workshop (*WHO*, 2004) and in a recent WHO Fact Sheet (*WHO*, 2005). The conclusions of these organisations have been broadly similar.

EHS is characterised by a variety of non-specific symptoms, which affected individuals attribute to exposure to EMF. The symptoms most commonly experienced include skin symptoms (redness, tingling, and burning sensations) as well as more general symptoms (fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitation, and digestive disturbances). This collection of symptoms is not part of any recognised medical syndrome.

EHS resembles multiple chemical sensitivity (MCS): a collection of symptoms associated with low-level environmental exposures to chemicals. Both EHS and MCS are characterised by non-specific symptoms that lack apparent toxicological or physiological basis or independent verification.

Studies on EHS can only be made on humans, and are either epidemiological (observational) or experimental (provocation). A number of studies have been conducted where EHS individuals were exposed to EMF levels similar to those that they attributed to the cause of their symptoms. The aim was to elicit symptoms under controlled laboratory conditions. The majority of such studies indicate that EHS individuals cannot detect EMF exposure any more accurately than non-EHS individuals. Well controlled and conducted double-blind studies have shown that symptoms were not correlated with EMF exposure.

It has been suggested that the symptoms experienced by some EHS individuals might arise from environmental factors unrelated to EMF. There are also some indications that these symptoms may be due to previous stressful life events, as well as to stress reactions as a result of worrying about EMF health effects, rather than EMF exposure itself.

The conclusion of WHO is that EHS is characterised by a variety of non-specific symptoms that differ from individual to individual. The symptoms are real and can vary widely in their severity. Whatever its cause, EHS can be a disabling problem for the affected individual. EHS has no clear diagnostic criteria and there is no scientific basis to link EHS symptoms to EMF exposure. EHS is not a medical diagnosis, nor is it clear that it represents a single medical problem (*WHO*, 2005).

An independent expert group set up by the Swedish authorities (*SSI*, 2004) came to similar conclusions. In studies of ELF fields no EHS individuals were able to detect electric or magnetic fields at levels that are comparable to those at which they claim to react. Too few RF exposure studies had reported by 2004 to permit any firm conclusions to be made concerning such exposure. However no study had, so far, been able to show a link between EMF and the occurrence of symptoms.

How the EHS problem is dealt with in Sweden

The dilemma in dealing with EHS individuals is that while their symptoms are real and at times disabling, there is no evidence to suggest that EMF exposure is the cause of their illness. So, what can be done?

In Sweden, where there appears to be a greater proportion of EHS than elsewhere, guidelines have been issued by the National Board of Health and Welfare concerning the treatment of such patients. These are in the main body of the report (section 4.5). The focus in Sweden is on the symptoms presented by the afflicted person and the right to sick leave, sickness benefits, disability pension etc is based on the degree of ill health and functional handicap of the person regardless of a known or unknown cause for the condition.

There is no standard medical treatment and since the clinical picture varies from case to case any recommendation for interventions or treatment is based on a broad evaluation of each individual's situation, including medical investigation, psychosocial situation and possible contributing environmental factors. Treatments known to reduce the type of symptoms presented have been used in Sweden (Annex 4).

It is important that a good patient-doctor relationship is established and that a physician is available to offer follow-up visits to ensure (after the initial examination aimed at excluding known medical conditions) that new medical evaluations are made when required by a change in symptoms, for example. EHS has not been accepted as a work injury in Sweden.

In its most recent review (*HCN*, 2005) the Health Council of the Netherlands concluded that there were no scientific grounds at present for supposing that physical complaints of EHS can be directly caused by exposure to EMF. This has been further confirmed by a recent detailed review and high quality study by *Rubin et al* (2005, 2006).

Question 6: Why do reports of scientific studies often appear to reach different conclusions on EMF health effects?

Response: There are three main reasons for this:

- **Studies that report positive findings will always receive more publicity than reports whose findings are negative.**
- **Studies whose findings are negative face more difficulty getting published in scientific journals.**
- **Differences in the results of broadly similar scientific research are to be expected, given differences in study methodology, analytical techniques and the experience and expertise of the researchers involved.**

Science advances on the basis of weight of evidence as represented by studies published in the most authoritative (peer-reviewed) journals. This weight of evidence is not necessarily reflected in popular reports of EMF health effects.

For over thirty years now, scares involving EMF have generated headlines around the world. The headline scares are generated by studies that suggest an association between EMF exposure and illness; by poorly conducted studies that would never pass the peer review stage of any reputable scientific journal; and by exaggerated rumour and gossip that the media might choose to reiterate on a day when little hard news is available. A good example of the latter was when a banner headline was published in a Dublin evening newspaper in May 1992.

It announced an epidemic of cancer in the suburb of Ballymun, said to be caused by exposure to overhead and buried electricity distribution lines. The article in question led to questions in the Dáil as well as to much comment in the media. In response the authorities undertook an assessment of indoor and outdoor electric and magnetic fields in the area. The Medical Officer of Health of the Eastern Health Board made a detailed study of all the reported cancers and of cancer incidence in the suburb.

The investigation found that public exposure to electric and magnetic fields in Ballymun was low and typical of fields found elsewhere in Ireland in urban areas (*McManus*, 1992). The Health Board report found that many of the reported cancers were double or triple counted or often did not exist. The only excess of cancer was found among heavy smokers aged 50 to 69. The main conclusions of the Health Board report were (*O'Donnell et al*, 1992):

- The overall death rate for the Ballymun area was similar to that for Dublin as a whole.
- The overall death rate and the cancer death rates were slightly increased in only one district for the years studied. One obvious cause was the high incidence of lung cancer.
- The pattern of deaths did not support a common environmental agent as a cause.
- Electromagnetic radiation levels were within normal limits.
- The local population can be completely reassured about electromagnetic radiation levels and their impact on health.

It was disappointing but hardly surprising that the newspaper that started the panic failed to give any mention to the Health Board report or its findings. There was no coverage provided elsewhere in the media either. Although this case study of

how the media deals with stories that can be categorised as 'health scares' is perhaps an extreme example of unbalanced reporting, the media will give more space to a study that is positive or suggests that exposure is a threat to health than one which is negative or fails to connect an exposure to a threat to health. Therefore, on the basis of headlines, column inches, and investigative television programmes, the average member of the public will see more adverse comment on EMF exposure than would an expert review of scientific publications indicate.

There is a further factor that leads to imbalance in the media's approach to handling health scares. This arises from the self-publicising activities of some scientists who by-pass the peer review assessment of the quality of their work and take their findings directly to the press. Much of the research reported in this way is never published in peer-reviewed journals. Authorities, in assessing the scientific literature, can consider only those papers that meet certain standards. In her covering letter to the Dutch Minister for the Environment, which accompanied the 2005 Electromagnetic Fields Update Report (*HCN*, 2005), the Health Council Vice-president stated:

> *"I would like to add that many publications on the influence of electromagnetic fields on health appear on closer scrutiny to be based on research that does not rise up to current scientific standards. This is specifically pointed out by the Committee in the present report."*

An International Evaluation Committee set up by the Italian Government to investigate the health risks of exposure to EMF, on the question of where can national authorities seek reliable scientific advice, stated (*Cognetti et al*, 2003):

> *"It is important for governments that they obtain the best advice possible on issues before formulating national policy. When there is a reliance on scientific and technical information to help formulate national policy, there is a hierarchy of levels in science for provision of reliable advice. International or national peer review panels of independent scientists are recognised in the scientific community as providing the most reliable and scientifically supportable information. Individual opinions, even when provided by scientists, are not as reliable as those provided by multi-disciplined panels of experts. This is especially true in the EMF area, which involves many branches of science and where some discordant opinions have been expressed."*

As well as having criteria for expert advisory groups, it is also necessary to have criteria to assess the scientific value of the scientific papers to be considered. Some of the aspects to be employed in weighting scientific papers for review by a national health advisory body are set out below.

Aspects to be considered for scientific reviews

- The research is of adequate quality according to the standards currently prevailing in the scientific community.
- The research has been published in internationally peer-reviewed journals, which are of a quality that is generally accepted as adequate in the scientific community.
- The results of the research have proved to be reproducible (for laboratory research) or consistent (for epidemiological research) based on research of the type referred to above, which has been conducted by other independent researchers.
- The outcome of the research has been substantiated by quantitative analysis, which leads to the conclusion that there is a statistically significant relationship between exposure and effect.
- The strength of the effect is related to the strength of the stimulus; i.e. there is a dose-response relationship. This relationship does not always need to be such that the effect increases as the stimulus becomes stronger; it may also signify a resonance effect, i.e. that there is a maximum effect for a particular stimulus and that the effect for a stronger or weaker stimulus is less marked or perhaps even completely absent.

(Source: HCN, 2005)

Question 7: The ICNIRP guidelines apply only to short-term exposure. How can they protect against long-term exposure?

Response: When the ICNIRP guidelines are drafted, the totality of the scientific evidence is assessed. Studies on both short-term and long-term exposures are evaluated to reach conclusions on health effects. Only short-term acute health effects have been established by the scientific evidence. However the ICNIRP limit values apply to all exposure situations, including long-term exposures.

ICNIRP

ICNIRP is the formally recognised non-governmental organisation responsible for non-ionising radiation protection for WHO, the International Labour Office (ILO), and the EU. Among other things it provides guidelines on limiting the exposure of the public to EMF, optical radiation, ultrasound and infrasound. The ICNIRP guidelines limiting public and occupational exposure to EMF are endorsed by the WHO; have been adopted by a great many countries around the world; and are incorporated into an EU occupational exposure Directive (*EU*, 2004) and a public exposure Recommendation (*EU*, 1999). In Ireland, the ICNIRP guidelines have been adopted by both the Communications Regulator and the Commission for Energy Regulation.

ICNIRP guidelines and long-term exposure

The ICNIRP guidelines are based on comprehensive reviews of all relevant published peer-reviewed literature. Exposure limits are based on effects relating to short-term acute exposure as the above question implies. However it is not the case that long-term exposures are disregarded or discounted, it is simply that the available information on long-term effects is considered to be insufficient to establish exposure limits. For example, there have been several very large lifetime exposure studies involving animals. These studies have involved exposures to both ELF and RF fields, corresponding respectively to power line fields and mobile phone fields. So far, none of these studies have established any adverse health effects at exposures corresponding to the present guideline limits or at higher levels.

Threshold levels

In its appraisal of the scientific literature ICNIRP monitors the accumulation of new evidence, leading, as appropriate, to updating its risk assessments. The latter are based on the totality of the science, not just on the latest information. In the health risk assessments the lowest level of EMF field that causes an adverse health effect is identified; this is termed the threshold level. Over the EMF frequency range from 0 Hz to 300 GHz, there are different thresholds at different frequencies. These differences arise because the nature of the interaction of EMF with the human body changes with frequency.

The lowest established threshold levels for an adverse health effect become the basis of the guidelines. To allow for uncertainties in science, this lowest threshold level is reduced further to derive the limit values for human exposure. For example, ICNIRP reduces the level of the threshold by 10 times for the occupational limits for workers and by 50 times to arrive at the exposure limits for the general public. The limits vary with frequency as has been explained (*WHO*, 2002).

Essentially the ICNIRP guidelines are based on established health effects. Any evidence that established an adverse health effect at exposures below the current threshold values would lead to a re-examination and review of the present guidelines. Following the publication of the WHO Environmental Health Criteria reports on static, ELF, and RF fields, the ICNIRP guidelines (*ICNIRP*, 1998) will be subject to further review.

Thermal and non-thermal effects

Sometimes it will be said, particularly in relation to the ICNIRP guidelines for RF exposure, that the limits are based on thermal effects of RF exposure and ignore non-thermal effects. While it is true the limits are based on thermal effects this is because they are the only effects established to have any adverse health consequences. The EU Co-operation on Science and Technology initiative, COST281, examined this question in a workshop on "Subtle Temperature Effects of RF-EMF" (*COST*, 2002). Concerning temperature effects, the conclusion reached was that many of the biological effects reported as taking place under isothermal conditions were in fact responses to minor changes in the bulk temperature of the investigated system (*COST*, 2003). In living cells, temperature changes as low as three one-hundredths of a degree are enough to increase their chemical, and therefore biological activity. Few experimental systems can control temperature to better than one tenth of a degree. In other words, reported non-thermal effects may be due to small thermal effects.

Conclusion

The ICNIRP guidelines are employed by governments and health advisory authorities worldwide to ensure the protection of citizens from any adverse health effects that might arise from exposure to EMF. The guidelines are under continual review and all medical and scientific evidence that meets specified criteria of scientific acceptability is taken into consideration by ICNIRP in these reviews.

Question 8: Should precautionary measures be adopted in relation to EMF exposure?

Response: There is no doubt that the prudent use of precautionary measures would help reassure many in Ireland who have concerns over EMF exposure. WHO's EMF Project has been working to develop guidance for Member States who want to adopt precautionary measures and it is hoped these will be available soon.

Precautionary Principle

The 'Precautionary principle' was first used in German environmental law in the early 1970s as the 'Vorsorge-prinzip'. 'Sorge' means care, and 'Vorsorge' means foresight or care for the future. The Precautionary principle has since been used widely in international policy statements; conventions dealing with environmental concerns and uncertain science; and sustainable development strategies.

The principle was introduced in 1984 at the First International Conference on Protection of the North Sea. Following this conference, the principle was integrated into numerous international conventions and agreements, including the Bergen declaration on sustainable development, the Maastricht Treaty on the European Union, the Barcelona Convention, and the Global Climate Change Convention (*Foster et al.*, 2000).

The World Commission on the Ethics of Scientific Knowledge and Technology (*COMEST*, 2005) has produced a working definition of the Precautionary Principle that is applicable to scientific issues.

When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm.

Morally unacceptable harm refers to harm to humans or the environment that is

- threatening to human life or health, or
- serious and effectively irreversible, or

- inequitable to present or future generations, or
- imposed without adequate consideration of the human rights of those affected.

The judgement of *plausibility* should be grounded in scientific analysis. Analysis should be ongoing so that chosen actions are subject to review.

Uncertainty may apply to, but need not be limited to, causality or the bounds of the possible harm.

Actions are interventions that are undertaken before harm occurs that seek to avoid or diminish the harm. Actions should be chosen that are proportional to the seriousness of the potential harm, with consideration of their positive and negative consequences, and with an assessment of the moral implications of both action and inaction. The choice of action should be the result of a participatory process.

A definition given by the European Environment Agency grasps the essential concept that it is a policy framework that allows rational and cost effective decisions to be made concerning potential dangers to health or the environment in areas of scientific uncertainty (*Gee*, 2001).

When should the precautionary approach be used?

In the public health arena, priority is usually given to controlling risks that are clearly established; that is, involving risk factors with a clear causal relationship to known diseases. However, rapid technological developments produce an ever-increasing variety of agents and exposure situations whose health consequences are less clear, and societies increasingly wish to address these uncertain consequences.

Waiting for conclusive evidence of a health threat can have unfortunate consequences (*Gee*, 2001). Therefore, when an agent is ubiquitous or the potential harm great or the possible effects are irreversible, it is sensible to consider taking precautions before a cause–effect relationship has been quantified or even established. Precaution can be integrated naturally into existing public health policy and should complement conventional disease prevention measures, which are usually taken only after a cause-effect relationship has been established.

However, care must be taken to have a due process when establishing policies based on precaution. Not all suggested health risks are found to be real. Indiscriminate use of precautionary measures may mean that innovations with undoubted health benefits will not be developed, or the benefits they bring will be delayed. Further, it may lead to widely differing national policies and to increased public anxiety.

What reasons are there for applying a precautionary approach to EMF?

The justification for considering a precautionary approach to limiting exposures to the ELF fields associated with the transmission, distribution and use of electricity is based, in part, on the classification of ELF magnetic fields as a possible human carcinogen by IARC. ICNIRP, in an assessment of the same evidence stated that the evidence for ELF fields causing cancer or other health effects at levels below those set out in their guidelines is not sufficient to warrant revised exposure limits at 0.3 or 0.4 μT. ICNIRP stated that this step was not appropriate because:

1. There is too much uncertainty in the interpretation of the epidemiological studies to be confident that these are indeed the appropriate levels.

2. Simplistic application of limits at these low levels is likely to have costs disproportionate to any benefit.

3. They could undermine the consistent adoption of ICNIRP guidelines.

However, given that there is still uncertainty about whether long-term exposure to ELF magnetic fields could cause childhood leukaemia, use of precautionary measures to lower people's exposure, that are low or no cost, would therefore appear to be warranted.

