

British Medical Association  
Board of Science and Education

# Mobile phones and health

An interim report

May 2001

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# Abbreviations and glossary

The following abbreviations are used throughout this report:

3G	Third generation mobile communication system (will operate at 2GHz)
Analogue	First generation of mobile phones
CENELEC	Comité Européen de Normalisation Electrotechnique – European Committee for Electrotechnical Standardisation
DECT	Digital Enhanced Cordless Telecommunications
DETR	Department of the Environment, Transport and the Regions
Dosimetry	The measurement of electromagnetic field penetration into the body
DTI	Department of Trade and Industry
EMF	Electromagnetic Field
EMI	Electromagnetic Interference
ESN	Electronic Security Number
FEI	Federation of the Electronics Industry
GSM	Global System for Mobile Communications. The international, pan-European operating standard for digital cellular mobile communications (operates at 900MHz or 1800MHz)
HFK	Hands-free Kit
Hz	Hertz; measurement of wave frequency, where 1Hz is one oscillation per second
ICNIRP	International Commission on Non-Ionising Radiation Protection
MRC	Medical Research Council
NRPB	(UK) National Radiological Protection Board
IEGMP	Independent Expert Group on Mobile Phones (Stewart Group)
in vitro	Studies conducted in an artificial environment outside the living organism
in vivo	Studies conducted 'within' a living organism
RFR	Radiofrequency Radiation
SAR	Specific Energy Absorption Rate
SIM	Subscriber Identity Module – security 'smart cards' contained in GSM phones
Stewart Group	The Independent Expert Group on Mobile Phones (IEGMP)
TETRA	Terrestrial Trunked Radio
WHO	World Health Organization





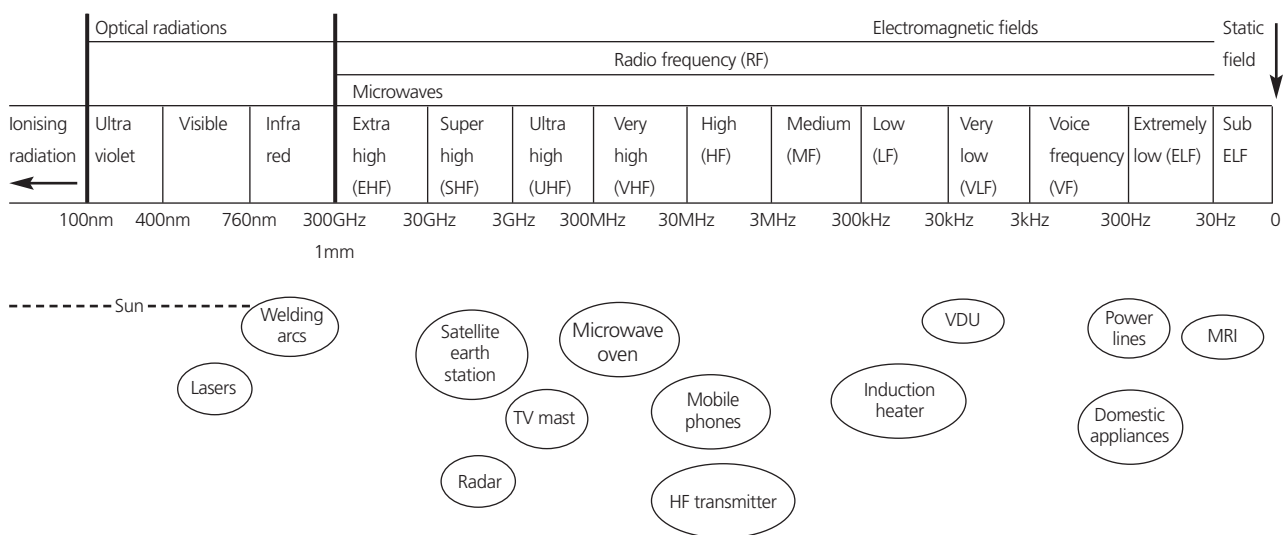
# Introduction

It has been estimated that there are currently 39.9 million users of mobile phones in the UK, and within 5 years an estimated 25% of all calls will be made from mobiles.<sup>1</sup> Worldwide, there are currently around 700 million users, and by the end of 2002 there could be as many as one billion. Concerns have been raised that use of this technology has increased dramatically without sufficient understanding of the potential adverse health effects of the electromagnetic fields produced by the phones and their base stations. The aim of this document is to summarise the current knowledge about mobile phones and public health, and to outline the on-going and planned research.

