

A Summary of Recent Reports on Mobile Phones and Health (2000–2004)

Z J Sienkiewicz and C I Kowalczyk

ABSTRACT

Since the publication of the Stewart Report in May 2000, a substantial number of reviews into the health effects of mobile phones and health have been produced by national and international committees, expert groups, and agencies. These reports have reviewed the relevant literature, formed conclusions on the likelihood of adverse health effects, and made recommendations for additional research.

The intention of this report is to bring the information from these various sources together and to highlight any commonality or differences in opinion.

© National Radiological Protection Board
Chilton
Didcot
Oxon OX11 0RQ

Approval: December 2004
Publication: January 2005
£13.00
ISBN 0 85951 552 4

CONTENTS

1	Introduction	1
2	Summary of Conclusions and Recommendations	3
3	Summary of individual reports	6
3.1	Health Council of the Netherlands (HCN, 2000)	6
3.2	Advisory Group on Non-ionising Radiation (AGNIR, 2001)	7
3.3	British Medical Association (BMA, 2001; 2004)	8
3.4	EC Scientific Committee on Toxicology, Ecotoxicology and the Environment (CSTEE, 2001)	9
3.5	US General Accounting Office (GAO, 2001)	9
3.6	Health Council of the Netherlands (HCN, 2001)	10
3.7	Royal Society of Canada (Krewski et al, 2001a; 2001b)	11
3.8	Zmirou Report (2001)	12
3.9	Health Council of the Netherlands (HCN, 2002)	15
3.10	French Senate Report (Lorraine and Raoul, 2002)	16
3.11	Swedish Radiation Protection Authority (SSI, 2002)	17
3.12	Advisory Group on Non-ionising Radiation (AGNIR, 2003)	17
3.13	Swiss Bundesamt für Umwelt, Wald und Landschaft (BUWAL, 2003)	19
3.14	Health Council of the Netherlands (HCN, 2003)	19
3.15	US National Council on Radiation Protection and Measurements (NCRP, 2003)	20
3.16	Swedish Radiation Protection Authority (SSI, 2003)	21
3.17	Health Council of the Netherlands (HCN, 2004a)	22
3.18	Health Council of the Netherlands (HCN, 2004b)	23
3.19	International Commission on non-Ionizing Radiation Protection (ICNIRP, 2004)	23
3.20	Institution of Electrical Engineers (IEE, 2004)	24
3.21	Medicines and Healthcare Products Regulatory Agency (MHRA, 2004)	25
3.22	National Radiological Protection Board (NRPB, 2004)	26
3.23	Nordic Authorities (2004)	27
3.24	World Health Organization (WHO, 2004)	28
4	Acknowledgements	29
5	References	29

1 INTRODUCTION

While the popularity of mobile phones continues to increase, concerns persist about their safety. Although much research does not suggest that exposure to radiofrequency (RF) fields at levels commonly encountered in the environment can cause detrimental effects in the short-term, opinion remains divided as to whether the symptoms experienced by some individuals represent a field-dependent phenomenon, and some research suggests adverse effects may occur after many years of phone use.

The possible health effects of RF fields have been considered and reviewed many times. However, the most influential of these reviews is arguably the Stewart Report (IEGMP, 2000). Published in May 2000, the Stewart Report not only considered health issues, but also offered advice to government, industry and others on a wide range of RF field-related topics, including advice on exposure standards and planning, and on public information and consumer choice. It also recommended setting up a substantial research programme. Regarding health issues, the Stewart Report concluded that the balance of evidence did not suggest that exposures below international guidelines could cause adverse health effects, although it acknowledged that biological effects may occur below these values. Importantly, the detrimental effects on drivers' responsiveness by the use on mobile phones while driving was highlighted and recommendations were made to dissuade drivers from using either hand-held or hands-free phones whilst on the move.

Since the publication of the Stewart Report, research into the effects of RF fields has continued and intensified, and in the intervening years a substantial number of other reviews from national and international committees, expert groups, and agencies have been produced. These groups have reviewed the relevant literature, formed conclusions on the likelihood of adverse health effects, made recommendations for additional research and, in some cases, made proposals for revisions to policy.

The intention of this paper is to bring the information from these various sources together and to highlight any commonality or differences in opinion. To that end, each report is briefly summarised, and most are listed in the table along with their main conclusions and recommendations. Where the language of the original report has not been English, the official translation into English has been used, if one is available. However a few reports have not been reviewed, including a report commissioned by l'Agence Française de Sécurité Sanitaire Environnementale (AFSSE, 2003a) and the subsequent opinion statement (AFSEE, 2003b), and the report published by L'Institut National de l'Environnement Industriel et des Risques (INERIS) on telecommunications and health for l'Autorité Régulation des Télécommunications (ART, 2002).

At the same time, a large and growing number of papers has been published that deal with the results of specific health studies or single laboratory

experiments, or review some specific aspect of the literature. However, these have not been included here as they are better considered as part of the scientific literature, and they have been considered elsewhere in recent reports by the independent Advisory Group on Non-ionising Radiation (AGNIR, 2003) and NRPB (2004). For similar reasons, most reports originating from colloquia, seminars or workshops* have not been included, nor have reports that consider technical or sociological impacts from the use of mobile phones, such as planning procedures or codes of practice.

The outstanding health-related concerns are being addressed by epidemiological (human population) studies and experimental investigations with volunteers, animals, and the use of *in vitro*, cell-based, techniques. In addition, dosimetric studies are necessary in understanding the exposure of people from various sources. However, technological change is rapid in this area and it is a challenge to carry out necessary research and to analyse the possibility of any effects.

Epidemiological studies provide the most direct information on long-term health effects of any potential harmful agent. To assess any damage to health generally requires long follow-up, frequently for many years. If the specific concern is with cancer then this can frequently arise many years after exposure, and may also require many more years before it fully manifests itself in an exposed population. Thus for the atomic-bomb survivors in Japan the follow-up still continues more than 60 years after the bombings. A period of ten years may be regarded a minimum period of follow-up for the identification of any long-term health effects in exposed groups. In addition, epidemiological studies do not have a high sensitivity for detecting subtle effects. In respect of exposures to emissions from mobile phones, the present period of follow-up is relatively short. The international pooling of 13 national studies on the possible effects of using mobile phones in the INTERPHONE study that is being co-ordinated by the International Agency for Research on Cancer (IARC) at Lyon, should provide the best way of obtaining information on any cancer-related health effects.

*In Europe, COST 281 and EMF-NET are very active in this regard. A number of international workshops have been held on topics such as the influence of RF fields on the expression of stress protein, sleep and cognitive functions, the blood-brain barrier and on genetic and cytogenetic effects (available at www.cost281.org). COST is the acronym for European Co-operation in the Field of Scientific and Technical Research. It is a framework for international research and development co-operation, allowing co-ordination of national research at European level. COST 281 is concerned with potential health implications from mobile communication systems. EMF-NET is a EU-funded project under the Sixth Framework Programme to provide a mechanism to co-ordinate research, and to aid in the dissemination of results from national and international research programmes.

Volunteer studies are also very important in enabling transient physiological phenomena, such as effects on sleep patterns or on particular aspects of cognitive function, to be studied. While these studies are important for indicating the likely response of people exposed under similar conditions, for ethical reasons they are usually restricted to the use of healthy adults and to investigating effects that are considered to be harmless.

Animal studies are frequently used to complement epidemiological studies. They are generally of shorter duration and have the advantage that they can use a homogeneous population exposed under well-controlled conditions. A range of exposure conditions can be used, and exposures are well quantified, allowing studies to be replicated. The disadvantage is that the results obtained cannot necessarily be extrapolated readily to human populations. Even in the case of studies of cancer incidence in animals, there can be very substantial differences in sensitivity between different species or strains of animals, making application to man difficult.

Cellular studies are valuable for examining the mechanisms involved in any interactions with body tissues. They are most usefully employed to understand demonstrated effects and have been particularly valuable through modern genetic analysis in understanding factors influencing the sensitivity of tissues to chemical or biological hazards. Applications involving the use of stem cells are of increasing importance in medical research and could well have an important place in understanding any effects of RF fields on body tissues.

2 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Most of the 26 reports examined here have reached similar conclusions and have made comparable recommendations. Overall, the reports acknowledge that exposure to low level RF fields may cause a variety of subtle biological effects on cells, animals or humans, particularly on brain activity during sleep, but the possibility of exposure causing adverse health effects remains unproven. Nevertheless, these reports suggest additional well-targeted, high quality research would be valuable to explore remaining uncertainties further. Such studies also provide reassurance to the public and help to address concerns about health. Further, these reports stress that very low level exposures, typical of base stations, are extremely unlikely to cause any effects on biophysical grounds, whereas localised exposures, typical of those from mobile phones, may induce effects as a result of mild heating of superficial tissues close to the handset.

It is of interest to note that a recently published, well-conducted, case-control study from Sweden (which has not been included any in of the reports considered here) identified an increased risk of acoustic neuroma among people using a mobile phone for ten or more years (Lönn et al, 2004). However, no

association was seen with less than ten years use (which is consistent with the results of previous studies). Epidemiological studies in progress should provide more information on this topic. In addition, Hardell et al (2004) have recently produced another analysis of data from their case-control study of brain tumours and use of cellular and cordless phones in central Sweden (Hardell et al, 2002a, 2002b, 2003). The earlier analyses were considered by AGNIR (2003). The new analysis looked particularly at whether any raised risk might vary by age. It was reported that the odds ratio (relative risk) of brain tumour associated with ipsilateral use of analogue cellular or cordless phones was highest among those aged 20-29 years at diagnosis. However, because the number of study subjects in this age group was small, the confidence intervals for the corresponding odds ratios were wide and generally inconclusive.