A second area where precautionary measures might be applied is to mobile phones. At this time there is no firm evidence to support a view that mobile phones are a health hazard. Indeed, the scientific evidence for RF fields causing adverse health effects at the levels where the general public are normally exposed is much weaker than that for ELF magnetic fields (*NRPB*, 2004). However a number of important research projects on this subject have yet to be completed and these could change the picture.

The UK Advisory Group on Non-Ionising Radiation (*AGNIR*, 2003) concluded that research published since the Stewart report (*IEGMP*, 2000) did not give cause for concern and the weight of evidence available did not suggest that there were adverse health effects from exposure to RF fields below the guideline levels. However, because the published research on RF exposures and health was considered to have limitations and because mobile phones had been in use for a relatively short time, the AGNIR felt the possibility remained open that there could be health effects from exposure to RF fields below the guideline levels; hence more research was needed. Until the results of current and planned scientific research studies become available it is prudent to consider some precautionary actions.

How might precautionary measures be applied to EMF?

A key point that must be made is that the adoption of a precautionary approach to EMF does not necessarily mean taking measures to reduce exposure. It can include other actions. A precautionary approach can cover a multitude of measures, varying from moderate measures such as the monitoring of scientific developments or the provision of information, through more active participation in the process of acquiring knowledge by carrying out research, up to stronger measures such as lowering exposure limits (*HCN*, 2004).

A hierarchy of options that might be considered when applying precautionary measures to (i) ELF fields and (ii) mobile phones is given below.

In the case of ELF fields:

- Take no action;
- More research;
- Better communications;
- Improved electric wiring in homes;
- Improved arrangement for the transmission and distribution of electric power;
- Improved electrical appliance design;
- Changes in land-use regime – new planning laws.

For mobile phones:

- Greater availability of data on phone emission levels;
- Encouragement of continued reduction of RF transmission levels used by phones;
- Improved design of hands-free kits;
- Greater provision of hands-free kits;
- Greater encouragement to use hands-free kits.

In the case of phone masts it is difficult to identify specific measures since masts are needed to provide RF communications in the surrounding environment. Their emissions are determined by network needs; too little signal causes gaps in mobile phone coverage, and too much signal would cause interference with neighbouring masts (cells). However information on EMF exposures, public consultation, and reducing public concern, should be part of improvements to base station licensing regimes and planning policy.

Are there drawbacks to precautionary policies?

The precautionary approach could be detrimental were it to become a bureaucratic obstacle to innovation or encourage high cost actions that provided little benefit to health.

The European Commission Resolution in 2000 stated that the Precautionary Principle can be invoked only when the risk is scientifically plausible, that the measures taken should be proportionate (costs should relate to benefits), and that the uncertainties should stimulate appropriate research. While the Precautionary Principle can reassure the public by showing that everything that can be done is being done, risk management should take into account risk perception and acceptability.

Conclusion

There is no doubt that the prudent use of precautionary measures would help reassure many in Ireland who are concerned over EMF exposure. Three specific areas in which this could be applied in Ireland are the use of mobile phones by children, the siting of high tension electricity supply cables, and the siting of mobile phone masts.

Question 9: How do the Planning Laws concerning phone masts have regard to public health and safety regarding EMF exposure?

Response: There is scope for improvements in the Planning Law and its application that could lead to an improvement in the public acceptance of base stations. Local Authorities are responsible for having them located where they are least objectionable but still permitting a high quality network to operate. WHO is drafting an advisory document for Local Authorities worldwide to assist them in dealing with planning applications for base stations and on how to best involve the affected community in an effective manner. This document should provide useful and relevant advice to Irish authorities.

Present planning arrangements

A common concern expressed by almost every individual, group and organisation that responded to the Expert Group's request for submissions to aid it in its work was dissatisfaction over the present arrangements in Ireland governing the erection of base stations. Neither concerned citizens' groups, local authority representatives nor the phone companies themselves considered the situation satisfactory. In some cases base stations were being erected without planning consent by exploiting loopholes in the Planning and Development Act (2000) and its Regulations (S.I. 600 of 2001). In other cases some local authorities adopt a policy that places restrictions on the location of masts in relation to buildings such as schools, hospitals and residences. This situation needs to be addressed so that such loopholes cannot be exploited and the public feel that the approval process for erection of new phone masts is open and transparent, and follows agreed rules.

An example of exploiting a planning loophole
Under Schedule 2, Part 1, of the Planning and Development Regulations (2001) antennas placed on an existing pylon structure are an exempted development under Planning Law. Therefore if pylon lighting is installed on a sports ground following planning consent and without objection, it becomes an existing pylon structure. A few weeks later mobile phone antennas are attached to one of the lighting pylons as exempted development.

Issues that concern the public

On the basis of the scientific evidence, there is no health consequence associated with exposure to the RF signals from base stations. Essentially, the RF fields emitted by the antennas

are not only too low to be a hazard, but are of comparable and often lower strengths than those produced by television and radio broadcasting, to which most people have been exposed for much longer. However there are other issues connected with the location of base stations. These are issues where the legitimate interests of the public could be better addressed.

Government policies, together with appropriate planning regulations, tailored to address the issues that concern the public would help provide the public with the reassurances it seeks. It could also improve the public's acceptance of new wireless communication technologies. Some issues that have given rise to particular concerns are:

- Proposals to locate base stations in areas of great natural beauty. There is scope for a disguised mast that blends with its surroundings.
- Proposals to locate base stations in places detrimental to the local urban architecture or streetscape. There is a case for housing the base station inside an existing structure. If no suitable structure exists then the base station should be located elsewhere.
- Proposals to locate base stations near places where children gather. While it is known that the RF emissions should not produce any health effects in children, it creates unnecessary sensitivities and concerns among parents.
- Insufficient information is provided on the physical size, shape and style of the proposed base station and the number and kinds of antennas to be attached to it; and on future plans for additional antennas likely to be placed on the mast and details of the additional antennas.
- There should be enough information on the RF energy emitted by each antenna and accurate estimates of the ground level exposures of the public in the vicinity of the proposed base station. Also, once erected a base station becomes an existing structure and further antennas are considered an exempted development; it should be a requirement that similar details be provided of all possible additional antennas at the time of submitting the planning application.
- Insufficient information on public exposures, both outdoors and indoors, to EMF fields from phone masts and the contribution of other RF sources to the public's overall exposure at these locations;
- Insufficient information on the safe distances from phone masts. This point relates to a question put to the Expert Group by Local Authority representatives. The question was "Can one calculate the safe distance from a phone mast antenna?" In other words, how close can a person go to a phone mast antenna before that person's exposure exceeds international exposure limits? In most cases the distance is less than 2 m.
- Absence of any central expert body the public can consult concerning phone masts and other EMF issues.
- Absence of regularly updated user-friendly information on EMF issues.

The final two points could be dealt with by a body in Ireland appointed to co-ordinate EMF activities, provide EMF advice, and publish information on the EMF issue in brochures, on a website, and in regular reviews of the scientific literature. This has been addressed in the recommendations of the Expert Group.

Consultation

In many European countries, efforts to resolve the problem of gaining public acceptance of building new phone masts have centred on involving people in the areas affected by the proposals in the decision making process. The decision is, however, not usually one of "Should the mast be built?" but "Where should it be built?" Public involvement in phone mast decisions works best where there is an acceptance by all that the mast needs to be erected somewhere in the area. WHO is drafting an advisory document for Local Authorities to assist them in dealing with planning applications for phone masts and on how best to involve the affected general public in an effective manner.

Chapter 4
Science Review

4.1 Radiofrequency Fields

Natural sources of radiofrequency (RF) fields

On a morning in February 1942 British radar operators, scanning the skies for enemy aircraft, detected massive interference or "jamming" on their screens. As the day progressed the source of the interference moved to the south, then to the west and finally ended after sunset. Surprisingly, it was only following several weeks of similar interference that the source of the jamming was found to be the sun. Studies of the sun some years before had failed to detect radio waves. Conventional wisdom at the time was that there were no extra-terrestrial radio sources. The explanation was sunspots! In 1942 the 12-year sunspot cycle was at its maximum; earlier measurements had been taken during a sunspot minimum. This discovery led to the creation of a new science, called radio-astronomy. Within the next thirty years radio-astronomers had detected the background radio signals that provided the most convincing evidence of the big-bang origins of our universe.

Today the sun is still the strongest natural source of RF fields. These are sufficiently powerful, at times, to interfere with satellite broadcasting and even caused a power failure across the north-eastern United States and Canada in the 1990s. Another natural source of radio waves is lightning, as evidenced by its interference with TV and radio receivers during thunderstorms. Indeed every object emits a constant measurable amount of RF radiation by virtue of its temperature.

Man-made sources

World-wide broadcasting began in the 1920s and there are now few people under the age of 80 who have not spent their entire lives bathed in radio waves from the increasing number of broadcasting transmitters. An exploratory trip along the wave bands of a good radio receiver will reveal several hundred AM, FM and short wave stations vying for our attention. Most of the analogue TV sets in use in Ireland have available some 60 channels to receive terrestrial television broadcasts. As there are only four national terrestrial stations plus four from the UK available, one might wonder why the TV sets are provided with 60 or more channels? The extra channels are needed to ensure that there is no interference from different transmitters using similar frequencies. While most people are aware of the large number of phone masts required for mobile phones (around 4500 at the latest count), few are aware that a large number of TV transmitters are also needed for terrestrial broadcasting, with over 500 transmitters around Ireland.

Besides radio and television the general public are exposed to many other common sources of RF fields. These include computer monitors and video display units, store and airport security systems, remote control access systems, induction heating elements, mobile phones and phone masts, paging systems, multi-point microwave distribution (MMDS) television, microwave ovens, radar, satellite broadcasting, microwave communication links, GPS navigation systems, and WLAN, WiFi and other wireless technologies used for in-house computer operation and internet access.

In medical treatment and diagnosis, patient exposure arises from many sources including diathermy equipment, electro-cautery devices, patient monitors, MRI scanners, hyperthermia machines used for cancer therapy and various surgical devices.

Figure 4.1 Photos of mobile phone mast and microcell-antennas.

General health effects

All established health hazards to people associated with RF fields occur at exposure levels that cause heating of the body tissues. The resulting temperature elevation depends on how well the body can dissipate the excess heat. In high intensity exposure situations RF heating can be sufficient to overcome the body's cooling ability and result in tissue damage. Tissues with a poor blood supply are particularly vulnerable. In the case of the lens of the eye, which has no blood supply, cataracts can result from high intensity exposures that raise the temperature of the lens by more than a few degrees. However the circumstances that give rise to such effects are very rare and confined to occupational environments where an accidental over-exposure may occur (*COMAR*, 2002).

Studies involving animals and human volunteers have found that adverse health effects are observed only when the heating produced by RF exposure raises tissue or body temperature by more than about 1ºC. Induced heating of this magnitude may provoke various physiological and thermoregulatory responses, including a decreased ability to perform certain tasks. The effects are similar to those experienced by people working in hot environments or suffering a prolonged fever. The development of the foetus may also be affected by induced heating, and birth defects could occur if the foetus' temperature were raised by 2-3 ºC for a number of hours. Induced heating can also affect

male fertility and, as described above, cause cataracts. It is quite unlikely, however, that a member of the public would ever be exposed to field strengths of the magnitude necessary to produce such significant heating (*WHO*, 1998).

From over 1300 peer reviewed scientific studies published since 1945 has come a consistent and clear conclusion that adverse health effects arise only where the absorption of RF energy generates a rise in temperature that cannot be accommodated by the body's cooling system. This conclusion has been supported by recent national reviews of RF health effects undertaken in a number of countries: (*Australia*, 2002); (*EU*, 2002); (*France*, 2001, 2005); (*Netherlands*, 1997); (*Hong Kong*, 2003); (*Japan*, 2001); (*New Zealand*, 2000); (*Canada*, 1999); (*Singapore*, 2002); (*Sweden*, 2003); (*UK*, 2004); and (*USA*, 2003).

Health effects of mobile phones

There is no doubt that concerns over the health and safety of mobile phone base stations have been raised by some members of the general public. There is significantly less concern over the mobile phones themselves, although RF exposures from the phones are considerably greater.

Base stations

A common concern about base stations is that whole body exposure to the RF signals they emit may have long term health effects. To date, the only acute health effects identified from RF fields are related to increases in temperature of more than about 1ºC, as discussed above. The levels of RF exposure from base stations (and other local wireless networks) are so low that the body's temperature rise is insignificant.

The strength of an RF field is greatest at its source and diminishes rapidly with distance. At or near ground level, in the vicinity of a typical 25-metre high base station mast, RF exposure is much lower than that received from a mobile phone. Because base station antennas do not radiate equally in all directions, but in a collimated beam tilted slightly to the ground, the maximum ground level exposure is always at some distance from the base of the mast. Recent measurements made in Ireland as part of the "400 Site" survey (*ComReg*, 2004) indicate that RF exposures from base stations are thousands of times below international exposure guidelines and are similar to or below those from radio and television broadcasting antennas.

Over the past 15 years a small number epidemiological studies have been undertaken to examine the association between cancer incidence and living near RF transmitters (*UK*, 2004; *WHO*, 2005). These studies have provided no evidence that RF exposure from transmitters increases the risk of cancer, even though the RF exposures are much higher than those found near base stations (*WHO*, 2006).

It is of interest to note that more of the energy from the RF fields emitted by TV and FM radio transmitters is absorbed in the body than those from base stations. This is because the frequencies used in FM radio (around 100 MHz) and in TV broadcasting (around 450MHz to 600MHz) are lower than those employed in mobile telephony (900 MHz and 1800 MHz). At these lower frequencies the height of the adult human acts as a more efficient receiving antenna. Children, because of their smaller size, absorb somewhat more RF energy at higher frequencies than do adults. While radio stations have been broadcasting for 80 years and TV for over 50 years without being associated with adverse health effects, there has been only a limited amount of research undertaken in this area. Essentially, there have been few reasons to carry out such studies.

Mobile telephony involves the transmission of complex digital signals. Soon many radio stations and most TV stations will also be transmitting their programmes digitally. Detailed reviews conducted on the possible health effects of digital signals have, so far, not revealed any hazard specific to different RF modulations (*Foster and Repacholi*, 2004; *WHO*, 2005)

In addition to these studies there have been occasional media reports of cancer clusters around mobile phone base stations and these have heightened public concern. When these clusters are analysed it is often found that the reported cluster doesn't exist. This can be due to a number of factors including multiple reporting of the same cases; some of the reported cancers having occurred many years before the existence of the base station; or that a number of the cancers were clearly associated with heavy smoking or some other more likely cause. Indeed, because cancer is primarily a disease that affects older people, over 20% of the Irish population will eventually die of cancer.

Although most cancer clusters reported in the media can be explained, the distribution of cancer in a population follows what is termed in statistics as a 'Poisson distribution'. Because of this, the distribution of the incidence of cancer in small areas will be very uneven, with some locations having many more cases than the average, and others far fewer. Further, since there are 4500 phone masts in Ireland, distributed relatively evenly among the population, it is to be expected that at any location where a cancer cluster is reported, there is likely to be a phone mast. This does not mean that the phone mast is the cause of the cluster.

Mobile phones

The reviews mentioned above have all concluded that while RF energy can interact with body tissues at levels too low to cause any significant heating, no study has established that any adverse health effects occur at exposure levels below international guideline limits. Most studies have examined the results of short-term, whole body exposure to RF fields at levels far higher than those normally associated with wireless communications. However the almost universal use of mobile phones in many countries has drawn particular attention to the possible consequences of localised RF exposure to the head and brain. It should be noted that current mobile phones use a digital signal, while earlier phones employed analogue signals. The power output of the digital phones is half or less than that of their analogue counterparts.

Several studies of animals exposed to RF fields similar to those emitted by mobile phones have found no evidence that RF causes or promotes brain cancer. While one study (*Repacholi et al*, 1997) found that RF fields increased the rate at which genetically engineered mice developed lymphoma, other studies have failed to support this finding (*Utteridge et al*, 2002; *Zook and Simmens*, 2001; *Heikkinen*, 2003). The Health Council of The Netherlands (*HCN*, 2003) concluded that there is no convincing evidence that, in experimental animals, the incidence of lymphomas and other types of tumours is influenced by lifetime, daily exposure to EMF such as those associated with mobile telephony.