## Mobile phones and base stations: the basics

Radiowaves, x-rays and light are all forms of electromagnetic radiation, which are known collectively as the electromagnetic spectrum. They vary in frequency (Hz) and hence the amount of energy they carry – the higher the frequency, the higher the energy (see figure 1).

**Figure 1: The electromagnetic spectrum<sup>2</sup>**



Mobile phone systems operate within the radiofrequency (RF) section (30kHz-300GHz) of the electromagnetic spectrum. Analogue phones operate at 450MHz and 900MHz, digital phones (GSM) at 900MHz or 1800MHz, and third generation phones (3G) to be launched in a few years, at approximately 2000MHz (2GHz). The phone systems depend on RF communication between handsets and fixed base stations. In engineering terms, “base station” describes the electronic equipment contained in the plant room at the base of the mast. However, this term is frequently used to refer to the complete installation comprising base station, mast and antenna (see figure 2).

Figure 2: Base station

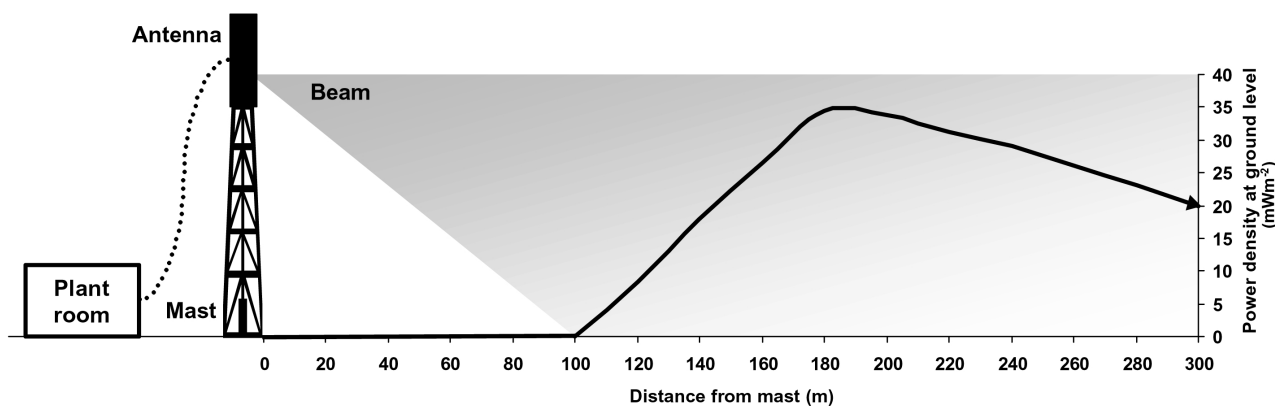


Figure 2 also shows the degree of exposure, in terms of power density, at ground level with increasing distance from a typical GSM900 antenna, where the top of the beam is situated 15m from ground level. The main beam is tilted downwards so that the lower edge of the beam touches the ground at a distance of 100m from the mast. Power density increases from 100m to a maximum of 35 mWm<sup>-2</sup> at a distance of 180m from the mast, after which it decreases with greater distance. There may be a small amount of exposure between 10-100m due to other radiating elements on the antenna, but this is unlikely to exceed 17 mWm<sup>-2</sup>.<sup>13</sup>

Each base station covers phone use in a specific area or 'cell', as great as 10km in rural areas, or as small as 0.2-0.5km in towns where demand is greatest. As the wavelengths at 900MHz are twice as long as those at 1800MHz, they are better at reaching the shielded regions behind obstructions as a result of diffraction (bending). So in order to obtain identical coverage, fewer base stations are needed at 900MHz than 1800MHz.<sup>3</sup> On receipt of a call, the base station closest to the handset will transmit and receive the RF signal. As the user moves, this signal may be transferred to a nearer base station in order to maintain an optimum user signal at the lowest possible power output.

Other forms of mobile communication that operate using a similar system of a handset and a base station include cordless telephones (analogue, operating at 914-960MHz, and the new digital DECT system, operating at 1.88-1.9GHz), and portable radio systems. A new cellular radio system, TETRA, is increasing in use across Europe. It operates at either 400MHz or 900MHz, and is designed for use in closed groups, particularly the emergency services.<sup>3</sup> Little research has been conducted into its possible adverse health effects, and therefore this research is necessary.

At high intensities RF radiation has heating properties that can be detrimental to health (thermal effects). For this reason guidelines are in place to limit the intensity of the radiation (see page 4). The use of RF radiation in daily life is not new, however, and figure 1 shows other technologies that operate at this frequency.