In late 2004, the Verum Foundation published a report on the results of the REFLEX project on their web site (www.verum-foundation.de). This project investigated the effects of (low frequency and) RF fields on the *in vitro* responses of cells, possibly associated with the development of cancer at the molecular level. A large number of responses were examined in a wide variety of cell types, and included effects on cell proliferation, chromosomal damage and programmed cell death (apoptosis) as well as gene and protein expression profiles. While not all responses yielded positive results, some field-dependent effects were reported, which may suggest that certain types of exposure can cause genetic damage in certain cell types. However, if RF fields do cause genotoxic or carcinogenic effects, a consistent pattern of responses would be expected in various cell types exposed to the same field, and evidence of a consistent dose-response relationship would also strengthen the plausibility of any response. The effects reported in the REFLEX project appeared to show very high levels of specificity with regard to cell type, exposure condition and the biological endpoint under consideration: while some of these responses do seem to have been repeated by different laboratories, others do not appear to have been seen consistently across the project; some only occurred in one cell type and not in others; and some changes were observed at one field intensity but not at higher or lower intensities. Overall this inconsistency does not suggest that robust responses had been observed, and the extent to which experimental artefacts may have been operating remains unclear. The physiological significance and biological relevance of some of the reported changes were questioned by the authors themselves. In summary, the REFLEX project provides some novel observations regarding the potential of RF fields to affect cellular and molecular processes *in vitro*, and the results will no doubt stimulate further highly focussed research.

The Swedish Radiation Protection Authority (SSI, 2004) have examined the data from the REFLEX project, and found it highly surprising that an effect could be present only in a narrow range of exposure levels. In addition, the positive data on DNA fragmentation effects were considered to contradict all recent findings. It was concluded that some of the positive responses will warrant replication once they have been published in the peer-reviewed literature. However, *in vivo*

research looking for effects possibly related to these findings was considered to be premature, if not inappropriate at this stage (SSI, 2004).

Regarding the potential increased sensitivity of children to RF fields, many reports suggest precautionary approaches may be appropriate in the absence of explicit scientific data. However, several reports also note that ethical or practical concerns may limit or prevent experimental studies with children. In contrast, the Health Council of the Netherlands (HCN) did not consider that there was sufficient evidence to suggest that use of mobile phones by children should be limited (arguing that it was unlikely that major changes in sensitivity of the brain to electromagnetic fields (EMFs) still occur after the second year of life). A recent World Health Organization (WHO) symposium on this issue concluded that the question remained largely unanswerable at present due to the paucity of relevant research (WHO, 2004). The Chairman of the International Commission on Non-Ionizing Radiation Protection (ICNIRP), Dr Paulo Vecchia, made the point that, without recognised health effects, it was not possible to produce science-based standards. In its research agenda, WHO has decided to focus attention on the potential effects of RF fields on children (WHO, 2004)

Although of particular interest in the UK, the effects of exposure to pulsed fields have received limited international attention. The main problem is the lack of an accepted biological model that shows consistent sensitivity to low level RF fields: without this model, it is not possible to examine and compare the effects of different signal modalities. Overall the evidence that modulated fields preferentially affect biological processes is fairly inconsistent and no expert groups appear to have identified any mechanism whereby modulation could cause increased effects. The US National Council on Radiation Protection and Measurements (NCRP, 2003) noted that some, but not all, studies suggest modulation-specific effects may occur, with pulsed fields generally more effective than unmodulated fields, but many of these require exposures well above guideline values. A report for the Royal Society of Canada reached broadly similar conclusions but recommended that differing frequencies and signal modulation should be investigated (Krewski et al, 2001a, 2001b). Lastly, in Switzerland, Bundesamt für Umwelt, Wald und Landschaft, considered the specific effects of modulation were few and contradictory (BUWAL, 2003).

Many recent reports also offer guidance on public policy to decision makers and legislators, and generally favour some form of precautionary or prudent approach to reducing personal exposures from mobile phones. A proven and important effect of mobile phone use on driving exists. Many reports acknowledge that the distracting effects of holding a conversation on a mobile phone, even when using a hands-free kit, represent a serious threat to the public from mobile telephony. However, there has been insufficient applied research to see how these dangers might be mitigated, or what factors make them particularly severe. Similar dangers may also exist in relation to using phones while operating machinery and heavy plant equipment.

3 SUMMARY OF INDIVIDUAL REPORTS

3.1 Health Council of the Netherlands (HCN, 2000)

This report comes from the Health Council of the Netherlands (HCN) Electromagnetic Fields Committee. It considers the biological effects and health risks associated with typical exposure to RF fields from GSM 900 and DCS 1800 base stations. This, and similar reports from the HCN, are written by a multidisciplinary group of about 12 Dutch scientists and physicians chaired by E W Roubos (Nijmegen University).

The report briefly describes the parts and functions of a base station and gives measurements of the intensity of RF fields near these installations. It summarises the scientific evidence for health effects and considers the appropriateness of the existing human exposure limits in the Netherlands for RF fields (proposed by HCN in 1997). The application of the precautionary principle is discussed.

The report concludes that there is no good scientific reason for the existing exposure limits in the Netherlands to be lowered: the indications that non-thermal effects could give rise to health problems were considered to be weak. The likelihood of health problems arising in work and residential areas near base stations due to the RF fields was considered to be extremely small, since the measured field strengths were considerably lower than the limits proposed by HCN (1997) and ICNIRP (1998). In addition, the report considered that disruption to medical implants or other devices from the RF fields associated with base stations could be ruled out provided the equipment meets the relevant EU immunity guidelines.

The report recommends that measures should be taken to avoid workers being able to come closer than 10 cm to the antenna, and that members of the public should not be able to approach closer than 3 m within the main beam and 0.5 m outside the beam. However, where an antenna is mounted on an external wall, the thickness of the wall may be used as the minimum approach distance. It also suggests that residents should be involved at the earliest possible stage in the construction of a base station. Because health complaints may arise as a result of fear of the unknown, adequate information should always be provided to residents. Where persistent complaints occur, it recommends the possibility of low frequency sounds or vibrations coming from the installation should be investigated. The remaining recommendations were specific to the Netherlands: in line with the EU Radio and Telecommunications Terminal Equipment directive, it was suggested that the Telecommunications Act or the Environmental Management Act should be amended to control the mounting of antennas in accordance with health considerations; it should be made clear to the public exactly which organisation is responsible for monitoring the set-up of base stations, measuring the field strengths transmitted, and enforcing the relevant legislation; and technical data and field strength calculations for each installation, with any measurements, should be registered centrally.

53 pages, 42 references

3.2 Advisory Group on Non-ionising Radiation (AGNIR, 2001)

This report is from the independent Advisory Group on Non-ionising Radiation (AGNIR). It is concerned with the possible health effects of terrestrial trunked radio (TETRA). It was written by a committee of six UK scientists chaired by Sir Richard Doll. The report specifically addressed the possibility, originally suggested by IEGMP (2000), that RF signals modulated around 16 Hz might increase the rate of efflux of calcium ions from brain and other tissues. TETRA hand portables and vehicle mounted mobile terminals may produce signals that pulse at 17.6 Hz (as a result of power modulation); signals from base stations, however, are not pulsed.

The Report summarises the technical aspects of TETRA and the exposure of people and reviews the evidence for biological effects of amplitude-modulated RF fields. Finally, it makes recommendations for further work. There is also a technical note describing the power modulation spectra of signals used in TETRA.

The report concludes that although there is evidence that that RF fields, amplitude-modulated at about 16 Hz may influence the leakage of calcium ions from tissues (referred to calcium efflux), these findings are contradictory and they are more uncertain for living than non-living tissues. Moreover no associated health risk from such a phenomenon was identified. Further, the report concludes that although areas of uncertainty remain about the biological effects of low level RF radiation in general, including modulated signals, current evidence suggests that it is unlikely that the special features of the signals from TETRA mobile terminals pose a hazard to health.

Eight recommendations for research were made concerning experimental biology, and physics and theoretical dosimetry. Further studies of the effects of RF induced changes on the behaviour of calcium in tissues using modern techniques were suggested, as were further studies on the effects of amplitude modulation or pulsing on neuronal activity and on signalling within and between nerve cells. Hippocampal slice preparations should be used to investigate the likelihood that modulated RF fields could induce epileptic seizures. Possible mechanisms should be investigated using modern patch-clamp techniques whereby living cells might "demodulate" amplitude-modulated RF fields. Human volunteer studies should be carried out to measure changes in cognitive performances arising from the use of TETRA handsets. Records of the use of TETRA should be kept (for future epidemiological studies). The audit of base stations (recommended by IEGMP, 2000) should be enlarged to include TETRA base stations. Assessments of the exposures from hand portables should be carried out using experimental techniques and computational dosimetry.

53 pages, 96 references; plus technical note 31 pages, 3 references

3.3 British Medical Association (BMA, 2001; 2004)

The report is from the British Medical Association (BMA) Science Department and the Board of Science and Education. It covers both health effects and broader issues arising from the use of mobile phones. The report was updated in 2004.

The 2001 report presents a simple summary of the major elements of the technology behind mobile telephony, lists some major publications in this field and very briefly considers the scientific evidence for biological and health effects. It reviews the consequences of using a mobile phone while driving, and the broad sociological implications of mobile phones. Finally it considers hands-free kits (HFKs) and other protective devices.

It concludes that further research into health effects is necessary since there are some gaps in knowledge although the report acknowledges that no definite adverse health effects from mobile phones or base stations have been established. It supports the precautionary approach.

The Report makes eight interim recommendations. It suggests that the precautionary approach should be adopted while research remains inconclusive; it supports the existing research initiatives; and it endorses the Department of Health's policy of issuing information about the health risks of mobile telephony to the general public. Further, the Report suggests that "quiet zones" should be established where the use of phone in public places is restricted; it suggests a standard test (and BSI kitemark) should be adopted for HFKs and shields; and it suggests that manufacturers of mobile phones should provide information about the power output of their phones. In addition, it recommends that hospitals and other healthcare premises should issues clear guidance and use signs to indicate that phones should be turned off. Lastly the Dept. of Environment, Transport and the Regions (whose responsibilities are now split between the Dept. of Environment, Farming and Regional Affairs, and the Office of the Deputy Prime Minister) was advised to revisit its campaign about the use of phones and driving to indicate that a driver should not use a phone while driving.