The first case-control study of brain tumours and mobile phone use was conducted in Sweden (*Hardell et al*, 1999). It indicated no overall association of phone use with either brain tumours or acoustic neuroma (a benign tumour of the acoustic nerve), nor was there any association with analogue or digital phone use, whether considered together or separately, and whether phone use was measured starting 1, 5 or 10 years before the diagnosis. Subsequent re-analysis of the same data (by side of the head that the phone was used versus side of tumour occurrence) showed an association, of borderline significance, for tumours to occur on the same side of the head that the phone was used (*Hardell et al*, 2001). While pooled analyses of studies conducted by the Hardell group (*Hardell et al* 2006a,b) suggest an association between mobile and cordless phone, use and an increase in the incidence of brain tumours and acoustic neuroma, the original studies were criticised on methodological grounds (*Boice and McLaughlin*, 2002; *Sweden*, 2003). More useful information will come from the pooled analyses of the very large, 13-country, WHO-sponsored INTERPHONE study that is due for publication in 2007.

The results of some individual INTERPHONE studies have been published in peer reviewed scientific journals. These results show generally little or no association between head tumours and mobile phone use (*SSI*, 2004). Some studies have shown (*Lönn et al*, 2004) an increased incidence of acoustic neuroma in those who have been using mobile phones for more than ten years. This finding will require further investigation and replication. However, those who have used mobile phones for more than ten years were almost always initially using the older analogue phones.

In other studies scientists have reported effects from mobile phone use that include changes in brain activity, reaction times, and sleep patterns. The effects are small and transitory, and unlikely to have any long-term health consequences. Further studies in this area are in progress.

Research has clearly demonstrated an increase in the risk of traffic accidents when mobile phones (either hand held or with a hands-free kit) are used while driving (*IEGMP*, 2000).

In a study of the prevalence of symptoms among mobile phone users in Norway and Sweden (*Oftedal et al*, 2000), heavy users of mobile phones reported feelings of warmth on, around or behind the ear, headache, dizziness, fatigue and difficulty concentrating. However the reported symptoms did not appear to be related to the kind of mobile phone being used (analogue or digital).

Standards and WHO response

The ICNIRP guidelines for limiting public exposure have been adopted in a great many countries. They have been adopted in Ireland and have been recommended by the EU, in its Council Recommendation (*EU*, 1999) and in the Physical Agents Directive (*EU*, 2004). The ICNIRP guidelines are under constant review and are likely to be reissued with or without amendment following the publication of the WHO Environmental Health Criteria report on RF, expected to be published in 2009, an initiative of the WHO International EMF Project.

Summary

With acknowledgement to the many reviews mentioned above and particularly to two recent publications from the UK (*NRPB*, 2003; 2005) the following is a summary of the findings so far on the health questions raised by mobile telephony.

- The scientific evidence suggests that RF fields do not cause mutation in the DNA or initiate, progress or promote tumour formation.
- The epidemiological evidence does not suggest a causal association between the occurrence of brain cancer and exposures to RF fields, in particular from mobile phones, and radio and TV transmitters.
- A recent, well-conducted, case-control study from Sweden (*Lönn et al*, 2004) has identified a slightly increased risk of acoustic neuroma among people using a mobile phone for ten years or more. This conclusion was based on small numbers. No association was seen with use for less than ten years, which was consistent with previous studies. Epidemiological studies in progress should provide more information on this.
- A member of the general public would not be exposed to RF fields that exceed the guideline limits if they are more than about 1-3 metres from the antennas of a base station.
- Exposures to RF fields of members of the public near mobile phone base stations are a very small fraction of the guideline limits; current scientific evidence indicates that such exposures are unlikely to pose any risk to health.
- Exposures of animals to RF fields characteristic of mobile phone systems have found no evidence of genotoxic, mutagenic, or carcinogenic effects.
- RF exposure does not affect survival or tumour incidence in animals when tumours are induced by x-rays or chemicals. Further well-conducted research in this area is soon to be published (PERFORM-A studies under the EU's Fifth Framework Research Programme), although preliminary results released by the investigators indicate that none of the studies found any increase in cancer risk from RF exposure.

- Male fertility studies in animals show a susceptibility to RF exposure at levels that result in a significant temperature increase, but not at lower levels of exposure.
- Most animal studies have not reported any RF-field exposure effects on the brain or nervous system.
- There is mixed scientific evidence concerning the effect of RF exposure on human brain activity and cognitive function. A recent study in the Netherlands suggested some effects of UMTS signals (but not GSM signals) on self-reported well-being, but a replication study in Switzerland with an improved design could not confirm this (Regel *et al* 2006). The evidence for a direct effect of mobile phone fields on cognitive performance is inconsistent and unconvincing.
- Acute exposure to high intensities of RF fields can cause thermal injury to tissues. The guideline limits have been designed to protect against this effect.
- Some individuals report symptoms (most commonly of warmth or altered sensation in the ear and adjacent parts of the scalp) when they use mobile phones. It is possible that localised heating occurs as a consequence of the RF fields from the phone's antenna although lack of conduction of the body's own heat from a handset made of thermally insulating materials, is a more likely explanation.
- The epidemiological studies conducted to date provide only indirect information on RF exposure, and this may have diluted real effects, if there are any. The design of the studies has often been weak, and data on potential confounders have been limited or absent. The power of many of the studies has been low. Hence, although the studies have not found any increased risk of cancer from RF exposure, more information is needed from ongoing large high quality studies.
- The weight of evidence does not suggest that there are adverse health effects from exposures to RF fields below the guideline limits. However mobile phones have only been in widespread use for a relatively short time, less than 20 years. As evidenced by the Lönn study (*Lönn et al*, 2004) the possibility remains that there could be health effects from long-term exposure to RF fields within the guideline limits: hence continued research is needed. Further there have been few studies completed on diseases other than cancer or that involve children.

4.2 Power Line & Extremely Low Frequency Fields

While life in Ireland would be close to impossible without access to electricity and the supply infrastructure that delivers it, our very existence is critically dependent on electricity. The kick that delivers a score in a football game and the subsequent reactions of the spectators, the cry of a baby and the response of the parent are all dependent on the harmonised operation of billions of circuits that carry the electric currents which control the signals sent back and forth between our brain and nerve and muscle cells (*Hille*, 1984).

These natural, or endogenous, currents are as much a part of our bodies' function as are our heart and lungs, and no less important. The induction of further additional currents within the body as a result of exposure to an external magnetic field is a biological effect. Should these additional currents be of sufficient magnitude to affect normal body function then this could result in an adverse health effect. The study of these interactions, between external ELF electric and magnetic fields and the endogenous currents within the body, is a major element in the science of bio-electromagnetics.

ELF electric and magnetic fields

ELF **electric** fields exist wherever a time-varying voltage, for example mains electricity at 50 Hz, is present, regardless of whether or not any current is flowing. Almost none of the electric field penetrates into the human body because the body is a good electrical conductor. At very high field strengths, electric fields can be perceived by hair movement on the skin. The main sources of public exposure to such electric fields are associated with the transmission, distribution and use of electricity.

ELF **magnetic** fields are produced whenever a time-varying electric current is flowing. Magnetic fields readily penetrate the human body with little attenuation. Exposure to a time-varying magnetic field will generate, within the body, time-varying electric fields and currents in any conducting tissue.

Figure 4.2 Power lines: an important source of ELF fields

Health effects

From its commencement in 1996 the International EMF Project of WHO has made major efforts to promote and co-ordinate targeted research programmes into the possible adverse health effects associated with exposure to ELF fields. These programmes have involved epidemiological, animal and in-vitro studies that explore possible health effects and interaction mechanisms at levels below current international guidelines.

In recent years there have been a number of authoritative reviews of this research. These were carried out by *ICNIRP* (1998), the (United States) National Institute for Environmental Health Sciences (*NIEHS*, 1998), *NRPB* (2001), *HCN* (2001, 2004 and 2005), *IARC* (2002), the (UK) Health Protection Agency (*HPA*, 2006) and by *WHO* (1998, 2001).

The reviews all agreed that there were no established adverse health consequences arising from exposure to ELF at levels below the limits set out in the ICNIRP 1998 guidelines.

The IARC position on ELF

IARC is the specialised WHO agency established to investigate any cancer risks of the many chemicals, substances and physical agents. In a formal assessment of the scientific information available, IARC, mainly on the basis of epidemiological studies on children, classified ELF magnetic fields as a "possible human carcinogen". Essentially, a classification of a substance or environmental agent as a "possible human carcinogen" denotes the agent to be one for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals. This classification is the weakest of the three categories used by IARC to classify potential carcinogens based on published scientific evidence. The three categories in ascending order of potential carcinogenicity are "possibly carcinogenic to humans"; "probably carcinogenic to humans"; and "is carcinogenic to humans".

Regulatory policies for agents classified as possible carcinogens vary by country and by agent. The classification of an agent by IARC does not automatically trigger a national regulatory response. While pickled vegetables and coffee are among agents classified as "possible human carcinogens" there has been little effort to limit their exposure.

ELF fields

WHO's International EMF Project has embarked on the most detailed and extensive analysis of the scientific literature on the possible adverse health effects of ELF yet undertaken. This report is due for publication in WHO's Environmental Health Criteria Series in 2007.

Previous reviews of the scientific evidence (e.g. *NRPB*, 2004) have concluded that:

- People can perceive electric fields by hair movement but there are no apparent adverse health effects, except when spark discharges occur.
- People cannot perceive magnetic fields until the field strength is very high and induces electric fields and currents sufficient to cause nerve and muscle stimulation. These field strengths are well above those encountered in our living environment.
- No consistent or convincing effects have been found at ELF field levels normally encountered in the environment on the cardiovascular, immune or haematological systems, or on reproduction or development.
- *IARC* (2002) classified ELF magnetic fields as a possible human carcinogen based on epidemiological studies suggesting an association between exposure to ELF magnetic fields and childhood acute leukaemia. However the evidence for a causal association is weakened considerably because there is very little support from laboratory studies. Also the evidence for an association with other childhood cancers remains very weak.

The IARC Classification System

Group 1: The agent is carcinogenic to humans

This category is used when there is *sufficient evidence* of carcinogenicity in humans. Exceptionally, an agent may be placed in this category when evidence of carcinogenicity in humans is less than sufficient but there is *sufficient evidence* of carcinogenicity in experimental animals and strong evidence in exposed humans that the agent acts through a relevant mechanism of carcinogenicity.

Group 2A: The agent is probably carcinogenic to humans

This category is used when there is *limited evidence* of carcinogenicity in humans and *sufficient evidence* of carcinogenicity in experimental animals. In some cases, an agent may be classified in this category when there is *inadequate evidence* of carcinogenicity in humans and *sufficient evidence* of carcinogenicity in experimental animals and strong evidence that the carcinogenesis is mediated by a mechanism that also operates in humans. Exceptionally, an agent may be classified in this category solely on the basis of *limited evidence* of carcinogenicity in humans.

Group 2B: The agent is possibly carcinogenic to humans

This category is used for agents for which there is *limited evidence* of carcinogenicity in humans and *less than sufficient evidence* of carcinogenicity in experimental animals. It may also be used when there is *inadequate evidence* of carcinogenicity in humans but there is *sufficient evidence* of carcinogenicity in experimental animals. In some instances, an agent for which there is in *inadequate evidence* of carcinogenicity in humans but *limited evidence* of carcinogenicity in experimental animals together with supporting evidence from other relevant data may be placed in this group.

Group 3: The agent is not classifiable as to its carcinogenicity to humans

This category is used most commonly for agents for which the *evidence of carcinogenicity is inadequate in humans and inadequate or limited in experimental animals.* Exceptionally, agents for which the evidence of carcinogenicity is inadequate in humans but sufficient in experimental animals may be placed in this category when there is strong evidence that the mechanism of carcinogenicity in experimental animals does not operate in humans. Agents that do not fall into any other group are also placed in this category.

Group 4: The agent is probably not carcinogenic to humans

This category is used for agents for which there is *evidence suggesting lack of carcinogenicity* in humans and in experimental animals. In some instances, agents for which there is inadequate evidence of carcinogenicity in humans but *evidence suggesting lack of carcinogenicity* in experimental animals, consistently and strongly supported by a broad range of other relevant data, may be classified in this group.

Health risk assessment

ELF electric and magnetic fields can induce electric fields and currents in the body. At very high exposure levels this can affect the nervous system with consequences for health such as nerve stimulation or involuntary muscle movement. Exposure at lower levels may induce changes in the excitability of nervous tissue in the central nervous system that could affect memory, cognition and other brain functions. These acute effects on the nervous system form the basis for international exposure guidelines. The international guidelines for public exposure are set to protect individuals from all of these effects. In any event exposure levels that lead to such effects, or exceed the international guidelines, are highly unlikely to be encountered by the general public under normal circumstances.

Epidemiological studies of the association between ELF magnetic field exposure and childhood leukaemia suggest that where the average exposure exceeds 0.3 μT to 0.4 μT the incidence of childhood leukaemia is doubled. However the exposure of children in Europe to ELF magnetic fields is generally much lower than this, averaging 0.025 μT to 0.07 μT, depending on the location of the particular epidemiological study. The proportion of children who are exposed to magnetic fields above 0.3 μT in Europe is estimated at less than 1% (*Greenland and Kheifets*, 2006). No Irish exposure data are available.

The interpretation of epidemiological studies

Epidemiologists study the causes of ill-health and the consequences of exposure to potentially harmful agents in human populations. Unlike animal studies, where generally exposure is precisely controlled, and the animals share environments identical apart from the exposure being studied, in human studies the level of exposure to the agent may not be very precisely known, and the people exposed will often live in very different environments and have different patterns of exposure to other agents. For example, some may smoke, and some not; some live in cities, others in rural areas; some may be rich and others poor.

There are two main types of epidemiological study used to explore the health effects of EMF. Cohort studies identify a group of people exposed at different levels to EMF, and see what happens to them over time. Case-control studies enrol a group of people with a specified disease, and a comparison group (controls) without, and both are then asked about previous exposures. These studies have different strengths and weaknesses.

Interpreting the results of epidemiological studies can be difficult. Many professionals argue that no single study is sufficiently reliable to stand alone. Similar results from several studies, especially from studies carried out in more than one country are much more likely to be true, than the results from any single study.

It is notable that only half of the children exposed to the highest levels of low frequency fields receive their exposure from overhead power lines. The rest receive their exposures from the electricity supply within the home either from the way the household wiring was configured or from using electrical appliances (*HPA*, 2005).

If the association between ELF magnetic field exposure and childhood leukaemia **were causal** then, given data on the number of children in Ireland who are exposed to fields greater than 0.4 μT, it would be possible to make an estimate of the number of additional cases that could be expected to arise from such exposure. Unfortunately no reliable data are available on the magnetic field exposures of Irish children that would permit this estimate to be made. If, however, we were to assume that the exposure of Irish children to magnetic fields is broadly similar to that of children in England and Wales where 0.5% of children are exposed to fields above 0.4μT, then an estimate can be made of the additional childhood leukaemia caused by this exposure. In England and Wales it was calculated that a causal association between magnetic field exposure and leukaemia in children would explain two cases in every five hundred cases of childhood leukaemia (*NRPB*, 2004). In Ireland the number of cases of childhood leukaemia reported annually varies from around 35 to 55. On the basis of the UK data, one could conclude that one case of childhood leukaemia every five years might theoretically be due to magnetic field exposure, if the association is causal.

Alternatively, if we use the estimate that up to 1% of European children are exposed to fields above 0.3 μT then one can estimate the number of Irish children so exposed to be around 10,000. On the basis of a doubling of the incidence of leukaemia among this group, then where the number of cases ranges from 35 to 55 each year, one case every second or third year might theoretically be due to magnetic field exposure, if the association is causal.

Uncertainties in the health risk assessment

Evidence of other possible effects associated with EMF exposure derives principally from epidemiological studies and from some experimental studies. The main but not the only subject of such studies has been cancer. These studies have been extensively reviewed by a number of expert groups. Their overall conclusion is that currently the results of these studies on EMF and health, taken individually or as collectively reviewed by expert groups, are insufficient either to make a conclusive judgement on causality or to quantify appropriate exposure restrictions (*NRPB*, 2004).

