

**Appendix 4 : Health Effects from Radiofrequency
Electromagnetic Fields: Summary of the Report of an
Independent Advisory Group on Non-ionising Radiation**



Overall summary and conclusions

This report examines possible health effects of exposure to radiofrequency (RF) fields, with an emphasis on studies conducted since the review by the Independent Expert Group on Mobile Phones (IEGMP) in 2000. There are many sources of RF fields – at work, at home, and in the environment – but recent emphasis in health-related studies has been on mobile phones and broadcasting masts. Studies reviewed by IEGMP suggested possible cognitive effects of exposure to RF fields from mobile phones, and possible effects of pulse modulated RF fields on calcium efflux from the nervous system. The overall evidence on cognitive effects 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. Exposure levels from living near to mobile phone base stations are extremely low, and the overall evidence indicates that they are unlikely to pose a risk to health. Little has been published specifically on childhood exposures to RF fields, and no new substantial studies on this have been published since the IEGMP report.

In aggregate the research published since the IEGMP report does not give cause for concern. The weight of evidence now available does not suggest that there are adverse health effects from exposures to RF fields below guideline levels, but the published research on RF exposures and health has limitations, and mobile phones have only been in widespread use for a relatively short time. The possibility therefore remains open that there could be health effects from exposure to RF fields below guideline levels; hence continued research is needed.

Research recommendations

1. The following recommendations are made for further research into possible health effects from exposure to radiofrequency (RF) fields. These should be seen in the context of the substantial programme of ongoing RF health effects research in the UK funded by the Mobile Telecommunications and Health Research (MTHR) Programme and government departments (see Appendix C).

ELECTROMAGNETIC FIELDS, SOURCES AND EXPOSURE

2. Several recommendations can be made to improve the quality and interpretability of future health-related research. The dosimetry in many published studies is unclear, often because no dosimetry measurement was performed in the actual experimental setting. Future experimental research should control the parameters of the RF signal directly, rather than relying upon the normal operation of commercial mobile phone handsets, and should measure the SAR in the actual experimental setting and under the conditions of exposure. Dosimetry will need to be developed in conjunction with any epidemiological study for ensuring sound exposure assessments.

CELLULAR STUDIES

3. There is still a need for a cellular model that has a robust response to RF exposure and that can be transferred between independent laboratories. The Advisory Group is aware of further studies comparing the effects of pulsed with continuous wave signals on cellular calcium ion flux. Whether more studies are required will need to be reviewed in the light of these findings. Another potentially promising area for further research is the induction of heat shock proteins in cells by RF exposure. Most of the reported *in vitro* studies have shown positive effects, but this research area would benefit from their independent replication.

ANIMAL STUDIES

4. There is no direct experimental evidence to suggest that exposure to RF fields increases the risk of cancer. However, recently developed animal models with targeted gene mutations that predispose the animals to brain tumours – particularly glioblastoma, a leading cause of brain cancer in human beings – may prove useful in further animal studies.
5. The central nervous system seems to be particularly susceptible to heat. However, possible effects on the development of the cortex, known to be particularly susceptible to other harmful agents, and the behavioural consequences of these effects on the nervous system have not been fully explored. In addition, it is not clear to what extent the increased susceptibility of the embryo and fetal central nervous system to raised body temperature continues during subsequent postnatal development through to adolescence. Such uncertainties can only be addressed through further investigation.
6. The least questionable evidence for low level RF effects on neurobehavioural function relates to the changes in cholinergic and opioid activity observed in studies using whole-body SARs of about 1 W kg^{-1} . Field-induced changes in cholinergic function might predict effects on learning and memory but the evidence for such effects is unclear, too few tasks and exposure conditions have been examined. Further studies should be carried out of cholinergic and opioid activity in the brain and associated behavioural or cognitive responses in animals. In addition, reported changes in excitability of hippocampal slices *in vitro* following exposure to very weak RF fields require independent verification.

BRAIN ACTIVITY AND COGNITIVE FUNCTION STUDIES

7. More research is needed to investigate what impact, if any, neural activity changes after RF field exposure have on cognitive performance – for example, by

measuring EEG patterns during specific cognitive tasks that have previously shown sensitivity to RF field exposure. Any possible health outcomes that may be associated with the altered EEG patterns caused by RF fields from mobile phones should also be identified. Finally, the biological mechanism whereby RF field exposure could alter EEG patterns remains unclear. Future cellular and animal studies may provide useful information about possible mechanisms underlying any EEG effects.

8. Possible effects of mobile phone signals on cognitive function could have important implications for health, and should be researched further. Future research should carefully control exposure levels, and should ensure that both participants and researchers are blind to exposure conditions. There has been little or no attempt to standardise cognitive tasks used across different experiments or different laboratories. Future research must be open to the possibility that performance on any cognitive task could potentially show RF field exposure effects. However, an overview of the balance of evidence across studies would be easier if the search for positive effects focused on a restricted number of standardised cognitive tests, with high face validity and proven sensitivity. Given the rapid pace of technological change in mobile telephony, standardisation of cognitive testing will be particularly important in assessing whether any new forms of RF signal do or do not affect cognitive function.
9. Previous research has often lacked statistical power, or proved difficult to replicate. Further research would therefore benefit from a multicentre approach, with identical experimental studies being carried out in parallel in two or more independent laboratories. International co-operation between research institutions should be encouraged as a means of achieving this.