In June 2004 an update to the report was published. This update summarised the main conclusions of several of the major reviews that had been produced since the first report was published. It also provides outlines of the IARC Interphone study and the UK Mobile Telecommunications and Health Research (MTHR) programme (which was set up in response to a recommendation of the Stewart Report), and recent changes to policy and exposure limits. The update concludes that the 2001 recommendation to adopt a precautionary approach was still valid while research into the health effects of mobile phones remained inconclusive. It states that the BMA will continue to support national and international research programmes into possible adverse effects of mobile phones, and a watching brief will be kept on forthcoming research and policy. It notes that the widespread adoption of picture messaging may raise new child protection issues.

2001 Report: 20 pages, 56 references; 2004 Update: 5 pages, 6 references

3.4 EC Scientific Committee on Toxicology, Ecotoxicology and the Environment (CSTEE, 2001)

The report comes from the Scientific Committee on Toxicology, Ecotoxicology and the Environment (CSTEE) of the European Commission. It was written by a working group consisting of ten international scientists chaired by B Terracini (University of Turin). It was prepared to update the 1998 Opinion of the Scientific Steering Committee which served as a basis for the EU Council Recommendation of 5 July 1999 for limiting the exposure of the general public to EMFs. The report considered exposure to power frequency EMFs (not considered here) as well as RF fields.

The report presents a brief summary of the evidence concerning the biological and health effects of exposure to RF fields. Extensive use is made of expert reviews, including that of the Stewart Report.

Overall, the report agrees with the findings and conclusions in the Stewart Report and other major reviews. It concluded that low level exposure to RF fields does not produce any consistent effects on any biological endpoint. The possibility of small effects on blood pressure in exposed volunteers was noted, however, as was the possibility of subjective symptoms resulting from hypersensitivity to RF fields. The epidemiological data, in particular, did not suggest consistent cancer excesses. This result was taken to be consistent with the results of genotoxicity and experimental carcinogenicity studies in cell and animal models, which were largely negative.

On the basis of this evaluation, the report had insufficient evidence to propose alternatives to the technical annex for the Council Recommendation setting up basic restrictions and reference levels limiting exposure to non-ionising radiation, which were based on the guidelines published by ICNIRP (1998).

The need for further epidemiological studies was recommended due to limitations of the existing studies, including the use of short observation periods and surrogate measures of exposure, plus many studies had insufficient statistical power. In addition the possible synergistic effects of RF fields with physical and chemical mutagenic or carcinogenic agents required investigation.

13 pages, 12 references

3.5 US General Accounting Office (GAO, 2001)

This report comes from the US General Accounting Office (GAO). It was written by Peter Guerrero and John Finedore with the assistance of five other members of GAO staff. The report provides an update on scientific studies into health effects associated with mobile phones, and gives information about the activities of the US federal government and its agencies relating to setting human exposure standards, testing emissions from phones, and disseminating information to the public about health issues. The report does not include issues

related to base stations, interference with medical devices or effects on driving ability. It updates a similar report from GAO published in 1994.

Following a very brief background on EMFs, the report summarises the epidemiological and laboratory evidence concerning the effects of RF fields on health. It considers research programmes in the USA and in other countries, highlighting the WHO International EMF Project. The report reviews the history of mobile phone health effects research in the USA, listing various shortcomings and controversies, describing the roles and responsibilities of organisations such as the Federal Communications Commission (FCC), the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA), as well as the Cellular Telecommunications and Internet Association (CTIA) research program.

The report concluded that existing scientific research does not demonstrate that RF fields from mobile phones cause adverse health effects, although the findings of some studies suggest the need for further research. It was noted that it may be many more years before a definitive conclusion can be reached on whether RF fields pose a risk to human health. The co-operative research effort between the FDA and the mobile phone industry through CTIA was thought useful, although of modest size compared to many other research programmes and it was funded solely by the industry. The lack of a standardised procedure to ensure compliance testing of mobile phones was seen as particular shortcoming. Finally it was concluded that the information provided to consumers by the FDA and FCC about health issues should be clear, accurate and timely.

The report made several recommendations to the FCC, including: to direct the Office of Engineering and Technology to issue revised guidance on SAR testing procedures to reduce variations in test results caused by a lack of standardised procedures and to incorporate measurements of uncertainty; and to direct the Consumer Information Bureau to develop clear, consistent and easily accessible consumer materials on exposure issues, including internet-based information on SAR values. The report also made recommendations to the FDA, including: to direct the Center for Devices and Radiological Health to publicly report on the extent to which CTIA is following FDA's recommendations in funding specific research proposals; and to develop (and regularly update) a new consumer document that provides a current overview of the status of the health issues and research related to mobile phones.

39 pages, 27 references/footnotes

3.6 Health Council of the Netherlands (HCN, 2001)

In addition to the advisory reports on possible health effects associated with EMFs, the Electromagnetic Fields Committee of the HCN also publishes annual updates on EMF health effects to enable topical issues to be considered and recent reports from HCN to be highlighted. Such annual updates have not been included in the table.

The first annual update (HCN 2001) summarised the base station report (HCN 2000). It considered four epidemiological papers that had been published (between 1999 and 2001) on mobile phones and brain tumours. Overall, it was concluded that these studies did not suggest any increased risk of brain tumours. A German study investigating mobile phones and ocular melanomas was reviewed, and it was considered that no conclusions about health effects could be drawn. Lastly, a study investigating effects of base stations fields on cattle was next reviewed: no consistent biological effects were demonstrated.

25 pages, 27 references

3.7 Royal Society of Canada (Krewski et al, 2001a; 2001b)

This review was drawn from the Expert Panel Report originally prepared at the request of the Royal Society of Canada for the Radiation Protection Bureau of Health Canada. This report, entitled Potential Health Risks of Radiofrequency Fields from Wireless Telecommunications Devices, was released by the Royal Society of Canada in 1999. The present review (2001a) contains most of the original report with minor editorial modifications including the updating of references that were in press at the time the original report was released. In addition, a second review (2001b) provides an update of advances in research and includes discussion of earlier results not included in the original report. Both reviews were authored by the same panel of eight scientists; in both cases, the lead author was D Krewski (University of Ottawa) who was the chair of the original Expert Panel.

The main review (2001a) presents a comprehensive and detailed summary of the biological and health effects associated with exposure to both low-level fields (non thermal effects) and high intensity fields (thermal effects). The adequacy of the existing RF guidelines in Canada for the exposures of workers and members of the public was addressed. Finally recommendations were made for further research.

Because this review largely predates the Stewart Report, a detailed commentary is not necessary here, beyond noting that the conclusions and recommendations of the original report were repeated by the review. Thus it was concluded that existing exposure guidelines in Canada (Health Canada's Safety Code 6) protected both workers and members of the public from adverse health effects associated with whole-body thermal exposure to RF fields. It was considered that protracted exposures of the head, neck and extremities at the local limits could lead to thermal effects, so it was recommended that the local exposure limits for workers be reviewed with respect to both intensity and duration of exposure, and that additional research be conducted to provide an adequate scientific basis for this (such as investigating effects ocular and retinal physiology). Lower local exposure limits were considered desirable for the eyes, and suggested that the local limit for workers be lowered to that of members of public.

The review also concluded that although exposure to non-thermal levels of RF field may produce biological effects in cells and animals, none of these are suggestive of causing adverse health effects. Nevertheless, further experimental work on these effects was recommended: these include studies investigating effects on melatonin physiology, opioid and cholinergic systems, transmembrane ion transport, the blood-brain barrier (BBB), and studies investigating the effects of differing frequencies and signal modulations. Epidemiological studies were endorsed as the primary means of assessing the potential effects of RF fields on health, although existing studies were considered inadequate for a comprehensive evaluation of risk. Further studies of highly exposed (occupational) groups and following long-term exposure were recommended, as were clinical studies addressing the possibility that certain subgroups in the population may be more sensitive to RF fields.

The update (2001b) summarises a number of more recently published studies on potential health risks of RF fields. These include cellular and animal studies investigating effects on ornithine decarboxylase, calcium efflux and the BBB, melatonin, cell proliferation, DNA damage and carcinogenicity, and testicular function and teratogenicity. Epidemiological studies and cognitive effects in humans and animals are also reviewed. Although all these results were considered valuable additions to the effects literature, it was concluded that they did not alter the conclusions of the original report, and further studies were again recommended. The epidemiology studies, in particular, were still considered inadequate for risk assessment due primarily to limitations associated with exposure estimation.

Review (2001a) 143 pages, 478 references; Update (2001b) 15 pages, 65 references

3.8 Zmirou Report (2001)

This extensive report was prepared by a group of seven French scientists and clinicians chaired by Dr Denis Zmirou (University of Grenoble). The group was convened by the French Health General Directorate (Direction Générale de la Santé) in response to the IEGMP and other recent reports to assess whether any changes were necessary to existing human exposure guidelines and regulations in France and Europe.

The report describes the sources and characteristics associated with mobile phones, and the biological rationale for setting exposure standards. Next the report summarises the biological and medical effects of RF fields: to do this, extensive use was made of five reports from other scientific bodies, including IEGMP, that had been published between 1996 and 2000. More recent literature was also reviewed and representatives of scientific organisations, industry and others were interviewed. Use was also made of the opinions of an international symposium on mobile phones and health held at the French Academy of Sciences

in 2000 (Actes de colloque, 2001). Based upon this assessment, conclusions were drawn and recommendations for further research made.

The report concluded that the possibility of non-thermal biological effects cannot be excluded, but it was not possible to state whether these represent a health hazard. It was considered that these uncertainties did not justify lowering the exposure limit values at present. The only known risk factor concerned the use of mobile phone while driving, but this was not associated with exposure to RF fields per se, but due to a loss of concentration from holding a conversation.

Therefore the report recommended an approach based on the precautionary principle to manage any potential risks associated with mobile telephony, with the general aim to reduce average exposure of the public to the lowest possible level compatible with service quality. To achieve this, the report made very detailed recommendations for further research.