Exposure standards

The aim of the ICNIRP exposure guidelines for ELF fields is to avoid situations where the electric fields and currents induced by external fields overcome or otherwise compromise the endogenous fields and currents in the body and so create an adverse health situation. The guideline values are based on reproducible threshold effects on human volunteers and experimental animals and are set 50 times lower than the relevant threshold effect.

Following the classification by IARC of ELF magnetic fields as a possible human carcinogen, ICNIRP issued a statement indicating that the evidence for these fields causing leukaemia in children was too weak to recommend any changes to their exposure guidelines (*ICNIRP*, 2001). Following publication of the WHO Environmental Health Criteria report on ELF fields, ICNIRP will undertake a further review of its ELF guidelines.

The European Union has also continued to recommend and use the ICNIRP guidelines: in the Recommendation of the Council of Health Ministers to limit public exposures to electromagnetic fields in Member States (*EU*, 1999) and more recently in the Physical Agents Directive limiting occupational exposure to EMF (*EU*, 2004).

4.3 Static Fields

Static magnetic fields

At the centre of the earth there is a solid core that is as big as the moon and as hot as the surface of the sun. It provides the heat and energy that melts and drives the surrounding layer of molten iron magma whose movement creates the earth's magnetic field. This natural geomagnetic field varies in strength from 35 to 70 microtesla (μT) and is enough to deflect compass needles, and assist in the navigation and migration of some birds and fish. Static man-made magnetic fields are generated wherever direct (DC) currents are used, as for example in Dublin's DART and LUAS suburban transportation systems, and in a number of industrial processes including aluminium manufacture and gas welding.

Figure 4.3 Photograph of a LUAS tram in Dublin

More recent technological innovations have led to the use of static magnetic fields often very much stronger than the earth's magnetic field. They are used in research and in medical applications such as magnetic resonance imaging (MRI) that provide three-dimensional images of the brain and other soft tissues. In routine clinical systems, scanned patients and machine operators can be exposed to strong magnetic fields of up to 3 T. In medical research applications fields of 10 T can be employed in whole body scanning. As the field strengths used in MRI systems increase, so to does the potential for various interactions of the field with the body.

Static electric fields

Collisions between cosmic rays and air molecules in the upper atmosphere produce a charged layer of around 300 000 volts some 25 km above the earth's surface. This creates a natural static electric field of around 10 to 100 volts per metre (V/m) at ground level to which we are all exposed. During thunderstorms this field can increase over a hundredfold and the potential for lightning strikes, discharges between the atmosphere and the earth, can pose a serious danger to anyone caught out in the open. Electrostatic fields in a hazardous atmosphere can initiate explosions. A common experience in daily life is the spark discharge experienced when touching something metallic after walking over a carpet. While these electrostatic fields can measure tens of thousands of volts per metre and can be an irritation, they are generally not hazardous because they are not associated with enough electrical charge to cause injury. However such sudden shocks can cause accidents when the affected person falls or drops something they are carrying.

Figure 4.4 Photograph of Lightning

The use of DC electricity, as in the DART and LUAS for example, is another source of static electric fields. Television and computer screens employing cathode ray tubes can also generate electrostatic fields as evidenced by dust particles attracted to the screen.

Health effects

Few studies have been carried out concerning the possible health effects of static electric fields.

Except for lightning strikes resulting from the discharge of the electric fields associated with thunderstorms, the results to date suggest that the only adverse acute effects are associated with the direct perception of the electric field through its interaction with body hair and discomfort from spark discharges. Chronic or delayed effects of static electric fields have not been intensively investigated, but such effects seem very unlikely. IARC noted that there was insufficient evidence to determine the carcinogenicity of static electric fields (*IARC*, 2002). A detailed explanation of the IARC classification system is given in the section on 'Power Line and Extremely Low Frequency Fields'.

The following observations are drawn from the WHO's Environmental Health Criteria report, *Static Electric and Magnetic Fields* (*WHO*, 2006).

In the case of static magnetic fields, acute effects are only likely to occur when there is movement in the field. This would arise from the motion of a person or of an internal body movement, such as blood flow or heart beat. A person moving within a field above 2 T can experience sensations of nausea and vertigo, and occasionally a metallic taste in the mouth and perceptions of light flashes. Although only temporary, such effects may have safety implications for workers executing delicate procedures (such as surgeons performing operations within MRI units).

Static magnetic fields exert forces on moving charges in the blood, such as ions, generating electric fields and currents around the heart and major blood vessels that can slightly impede the flow of blood. Possible effects range from minor changes in the heartbeat to an increase in the risk of abnormal heart rhythms (arrhythmia) that might be life-threatening (such as ventricular fibrillation). However, such kinds of acute effects are only likely in fields above 8 T.

With regard to chronic and delayed effects such as cancer, the available evidence from epidemiological and laboratory studies is insufficient to draw a conclusion. IARC concluded that there was inadequate evidence in humans for the carcinogenicity of static magnetic fields, and no relevant data was available from experimental animals. They are therefore not at present classifiable as to their carcinogenicity to humans (*IARC*, 2002).

Static magnetic fields can affect implanted metallic devices such as pacemakers, and this could have direct adverse health consequences. It is suggested that the wearers of cardiac pacemakers, ferromagnetic implants and other implanted medical and surgical devices should avoid locations where the magnetic field exceeds 0.5 millitesla (mT). Also, precautions should be taken to prevent hazards from loose ferromagnetic objects becoming projectiles in areas where the field exceeds 3 mT.

Standards

Recommended static field exposure limits were issued by ICNIRP some years ago (*ICNIRP*, 1994). These limits are now under active review following the WHO Environmental Health Criteria report on static electric and magnetic field exposure (*WHO*, 2006) and the European Union's Physical Agents (Electromagnetic Fields) Directive (*EU*, 2004). As there were insufficient data available on static magnetic fields, the EU did not include them in this occupational EMF directive. The review being undertaken by ICNIRP of its static fields exposure guidelines is particularly relevant in the context of the high static magnetic field strengths now being employed in many MRI imaging systems. However in the vicinity of MRI machines, exposures are confined to medical and support technical staff who work near the magnet and to patients and volunteer personnel undergoing scans. No member of the general public will experience such fields unless he or she becomes a patient. The current static magnetic field exposure limit recommended by ICNIRP is 40 mT for the general public.

4.4 New Wireless Technologies and Health

Wireless communication

Einstein, when questioned by a young correspondent about radio, explained:

> *"You see, wire telegraph is a kind of a very, very long cat. You pull his tail in New York and his head is meowing in Los Angeles. Do you understand this? And radio operates exactly the same way: you send signals here, they receive them there. The only difference is that there is no cat."*

In the seventy years that followed Alexander Graham Bell's invention of the telephone half a billion fixed telephone lines were installed world-wide. Yet this impressive statistic is dwarfed by the uptake of the mobile phone: one billion in use within ten years of its introduction and around two billion at present. Neither the motor car, nor the television set, nor any other invention in the history of mankind has been so quickly and universally accepted or has achieved such a rate of growth.

Einstein might have mentioned that instead of the cat you needed a transmitter and a receiver. In mobile telephony the phone and the base station transmitter (the phone mast) have antennas that can both transmit and receive signals. While the public's love affair with mobile phones grows, and the applications and functions provided by them seem limited only by our imagination, the necessary corollary of providing more and more phone masts to facilitate their use generates an opposite emotion.

It is unavoidable that all new wireless technologies will require transmitters and receivers. It is also the case that many new technologies will require large numbers of radio transmitters located in places where they are readily observable and generate further public concern. The purpose of this chapter is to highlight the developments in wireless technology most likely to impact the general public over the next five or so years and identify and comment on the radio-frequency exposures associated with these technologies.

The new technologies

GSM

Ten years ago there were fewer than 400,000 mobile phones in use in Ireland; today there are 4 million. These require some 4500 base stations to provide an almost total national coverage. These base stations operate under the Global System for Mobile Communication (GSM). It is the most widely used mobile standard with around two billion customers in 200 countries. GSM can operate in two main frequency bands: one between 880MHz and 960MHz, the other between 1710MHz and 1880MHz. The phones communicate with the masts by means of coded pulsed signals and avoid interfering with one another by staying within the confines of their allocated frequency bands or 'carrier wave'.

Typical mobile phone handset transmitter power during a call lies in the range of 0.2 to 0.6 W which contrasts with other hand-held transmitters, such as “walkie talkies” that can transmit up to 5 W. Because the design of the handset and the common position of use (against the head), the head of the user receives the highest exposure.

Since October 2001, under a voluntary agreement between the European industry associations and the EU, all phones on sale within the EU are provided with information on their specific absorption rate (SAR). The SAR is a measure of how much RF energy is deposited in the head per second when the phone is operating at maximum power. All mobile phones on sale must operate below a SAR limit of 2.0 watts per kilogram (W/kg), measured over any 10 grams of tissue. Typical SAR levels for phones currently on sale in Ireland range from 0.2 to 1.2 W/kg. The exposure levels fall off very rapidly with distance from the handset. For example, the RF exposure to a person 30 cm from a transmitting phone is only one-hundredth that received by the phone user (*ICIA*, 2001; *WHO*, 2000).

Third generation (3G) mobile telephony – UMTS

The introduction of a 3G network for mobile telephony is currently underway in Ireland. Handheld 3G phones generally operate at lower power levels than GSM handsets. The typical power output from a 3G phone can vary between 0.125 W and 0.250 W. 3G phones are similar to GSM phones in that they utilise adaptive control technology that enables them to operate at the lowest power required for good radio communication at any time. The SARs from 3G phones are between one half and one tenth of those produced by GSM phones.

The broadband communications that 3G provide enables high-speed access to services such as the Internet, video conferencing and faster e-mail. The 3G network in Europe is based on the Universal Mobile Telecommunications System (UMTS) standard. Planned terrestrial operation will employ frequencies between 1900 and 2170 MHz. The frequency range from 2170 to 2200 MHz is reserved for satellite phones.

The average RF emission from 3G base station transmitters, around 3 W, is lower than from GSM base stations. The reason for the lower antenna power is due to the use of smart technology to encode information on a broadband radio signal and to the smaller size of the 3G cell. Maximum public exposure levels from 3G masts are usually less than one thousandth of the international exposure limits. At a distance of 200 metres from a 3G base station, public exposures fall to one fifty thousandth of these limits. (*Australia*, 2003)

Terrestrial Trunked Radio (TETRA)

TETRA is a dedicated digital mobile telephone system for emergency services and particularly national police forces. TETRA will replace the analogue radio systems that are in use by An Garda Síochána. The advantage of TETRA is that it can provide clearer, more secure and extensive coverage than the analogue system. TETRA allows group calls to be set up quickly and it can cope with very high peak demand. An additional benefit is that emergency services and Garda operations will not be impeded during a major incident: in such circumstances it is not unusual for GSM and analogue communication networks to become overloaded by public use. The reference to “trunked” in the TETRA acronym means that radio channels can be shared by two or more users at the same time.

TETRA operates at frequencies from 380 to 399.9 MHz and from 870 to 921 MHz. In trunked operation the radio equipment communicates through base stations similar to the GSM mobile telephone system. The transmission power employed by TETRA base stations can be 25 W per carrier. However TETRA also supports direct mode operation whereby TETRA radio equipment can link directly to other TETRA radio equipment without going through a base station.

TETRA handsets can operate at either 1 or 3 W in data transmission mode. In speech mode the outputs are reduced to 0.25 or 0.75 W depending on the class of radio used. The TETRA base stations have outputs of a few tens of watts and are similar in this respect to GSM base stations (*UK*, 2004). However TETRA base stations operate continuously, whereas GSM base stations operate only when mobile phone users in the area are making calls.

Wireless local area network (WLAN) and WiFi

The first Wireless Local Area Network or WLAN began operation in 1971 as a research project at the University of Hawaii. ALOHANET, as it was called, was deployed over four islands and connected to a computer on Oahu without using conventional phone lines. Today, laptops, personal computers, personal digital assistants use WLAN, or WiFi as it is more often called in Ireland, to communicate with one another, to provide users with go-anywhere Internet access, and to connect to wireless hubs that connect a range of home devices. (*Link*, 2002)

While WiFi wireless networks can reach up to one kilometre in range, the most widely used applications (in offices, schools, homes and hotels) have a much shorter range. Computers with WiFi have antennas mounted externally or internally to effect the radio communication, which uses frequencies between 2.4 and 5.88 GHz. Each WiFi cell requires a central antenna. Due to the frequencies employed and the generally small size of a cell the central antennas are usually very small and low powered.

Many mobile phones now contain WiFi chips to allow them hook up to the Internet wirelessly. Users will then be able to use the WiFi network to make phone calls over the Internet using Voice over Internet Protocol (VoIP). At a touch of a button on their phones, users will bypass their mobile phone network and connect to the WiFi network instead.

WiFi equipment operates in one of four designated frequency bands. The maximum power output per device ranges from 0.1 W at 2.4 GHz to 2 W at 5.88 GHz. WiFi users can expect maximum transmission speeds of between 24 to 35 megabits per second (Mbps) over open spaces of about 50 metres. At greater distances or indoors in the presence of obstacles, WiFi, like all short range radio systems, reduces

its data transmission speed to compensate. Because WiFi transmissions are intermittent, on a time averaged basis, user exposure will be lower and depend on the amount of data being transmitted. Actual exposure of a user of WiFi equipment will also depend on where the transmitting antennas are located with respect to the user's body. Intensity levels within offices equipped with WiFi are well below exposure guideline limits. However, in situations where the antenna in a laptop computer is within a centimetre or so from the lap on which the computer is placed, exposure levels will be higher (*Leeper*, 2002; *UK*, 2004). Only one report on EMF exposure is available at this time (*Schmid*, 2005).

DECT (Digitally enhanced cordless telephones)
Cordless phones operating in a domestic environment are similar to GSM phones in that they also need a base station. However the base station usually doubles as a cordless phone holder and is powered by mains electricity. This small base station communicates with up to six cordless phones linked to the system by radio signals.

The signals are digitally encoded to prevent eavesdropping. DECT systems operate at frequencies between 1880 and 1900 MHz. They are extremely low powered – their range is typically 50 metres from indoors. (*Eircom*, 2003). The base station power outputs are limited to 12 milliwatts (mW) and the phone outputs to 10 mW. A typical GSM base station can have an output between 20 and 50 W, which is some 2000 to 5000 times greater than DECT.

Bluetooth
Short-range wireless communication among electronic devices can be achieved by use of Bluetooth (the name derives from that of a tenth century Danish king who, unusual for the time, fostered peace and harmony among his neighbours). Bluetooth is the best known of what are called wireless personal area networks (PANs). Wireless PANs can replace the USB and other cables used to pass data among closely located electronic equipment. The typical data transmission speed of Bluetooth is around 700 kilobits per second over distances up to 10 metres. Devices incorporating Bluetooth include mobile phone headsets and computer accessories such as printers, keyboards, the computer mouse, and personal digital assistants. This technology is being increasingly used in business and in the home. Bluetooth operates in a frequency band around 2.45 GHz. The maximum power of Bluetooth devices is 100 mW, 25 mW or 1 mW, depending on the power class of the device. (*UK*, 2004)

Ultra-Wideband (UWB)
Few technical developments better illustrate the march of communications technology than ultra-wideband (UWB) wireless technology. Whereas one hundred years ago Marconi, by means of bulky coils and capacitors, could convey the equivalent of 10 bits of data per second, UWB technology, with tiny integrated circuits and tunnel diodes, can send more than 100 million bits of digital information in the same time.

UWB wireless is unlike other more familiar forms of radio communication such as AM/FM, short wave, emergency services, radio and television. The latter are all narrow band services, which avoid interference with one another by staying within the confines of their allocated frequency bands, using what is called a carrier wave. There, the data messages are impressed on the underlying carrier signal by modulating its amplitude, frequency or phase. UWB technology is quite different. Instead of a carrier signal, UWB messages are composed of a series of intermittent pulses. By varying the pulses' amplitude, polarity, timing or other characteristic across a range of frequencies information is coded into a stream of data.