CLINICAL STUDIES AND NON-CANCER EPIDEMIOLOGY

10. On the basis of the studies reviewed, no priorities for further epidemiological research on non-cancer outcomes have been identified. There are uncertainties, but nothing suggestive of an important health concern that is being missed. Any recommendations would therefore depend on suspicions from *in vitro* or *in vivo* laboratory studies.
11. It would be helpful to carry out further experimental trials on individuals who claim to be sensitive to RF fields and suffer acute symptoms from the use of mobile phones.

CANCER EPIDEMIOLOGY

Mobile phones

12. A large international case-control study is currently underway coordinated by the International Agency for Research on Cancer. It is expected to include 6500 cases of brain tumour from 13 countries, as well as 1000 cases of acoustic neuroma and 700 cases of salivary gland tumour, plus a similar number of controls, who are being interviewed using an extensive questionnaire about mobile phone use. The study also includes a methodological investigation about exposure assessment. There is not currently an international study of leukaemia risk in relation to mobile phone use, but there is such a study in the UK, which is expected to include about 900 cases and 900 controls. In view of the size and scope of these studies, the Advisory Group does not believe there is a case for inaugurating further general population case-control studies of cancer in relation to mobile phone use in the UK until the results of the studies now underway are known.
13. Future studies need to address the shortcomings of those published to date: ie to study longer periods of use, longer induction periods and greater cumulative

exposures, to obtain more precise estimates of exposure (although with the difficulty that the appropriate metric is unknown), and to analyse risk according to the anatomical locations of the tumour and antenna. Examination of risks for longer induction periods is desirable, both intrinsically and also because it may avoid the bias in analyses of shorter periods that pre-diagnostic effects of the brain tumour might alter phone use, and hence distort any association.

14. Continuing follow-up and analyses of cohort studies already underway would be desirable, as would further cohort studies (or addition of mobile phone information to ongoing cohorts), if practical. Nested case–control studies may have the potential to address some of the deficiencies of cohort studies for exposure assessment (eg to gain data on whether the bill payer was the phone user). Specifically for TETRA phone systems, the Advisory Group noted in 2001 the need for the working practices and conditions of exposure of TETRA users to be characterised, and for records of use to be kept, in order that they would be available for potential future epidemiological studies.
15. Although routinely collected data on cancer incidence are a blunt instrument by which to try to ascertain whether or not aetiology occurs, they could nevertheless give useful information on whether there are likely to be major aetiological effects of mobile phone use on cancer risk over the induction periods through which a substantial proportion of the population has passed. Examination of such associations would be greatly improved if data were available on the age- and sex-specific prevalence of phone use over time within countries. Even without this, however, it might be expected that if there were major effects of phone use on incidence of particular cancer(s), then after a suitable induction period this ought to become apparent in countries such as Norway and Sweden, where prevalence of use rose earliest, and later should become apparent in countries such as Italy or France, where widespread take-up of mobile phones occurred later. There are, of course, many factors, mostly unknown, that may influence brain tumour trends, so that data from any one country would not in themselves be persuasive. International data on brain tumour incidence trends in the age groups most exposed, however, although they could not address subtle or long-duration effects, would at least address whether there are likely to be major short-induction period effects of mobile phone use on incidence of these tumours.

Occupational exposure

16. Again there is a need for better studies rather than simply for more. In particular, the studies need to be of occupational groups for whom measurements show that there is genuinely a substantially raised exposure to RF fields. If the studies are to be more informative than those so far, a key requirement will be for improved exposure measurement (or improved estimation of exposure) for individuals, or at least for occupational groups. It would be desirable, as far as practical, that the studies should measure the intensity and timing of RF field exposures, and also that they should include some assessment of major RF field exposures from sources other than the current occupation – ie domestically, from mobile phones, and from previous jobs. Ideally, exposure assessment needs to be anatomical site (organ)-specific, because some sources result in greatly differing doses to different parts of the body. It is a difficulty in these prescriptions, of course, that the appropriate exposure metric is unknown.

Exposures from broadcasting and mobile phone masts

17. The methodological barriers to conducting valid assessments of cancer risks in relation to these low level exposures are very great, as described in Chapter 7. In addition to the difficulties described there regarding radio and TV broadcasting

masts, for analyses in relation to mobile phone masts there is the further difficulty that their locations have multiplied rapidly and continue to increase. This would make calculation of historical exposures harder.

18. If future studies are conducted, they need to be in locations where appreciable geographical variations in RF field exposure levels attributable to masts have been demonstrated and characterised by measurements in the study area. At present it seems likely that the most useful information on the possibility of a substantial carcinogenic effect of residential exposure to RF field from broadcasting/phone masts will come from extrapolation from results for other, more highly exposed groups – for instance, from studies of occupationally exposed populations.