Three areas of epidemiological research were recommended. Existing prospective cohort studies should be used to investigate relatively benign effects, such as headaches, associated with exposures from mobile phones. Additional studies should focus on children, migraine sufferers as well as occupational studies. In addition, work was recommended towards investigating the existence of the phenomenon of hypersensitivity. Initial studies would aim to define and characterize the phenomenon, with a view to identifying groups of users to include in later case control studies, or groups for targeted monitoring. Exploring effects of mobile phone use on traffic accidents further, studies should compare the risks of using a hand-free phone whilst driving with those from holding a conversation with a passenger. Although the risks of cancer associated with exposures from base stations was assumed to be very small, it was recommended that studies should be carried out to verify this, if at all possible. No further studies were considered necessary to investigate cancer risks from mobile phones at the present time (because of the Interphone project, a large case-control study being co-ordinated by IARC), however a cancer-related mortality study of a cohort of workers in France was suggested. In addition, a measurement programme was considered worthwhile to provide information about exposures of workers and members of the public.

Volunteer studies should investigate a wide range of neurobehavioural endpoints, including brain activity, cognitive function, cardiovascular effects and immune function. These tests should be carried in healthy volunteers and patients with pathologies that may be aggravated by RF fields, including migraine, inflammatory skin diseases, epilepsy and glaucoma. Effects on children and adolescents should be investigated, as should studies with self-reporting hypersensitives and others who present subjective symptoms with mobile phone use.

Animal studies should investigate effects of RF on the growth of induced tumours and on the integrity of DNA, effects on learning and memory, neurotransmitters, neuron excitability, effects on the BBB, and the microwave auditory effect. Other potential investigations considered worthy of study but which have not received

attention included the potential synergy of RF fields with other teratogens and carcinogens, and with chronic or acute pathologies (either man-made or natural). Effects on cells of the immune system and on reproductive and teratogenic effects were highlighted. Studies should also be made using immature animals to model the susceptibility of children and adolescents.

Cellular studies should address the possibility of genotoxic effects using established cytogenetic and clastogenic methodologies, effects on apoptosis, and effects on gene expression especially of heat shock proteins (HSPs). Further studies on electrophysiology using brain slice techniques was also recommended. It was considered that all these investigations should be repeated in the presence of chemical and physical mutagens to identify any interaction between these agents and RF fields.

Several general recommendations for research were made, including the development of standardised experimental protocols, and to monitor major physiological variables during in vivo exposures. The need to start research using the signals associated with new and emerging technology was also stressed.

The report also recommended that all users of mobile phones should adopt prudent avoidance measures to reduce exposures as much as possible. Children, in particular, should be advised by their parents of the need for this, and a recommendation to this effect should be included within the instructions supplied with mobile phones. Manufacturers should reduce emissions to the lowest possible level compatible with service quality. It was further recommended that buildings, such as hospitals, day-care centres or schools which may contain individuals with increased sensitivity to RF fields, should not be directly in the path of the transmission beam if they are located less than 100 m from a base station. It was also recommended that exclusion areas in the immediate vicinity of base stations must be clearly marked with approved signs. The report did not support the idea of site sharing for base stations, as proposed by IEGMP, as this was considered to lead to a more heterogeneous exposure of the population.

The report further recommended that the European Commission's July 1999 recommendations should be applied into French legislation. More extensive information should be made available to the public, with regard to emissions from both mobile phones and base stations, and about the potential interference with implanted medical devices. As part of the latter, an extensive, long-term measurement campaign of emissions from base stations should be instigated. In addition, there should be stricter laws on mobile phone use whilst driving. Lastly, it was recommended that the scientific data should be regularly reviewed and updated by an ad hoc scientific body recognised by the EU in order to examine whether existing exposure guidelines and legislation required modification.

270 pages; 942 references

3.9 Health Council of the Netherlands (HCN, 2002)

This is another report from the HCN Electromagnetic Fields Committee. It considers the health effects associated with mobile phones, and complements the HCN (2000) report on base stations.

The report begins with a description of the principals for setting human exposure limits to RF fields, and with the basic technology behind mobile telephony. It reviews the evidence for biological and health effects from exposure to RF fields, highlighting effects on the head, with emphasis on local heating. Finally the report considers the effects of interference from mobile phones on medical equipment, and the impact mobile phone usage has on driving.

After reviewing the relevant literature, the report concludes that no conclusions can be drawn concerning a causal link between mobile phone usage and general health problems and symptoms: the studies are not sufficiently robust. The report concludes that exposure to RF fields from a mobile phone may have very subtle effects on brain function, and affect the performance of some cognitive tasks, and perhaps influence brain activity. Nevertheless, it was considered that these only represent acute biological effects and do not herald health effects. For cancer, the report concluded that epidemiological studies did not suggest a correlation between mobile phone use and the occurrence of brain tumours and other forms of cancer: this was supported by the results of animal studies. No convincing evidence could be found that RF fields had any significant effect on the cardiovascular system, on melatonin and other hormones, or on immune system. However, potential interference effects from mobile (and cordless) phones were noted on some common medical devices: maintaining a minimum separation of 1.5 m was recommended. Finally, driving while using a phone equipped with hands-free kit (HFK) was concluded to (still) produce a detrimental impact on attention, which would increase the likelihood of having an accident.

A number of recommendations were made based on these conclusions. The report recommends that further dosimetry work be undertaken to model the temperature rises in the head caused by the use of mobile phone, and this be linked to studies measuring temperature. Further work was also recommended on exploring subtle cognitive and behavioural changes in humans and animals exposed to RF fields, and more epidemiological studies and research with laboratory animals was recommended to investigate the effects on cancer. However after considering the differences between children and adults, the report found no reason to recommend that that children should restrict their use of mobile phones. The final recommendations were made to the Dutch government: they should take steps to decrease the likelihood that normal use of mobile phones could cause interference problems arise with medical equipment; and they should discourage all drivers of motor vehicles from making long or demanding phone calls, even if they are using a HFK.

96 pages, 134 references

3.10 French Senate Report (Lorraine and Raoul, 2002)

The report was prepared by two members of the French Senate, M. Jean-Lois Lorraine and M. Daniel Raoul, with the assistance of a steering committee comprising of three French scientists and two representatives from the mobile phone industry. Fifty two scientists and industry representatives, mainly from France, but including some from Italy and from NRPB, were also interviewed.

The report summarises mobile phone technology, dosimetry, and typical public exposures from mobile phones and base stations. Developing technologies and their potential consequences are covered. Current European and French legislation and their underlying principles are also discussed.

The biological effects of RF fields are reviewed, with discussion of the effects on cancer, reproduction and development, and on the nervous system. Effects on the cardiovascular, immune and endocrine systems are also considered as are subjective symptoms, and heat shock proteins. The importance of distinguishing between biological effects and adverse health effects, and between thermal and non-thermal effects is emphasised.

The report concludes that biological effects of mobile phones have been observed in some studies, but the consequences to health are unknown. No biological or health effects can be attributed to the fields associated with base stations. The report highlights a paradoxical situation that is considered particularly French: whilst there is no evidence to support any risk from base stations, these have generated an extremely high level of public concern; mobile phones, on the other hand may produce quite substantial exposures, but have generated relatively little concern.

The report notes that whilst their conclusions and recommendations do take account of the precautionary principle as defined by the European Commission, they also focus on improved communication and education by providing information to the public and local councils. Recommendations are made for the support of biological, epidemiological and dosimetric research. Priority areas include epidemiological studies of mobile phone users and studies with developing technologies.

The report recommended that a new Foundation should be set up under the Institute of France to be responsible for the direction of scientific research on the health effects of mobile phones. The Foundation would be funded jointly by government and industry. It is also proposed that two existing French national bodies (l'Agence Nationale des Frequences and le Bureau National de Métrologie) should work in closer co-operation.

292 pages, 0 references

3.11 Swedish Radiation Protection Authority (SSI, 2002)

This report was commissioned by the Swedish Radiation Protection Authority (Statens strålskyddsinstitut, SSI). It was written by two epidemiologists, J D Boice Jr. and J K McLaughlin (2002) from the International Epidemiology Institute, USA. It reviews the epidemiological studies dealing with cancer risks in relation to the use of mobile phones.

The report considers each study in some depth: comments are provided on the design of each study, their results, strengths and weakness, and a critique of the results. The report also includes a brief overview of experimental studies and a summary of ongoing epidemiological research.

After reviewing the evidence, the report considers that no significant associations have been seen between all brain tumours combined and phone use with relative estimates of relative risk ranging from 0.9 to 1.3. Further, subgroup analyses of different type of phone (analogue or digital) tumour histologies (gliomas, meningiomas or acoustic neuromas), durations of use, and tumour laterality showed no consistent pattern of increased risk. One series of papers from Sweden which suggested associations between analogue phone use and brain tumours was criticised for having serious methodological weaknesses with evidence of selection, responses and interviewer bias. In addition, it was considered that it was not biologically plausible that exposure to RF fields could increase the risk of cancer either through initiation or promotional events. The report concludes that the studies so far conducted have ruled out with a reasonable degree of certainty that mobile phone use causes cancer, at least for durations up to 5 years. Although longer term effects have not been evaluated, no well-founded clues have arisen to suggest long-term effects exist.

The report considered it prudent to conduct further studies to evaluate the potential impact on health of mobile phone use. The immediate impact from increased car accidents associated with the distractions of using a mobile phone while driving was acknowledged.

40 pages, 81 references

3.12 Advisory Group on Non-ionising Radiation (AGNIR, 2003)

The report was the response to a specific recommendation of the Stewart Report that the issue of health effects from mobile phone technology should be further reviewed by 2003. Thus emphasis was placed on examining new evidence published since 2000. It was written by a committee of eight UK scientists initially chaired by Sir Richard Doll (ICRF, Oxford) and then by A J Swerdlow (ICR, London).

Following a detailed review of the sources and exposures from RF fields, the experimental evidence for biological effects on cells, animals and humans is

critically reviewed, with emphasis on carcinogenic and neurocognitive endpoints. Finally the results of studies investigating cancer and non-cancer epidemiology and relevant clinical research are summarised and reviewed.