Because of their extremely short duration – a pulse only lasts for a fraction of a billionth of a second – these ultra wideband pulses function in a continuous band of frequencies that can span several GHz. UWB transceivers are now able to provide very high data transmission speeds in the range 100 to 500 Mbps across distances of five to 10 metres. Ultra wideband communication systems operate at power levels so low that they emit less radio energy than a hair dryer or an electric drill or even a laptop computer. This low power, however, restricts the range of UWB devices to usually around 10 metres. A typical 200 microwatt (μW) UWB transmitter radiates only one three-thousandths of the average energy emitted by a 0.6 W mobile phone. (*Leeper*, 2002)

Radio-frequency Identification (RFID) Systems
Low power wireless communication is widely used in radio-frequency identification (RFID) of people and objects.

There are two basic types of RFID – active and passive. In the active system the object or person whose movements are controlled or monitored carries a radio transmitter. The signal from the transmitter is detected by a fixed receiver mounted on the entry or exit under surveillance. Information from the receiver is then analysed by a computer that sends instructions to permit or prevent passage.

Figure 4.5 Photo of one day old baby wearing RFID tag

In the passive system the object or person carries a microchip attached to a tiny antenna, called a transponder. The radio transmitter is mounted on the entry or exit under surveillance. The signal from the transmitter prompts a responding signal from the transponder. This response is then relayed to a computer, which takes the appropriate action. Most of the RFID devices to which the public are exposed are passive (i.e. non broadcasting) devices.

An interesting new application in use in some Irish maternity hospitals is the use of RFID ankle bands on newborn babies as a more secure alternative to their conventional identification by a handwritten identification tag. Doors can be automatically closed and alarms sounded should an unauthorised person move the baby out of a designated area.

The power output of RFID devices is generally small, of the order of 10 mW. A large number of specific wireless frequencies are approved for short range RFID devices, from 9 kHz to 17.3 GHz.

Health effects of new wireless technologies

A question that is often asked, particularly in the field of wireless technology, is why new technologies continue to be introduced without being subject to a kind of health check? New pharmaceutical products must undergo rigorous testing before they can be prescribed. Why are the same measures not undertaken prior to the introduction of new commercial applications of wireless technology?

This important question is dealt with in detail elsewhere in this report. The answer is founded on standards. Essentially, there exist scientifically well-supported exposure standards based on extensive and on-going research that can be used as a yardstick to assess the safety of virtually all new applications of wireless technology. If one knows the operational power output of the new device, the frequency or frequencies at which it operates, and the proximity of the user or the general public to the device, then it is possible to calculate or measure the maximum field strength and the nature of the radio-frequency field to which a member of the public is subjected.

This measured or calculated exposure is then compared to the maximum recommended exposure limits set out in the standard. The standards for public exposure have safety factors of more than 50 built into their values and any exposure less than this limit is not harmful. Likewise any small excursion in exposure above the limits, while requiring investigation, is unlikely to present an adverse health risk because of the safety factor incorporated into the limit.

One way of looking at the new technologies discussed above is to compare them to the GSM mobile phone exposures that are discussed earlier. UMTS 3G phone systems operate around 2000 MHz. This frequency penetrates less into the human body than the GSM frequencies (900 MHz and 1800 MHz).

The maximum power output of a UMTS phone varies is 0.25 W, compared to 2 W at 900 MHZ and 1 W at 1800 MHz for the GSM phones. However because the UMTS handset transmits continuously while the GSM handset operates in pulsed mode, the exposure to a UMTS handset is essentially the same as that from a 1800 MHz GSM handset. UMTS base station outputs are smaller than those of GSM base stations because the UMTS cell size is generally smaller.

TETRA handsets operate at either 1 or 3 W in data transmission mode. When operating in speech mode the outputs are reduced to 0.25 or 0.75 W depending on the class of radio used. The TETRA base stations have outputs of a few tens of watts and are similar in this respect to GSM base stations. Measurements undertaken using an artificial head (*UK,* 2004), have shown that a 3 W handset operating at maximum power, held close to the head for longer than six minutes, could result in the maximum exposure standard for a member of the public being exceeded. However this exposure would not exceed the occupational exposure guideline. The occupational exposure limits are five times higher than those for the general public, but still incorporate a safety factor of 10 over the level at which any health risk might arise.

DECT, WiFi, Bluetooth, UWB and RFID technologies involve short range radio signalling with associated low power outputs and correspondingly low user exposures. However these exposures can be higher than expected because it is possible for the user to get extremely close to the transmitter. This is particularly the case with DECT, WiFi and Bluetooth transmitters. Recalling that the limiting SAR for GSM phones is 2 W/kg, the following peak spatial SAR exposure measurements were reported at the WHO 2005 workshop on base stations (*Kuhn et al*, 2005):

- DECT: Four devices, maximum SARs: 0.019 W/kg to 0.052 W/kg
- WiFi: Three devices, maximum SARs: 0.06 W/kg to 0.81 W/kg
- Bluetooth: Four devices, maximum SARs: 0.005 W/kg to 0.466 W/kg

4.5 Electromagnetic Hypersensitivity

What is EHS?

The term ‘electromagnetic hypersensitivity’ (EHS) is often used to denote a phenomenon where individuals experience adverse health effects while using or being in the vicinity of electric, magnetic, EMF sources and devices, and when the individuals themselves attribute their symptoms to EMF emissions from these sources and devices. There are no standardised diagnostic criteria available and, although the symptoms experienced vary substantially among the affected individuals, they are generally non-specific with no objective signs present. The severity of the condition varies; the majority of cases present mild symptoms, but some people experience severe problems with major consequences for work and everyday life (*SSI*, 2004).

There is little support for the term ‘electromagnetic hypersensitivity’ to describe this condition among medical specialists. The symptoms and the distress they cause clearly exist, but, so far, no study has been able to prove a link between EMF exposure and the occurrence of symptoms. At a recent workshop organised by the WHO on the subject (*WHO*, 2004), it was proposed that, the term should not be used. Instead the expression ‘idiopathic environmental intolerance’ or IEI was suggested. The Independent Expert Group to the

Swedish Radiation Protection Agency, who also recommend against the use of the term 'electromagnetic hypersensitivity', believe that any term that combines exposures and health consequences will hinder further studies (*SSI*, 2004).

Prevalence of EHS

Assessments of the prevalence of EHS depend on the methods used to identify cases, and the questions asked in each specific survey. The reported prevalence of EHS varies considerably throughout the world and between reports. At the time of a major investigation for the European Commission (*Bergqvist*, 1997) EHS was most common in the Nordic countries and Germany but rare or non-existent in the UK and The Netherlands. A survey of the population of Stockholm reported a prevalence of 1.5% (*Hillert, et al*, 2002), while a survey in California estimated EHS prevalence at 3.2% (*Levallois, et al*. 2002). However, the reported prevalence of EHS in different studies strongly depends on the definition of EHS and the method used to collect the data.

Sources and symptoms

In a Swiss EHS study (*Röösli et al*, 2004) it was found that the most common reported symptoms were sleep disorders, followed by headaches, nervousness or distress, fatigue and concentration difficulties. The most common sources to which the subjects attributed their symptoms were mobile phone base stations (74%), mobile phones (36%), cordless phones (29%) and power lines (27%). Symptoms reported in other studies include those of the skin (redness, tingling, and burning sensations) as well as tiredness, dizziness, nausea, heart palpitation, and digestive disturbances.

There is no doubt that the symptoms affecting EHS individuals are real. This has led national and international authorities to set up investigations to determine if and how exposure to EMF might give rise to these symptoms.

Studies of individuals

In 2005, a major review was published of 31 provocation studies involving, in total, 725 individuals who suffered EHS symptoms (*Rubin et al*, 2005). Only blind or double blind studies were included in the review. A blind provocation study is an experiment in which the participants are systematically exposed or not to EMF without knowing whether the EMF source is on or off.

The authors concluded that while the symptoms described by EHS sufferers can be severe and are sometimes disabling, it was difficult to show under blind conditions that exposure to EMF can trigger these symptoms. They concluded that EHS was unrelated to the presence of EMF. This conclusion is shared by a United States review (*Ziskin*, 2002) which concluded that in tests where the subjects did not know whether or not they were actually exposed to EMF, there was a correlation between the presence of the symptoms and when the subjects believed they were exposed, but no correlation to actual exposures.

More recently *Rubin et al* (2006) reported the results of a double blind study involving 60 EHS people and 60 controls (people unaffected by EHS) who were exposed to (i) a 900MHz GSM phone signal; (ii) a non-pulsing carrier wave signal, and (iii) a sham condition with no signal present. The principal outcome in the experiment was headache severity. Six other subjective symptoms were also monitored, including the participant's ability to judge whether a signal was present or not. The results showed that headaches and other symptom severities increased during the experiment and decreased immediately afterwards. The symptoms were not trivial and some experiments had to be stopped early and some of the participants withdrew from the study. However these reactions occurred under both active and sham exposure situations.

The authors concluded that there was no evidence to indicate that people with self reported sensitivity to mobile phone signals are able to detect such signals or that they react to them with increased symptom severity. As sham exposure was sufficient to trigger severe symptoms in some participants, psychological factors may have an important role in causing this condition.

How the EHS problem is dealt with in Sweden

The dilemma in dealing with EHS individuals is that while their symptoms are real and at times disabling, there is no evidence to suggest that EMF exposure is the cause of their illness. So, what can be done?

In Sweden, where there appears to be a greater proportion of EHS than elsewhere, guidelines have been issued by the National Board of Health and Welfare concerning the treatment of such patients. These guidelines, which are aimed at doctors, particularly in primary care, read as follows:

> *"In many cases, the investigation does not result in a specific medical diagnosis. Besides skin changes, it is rare to find any pathological abnormalities in the clinical investigation or in the laboratory tests. The patient's conception that the symptoms are caused by electricity (electromagnetic fields) may persist and the patient may insist that reducing the exposure to electromagnetic fields is important. The doctor's job is then to provide information on current knowledge based on science and medical experience.*
>
> *It is not the job of attending physicians to recommend whether actions to reduce exposure to electromagnetic fields should be carried out. There is no firm scientific support that such treatment is effective. Instead, these questions may be dealt by the employers or local authorities, who in some cases have decided to grant home adaptation grants (for such actions).*
>
> *Replacement of electric equipment e.g. fluorescent tubes with light bulbs, replacement of cathode ray tubes with displays of liquid crystals, so-called LCD, may be tested as a part in a rehabilitation plan. Some measures to reduce exposure to electromagnetic fields is sometimes also part of such actions. Advantages and potential drawback of such actions should*

carefully be considered in each individual case, before implementation, e.g. how to handle the situation if there is no improvement in health." (Hillert, 2005)

The focus in Sweden is on the symptoms presented by the afflicted person and the right to sick leave, sickness benefits, disability pension etc is based on the degree of ill health and functional handicap of the person regardless of a known or unknown cause for the condition. There is no scientific treatment and since the clinical picture varies from case to case any recommendation for interventions or treatments to be tried is based on a broad evaluation of each individual's specific situation, including medical investigation, psychosocial situation and possible contributing environmental factors. Treatments known to reduce the type of symptoms presented by the patient can be tried.

It is important that a good patient-doctor relationship is established and that a medical physician is available to offer follow-up visits to ensure (after the initial medical work aimed at excluding known medical conditions) that new medical evaluations are made when required by a change in symptoms, for example. EHS has not been accepted as a work injury in Sweden.

The 2005 UK HPA report on EHS

A major review of EHS incidence and treatment was published recently by the UK Health Protection Agency (*Irvine*, 2005). The starting point for the review was recognition by the HPA of the need to consider EHS in terms other than its aetiology – the medical study of the causation of disease – as this position alone was failing to meet the needs of those who consider themselves affected by EHS.

The EHS symptoms that predominated in the UK were headache and fatigue. These symptoms can have severe consequences for the social functioning of those affected. There was a considerable overlap between EHS and a group of other conditions known as symptom-based conditions, functional somatic syndromes or idiopathic environmental intolerances.

No useful estimate of the prevalence of EHS in the UK was found. Recommendations for future research included carrying out studies to describe and understand EHS and estimate its prevalence within the UK; engaging with therapists currently treating sufferers to identify other treatments; and conducting robust trials of cognitive behavioural therapy.

Conclusion

A WHO workshop in Prague (*WHO*, 2004), attended by leading European researchers on EHS, concluded that EHS has no scientific basis to link its symptoms to EMF exposure. Further, EHS is not a medical diagnosis; it has no clear diagnostic criteria, nor is it obvious that it represents a single medical problem. A WHO fact sheet on EHS summarises the symptoms, known prevalence and current treatments, but concludes from the existing scientific evidence that EMF exposure is not the cause of the symptoms (*WHO*, 2005).

4.6 Children and EMF

Children and disease

Children everywhere are exposed to a variety of chemical, physical and biological environmental agents. These include indoor and outdoor air pollution, water and food contaminants, chemicals (e.g., pesticides, lead and mercury), and physical agents, such as ultraviolet radiation and excessive noise. Changes in exposure to these agents are linked to increases in the incidence of certain childhood diseases, such as asthma, leukaemia, brain cancer, and some behavioural and learning disabilities. Environmental exposures can be particularly harmful to children because of their vulnerability during development.

Children are not small adults. They may be more vulnerable to environmental toxins than adults. They may receive higher doses than adults, either because of specific behaviours, or because of their smaller body size. They have a longer time to demonstrate harmful effects of accumulated exposures, as they can expect to live longer than adults.

It has been recognised for some time that children are more susceptible than adults to the health risks associated with over-exposure to infra red and UV radiation. Sunburns in childhood seem to be particularly potent in increasing the risk of skin cancer later in life (*Nole and Johnson*, 2004). There are also indications that children may be more prone to leukaemia from exposure to ELF magnetic fields arising from the distribution and use of electricity. This raises the question of whether children are likely to be more sensitive than adults to RF fields.

Children and ELF magnetic fields

IARC has classified ELF magnetic fields as "possibly carcinogenic to humans" (*IARC*, 2002). This classification was based on epidemiological studies of childhood leukaemia that consistently demonstrated an association that was considered credible, but for which other explanations could not be ruled out. Experimental studies using cultured cells and animals did not, however, support the view that ELF magnetic fields induce, promote or accelerate the progression of cancer (*Kheifets et al*, 2005).

Acute leukaemias, especially acute lymphoblastic leukaemia (ALL), are the most common cancer to affect children, accounting for 25% to 35% of all childhood malignancies. In Ireland and other developed countries, the incidence of ALL rises rapidly after birth to peak around 3 years of age before declining. The rate of leukaemia among children under 15 has been estimated at around 4 cases per 100,000 children per year in Western Europe.

Everyone is exposed to ELF electric and magnetic fields at home. High voltage power lines are a major source of exposure to those children who live near them. However only about 1% of children live close to power lines. For most children, exposure to ELF magnetic fields is made up of a continuous low-level exposure from the house wiring and an intermittent exposure to higher fields produced by domestic appliances. Typical magnetic fields in the home are in the range 0.05 to 0.1 μT. Based on UK data it is unlikely that more than 1% to 2% of Irish homes have fields greater than 0.2 μT (*HPA*, 2005).

Results of pooled analysis of around twenty epidemiological studies suggest a doubling of the risk of leukaemia for children exposed to average magnetic fields over 0.3 to 0.4 μT. However, because of the limited knowledge of the aetiology of childhood leukaemia, it is possible that some other exposure, (a confounder) may be the cause of this association. At present there is no experimental evidence that supports the view that this relationship is causal (*Kheifets et al*, 2005). However two explanatory hypotheses were advanced at a WHO expert workshop (*WHO*, 2004) devoted specifically to an evaluation of children's sensitivity to EMF and to identify research needs in this area.

The implications for the incidence of leukaemia in children of the above findings are dealt with in detail in the *health risk assessment section*. Essentially the increased incidence of childhood leukaemia in Ireland, if caused by ELF magnetic fields, would be one extra case every three to five years where the annual incidence from other causes ranges from 35 to 55.

Children and RF fields

Concerns about the potential vulnerability of children to RF fields from mobile telephony were first raised in the UK Stewart Report (*IEGMP*, 2000). The basis for this concern was that children would have a longer lifetime exposure than adults and, from a physiological point of view, they have developing nervous systems; the possibility that their brain tissue is more conductive; a greater potential for absorption of RF energy in the head at mobile phone frequencies. This view was re-affirmed by the UK *NRPB* (2004).

This question of whether children absorb greater doses of EMF than adults was discussed at both an EU Co-operation on Science and Technology (COST Action 281) workshop (*COST*, 2002) and at a WHO workshop in Istanbul (*WHO*, 2004). Recent expert analysis of this question led *Christ and Kuster* (2005) to conclude:

> *"The analysis of the results could not reveal major effects due to focussing or other properties of child heads, which might result in higher specific absorption rates (SAR). … The variations between child and adult phantoms are not higher in magnitude than those between different adult phantoms. …In conclusion no evidence could be found for a correlation between energy absorption and head size."*

Keshvari and Lang (2005) came to a similar conclusion:

> *"The analyses suggest that the SAR difference between adults and children is more likely caused by the general differences in the head anatomy and geometry of the individuals rather than age. It seems that the external shape of the head and the distribution of different tissues within the head play a significant role in RF energy absorption. …There is no systematic difference in the RF energy absorption between anatomically correct MRI-based child and adult head models."*

In 2002, the Health Council of The Netherlands (*HCN*, 2002) conducted an evaluation of the health effects of mobile phones and for children it concluded, on the basis of the available scientific data on the development of children's heads and brain tissue, that:

> *"It is unlikely from a developmental point of view that major changes in brain sensitivity to electromagnetic fields still occur after the second year of life. The Committee, therefore, concludes that there is no reason to recommend that mobile telephone use by children should be limited as far as possible."*

Two years later, when the Health Council revisited the topic (*HCN*, 2004) in the light of additional scientific information, it concluded that there was no reason to revise its recommendations with regards to public exposure limits in The Netherlands and reiterated its opinion that

> *"there are no health-based reasons for limiting the use of mobile phones by children".*

This position is in contrast to that of the UK Stewart Report (*IEGMP*, 2000) where it was suggested that the widespread use of mobile phones by children for non-essential calls should be discouraged and that the mobile phone industry should refrain from promoting the use of mobile phones by children. However the UK report did not base their recommendations on specific scientific evidence, but on precautionary measures.

The WHO workshop on children and EMF

Under the auspices of the WHO International EMF Project, 150 of the world's leading EMF researchers and paediatric specialists met in June 2004 for a scientific workshop in Istanbul (*WHO*, 2004). The aims of the meeting included:

- To examine at what stage of development children may be more sensitive to EMF,
- To assess the scientific literature with regard to possible health effects from EMF exposure to children,
- To identify gaps in knowledge that need further research to better evaluate children's EMF sensitivity,
- To compile a research agenda,

There is no direct evidence that children are more vulnerable to EMF.

- There is, however, little specific research that addresses this question.
- There is consensus that, from present knowledge, the current international exposure guidelines (*ICNIRP*, 1998) incorporate sufficient safety factors in their general public limits to be protective of children.

During the meeting a research agenda was developed to identify gaps in knowledge affecting the understanding of the effects of EMF exposure on children (*WHO*, 2005). Later, the RF component of this research agenda was incorporated into a "Consolidated WHO research agenda for radio frequency fields" (*WHO*, 2006). As a result further epidemiological studies relating to children were recommended by WHO and some are already underway in a number of countries.

Overall conclusion

Epidemiological studies suggest that ELF magnetic fields above 0.3 to 0.4 μT are associated with an increased incidence of childhood leukaemia, but there is little or no support for this by well conducted laboratory studies. However we have no understanding of how, or even if, ELF magnetic fields might be associated with leukaemogenesis. Essentially, the evidence for a causal relationship is insufficient.

In the case of RF fields the scientific evidence does not suggest that children are more susceptible than adults to such exposure. However, without further research, the absence of an observed effect does not rule out the possibility that RF exposure might have some latent adverse health effect. Much of this necessary research is now underway, in coordinated studies across Europe and elsewhere, and more is planned. The results of this work will help answer many of the outstanding questions on the health effects of children's exposure to RF fields.

4.7 Risk Communication

Perception of Risk

Some 30 km from the Norwegian city of Stavanger you will find Lysefjord. Here an arm of the North Sea cleaves a gorge between two vertical cliffs. Halfway along the northern side is a prominent feature called 'Preikestolen' or 'Pulpit Rock'. Pulpit Rock has an interesting geology: it is over 2000 ft high; it overhangs the fjord; it has a flat top the size of a football field, and it is separated from the surrounding rock by a deep vertical fissure. Once the prospect of six million tonnes of rock slipping into the fjord was enough to discourage all but the most foolhardy from venturing on to Pulpit Rock. Residents of the village of Forsand at the mouth of Lysefjord worried that the next thunderstorm might bring down the rock and wash them away in a tidal wave.

But today no one worries. The top of Pulpit Rock provides a platform for sunbathers, a challenge to rock climbers and a haven for those wishing to distance themselves from the pressures of modern life. The village at the mouth of the fjord is now a sizeable town. So, what has changed? The fissure isolating Pulpit Rock is as deep and wide as ever and thunderstorms are no less frequent. This change in attitude follows an investigation by a team of Norwegian geologists and engineers whose findings are summarised thus in a local guidebook:

> *"Scientists have now surveyed the area and can assure everyone that the Pulpit Rock is perfectly safe."*

The contrast between the casual attitude to risk of the sunbathers on Pulpit Rock and the continuing fears many people in Ireland (and elsewhere in Europe) have concerning EMF and particularly mobile phone masts is puzzling. The fears of the public invite explanation, particularly when there have been numerous assurances from national and international health advisory authorities that phone masts, for example, do not present a hazard to health.

Risk perception

Many factors can influence a person's perception of a risk and their decision to take or reject that risk. However, by far the most important factor is whether exposure to the risk is voluntary or involuntary. Hiking to the top of Pulpit Rock is a challenge to the young and fit. To the overweight, middle-aged businessman on beta-blockers the climb could become a serious risk to health. Fortunately the Norwegian authorities do not require that all visitors to Stavanger make a pilgrimage to the rock. It is something that is entirely voluntary.

In contrast, when we come to consider exposure to phone masts, there is no escape. The 4,500 phone masts in Ireland are in continual communication with every mobile phone in Ireland that happens to be switched on. That could mean four million phones owned by Irish residents plus hundreds of thousands more brought in by visitors. Exposure to EMF associated with mobile wireless telephony is involuntary.

Where exposure to an environmental agent is involuntary and there is good evidence that the exposure has a potential adverse health effect then the authorities will be pressed to take action to eliminate or reduce the public's exposure. Such pressures led, in the 1960s, to the ending of atmospheric nuclear weapons testing and more recently to the removal of lead from petrol. However the dilemma with phone masts is that there is no good evidence of an adverse health effect and their removal would stop everyone using their mobile phone. The sudden adverse impact on business, social life, health and safety can only be imagined.

Health hazard and risk

Progress in the broadest sense of the word has always been associated with various hazards and risks, both perceived and real. The industrial, commercial and household application of EMF is no exception. Some people are concerned that exposure to EMF from such sources as high voltage power lines, electricity substations, radars, mobile phones and phone masts could lead to adverse health consequences, especially in children. As a result, the construction of new power lines and mobile phone networks has met with considerable opposition in a number of countries.

In examining people's perception of risk, it is important to distinguish between a health *hazard* and a health *risk*. A hazard can be an object or a set of circumstances that has potential to harm a person's health. A risk, in the sense used by professionals, is the likelihood or probability that a person will be harmed by a particular hazard. The public use of the word 'risk'

can be quite different. Rock climbing is an activity associated with the *hazard* of falling. The *risk* or probability of death is once in 250,000 climbs (*H&SE*, 1997).

Almost every activity has an associated risk. Simply getting out of bed in the morning and getting dressed are associated with risks. Each year in the UK, for example, 20 people are electrocuted by bedside lights and alarm clocks; another 20 are killed falling over as they get out of bed and 60 are seriously injured pulling on their socks. Even staying in bed and not getting up doesn't avoid risk. In the United States some 6000 adults manage to injure themselves on their bedclothes every year (*Equinox*, 1999). Indeed, autopsy studies show that the risk of thrombosis followed by a lethal pulmonary embolism is directly related to the duration of time spent in bed prior to death (*Le Fanu*, 1996). Living is associated with a great many risks. These include EMF-emitting sources, which can be hazardous under certain circumstances. There is no such thing as zero risk.

Influencing a person's decision to accept or reject a risk

People usually perceive risks as negligible, acceptable, tolerable, or unacceptable. The nature of the risk is then compared to the benefits. Where the benefits greatly exceed the risk, then the risk may be considered worth taking. Opinions and decisions will depend on a person's age, sex, education and cultural background. Some young people find the fun of bungee jumping outweighs the attendant risk: a view that would be unlikely to be shared by their parents.

The nature of the risk can lead to different perceptions. Surveys have found that the particular characteristics of a situation affect a person's views of the risk of EMF (and other exposures) (*WHO*, 1998):

- *Voluntary or involuntary exposure.*
  People who do not use mobile phones perceive the risk from base stations as high, despite the low power of the fields emitted from this source. In contrast, most mobile phone users perceive the fields from their phones as low even though they are in fact much more intense.

- *Lack of personal control over a situation.*
  If people have no say over the installation of power lines or phone masts, especially near their homes, schools or play areas, they will perceive the risk from such installations as being high.

- *Familiar or unfamiliar situation.*
  Where people are familiar with a situation or feel they understand the technology, the level of perceived risk is smaller. The perceived risk increases when the situation or the technology, such as EMF technology, is new or unfamiliar or hard to understand. Perception about the level of risk can be significantly increased where there is an incomplete scientific understanding of the potential health effects from a particular situation or technology.

- *Degree of dread.*
  Some diseases and health conditions, such as cancer, severe or lingering pain and disability, are more feared than others. Thus, even the smallest possibility of cancer, especially in children, from EMF exposure receives significant public and media attention.

- *Fairness or unfairness of situation.*
  If people are exposed to RF fields from phone masts, but do not have a mobile telephone, or if they are exposed to the electric and magnetic fields from a high voltage transmission line that does not provide power to their community, they consider it unfair and are less likely to accept any associated risk.

The phone mast dilemma

While it might be argued that it is not unreasonable for people who neither own nor use a mobile phone to object to being exposed to unwanted RF fields from phone masts, it is a fact that we are also exposed to the broadcasts of several hundred radio and TV stations, many of which we neither listen to nor are even aware exist.

There clearly must be some particular kind of fear associated with phone masts that concerns significant numbers of people, most of whom are mobile phone users. The fact that many national and international health advisory authorities have reiterated that there are no reasonable grounds for believing phone masts are a hazard to health has done little to allay public fears. RF exposures to the head from masts are some thousands to tens of thousands weaker than those generated by mobile phone use. Why should people worry over the lesser exposure and generally ignore the greater one? The examination of such questions brings us into the science of Risk Communication.

Risk communication about EMF

In the specific issue of EMF exposure and health, complexity, uncertainty and ambiguity all play a part.

Most scientists agree that significant adverse health impacts of EMF are unlikely, but not impossible. However, the possibility of negative health effects cannot be excluded. Science can only provide proof that something might be unsafe or might pose a risk. This can be difficult to communicate and can lead to the public asking that society refrain from any activity if there is the remotest possibility that it is dangerous. From the scientific point of view such a proposition can never be supported. This is frustrating for many people.

We have only limited knowledge about the long term effects of EMF. Many will use this uncertainty as a reason for asking regulators to adopt a precautionary approach and, by reducing exposure guidelines below the present levels, provide a greater measure of safety. The existing guidelines for public exposure are set at safety of 50 times below the established threshold for harm. It should be noted however, that mobile phone exposure is short term at high levels while base stations give long term low level exposures. People generally worry more about the long term effects that are unknown than short term acute effects.

For most people it makes a difference if they feel the risk is voluntary and under their control, like driving, rather than having a safety level imposed on them by some government agency. Risk perception studies show that in Germany, for example, a majority of the population believes that mobile phones are fairly safe, whereas base stations are believed to pose greater risks (*Zwick and Renn*, 2001; *Wiedemann et al*, 2003). Yet from a scientific point of view there is no doubt that mobile phone users receive much greater exposures than people living near base stations. Even when informed about this difference, residents will maintain that the base station antennas are the more serious problem because they are erected without their approval or their being able to avoid them.

The table below gives examples of the probability of various causes of injury or death in everyday life.

Some causes of death, injury or illness and the chances of them affecting you in your lifetime	
Death by heart attack	1 in 4
Having asthma as a child	1 in 7
Seeking help for mental illness in your lifetime	1 in 8
Becoming dependent on alcohol	1 in 25
Having a serious fire at home	1 in 160
Death in a car accident	1 in 200
Death related to smoking 10 cigarettes a day	1 in 200
Death from a fall	1 in 380
Seriously injuring yourself on exercise equipment	1 in 400
Death while hang-gliding	1 in 560
Being allergic to a food additive	1 in 1,000
Death as a result of motor cycling	1 in 1,100
Death as a result of mountain climbing	1 in 1,750
Death from the flu	1 in 5,000
Death in a domestic accident	1 in 25,000
Being murdered	1 in 100,000
Death from tampon-related toxic shock syndrome	1 in 1.4 million
Death by lightning	1 in 10 million
Being injured or killed in a single trip in a lift	1 in 17 million
Death as the result of a plane falling on you	1 in 25 million
Death as the result of a meteorite falling on you	1 in 1 million million

Box 4.1: Lifetime Risks

Communities feel they have a right to know what is being proposed and planned with respect to the construction of EMF facilities that they perceive to affect their health. They want to have some control over, and be part of, the decision making process. Unless or until an effective system of public information and communications amongst stakeholders is established, and they have involvement in the siting process, new EMF technologies will continue to be mistrusted and feared. Useful advice on dealing with the public on the EMF issue can be found in the WHO booklet "Establishing a dialogue on risks from electromagnetic fields" (*WHO*, 2002).

Overall conclusion

WHO have produced a set of principles for risk communication in this area:, and we reproduce these:

"In all situations where local government has a responsibility to address public and other stakeholder concerns about health issues it is essential to carry out "risk management" and not "crisis management"."

That is, early dialogue with all stakeholders – carriers, landlords, local communities and interest groups to find acceptable solutions is preferable to "11th hour" attempts to resolve conflicts between strongly held views, rights and responsibilities.

The WHO International EMF Project has a key role in health risk communication by giving unambiguous advice on health aspects. All stakeholders – carriers, regulators, local government and local public should recognise that trust is a valuable commodity and, that rights, and responsibilities go hand in hand.

Central government – policy makers and regulators – need to take a more proactive role in providing health advice in relation to EMF.

- Local government should accept more responsibility by avoiding the imposition of arbitrary siting policies that may undermine health-based exposure guidelines.
- Mobile telecoms operators (carriers) need to remain pro-active and meet commitments for communicating with all stakeholders on RF issues of concern.

Communicating with stakeholders on RF is a challenge – it requires a strategy, planning, expertise, consistency and training. A tri-partite approach to dialogue between mobile telecoms operators, local government and local community groups works well when there is a joint commitment to finding workable solutions.

WHO can provide essential clarity and a framework – but it is necessary for national, state and local governments to take a greater share of the responsibility for communication on these issues by providing consistent and unambiguous advice.

4.8 Ultraviolet Light

Lasers and ultraviolet (UV) light are the two type of electromagnetic radiation where the health hazards are best established. Despite this they give rise to little public concern, and UV in particular is less regulated than other EMF sources. We have summarised the main conclusion of a recent report on 'Ultraviolet radiation and health' (*AFFSET*, 2005). We have adapted a WHO fact sheet on laser pointers (*WHO*, 1998), with permission from WHO, to provide a convenient reference.

Ultraviolet light

Ultraviolet light is electromagnetic radiation, which lies between visible light and ionising radiation, with wavelengths of 400nm to 100nm. It is conventionally divided into UVA, UVB and UVC. The standard definition of these is the CIE definition given in the table below, but other definitions have been used in the recent past.

Source	UVC	UVB	UVA
CIE, 1989	100-280nm	280-315nm	315-400nm
Parrsh et al., 1978	200-290nm	290-320nm	320-400nm
Riordan C et al., 1990	<280nm	280-320nm	320-400nm

Box 4.2: Definitions of UV Regions

The dominant source of UV light exposure is, of course, the sun. Other common exposures are occupational exposures, for example welders, metal workers, certain food workers, and some other industrial workers, and tanning salons. Very little solar UVC light, the most energetic and shortest wavelength UV light, reaches the ground. However both UVB and UVA are classified as probable human carcinogens.