The report concludes that overall the evidence for RF field effects on cognitive functions in humans is inconsistent and remains inconclusive, while the suggestions of effects on calcium efflux have not been supported by more recent better-conducted studies. The biological evidence suggests that RF fields do not cause mutation or initiate or promote tumour formation, and the epidemiological data overall do not suggest causal associations between exposures to RF fields, in particular from mobile phone use, and the risk of cancer. It further concludes that exposure levels for those living near to mobile phone base stations are extremely low and the evidence indicates that they are unlikely to pose a risk to health. The paucity of RF studies with children was noted. The report concluded “in aggregate the research published since the Stewart Report does not give cause for concern”. However, limitations in the existing database suggest continued research is needed.

Detailed recommendations for further research were made for each area covered by the review. For cellular studies, the lack of a model that demonstrated a robust response to RF exposure was an impediment to progress as was a lack of independent replication of reported positive effects. However, RF-induced changes in heat shock protein in cells were considered promising for further research.

For animal studies, models with targeted gene mutations that predispose the animals to brain tumours were thought potentially useful to explore carcinogenic effects. Uncertainties regarding the time course of the increased susceptibility of the central nervous system to the effects of heat during postnatal development should be addressed. In addition, it was recommended that potential RF effects on neurotransmitter function should be investigated further and changes in excitability of hippocampal slices *in vitro* require independent verification.

For human experimental studies, more research was recommended to investigate what impact, if any, the reported changes in brain activity after RF field exposure have on cognitive performance, and the health outcomes should be identified that may be associated with these changes. International co-operation to allow a multicentre approach was also encouraged. Trials on individuals who claim to be sensitive to RF fields and suffer acute symptoms would be helpful.

Regarding cancer epidemiology, national and international studies already in progress mean that there is no need to inaugurate further general population case-control studies in relation to mobile phone use. Future studies were recommended to avoid shortcomings of studies published to date, to lengthen the study period, and to make more precise estimates of exposure. Consideration was given as to how best to undertake further occupational and residential studies.

177 pages; 367 references

3.13 Swiss Bundesamt für Umwelt, Wald und Landschaft (BUWAL, 2003)

This report from Switzerland was written by M Rösli and R Rapp of the Institut für Sozial- und Präventivmedizin der Universität Basel. It assessed the risk to health from exposure to RF fields at environmental levels. Only a summary is available in English.

Over 200 scientific papers dealing with the effects of RF fields were surveyed, and reported RF effects were assessed according to a five point scale (established, probable, possible, improbable, or not assessable) and their relevance to health classified into three groups (serious, reduced well-being, or not assessable). Where possible, the thresholds for effects were determined.

Interference effects on implanted medical devices, and the microwave hearing phenomenon in pulsed fields were identified as being established (highly replicable, plausible biological mechanism). Unspecific symptoms, changes in sleep and subtle effects on brain function were considered probable (repeatedly found, no plausible mechanism). The risks of leukaemia and lymphoma from TV and radio transmitters, brain tumours from mobile phone use, and hypersensitivity and insomnia were considered possible (occur sporadically, but could result from study weaknesses). Total mortality and the risks of other cancers were classified as being improbable (multiple indications of absence, no plausible mechanism). Finally, other effects were considered not assessable (scant or contradictory evidence, study methods insufficient). Modulation-specific effects were considered few and contradictory.

The report concluded that there were insufficient data at present to assess the risk to health from low level exposure to RF fields. Some studies suggested the existence of non-thermal effects but their relevance was unclear. Nevertheless, it was concluded that no new health effects had been established below ICNIRP (1998) guideline values, but the effects classified as being probable or possible may occur with exposures to mobile phones (with rates of energy absorption between 20 mW kg⁻¹ and 2 W kg⁻¹) and effects classified as possible may occur with broadcast transmitters. Overall, a continued precautionary approach to RF fields was recommended, with intensified research on human health effects.

167 pages, 207 references

3.14 Health Council of the Netherlands (HCN, 2003)

The Electromagnetic Fields Committee of the HCN has issued a set of recommendations for further research into the health effects of RF fields (HCN 2003). Only an executive summary is available in English. This report has not been summarised in the table.

A range of studies were proposed. For example, it was suggested that *in vitro* studies were necessary to investigate the interaction of RF fields with chemical

and physical agents, although studies with animals were not recommended (since it was considered that sufficient research was being carried out elsewhere). Laboratory and epidemiology studies investigating subjective complaints were recommended, as was a large-scale cohort study investigating field exposure and a variety of health effects, including cancer. Doubts were expressed about the usefulness of investigating the incidence of cancer or other diseases in people living near base stations (but not about radio and TV transmitters). Additional modelling and computational dosimetry studies were proposed to better characterise local exposure in the head from the use of mobile phones.

Finally, it was suggested that a centre of expertise should be established in the Netherlands to consolidate and co-ordinate research concerning the health effects of EMFs.

3 pages, 0 references

3.15 US National Council on Radiation Protection and Measurements (NCRP, 2003)

This commentary was prepared for the US National Council on Radiation Protection and Measurements (NCRP) by Scientific Committee 89-4. This committee comprised seven scientists from the USA chaired by O P Gandhi (University of Utah). The report reviews the scientific literature on the biological interactions and human health effects of pulsed and amplitude-modulated RF fields in the frequency range 3 kHz to 300 GHz. Its objective was to determine whether existing exposure standards and guidelines need to be modified to take modulation into account. Much emphasis is placed on the older literature, and relatively few studies are included which use the fields associated with mobile phones.

Following a discussion of exposure standards, and definitions of the types of modulated signals, the report considers the effects of RF fields on a wide variety of *in vitro* studies (including effects on cell physiology, genotoxicity and DNA damage), behavioural and nervous system studies in animals, volunteer studies, and epidemiological studies. Lastly, biophysical mechanisms through which modulation-dependent effects might arise were considered.

The report concludes that apart from studies that allow a comparison of effects of continuous wave versus pulsed wave exposure, the literature relevant to modulation is very scattered. Several, but not all, studies suggest some modulation-specific effects may occur, with pulsed fields generally more effective than continuous wave fields, but none of these studies provided evidence of sufficient quality to recommend modifications to existing standards. In addition, most of the studies that report modulation-specific effects involve very high exposure levels, well above guideline values. Foster and Repacholi (2004) reached similar conclusions regarding the ability of different signal modulations to cause specific biological effects.

Overall, the report concluded that heating remains the only mechanism whereby low level RF fields, modulated or not, could produce observable effects, although intense RF pulses may produce biological effects through a mechanism related to the rate of heating. These particular effects were considered to warrant closer examination although they may only occur under unrealistic exposure conditions from specialised military equipment.

52 pages; 152 references

3.16 Swedish Radiation Protection Authority (SSI, 2003)

This is the first annual report from the SSI Independent Expert Group on Electromagnetic Fields*. It considers research available in 2000 and onwards on mobile telephony and cancer. It was written by an team of eight European scientists chaired by A Ahlbom (Karolinska Institutet, Stockholm).

The report describes epidemiological studies on cancer and exposure from mobile phones and base stations (and radio and TV transmitters), as well as experimental cancer research. In addition, laboratory studies investigating specific effects on HSPs and the BBB are considered. Finally, a brief treatment of a precautionary framework for dealing with the uncertainty in the scientific evidence is included.

It was reported that the majority of studies have found no indication of increased risk of cancer with phone use, although some positive findings have been reported in two studies. But since limitations were considered to exist in all studies because of small numbers of cases or very short follow-up periods, the current evidence was considered to be inconclusive regarding mobile phone use. Research into exposures from base stations and cancer was also considered to be at a very early stage of development, and the existing data concerning radio and TV transmitters are subject to many limitations (especially regarding personal exposure assessment) to draw any conclusions.

Results of recent animal studies did not suggest that exposure to RF fields could induce cancer or enhance the effects of known carcinogens. It was concluded that there was no consistent evidence for effects relevant to non-genotoxic mechanisms of carcinogenesis such as cell proliferation or apoptosis, or for the induction or enhancement of neoplastic transformation *in vitro*. Regarding possible RF effects on the expression of HSPs, it was concluded that it was not possible to make conclusions about the existence and the mechanism for such effects at present. Similarly, regarding RF effects on the BBB, it was concluded that the available data did not indicate the existence of a health risk. The precautionary framework being developed by WHO was endorsed as it would

* The second annual report was published in December 2004 (SSI, 2004).

allow the development of reasonable policies when taking uncertainties into account.

The report concluded that despite much research effort, no breakthrough results had emerged in recent years that allowed firm conclusions to be drawn about the carcinogenic potential of RF fields and possible effects on HSPs and the BBB. The overall scientific assessment had not changed markedly since the Stewart Report was published and the conclusions that were formulated at that time were considered to remain valid.

The report made a strong recommendation for the development of a personal RF meter that can be used in large-scale epidemiological research. With such a meter available, it was considered that studies of exposures from base stations and transmitters might become a high priority research area. In addition, epidemiological research on the effects of long-term exposure as well as investigation of diseases other than cancer were recommended. Since it was considered that expression of HSP might be used a marker of RF exposure, further studies on HSPs were recommended, as was work on the RF effects on the BBB. It was suggested that, given the complexity of the research area, replication of both negative and positive data was recommended before results should be accepted as part of a health risk assessment.

28 pages; 66 references

3.17 Health Council of the Netherlands (HCN, 2004a)

In addition to issuing advisory reports on possible health effects associated with EMFs, the Electromagnetic Fields Committee of the HCN also publishes annual updates on EMF health effects to enable topical issues to be considered and recent reports from HCN to be highlighted.

The second annual update (HCN, 2004a) covered the period from May 2001 until May 2003. This summarised the mobile phone report (HCN 2002, see the table) and considered developments in the area of (low frequency and) RF fields. It was concluded that no potential adverse effects could be identified from the introduction of new telecommunication systems, such as UMTS (or 3G) and TETRA. The results of recent animal carcinogenesis studies and human epidemiological studies did not give cause for concern. Similarly, it was also concluded that effects of RF fields on the BBB have not been established, nor has an association between mobile phone use and the incidence of melanoma of the eye been shown to exist. The report also discusses non-specific symptoms arising from exposure to EMFs, concluding that no causal relationship has been shown to exist.