Biological effects

UV light has one beneficial biological effect – it promotes the synthesis of vitamin D in the skin. Quite a small exposure, 15 to 25 minutes of head and arms for example, maximises UV induce vitamin-D synthesis. In Ireland dietary intake of vitamin-D is usually far greater than UV induce synthesis, and is definitely a safer way of treating vitamin-D deficiency.

UV light also induces a series of physiological and pathological changes in skin. UV exposed skin becomes thicker rather rapidly, and in people who can tan, pigmentation increases. The skin is also damaged by long term UV exposure, leading to what is known as 'heliodermatosis'. This includes a variety of changes including thickened, dry sagging skin, changes in skin colour, lines and wrinkles, spots, reddening, prominent blood vessels, and others.

Finally UV light directly damages DNA in skin cells leading to various types of skin cancer.

Cancers

The major adverse health effect of UV exposure is skin cancer. Skin cancers are divided into two main groups, melanoma, which is relatively rare, but has a high risk of death, and non-melanoma skin cancer, which is very common, the commonest single cancer, but very seldom leads to death. In Ireland there are about 500 cases of melanoma a year, and 60 to 90 deaths; there are 5,200 cases of non-melanoma skin cancer but only 30 to 40 deaths. The number of deaths and new cases of these cancers is rising rapidly in most countries where the population are of Northern European ancestry.

Skin types

One common skin classification was originated by Fitzpatrick in 1974, although many slightly different versions of it are in use.

Type	Sunburn Tendency	Tan Tendency	Skin, Hair, and Eye Colour
I	I always get a sunburn.	I never get a tan.	white skin, freckles, blond or red hair, blue or green eyes.
II	I usually get a sunburn.	I sometimes get a tan.	white skin, blond hair, blue or green eyes.
III	I seldom get a sunburn.	I usually get a tan.	white skin, usually dark hair, and brown eyes.
IV-VI	I never get a sunburn.	I always get a dark tan.	brown to dark skin/ brown or black hair/ brown eyes.

Box 4.3: Skin types after Fitzpatrick*, (1974). Most Irish people are skin types I and II – the highest risk skin types.*

Preventing skin cancer

Skin cancer is preventable. Australia has managed to improve survival from skin cancer and reduce the occurrence of new cases by a tightly focussed campaign concentrating on sun exposure, use of sun protection, and use of skin creams (*Australian Cancer Society* 2006). There is good evidence that it is especially important to provide sun protection to babies and children.

Tanning parlours and health

Tanning by exposure to controlled levels of UV light is increasingly common. The physiological effect of tanning salons is not the same as that of natural UV exposure. In particular, it does not increase melanin synthesis, nor does it lead to increased skin thickness. Substantial evidence from epidemiological studies suggests that the use of tanning salons leads to a significant increase in the risk of melanoma (a 25% increase generally, rising to a 160% increase in women who used salon under the age of thirty). There is less evidence for non-melanoma skin cancer, but the available evidence suggests a similar risk increase. Widespread use of tanning salons will lead to a serious effect on public health, and the closest regulation of this sector will be needed to prevent this.

4.9 Lasers

Lasers are devices that produce beams of coherent light. This has unique properties that distinguish laser-produced light from light from more familiar sources such as the sun or domestic lamps. The latter emit light that is highly divergent, i.e., that spreads out almost equally in all directions. These sources also have many different wavelengths (colours), which together give a characteristic colour to the light. A laser produces light with a very narrow range of wavelengths, so narrow that lasers are referred to as a monochromatic (one colour) sources. Lasers also produce a very narrow beam that diverges little. This means that laser light is highly directional, forming a pencil-like beam and appears as a small spot when shone onto a surface, even at distances of hundreds of metres. As a consequence, high power lasers can be hazardous to the eye over considerable distances. Because laser light is monochromatic and basically low-divergent, the beam is better focused by the lens of the eye than any other light source, thus producing images on the retina with much greater intensities than is possible with domestic lamps.

Laser pointers

Laser devices are in common use in domestic settings, however most of these are locked away from the users in devices such as CD players and DVD players. There are also many occupational settings in which lasers are used. The only commonly used open laser devices are laser pointers, and laser levels. These are low power devices, Laser pointers are portable, battery-operated, hand-held laser devices used by lecturers during their presentations, and by builders and DIY enthusiasts respectively for alignment purposes. Commonly available laser pointers emit red-coloured light, (wavelength between 630 and 670 nm), although more expensive pointers are available which emit green-coloured light (532 nm).

Safety standards and classification

Laser pointers are classified according to the International Electrotechnical Commission (IEC) standard on laser safety. This standard specifies requirements for the laser to ensure that the risk of accidental exposure is minimised through the use of engineering control features and that there is product labelling and safety information. The IEC also sets out five classes of laser: 1, 2, 3A, 3B and 4. This classification gives the user an indication of the degree of laser hazard.

The IEC60825-1 is an IEC standard which regulates safety of laser products and the class standard and class judgment standard were revised in 2001 by the IEC standards constitution committee. According to this revision, new classes, namely class 1M, class 2M and class 3R were newly established. In addition, the JIS standard relating to the laser safety standard (*JIS*, C6802) was also revised in January 2005 so that the laser class standard conforms to the IEC standard.

Summary of requirements according to IEC

Classification	Outline of risk assessment
Class 1	Lasers that are safe under reasonably foreseeable conditions of operation, including the use of optical instruments for intrabeam viewing.
Class 1M	Lasers emitting in the wavelength range from 302.5 to 4,000 nm which are safe under reasonably foreseeable conditions of operation, but may be hazardous if the user employs optics within the beam.
Class 2	Lasers that emit visible radiation in the wavelength range from 400 to 700 nm where eye protection is normally afforded by aversion responses, including the blink reflex. This reaction may be expected to provide adequate protection under reasonably foreseeable conditions of operation including the use of optical instruments for intrabeam viewing.
Class 2M	Lasers that emit visible radiation in the wavelength range from 400 to 700 nm where eye protection is normally afforded by aversion responses including the blink reflex. However, viewing of the output may be more hazardous if the user employs optics within the beam.
Class 3R	Lasers that emit in the wavelength rage from 302.5 to 106 nm where direct intrabeam viewing is potentially hazardous but the risk is lower than for Class 3B lasers.
Class 3B	Lasers that are normally hazardous when direct intrabeam exposure occurs. Viewing diffuse reflections is normally safe.
Class 4	Lasers that are also capable of producing hazardous diffuse reflections. They may cause skin injuries and could also constitute a fire hazard. Their use requires extreme caution.

- Class 1 lasers have an output power that is below the level at which eye injury can occur, even if the beam is viewed with an optical device, such as a binocular or telescope.
- Class 1M emit in the wavelength range from 302.5 to 4,000 nm, and have an output power that is below the level at which eye injury can occur, but may be hazardous if the user employs optics within the beam.
- Class 2 lasers emit visible light (400 to 700 nm) and are limited to a maximum output power of 1-milliwatt (mW). A person receiving an eye exposure from a Class 2 laser will be protected from injury by their natural blink reflex, an involuntary response which causes the person to blink and turn their head, thereby avoiding eye exposure. These

lasers are safe, even if used with an optical device. Children, however, may not look away, and indeed may gaze directly into the beam. For this reason lasers should not be made available to children.

- Class 2M are like Class 2, but are not safe if used with an optical system.
- Class 3R lasers emit in the wavelength rage from 302.5 to 106 nm where direct intrabeam viewing is potentially hazardous but the risk is lower than for Class 3B lasers.
- Class 3B lasers are normally hazardous when direct intrabeam exposure occurs. Viewing diffuse reflections is normally safe.
- Class 4 lasers are also capable of producing hazardous diffuse reflections. They may cause skin injuries and could also constitute a fire hazard. Their use requires extreme caution.

The IEC provides advice on the use of lasers for demonstrations, displays and exhibitions and states that only Class 1 or Class 2 devices should be used in unsupervised areas unless under the control of experienced, well-trained operators. Laser pointers used by, for example, professional lecturers in the workplace are considered to fall within this category. Training requirements are specified for operators using lasers of a higher class for these purposes, as there is a risk of eye injury.

Laser pointers currently available

It appears that the output power of laser pointers currently widely available is generally less than 5 mW. The body's natural aversion responses are unlikely to provide adequate protection from eye injury for Class 3B laser pointers and Class 3A laser pointers used with optical aids. Although the risk of permanent eye injury from a laser pointer may be small, a person receiving even a transient eye exposure will experience a bright flash, a dazzling effect, which is likely to cause distraction and temporary loss of vision in the affected eye and possibly after-images. The time taken to recover from these effects will vary for different people and will also be dependent on the ambient light level at the time of exposure. Medical attention should only be sought if after-images persist for hours, or if a disturbance in reading vision is apparent.

Higher-powered laser pointer devices are becoming available, and in particular can be purchased over the Internet. Devices with 120mw power are readily available. These are potentially very dangerous, and could cause severe permanent visual damage very quickly. Some of these devices physically resemble lower powered devices, and there is potential for dangerous confusion.

WHO advice

In general, laser pointers are classified as Class 1, Class 2 or Class 3B products. However, national authorities making measurements of the power output of these lasers have noted that significant misclassification is occurring by manufacturers. In many cases, lasers have been classified as Class 2 when they were really Class 3B. More accurate classification needs to be enforced by appropriate authorities.

On Laser Pointers.

WHO considers the professional use of a Class 1 or Class 2 laser pointer as a training aid to be justified, and regards these classes of laser product as being adequate for such use. The use of Class 3B laser pointers up to 5 mW may be justified for some applications in the workplace where the user has received adequate training (*WHO*, 1998).

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Annex 1
Expert Group Membership

Dr Michael Repacholi (Chair)
Michael Repacholi is a graduate of the University of Western Australia (BSc, physics), London University (MSc, radiation biology) and Ottawa University (PhD, biology). He is the author or co-author of over 200 scientific publications.

He was the Coordinator of the Radiation and Environmental Health Unit at the World Health Organisation in Geneva until the 30 June 2006, and has participated in twelve WHO non-ionising radiation task groups.

He is an Emeritus Chairman of the International Commission on Non-Ionising Radiation Protection, Fellow and Past President of the Australian Radiation Protection Society and of the Australasian College of Physical Scientists and Engineers in Medicine. He is also a Fellow of the Institute of Physics and Australian Institute of Physics and is a member of the Health Physics Society and of the Bioelectromagnetics Society.

Dr Eric van Rongen
Eric van Rongen is currently Scientific Secretary with the Health Council of the Netherlands where his main focus is on the biological and health effects of non-ionising radiation, primarily electromagnetic fields. Presently, he is secretary to the semi-permanent Electromagnetic Fields Committee and of the Standing Committee on Radiation Hygiene.

He has been part-time seconded to WHO to work on the Environmental Health Criteria on Static Fields. He is Vice-president of the European Bioelectromagnetics Society, member of the International Advisory Committee of the WHO EMF Project, national representative for the Netherlands in COST 281, corresponding member of ICNIRP and member of subcommittees 3 and 4 of the International Committee on Electromagnetic Safety (ICES) of the IEEE.

Dr Tom McManus
Dr McManus BSc., PhD., CEng., MIChemE., MIEEE., holds qualifications in engineering and applied science from the Universities of Strathclyde, Durham and Cambridge. Following work in the oil and chemical industries in England and Canada he moved to Ireland in 1970 to set up a national environmental advisory group in the IIRS. In the 1980s he began working for the Department of Energy and was involved in the introduction of natural gas to Ireland and the subsequent development of the national gas transmission grid. From 1986 he held the post of Chief Technical Adviser to the Department of Transport, Energy and Communications and its successor Departments until his retirement in 2002. From 1988 until 2006 he was the leading adviser to various Irish Government Departments on the subject of electromagnetic fields. He is currently Chairman of the Gas Safety Committee set up by the Commission for Energy Regulation in 2004 and continues to assist the European Commission on electromagnetic fields projects undertaken by its Joint Research Centre in Italy.

Dr Anthony Staines
Dr, Anthony Staines graduated from Trinity College Dublin with a degree in medicine, and trained in epidemiology at the London School of Hygiene and Tropical Medicine and at the University of Leeds. He worked on electromagnetic field health effects in the UK Childhood Cancer Case-Control Study. He now leads the Environment and Health group, and is a Senior Lecturer, in the School of Public Health and Population Sciences at University College Dublin. He has a special interest in health impact assessment and risk assessment.

Expert Review Panel
The Expert Group consulted with four international experts to garner further views and to engage in peer review of the report.

Dr Anders Ahlbom
Anders Ahlbom is a Professor of Epidemiology, Head of the Division of Epidemiology and deputy director of the Institute of Environmental Medicine at the Karolinska Institute, Stockholm, Sweden. Main research interests are environmental epidemiology with an emphasis on cancer, in particular non-ionising radiation and cancer. He has a longstanding interest in cardiovascular diseases and their relation to the interaction of environmental factors and biomedical risk factors. His work spans epidemiologic theory and methods, including the basis for causal inference. Dr. Ahlbom is chairman of the ICNIRP Standing Committee on Epidemiology and has been an ICNIRP member since 1995.

Dr Carmela Marino
Carmela Marino received her degree in Biology in 1982 from the University of Rome “La Sapienza”. She is now working as a research scientist at the Department of Biotechnology, Health and Ecosystems protection of ENEA where she coordinates the bioelectromagnetic research activity. She is also a contract professor of “Radiobiology and Thermobiology” and “Biological effects of electromagnetic fields” in the Post-graduate School of Health Physics, Tor Vergata University, Rome, Italy.

After previous experience in the studies of biological effect of ionising and non-ionising radiation applied to the cancer therapy, in in vivo system in particular (especially as a Scientific research Fellow at the Gray Laboratory, Cancer Research

Campaign, Mount Vernon Hospital, Northwood, UK), she has been involved in experimental studies on risk assessment of electromagnetic fields. In particular she was the coordinator of the research activity Subject 3 – Interaction between sources and biosystems on behalf of ENEA (MURST/ENEA-CNR program "Human and Environmental Protection from Electromagnetic Emissions"), and was involved in PERFORM B in vitro and in vivo replication studies related to mobile telephones and base stations; GUARD, Potential adverse effects of GSM cellular phones on hearing, RAMP 2001, Risk Evaluation of Potential Environmental Hazards from Low Energy EMF on Neuronal Systems from modelling to tissues. Currently, she is also involved in EMF-NET, Effects of the exposure to electromagnetic fields: from science to public health and safer workplace; and EMF-Near, Exposure at UMTS electromagnetic fields: study on potential adverse effects on hearing". She has also been a member of Working group 1 of Cost 244bis and is now a member of the EBEA and BEMS, and of the Italian Society for Radiation Research, SIRR. She is the author of about 35 Referred Papers and 140 National and International Conference Contributions.

Dr Alastair McKinlay

Alastair McKinlay is Head of the Physical Dosimetry Department at the United Kingdom Health Protection Agency's Centre for Radiation, Chemical and Environmental Hazards. He is a graduate of Strathclyde University Scotland where he received a B.Sc. (Hons.) in Natural Philosophy. He was awarded a Ph.D. by the UK National Council for Academic Awards for studies in thermoluminescence dosimetry. Appointments held previously included: Membership of the United Kingdom "Application of Radioactive Substances Advisory Committee" (ARSAC): President of the UK National Committee of the International Commission on Illumination (CIE): Chairman of the European Commission Expert Group on Mobile Telephony and Human Health and: Founding member of the European Society of Skin Cancer Prevention (EUROSKIN). Alastair is currently President of EUROSKIN: A member of the Programme Management Committee of the UK Mobile Telephone Health Research Programme and: A member of the International Advisory Committee of the WHO EMF Project. He was a Main Commission Member of ICNIRP from its inception in 1992 until 2004, Vice-chairman from 1996 to 2000 and Chairman from 2000 to 2004.

Dr Berndt Stenberg

Berndt Stenberg, associate professor at the Dept of Dermatology, University Hospital, Umeå, Sweden. He is a specialist in dermatology and venereology and PhD in Epidemiology. He is chairman of the Swedish Contact Dermatitis Research Group, a member of the executive group for the Swedish Dermato-Epidemiology Network and country representative in the Council of the European Society for Contact Dermatitis (ESCD). Main research interests are indoor environment (including indoor air quality and EMFs) and health and epidemiology of occupational and environmental dermatoses.

Submissions Received

The Expert group advertised for submissions from interested parties in December of 2005 in order to garner the views of the wider public. Submissions were received from representatives of those organisations listed below.