57 pages, 76 references

3.18 Health Council of the Netherlands (HCN, 2004b)

This report comes from the Electromagnetic Fields Committee of the HCN. It considers the scientific quality, design and execution of a study from the Netherlands Organisation for Applied Scientific Research (TNO) on the effects of GSM and UMTS signals on well-being and cognition.

The original TNO report (Zwamborn et al, 2003) described a double-blind study which explored the effects of exposure to GSM and UMTS signals on self-reported well-being and cognitive function. Using a questionnaire to measure well-being, small, but significant, field-dependent effects with UMTS signals were seen in a group of subjects who had previously reported complaints attributed to GSM fields and in a control group who had not reported any complaints. No effects were seen using GSM signals at either 900 or 1800 MHz. At the same time, a rather diffuse and inconsistent pattern of field-dependent effects on a range of different cognitive tasks were observed following exposure to GSM and UMTS fields. Explanations based on heating effects seem unlikely, due to the small amounts of power absorbed by the tissues in the head.

The HCN report found the TNO study to be of good quality but the interpretation of some of the results was questioned. In particular, the validity of the questionnaire used to measure well being was unclear, such that it could not be concluded that a change in score reflected an actual change in well being. The effects on well-being were also found after about a 30-minute exposure period to UMTS signals at levels that would not normally be experienced by members of the public. Moreover, the results of the cognitive tests only produced a single significance difference when corrected for multiple comparisons, and the implications of this result are unclear. There were also differences between the groups of subjects which makes comparison between them inadvisable. Nevertheless, the study was considered sufficiently important that it was recommended for independent replication using improved designs, including larger numbers of well-matched groups of subjects.

Overall, it was concluded that it was not possible, on the basis of the results of this study, to determine the existence of a causal relationship between exposure to EMFs and decreased well-being. A similar interpretation of the study was reached by AGNIR (2003).

55 pages, 24 references

3.19 International Commission on non-Ionizing Radiation Protection (ICNIRP, 2004)

This report comes from the ICNIRP Standing Committee on Epidemiology. It was written by an international group of six epidemiologists chaired by A Ahlbom (Karolinska Institutet, Stockholm). The reports covers the epidemiological evidence relating to possible adverse health effects from long-term exposure to RF fields between 100 kHz and 300 GHz.

First, the report briefly describes the sources and distribution of exposure in the population, as well as outlining problems associated with exposure assessment in epidemiological studies. The report reviews the risks of cancer, cardiovascular disease, adverse outcomes of pregnancy, and cataract formation associated with RF field exposure at work. It then reviews the risk of leukaemia to populations who live close to RF transmitters used in broadcasting and telecommunications, and the risks of brain cancer and acoustic neuromas from mobile phone use. Indirect effects of RF fields - for example, on pacemaker function or on driving performance - are not considered.

The report concludes that the research performed to date, including studies of mobile phone users, give no consistent or convincing evidence of a causal relationship between RF field exposure and any adverse health effect. However, it was further concluded that these studies have too many deficiencies to rule out an association. The quality of RF field assessment was considered to be a key concern. Another general concern in mobile phone studies was that the lag periods that have been examined to date are necessarily short, and no data are available on childhood exposure. The report also concluded that little was known about population exposure from RF sources and less was known about the relative importance of different sources.

Overall, further epidemiological research with mobile phones was recommended to address the potential effects of long-term exposure, including that of children, and to examine health effects not currently under investigation, such as neurodegenerative diseases and cognitive function. The need for a personal field meter to monitor individual exposure in these studies was highlighted.

62 pages, 92 references

3.20 Institution of Electrical Engineers (IEE, 2004)

This report is from the Institution of Electrical Engineers (IEE) Biological Effects Policy Advisory Group. It considers the biological effects and health risks associated with exposure to low frequency and RF fields. It was written by a group of six UK scientists, chaired by A T Barker (University of Sheffield). Similar reports have been published every two years since 1994.

The report broadly summarises the findings of the epidemiology and laboratory studies that have been published in the peer-reviewed literature during the previous two years (amounting to 121 papers for RF fields). It also considers the conclusions of recent reviews by scientific bodies on this literature.

The 2004 report concludes that the research published during the previous two years does not suggest harmful effects exist from exposure to low level RF fields. In particular, the report notes that results from seven epidemiological studies fail to provide convincing evidence to suggest that the use of mobile phones increases the risk of brain cancer and acoustic neuromas in adults. More generally, none of the epidemiological studies of occupational exposure to RF

fields from various sources that has been published over a span of many years have been able to satisfactorily deal with dosimetry issues. It was concluded that none of these studies was readily interpretable and, although some suggest risks, they were low and generally not repeatable. Studies on residential proximity to radio antennas and the risk of cancer were considered generally weak and to have methodological deficiencies. Results of recent laboratory studies also made the possibility of adverse health effects following acute exposure seem less likely. For example, it was considered that studies with volunteers or animals failed to demonstrate any clear pattern of field-induced biological responses, and inconsistencies existed within the studies reporting positive results. In addition, doubts remained about the validity of most claimed effects of EMF exposure at the cellular level as there was a poor record of reproducibility of findings; the results did not appear to form part of any pattern in terms of exposure or biological response; and there was no known mechanism of action. Finally, it was concluded that no plausible mechanism had emerged by which RF fields could have biological effects at levels below those that cause heating. It was noted that free radical reactions continue to be investigated, but experimental evidence to support this mechanism in biological systems has yet to be found.

The IEE report recommends that further epidemiological and experimental research should be supported, if only to address public concern rather than a likelihood that harmful effects exist. It notes that the projects funded by the UK MTHR Programme go some way to addressing this need. The report suggests that the continuing absence of any new and robust evidence of harmful effects in the past two years should be reassuring, and this fact should be taken into account by policy makers both when considering the implementation of a precautionary approach to public exposure and also during the development of exposure standards.

8 pages, 6 references

3.21 Medicines and Healthcare Products Regulatory Agency (MHRA, 2004)

This report from the UK Medicines and Healthcare products Regulatory Agency (MHRA) is concerned only with the use of mobile communications systems, including mobile phones, in hospitals. It proposes that some restrictions are necessary to minimise the risk of electromagnetic interference with critical medical equipment, and reinforces existing MHRA guidance that a total ban on mobile phones in hospitals is not necessary. Indeed, it concludes that overly restrictive policies may act as obstacles to beneficial technology, although unmanaged use of mobile phones could place patients at risk.

The report lists analogue emergency service radios and private business radios as having a high risk of causing interference, and these should only be used in an emergency and never for routine communication in a hospital. Mobile phones,

TETRA handsets, laptop computers, palmtops and gaming devices fitted with data transfer radio systems (General Packet Radio System (GPRS) or 3G), as well as high performance radio local area networks (HIPERLANs), were assessed to have a medium risk of causing interference, and these should be only used in designated areas and be switched off near critical care or life-support equipment. Cordless phones (including digital enhanced cordless telephones, DECT) radio local area networks (RLANs) and Bluetooth were considered very unlikely to cause interference and need not be restricted.

The report recommends measures that hospitals should introduce to balance the risks of mobile phones interfering with critical devices and the desire for better communication. For example, hospitals should identify staff to manage how mobile technology is used within the hospital and to identify interference risks. Hospitals should also consider designating areas where staff and visitors can use mobile phones safely. Particular mobile wireless systems that have a low interference risk with medical equipment could be issued to doctors and other hospital staff and comprehensively managed. Lastly, the report recommends that any interference problems should be reported to MHRA.

3 pages, 4 references/links

3.22 National Radiological Protection Board (NRPB, 2004)

This report from NRPB reviews the scientific evidence for limiting human exposure to electromagnetic fields (EMFs) from static electric and magnetic fields, low frequency EMFs and RF fields (from 0 to 300 GHz). It was prepared by a committee of nine UK scientists chaired by A F McKinlay, at the request of the UK Department of Health. Its primary purpose was to provide the scientific basis of NRPB advice on quantitative restrictions on exposure. It also examined the issues of uncertainty in the science, aspects of precaution, and explored recent evidence on the possibility of variations in sensitivity between different groups in the population.

To formulate this advice, the views were taken of individuals in the UK, international scientific experts, and from published material including comprehensive reviews by expert groups. Advice was also taken from an *ad hoc* expert group, chaired by C Blakemore (University of Oxford), on the effects of weak ELF electric fields in the body. In addition, consideration was given to the views expressed in response to a draft version of the report (issued for consultation in May 2003) and to the concerns of the public about health raised at an open meeting on power lines (held in December 2002) and at the meetings held around the country by IEGMP.

The epidemiological evidence that exposure to RF fields might have an adverse effect on the health of people is examined in the report, with emphasis on the risk of brain cancer from the use of mobile phone handsets. Next, the effects of whole-body and localised heating on people and the physiological responses to

thermal stress are reviewed, and possible biological effects of RF fields in the absence of overt heating are considered for humans, animals and cells. Finally, methods used in computational dosimetry are described and results of such techniques reviewed. Limitations and uncertainties in the literature are highlighted for each of these topics.

The report concluded that, for RF fields, the most plausible and coherent set of data from which guidance can be developed concerns raised temperatures and the physiological stress induced by increased heat loads. All other studies that were reviewed were considered to lack plausibility, coherence and consistency. However, the need was identified for key uncertainties in these data to be addressed through further research. In particular, the distribution of increased sensitivity to the effects of heat in members of the population was not considered to be well defined at present.

In line with the AGNIR (2003) report, it was concluded that, overall, the recent research does not give cause for concern, and that the weight of evidence does not suggest that there are adverse health effects from exposures to RF fields below guideline levels. Limitations of the published research were noted, however, as was the fact that mobile phones had only been in widespread use for a relatively short time. Therefore it was considered that the possibility remained open that there could be health effects from exposure to RF fields below guideline levels, and hence continued research was needed. The report noted that there was a great deal of ongoing scientific research on mobile phones and health, and indicated the need to monitor the results of this research and to keep the guidelines under review.