- Dublin City Council
- Irish Electromagnetic Radiation Victims Network (IERVN)
- Principal Environmental Health Officer, Sth Dublin Co. Co.
- Commission for Communications Regulation
- Better Environment and Safer Telecommunications (BEST)
- Huntstown Mast Group
- Limerick County Council
- Defence forces
- GSM Association
- Office of the Chief Medical Officer
- Electronic & Communications Engineering, Dublin Institute of Technology
- O_2 Ireland
- Irish Campaign Against Microwave Pollution
- Vodafone Ireland
- Mobile Manufacturers Forum
- South Dublin County Council
- Irish Cellular Industry Association
- Department of Enterprise Trade and Employment (Health and Safety Authority)
- Health Services Executive, Faculty of Public Health Medicine
- Glenbeigh Residents Association

Annex 2

Base Stations and Wireless Technologies

Fact sheet No. 304, May 2006

Mobile telephony is now commonplace around the world. This wireless technology relies upon an extensive network of fixed antennas, or base stations, relaying information with radiofrequency (RF) signals. Over 1.4 million base stations exist worldwide and the number is increasing significantly with the introduction of third generation technology.

Other wireless networks that allow high-speed internet access and services, such as wireless local area networks (WLANs), are also increasingly common in homes, offices, and many public areas (airports, schools, residential and urban areas). As the number of base stations and local wireless networks increases, so does the RF exposure of the population. Recent surveys have shown that the RF exposures from base stations range from 0.002% to 2% of the levels of international exposure guidelines, depending on a variety of factors such as the proximity to the antenna and the surrounding environment. This is lower or comparable to RF exposures from radio or television broadcast transmitters.

There has been concern about possible health consequences from exposure to the RF fields produced by wireless technologies. This fact sheet reviews the scientific evidence on the health effects from continuous low-level human exposure to base stations and other local wireless networks.

Health concerns

A common concern about base station and local wireless network antennas relates to the possible long-term health effects that whole-body exposure to the RF signals may have. To date, the only health effect from RF fields identified in scientific reviews has been related to an increase in body temperature (> 1°C) from exposure at very high field intensity found only in certain industrial facilities, such as RF heaters. The levels of RF exposure from base stations and wireless networks are so low that the temperature increases are insignificant and do not affect human health.

The strength of RF fields is greatest at its source, and diminishes quickly with distance. Access near base station antennas is restricted where RF signals may exceed international exposure limits. Recent surveys have indicated that RF exposures from base stations and wireless technologies in publicly accessible areas (including schools and hospitals) are normally thousands of times below international standards.

In fact, due to their lower frequency, at similar RF exposure levels, the body absorbs up to five times more of the signal from FM radio and television than from base stations. This is because the frequencies used in FM radio (around 100 MHz) and in TV broadcasting (around 300 to 400 MHz) are lower than those employed in mobile telephony (900 MHz and 1800 MHz) and because a person's height makes the body an efficient receiving antenna. Further, radio and television broadcast stations have been in operation for the past 50 or more years without any adverse health consequence being established.

While most radio technologies have used analog signals, modern wireless telecommunications are using digital transmissions. Detailed reviews conducted so far have not revealed any hazard specific to different RF modulations.

Cancer: Media or anecdotal reports of cancer clusters around mobile phone base stations have heightened public concern. It should be noted that geographically, cancers are unevenly distributed among any population. Given the widespread presence of base stations in the environment, it is expected that possible cancer clusters will occur near base stations merely by chance. Moreover, the reported cancers in these clusters are often a collection of different types of cancer with no common characteristics and hence unlikely to have a common cause.

Scientific evidence on the distribution of cancer in the population can be obtained through carefully planned and executed epidemiological studies. Over the past 15 years, studies examining a potential relationship between RF transmitters and cancer have been published. These studies have not provided evidence that RF exposure from the transmitters increases the risk of cancer. Likewise, long-term animal studies have not established an increased risk of cancer from exposure to RF fields, even at levels that are much higher than produced by base stations and wireless networks.

Other effects: Few studies have investigated general health effects in individuals exposed to RF fields from base stations. This is because of the difficulty in distinguishing possible health effects from the very low signals emitted by base stations from other higher strength RF signals in the environment. Most studies have focused on the RF exposures of mobile phone users. Human and animal studies examining brain wave patterns, cognition and behaviour after exposure to RF fields, such as those generated by mobile phones, have not identified adverse effects. RF exposures used in these studies were about 1000 times higher than those associated with general public exposure from base stations or wireless networks. No consistent evidence of altered sleep or cardiovascular function has been reported.

Some individuals have reported that they experience non-specific symptoms upon exposure to RF fields emitted from base stations and other EMF devices. As recognised in a recent WHO fact sheet "Electromagnetic Hypersensitivity", EMF has not been shown to cause such symptoms. Nonetheless, it is important to recognise the plight of people suffering from these symptoms.

From all evidence accumulated so far, no adverse short- or long-term health effects have been shown to occur from the RF signals produced by base stations. Since wireless networks produce generally lower RF signals than base stations, no adverse health effects are expected from exposure to them.

Protection standards

International exposure guidelines have been developed to provide protection against established effects from RF fields by the International Commission on Non-Ionising Radiation Protection (ICNIRP, 1998) and the Institute of Electrical and Electronic Engineers (IEEE, 2005).

National authorities should adopt international standards to protect their citizens against adverse levels of RF fields. They should restrict access to areas where exposure limits may be exceeded.

Public perception of risk

Some people perceive risks from RF exposure as likely and even possibly severe. Several reasons for public fear include media announcements of new and unconfirmed scientific studies, leading to a feeling of uncertainty and a perception that there may be unknown or undiscovered hazards. Other factors are aesthetic concerns and a feeling of a lack of control or input to the process of determining the location of new base stations. Experience shows that education programmes as well as effective communications and involvement of the public and other stakeholders at appropriate stages of the decision process before installing RF sources can enhance public confidence and acceptability.

Conclusions

Considering the very low exposure levels and research results collected to date, there is no convincing scientific evidence that the weak RF signals from base stations and wireless networks cause adverse health effects.

WHO initiatives

WHO, through the International EMF Project, has established a programme to monitor the EMF scientific literature, to evaluate the health effects from exposure to EMF in the range from 0 to 300 GHz, to provide advice about possible EMF hazards and to identify suitable mitigation measures. Following extensive international reviews, the International EMF Project has promoted research to fill gaps in knowledge. In response national governments and research institutes have funded over $250 million on EMF research over the past 10 years.

While no health effects are expected from exposure to RF fields from base stations and wireless networks, research is still being promoted by WHO to determine whether there are any health consequences from the higher RF exposures from mobile phones.

The International Agency for Research on Cancer (IARC), a WHO specialised agency, is expected to conduct a review of cancer risk from RF fields in 2006-2007 and the International EMF Project will then undertake an overall health risk assessment for RF fields in 2007-2008.

Further reading

IEEE (2006) IEEE C95.1-2005 "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz"

Annex 3

Electromagnetic Hypersensitivity

Fact sheet No. 296, December 2005

As societies industrialise and the technological revolution continues, there has been an unprecedented increase in the number and diversity of electromagnetic field (EMF) sources. These sources include video display units (VDUs) associated with computers, mobile phones and their base stations. While these devices have made our life richer, safer and easier, they have been accompanied by concerns about possible health risks due to their EMF emissions.

For some time a number of individuals have reported a variety of health problems that they relate to exposure to EMF. While some individuals report mild symptoms and react by avoiding the fields as best they can, others are so severely affected that they cease work and change their entire lifestyle. This reputed sensitivity to EMF has been generally termed "electromagnetic hypersensitivity" or EHS.

This fact sheet describes what is known about the condition and provides information for helping people with such symptoms. Information provided is based on a WHO Workshop on Electrical Hypersensitivity (Prague, Czech Republic, 2004), an international conference on EMF and non-specific health symptoms (COST244bis, 1998), a European Commission report (Bergqvist and Vogel, 1997) and recent reviews of the literature.

What is EHS?

EHS is characterised by a variety of non-specific symptoms, which afflicted individuals attribute to exposure to EMF. The symptoms most commonly experienced include dermatological symptoms (redness, tingling, and burning sensations) as well as neurasthenic and vegetative symptoms (fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitation, and digestive disturbances). The collection of symptoms is not part of any recognised syndrome.

EHS resembles multiple chemical sensitivities (MCS), another disorder associated with low-level environmental exposures to chemicals. Both EHS and MCS are characterised by a range of non-specific symptoms that lack apparent toxicological or physiological basis or independent verification. A more general term for sensitivity to environmental factors is Idiopathic Environmental Intolerance (IEI), which originated from a workshop convened by the International Program on Chemical Safety (IPCS) of the WHO in 1996 in Berlin. IEI is a descriptor without any implication of chemical etiology, immunological sensitivity or EMF susceptibility. IEI incorporates a number of disorders sharing similar non-specific medically unexplained symptoms that adversely affect people. However since the term EHS is in common usage it will continue to be used here.

Prevalence

There is a very wide range of estimates of the prevalence of EHS in the general population. A survey of occupational medical centres estimated the prevalence of EHS to be a few individuals per million in the population. However, a survey of self-help groups yielded much higher estimates. Approximately 10% of reported cases of EHS were considered severe.

There is also considerable geographical variability in prevalence of EHS and in the reported symptoms. The reported incidence of EHS has been higher in Sweden, Germany, and Denmark, than in the United Kingdom, Austria, and France. VDU-related symptoms were more prevalent in Scandinavian countries, and they were more commonly related to skin disorders than elsewhere in Europe. Symptoms similar to those reported by EHS individuals are common in the general population.

Studies on EHS individuals

A number of studies have been conducted where EHS individuals were exposed to EMF similar to those that they attributed to the cause of their symptoms. The aim was to elicit symptoms under controlled laboratory conditions.

The majority of studies indicate that EHS individuals cannot detect EMF exposure any more accurately than non-EHS individuals. Well controlled and conducted double-blind studies have shown that symptoms were not correlated with EMF exposure.

It has been suggested that symptoms experienced by some EHS individuals might arise from environmental factors unrelated to EMF. Examples may include "flicker" from fluorescent lights, glare and other visual problems with VDUs, and poor ergonomic design of computer workstations. Other factors that may play a role include poor indoor air quality or stress in the workplace or living environment.

There are also some indications that these symptoms may be due to pre-existing psychiatric conditions as well as stress reactions as a result of worrying about EMF health effects, rather than the EMF exposure itself.

Conclusions

EHS is characterised by a variety of non-specific symptoms that differ from individual to individual. The symptoms are certainly real and can vary widely in their severity. Whatever its cause, EHS can be a disabling problem for the affected individual. EHS has no clear diagnostic criteria and there is no scientific basis to link EHS symptoms to EMF exposure. Further, EHS is not a medical diagnosis, nor is it clear that it represents a single medical problem.

Physicians: Treatment of affected individuals should focus on the health symptoms and the clinical picture, and not on the person's perceived need for reducing or eliminating EMF in the workplace or home. This requires:

- a medical evaluation to identify and treat any specific conditions that may be responsible for the symptoms,
- a psychological evaluation to identify alternative psychiatric/psychological conditions that may be responsible for the symptoms,
- an assessment of the workplace and home for factors that might contribute to the presented symptoms. These could include indoor air pollution, excessive noise, poor lighting (flickering light) or ergonomic factors. A reduction of stress and other improvements in the work situation might be appropriate.

For EHS individuals with long lasting symptoms and severe handicaps, therapy should be directed principally at reducing symptoms and functional handicaps. This should be done in close co-operation with a qualified medical specialist (to address the medical and psychological aspects of the symptoms) and a hygienist (to identify and, if necessary, control factors in the environment that are known to have adverse health effects of relevance to the patient).

Treatment should aim to establish an effective physician-patient relationship, help develop strategies for coping with the situation and encourage patients to return to work and lead a normal social life.

EHS individuals: Apart from treatment by professionals, self help groups can be a valuable resource for the EHS individual.

Governments: Governments should provide appropriately targeted and balanced information about potential health hazards of EMF to EHS individuals, health-care professionals and employers. The information should include a clear statement that no scientific basis currently exists for a connection between EHS and exposure to EMF.

Researchers: Some studies suggest that certain physiological responses of EHS individuals tend to be outside the normal range. In particular, hyper reactivity in the central nervous system and imbalance in the autonomic nervous system need to be followed up in clinical investigations and the results for the individuals taken as input for possible treatment.

What WHO is doing

WHO, through its International EMF Project, is identifying research needs and co-ordinating a world-wide program of EMF studies to allow a better understanding of any health risk associated with EMF exposure. Particular emphasis is placed on possible health consequences of low-level EMF. Information about the EMF Project and EMF effects is provided in a series of fact sheets in several languages www.who.int/emf/.

Further Reading

WHO workshop on electromagnetic hypersensitivity (2004), October 25 -27, Prague, Czech Republic, www.who.int/peh-emf/meetings/hypersensitivity_prague2004/en/index.html

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Annex 4

Guidelines from the National Board of Health and Welfare Concerning the Treatment of Patients who Attribute their Discomfort to Amalgam and Electricity

If specific disease cannot be detected

In many cases, the investigation does not result in a specific medical diagnosis. Besides skin changes, it is rare to find any pathological abnormalities in the clinical investigation or in the laboratory tests. The patient's conception that the symptoms are caused by electricity (electromagnetic fields) may persist and the patient may insist that reducing the exposure to electromagnetic fields is important. The doctor's job is then to provide information on current knowledge based on science and medical experience.

Reducing exposure to electromagnetic fields

> *It is not the job of the attending physicians to recommend whether actions to reduce exposure to electromagnetic fields should be carried out. There is no firm scientific support that such treatment is effective. Instead, these questions may be dealt by the employers or local authorities, who in some cases have decided to grant home adaptation grants (for such actions).*
>
> *Replacement of electric equipment e.g. fluorescent tubes with light bulbs, replacement of cathode ray tubes with displays of liquid crystals, so-called LCD, may be tested as a part in a rehabilitation plan. Some measures to reduce exposure to electromagnetic fields is sometimes also part of such actions. Advantages and potential drawback of such actions should carefully be considered in each individual case, before implementation, e.g. how to handle the situation if there is no improvement in health."*

In Sweden the focus is on the symptoms presented by the afflicted person (symptom diagnosis) and the right to sick leave, sickness benefits, disability pension etc is based on the degree of ill health and functional handicap of the person regardless of known or unknown cause for the condition. There is no specific treatment and since the clinical picture varies from case to case any recommendation for interventions or treatments to be tried has to be based on a broad evaluation of each individual's specific situation (including medical investigation, psychosocial situation and possible contributing environmental factors). Treatments known to reduce the type of symptoms presented by the patient might be tried. It is important that a trustful patient-doctor relationship is established and that a medical physician will offer follow-up visits to ensure (after the initial medical work up aimed at excluding known medical conditions that require interventions and treatments) that new medical evaluations are made when motivated e.g. by change in symptoms.

Electromagnetic hypersensitivity has not been accepted as a work injury.

Five Swedish authorities (responsible for activities related to electromagnetic fields: The Swedish National Board of Occupational Safety and Health, National Board of Housing, Building and Planning, National Electrical Safety Board, National Board of Health and Welfare, Radiation Protection Institute) have recommended a precautionary principle primarily aimed at low frequency magnetic fields based on suspected cancer risks (issued 1996). The document declares that the recommendation does not refer to electromagnetic hypersensitivity (the authorities "refrain from issuing any joint, general recommendation on this subject. It is very important, however, that electrically hypersensitive persons should be unconditionally examined by health and medical services, on the basis of their symptoms.")

The Swedish Board of Health and Welfare is the Swedish authority to grant financial support through the national budget to disability organisations. A disability organisation is according to the authorities understood to be an organisation which members (at least a majority of) meet substantial difficulties in everyday life due to some kind of disability. The National Board of Health and Welfare thus make their decisions based on the consequences for the afflicted individuals and not based on any known underlying cause of the disability/problems. The Swedish Association for the Electrosensitive was granted financial support as a disability organisation. Most disability organisations that have received this type of financial support join the Swedish Disability Federation, as has The Swedish Association for the Electrosensitive. This fact has sometimes been misinterpreted as if electromagnetic hypersensitivity is a recognised medical diagnosis in Sweden.

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