Overall, the major recommendation of the NRPB report was the adoption of the ICNIRP exposure guidelines for occupational and general public exposure between 0 and 300 GHz (ICNIRP, 1998) Exposure to fields below these guidelines was not considered to be harmful.

215 pages, 1002 references

3.23 Nordic Authorities (2004)

This was a statement expressing a common view on mobile phones and health from six intuitions with responsibility for radiological protection in the Nordic countries. The institutions were the Danish National Board of Health (Sundhedsstyrelsen), the Radiation and Nuclear Safety Authority of Finland (Säteilyturvakeskus), the Icelandic Radiation Protection Institute (Geislavarnir Ríkisins), the Norwegian Radiation Protection Authority (Sataens strålevern) and the Swedish Radiation Protection Authority (Statens strålskyddsinstitut). This statement has not been included in the table.

It was concluded that there was no scientific evidence for any adverse health effects from mobile telecommunications systems, either from mobile phones or their base stations, below the basic restrictions and reference values

recommended by ICNIRP (1998). However, more research was justified since some gaps in knowledge were considered to exist and some published studies suggested biological effects may occur at levels below guidelines values. The paucity of data precluded any judgement regarding the comparative sensitivity of children to RF fields.

Overall, the gaps in knowledge and prevailing scientific uncertainty were considered sufficient to justify a precautionary attitude regarding the use of mobile phones, and the use of hands-free kits that reduced exposures to the head was considered prudent for adults, young people and children. It was also considered important that parents should inform their children about the different ways to reduce exposure from mobile phones.

2 pages, 0 references

3.24 World Health Organization (WHO, 2004)

A two-day international workshop was held in Istanbul in June 2004 to address the potentially greater sensitivity of children to EMF exposure. Co-sponsors included ICNIRP and the European Commission (through EMF-NET and COST 281).

In summary, there were clear biological and dosimetric differences between children and adults, but no good evidence indicating that children were susceptible to levels of RF fields below ICNIRP guidance values. However, it was appreciated that little research had specifically addressed the potential vulnerability of children to RF fields, and that individual countries might wish to address this resulting uncertainty through policy options incorporating some degree of precaution.

A set of research proposals was drafted aimed at overcoming this lack of knowledge. The epidemiological proposals given high priority included a prospective cohort study of childhood mobile phone users and cognitive and general health effects, and an exploration of the feasibility of a case-control study of brain cancers amongst children who use mobile phones. Research of cognitive effects and other endpoints in volunteer studies were addressed, although it was acknowledged that there would be clear ethical problems using children as experimental subjects.

Research with appropriate animal models would be able to address some of these issues, although interpretation of the health consequences is less straightforward. One proposal was a study of the impact of RF field exposure on nervous system development of immature animals using behavioural, morphological and molecular techniques. *In vitro* studies of effects on nerve cell growth, along with further exploration of possible non-thermal interaction mechanisms, were also recommended. Finally, recommendations concerning further dosimetric studies included the development of dosimetric models of RF

energy deposition in children and fetuses, combined with appropriate models of thermoregulatory responses in children.

Publication of the workshop proceedings and separate papers summarising the presentations and discussions at the workshop is underway. The workshop agenda, rapporteur report and individual presentations are available at http://www.who.int/peh-emf/meetings/children_turkey_june2004/en/.

4 ACKNOWLEDGEMENTS

This has been enlarged from material originally published in *Mobile Phones and Health* (2004), *Doc NRPB* 15(5),1-114. Available at <http://www.nrpb.org>. The assistance of Marisa Priestner in preparing the table is gratefully acknowledged.

5 REFERENCES

- Actes de colloque (2001). Mobile phones - Biological Effects. Academy of Sciences/CADAS/National Academy of Medicine. Paris, TEC & DOC.
- AFSSE (2003a) Téléphonie mobile et santé. Report by J-M Aran, J-C Bolomey, P Buser, R de Seze, M Hours, I Lagroye and B Veyret, March 2003. L'Agence Française de Sécurité Sanitaire Environnementale 21. Available at <http://www.afsse.fr>.
- AFSSE (2003b) AFSSE Statement on Mobile Phones and Health. Available at <http://www.afsse.fr/documents/Afsse.statement.on.mobile.phones.and.health.pdf>.
- AGNIR (2001). Possible Health Effects from Terrestrial Trunked Radio (TETRA). Report of an Advisory Group on Non-ionising Radiation. *Doc NRPB*, 12(2) 1-86. Available at http://www.nrpb.org/publications/documents_of_nrpb/abstracts/absd12-2.htm.
- AGNIR (2003). Health Effects from Radiofrequency Electromagnetic Fields. Report of an independent Advisory Group on Non-ionising Radiation. *Doc NRPB*, 14(2). 1-177. Available at http://www.nrpb.org/publications/documents_of_nrpb/abstracts/absd12-4.htm.
- ART (2002). Télécommunications et santé. Report by R De Seze, G Vastel, B Veyret and I Lagroye, November 2002. L'Institut National de l'Environnement Industriel et des Risques (INERIS) for l'Autorité Régulation des Télécommunications. Available at <http://www.art-telecom.fr/publications/etudes/tel-sante-nov02.htm>.
- BMA (2001). Mobile phones and health: an interim report. A publication from the British Medical Association Science Department and the Board of Science and Education. ISBN 0 7279 1647 5.
- BMA (2004). Mobile phones and health: an update, June 2004 Available at <http://www.bma.org.uk/ap.nsf/Content/mobphonupd>.
- Boice JD and McLaughlin JK (2002). Epidemiologic Studies of Cellular Telephones and Cancer Risk – A Review. SSI Report 2002:16. Stockholm, Statens strålskyddsinstitut. Available at http://www.ssi.se/english/Press_release_rapp2001_16.html.

- BUWAL (2003). Hochfrequente Strahlung und Gesundheit. BUWAL Umwelt-Materialien Nr. 162. Bern, Bundesamt für Umwelt, Wald und Landschaft, . Available at <http://www.umwelt-schweiz.ch/imperia/md/content/luft/nis/gesundheit/UM-162-D.pdf>.
- CSTEE (2001). Opinion on possible effects of electromagnetic fields (EMFs), radio frequency fields (RF) and microwave radiation on human health. Expressed at the 27th CSTEE plenary meeting, Brussels, 30 October 2001. Brussels, C2/JCD/csteeop/EMF/RFF30102001/D(01), Scientific Committee on Toxicology, Ecotoxicology and the Environment.
- Foster KR and Repacholi MH (2004). Biological effects of radiofrequency fields: does modulation matter? *Radiat Res*, **162**, 219-225.
- GAO (2001). Telecommunications: Research and Regulatory Efforts on Mobile Phone Health Issues. Report to Congressional Requesters. GAO-01-545. Washington DC, United States General Accounting Office. Available at <http://www.gao.gov/new.items/d01545.pdf>.
- Hardell L, Hallquist A, Mild KH, Carlberg M, Pahlson A and Lilja A (2002a). Cellular and cordless telephones and the risk for brain tumours. *Eur J Cancer Prev*, **11**, 377-86.
- Hardell L, Mild KH and Carlberg M (2002b). Case-control study on the use of cellular and cordless phones and the risk for malignant brain tumours. *Int J Radiat Biol*, **78**, 931-6.
- Hardell L, Mild KH and Carlberg M (2003). Further aspects on cellular and cordless telephones and brain tumours. *Int J Oncol*, **22**, 399-407.
- Hardell L, Mild KH, Carlberg M and Hallquist A (2004). Cellular and cordless telephones and the association with brain tumors in different age groups. *Arch Environ Health* (in press).
- HCN (1997). Radiofrequency Radiation Committee. Radiofrequency Electromagnetic Fields (300 Hz –300 GHz). Publication Number 1997/01. Rijswijk, Health Council of the Netherlands.
- HCN (2000). GSM Base stations. Publication Number 2000/16E. The Hague, Health Council of the Netherlands.
- HCN (2001). Electromagnetic Fields Committee. Electromagnetic Fields: Annual Update 2001. Publication Number 2001/14. The Hague, Health Council of the Netherlands.
- HCN (2002). Mobile telephones: an evaluation of health effects. Publication Number 2002/01E. The Hague, Health Council of the Netherlands.
- HCN (2003). Health effects of exposure to radiofrequency electromagnetic fields: Recommendations for research. Publication Number 2003/03. The Hague, Health Council of the Netherlands, 2003 (in Dutch). Executive summary in English available at www.healthcouncil.nl
- HCN (2004a). Electromagnetic Fields: Annual Update 2003. Publication Number 2004/1. The Hague, Health Council of the Netherlands.
- HCN (2004b). TNO study on the effects of GSM and UMTS signals on well-being and cognition. Publication Number 2004/13E. The Hague, Health Council of the Netherlands.
- ICNIRP (1998). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). *Health Physics*, **74**, 494-522.
- ICNIRP (2004). Standing Committee on Epidemiology: A Ahlbom, A Green, L Kheifets, D Savitz and A Swerdlow. Epidemiology of Health Effects of Radiofrequency Exposure. *Environ Health Perspect*, **121**, 1741-54. Available at <http://dx.doi.org>

- IEE (2004). The Possible Harmful Biological Effects of Low-level Electromagnetic Fields of Frequencies up to 300 GHz. IEE Position Statement, May 2004. London, Institution of Electrical Engineers Available at <http://www.iee.org/Policy/Areas/BioEffects/POSTAT02final.pdf>.
- IEGMP (2000). Mobile Phones and Health. Report of an Independent Expert Group on Mobile Phones (Chairman : Sir William Stewart). Chilton, NRPB. Available at <http://www.iegmp.org.uk/report/index.htm>
- Krewski D, Byus CV, Glickman BW, Lotz W G, Mandeville R, McBride ML, Prato FS and Weaver DF (2001a). Potential health risks of radiofrequency fields from wireless telecommunication devices. *J Toxicol Environ Health B Crit Rev*, **4**, 1-143.
- Krewski D, Byus CV, Glickman BW, Lotz WG, Mandeville R, McBride ML, Prato FS and Weaver DF (2001b). Recent advances in research on radiofrequency fields and health. *J Toxicol Environ Health B Crit Rev*, **4**, 145-59.
- Lönn S, Ahlbom A, Hall P and Feychting M (2004). Mobile phone use and the risk of acoustic neuroma. *Epidemiology*, **15**, 653-9.
- Lorraine J-L and Raoul D (2002). Rapport sur l'incidence éventuelle de la téléphonie mobile sur la santé. Paris, Office parlementaire d'évaluation des choix scientifiques et technologiques. Assemblée Nationale No 346: Sénat No 52.
- MHRA (2004). Mobile Communication Systems. Medicines and Healthcare products Regulatory Agency. Available at <http://devices.mhra.gov.uk>.
- Nordic Authorities (2004). Mobile Telephony and Health - A common approach for the Nordic competent authorities. Available at http://www.ssi.se/english/english_news.html.
- NCRP (2003). Biological Effects of Modulated Radiofrequency Fields. NCRP Commentary No 18. Bethesda, Maryland, National Council on Radiation Protection and Measurements.
- NRPB (2004). Review of the Scientific Evidence for Limiting Exposure to Electromagnetic Fields (0-300 GHz). *Doc NRPB*, **15** (3), 1-215. Available at http://www.nrpb.org/publications/documents_of_nrpb/abstracts/absd15-3.htm.
- SSI (2003). Recent Research on Mobile Telephony and Cancer and Other Selected Biological Effects: First Annual Report from SSI's Independent Expert Group on Electromagnetic Fields. Available at http://www.ssi.se/english/EMF_exp_Eng_2003.pdf.
- SSI (2004). Recent Research on Mobile Telephony and Health Risks: Second Annual Report from SSI's Independent Expert Group on Electromagnetic Fields. Available at http://www.ssi.se/english/EMF_exp_Eng_2004.pdf
- VERUM Foundation (2004). REFLEX: Risk Evaluation of Potential Environmental Hazards from Low Energy Electromagnetic Field Exposure Using Sensitive in vitro Methods. Available at <http://www.iaea.or.at/http://www.verum-foundation.de/>
- WHO (2004). Sensitivity of Children to Electromagnetic Fields. Workshop held in June 2004, Istanbul, Turkey. The agenda, rapporteur report and presentations are available at http://www.who.int/peh-emf/meetings/children_turkey_june2004/en/.
- Zmirou Report (2001). Mobile Phones, their Base Stations, and Health. Report to the French Health Directorate, Chairman, Denis Zmirou. France, Direction Générale de la Santé. Available from <http://www.sante.gouv.fr>. Summary in English available at http://www.sante.gouv.fr/hm/dossiers/telephon_mobil/pdf/teleph_uk.doc.
- Zwamborn A P M, Vossen S H J A, van Leersum B J A M, Ouwens M A and Makel W N (2003). Effects of Global Communication System Radio-frequency Fields on Well Being and Cognitive Functions of Human Subjects with and without Subjective Complaints. The Hague, Netherlands Organisation for Applied Scientific Research (TNO). FEL-03-C148.

Summary of Major Reports on Mobile Phones and Health published since 2000

Reference	Frequency range	Summary of conclusions	Summary of recommendations
HCN (2000)	900 MHz and 1800 MHz (base stations)	No good evidence of health risks from base stations Field strength near base stations very small Possible interference with implanted medical devices No change to existing guidelines	Restrict access to base stations Resident participation in base station siting decisions Possibility of noise/vibrations to be considered
AGNIR (2001)	400 MHz (TETRA)	Hazard to health from TETRA signals is unlikely Studies on calcium efflux contradictory Further research necessary	Keep TETRA usage records Include TETRA base stations in the ongoing base station audit Carry out exposure assessments for hand portables
BMA (2001, 2004)	450 MHz – 2 GHz	No adverse health effects Supports precautionary approach Further research necessary	Research on 3G and any risks of texting Use of “quiet zones” BSI kitemark for HFKs and shields Information on power outputs of phones Signs in hospitals to switch off phones Avoid all phone use while driving
CSTEE (2001)	1 kHz – 300 GHz	No evidence that RF fields are carcinogenic Possibility of effects on blood pressure and on subjective symptoms	Further epidemiology studies necessary Investigation of synergistic effects of RF fields with carcinogens
GAO (2001)	Mobile phones	No adverse health effects observed Findings of some studies suggest further research needed Clear, accurate and timely public information necessary	Adopt standard SAR testing methods Publish SAR data on internet Improve public information on health issues
Krewski (2001a, 2001b)		Non thermal levels may produce biological effects, but not suggestive of causing adverse health effects Limitations with epidemiology studies Existing exposure guidelines in Canada adequate to provide protection but exposure guideline for the head/neck to be reviewed for workers exposure guideline for the eyes of workers should be reduced to that of the public	Further experimental studies, including melatonin physiology neurotransmitters transmembrane ion transport Blood-brain barrier function different signal modulations Epidemiological studies of highly exposed workers Clinical studies investigating increased sensitivity

Reference	Frequency range	Summary of conclusions	Summary of recommendations
Zmirou (2001)	400 MHz – 2.2 GHz	<p>Possibility of non-thermal biological effects; relevance to health uncertain</p> <p>Adopt precautionary approach, especially for children</p> <p>Need to regularly review literature</p>	<p>Research on a wide range of endpoints, including</p> <p>benign effects in workers, children and patients</p> <p>hypersensitivity</p> <p>cancer risks from base stations, if possible</p> <p>brain function in healthy adults and children, and in patients</p> <p>cellular responses</p>
HCN (2002)	400 MHz – 2.4 GHz	<p>No adverse health effects</p> <p>Possible subtle biological effects</p> <p>Detrimental effects on driving with hands-free kits</p> <p>Possible interference with common medical devices</p>	<p>Further research on brain function and cancer</p> <p>Model temperature rises in head</p> <p>Children need not restrict use of mobile phones</p> <p>Discourage prolonged use of phones while driving</p>
Lorraine and Raoul (2002)	Mobile phone frequencies	<p>Biological effects possible, but implications for health unknown</p> <p>No effects from fields associated with base stations</p>	<p>Improved public information and communication</p> <p>More research necessary, especially epidemiology of phone uses</p> <p>New Foundation to consolidate study of RF effects in France</p>
SSI (2002)	450 MHz – 2.2 GHz	<p>No increased risk of brain tumours</p> <p>Increases in cancer risk are not biologically plausible</p>	<p>Further research on long-term exposure and cancer</p>
AGNIR (2003)	3 kHz – 300 GHz	<p>Recent published research does not give cause for concern</p> <p>Cognitive effects inconsistent</p> <p>No suggestion of carcinogenic effects</p> <p>Exposure from base stations unlikely to pose a risk to health</p> <p>Paucity of studies with children</p>	<p>Research on:</p> <p>heat shock proteins in cells</p> <p>brain tumours in animals</p> <p>heating on CNS development</p> <p>cognitive effects in humans</p> <p>longer term studies on cancer risks, with improved dosimetry</p> <p>No further research on non-cancer endpoints or on cancer risks from base stations</p>
BUWAL (2003)	100 kHz- 300 GHz	<p>Conclusive health assessment not possible</p> <p>Probable increase in symptoms, and effects on the brain from phones</p> <p>Possible increased risks of brain cancer from phones, and of leukaemia or lymphoma from transmitters; hypersensitivity and insomnia possible</p>	<p>Continued need for precautionary approach</p> <p>More research on human health effects</p>
NCRP (2003)	3 kHz – 300 GHz	<p>Existence of modulation-dependent effects not clearly defined</p> <p>RF effects mediated by heating</p> <p>No change to existing standards necessary</p>	<p>Further research useful, especially on the effects of high intensity RF pulses</p>

Reference	Frequency range	Summary of conclusions	Summary of recommendations
SS1 (2003)	Mobile phones	No increased risk of cancer from mobile phones, no firm conclusions with regard to base stations Experimental studies do not suggest RF is carcinogenic Relevance of possible effects on blood-brain barrier and heat shock proteins unclear	Recent studies do not alter conclusions of IEGMP Personal RF exposure meter needed to further long-term epidemiological studies Replication of all studies essential Endorse precautionary approach
HCN (2004b)	900 and 1800 MHz GSM, 2100 MHz UMTS	TNO study of good quality Relevance of effects on well being questioned Only one significant cognitive change Inherent differences between experimental groups	Independent replication essential with improvements to design Other follow up studies advisable
ICNIRP (2004)	100 kHz-300 GHz	No consistent or convincing evidence for adverse health effect or symptoms But existing (mobile phone) studies have many deficiencies, including uncertain exposure assessment and short lag times No research on children	Better exposure assessment essential - meter needed to monitor personal exposure Future research should include long-term exposure (15 years) and effects on children Wide range of health effects should be considered, including eye diseases, neurodegenerative diseases and cognitive effects
IEE (2004)	<1 – 300 GHz	No adverse health effects; biological effects not consistently demonstrated No plausible mechanism for low level effects	Further research to address public concerns Replication of effects essential
MHRA (2004)	Mobile RF communication systems	Some restrictions on use of mobile phones are necessary near critical care or life-support equipment Total ban in hospitals not necessary	Manage the use of mobile devices in hospitals Report interference problems to MHRA
NRPB (2004)	0 – 300 GHz	No cause for concern No adverse health effects below guideline values, but subtle biological effects possible Further research necessary to address uncertainties	Adopt ICNIRP guidelines in UK Monitor results of ongoing research
WHO (2004)	EMFs	No good evidence that children are susceptible to RF fields below guideline values Little research done on vulnerability of children Precautionary approaches could be adopted	Further epidemiological and experimental work necessary but ethical concerns acknowledged Work with animals <i>in vitro</i> models recommended Relevant dosimetric and thermoregulatory models need to be developed