## Major publications and sources of public information about mobile phones and base stations (1996-2000)

- EC Expert Group on Telecommunication Technology Report, 1996<sup>4</sup>
- The World Health Organization established its International EMF project in 1996
- May 1998 WHO produced a fact sheet for the public, revised in June 2000<sup>5</sup>
- Department of the Environment, Transport and the Regions and The National Assembly for Wales, *Code of Best Practice, Telecommunications prior approval procedures as applied to mast/tower development*, 1998<sup>6</sup>
- EC Council passed its recommendations about research into electromagnetic fields, July 1999<sup>7</sup>
- The Royal Society of Canada Report, *A review of the potential health risks of radiofrequency fields from wireless telecommunication devices*<sup>8</sup>, March 1999
- COST (Co-operation in the Field of Scientific and Technical Research) report, *Possible health effects related to the use of radiotelephones*, was published in September 1999, updating the 1996 EC Expert Group report<sup>9</sup>
- The House of Commons Science and Technology Select Committee on the Scientific Advisory System published its report, *Mobile phones and health* in September 1999<sup>10</sup>
- Scottish Parliament Transport and the Environment Committee, *Report into the proposals to introduce new planning procedures for telecommunications development*, March 2000<sup>11</sup>
- The UK Consumers' Association report on protective devices for mobile phones, *The Ring of Truth*,<sup>12</sup> April 2000
- UK Independent Expert Group on Mobile Phones (IEGMP) commissioned by the Government and chaired by Sir William Stewart, published *Mobile phones and health*<sup>3</sup> in May 2000. Often referred to as "The Stewart Report"
- NRPB report, *Exposure to radio waves near mobile phone base stations (NRPB-R321)*, June 2000<sup>13</sup>
- Australian Consumers' Association report, *Is hands-free safer?*<sup>14</sup> August 2000
- Department for Trade and Industry report, *SAR test on mobile phones used with and without personal hands-free kits*,<sup>15</sup> August 2000
- UK Consumers' Association published further data on hands-free kits in November 2000<sup>16</sup>
- Department of Health produced two public information leaflets in December 2000<sup>17</sup>

# Possible adverse health effects

## Guidelines

To prevent adverse health effects from heating by radiofrequency radiation, guidelines have been established that limit the exposure to members of the public. These guidelines set out the “basic restrictions” on the amount of energy that can be safely absorbed by a given mass of body tissue, and are called SAR (Specific Absorption Rate – watts per kilogram,  $\text{Wkg}^{-1}$ ). Unfortunately, it is not easy to measure SARs in living people, and so “investigation levels”, eg power density in watts per square metre ( $\text{Wm}^{-2}$ ), may be used instead to indicate radiation exposure levels.

Sets of SAR guidelines and “investigation levels” have been produced by the UK National Radiological Protection Board (NRPB)<sup>18</sup> and an international body of experts, called the International Commission on Non-ionising Radiation (ICNIRP),<sup>19</sup> whose recommendations have been accepted by the EU Council.<sup>7</sup>

The NRPB guidelines and “investigation levels” relate to all people, whereas the ICNIRP guidelines and “investigation levels” distinguish between public and occupational exposure. The limits for occupational exposure are similar to those recommended by the NRPB, but those for the public are five times lower, on the basis that whilst occupational exposure can be controlled, that for the public is uncontrolled and cannot be monitored. The House of Commons Select Committee on Science and Technology<sup>10</sup> recommended, and the Government agreed, that the ICNIRP limits should be adopted in the UK “as a precautionary measure”. The NRPB argues that there is no conclusive scientific evidence to support lowering the SAR levels, but all modern digital mobile phones (and most base stations) comply with the ICNIRP guidelines already.

There is evidence to suggest that even below these restrictions there are biological effects, although there is a need to distinguish between those that result in an adverse health effect, and those that do not. Those effects that are not due to heating are called ‘non-thermal’. The NRPB does not consider that there is sufficient evidence for these effects to justify considering them in its guidelines for maximum exposure, although the UK Science and Technology Select Committee recommended that the NRPB should regularly review the scientific evidence for them.

There are various hypotheses relating to the mechanisms for non-thermal effects (see Stewart Report,<sup>3</sup> chapter 5, for in-depth analysis). These include changes in cell membranes, effects on the blood-brain barrier, and attraction between neighbouring cells. Concerns about the possible health effects cover a variety of conditions and a number of reports review the evidence for these.<sup>3,4,8,9</sup> Below is a summary of the recommendations to date for some of these conditions – readers should consult the reports for full details of these and other conditions. Evidence is derived from *in vivo* and *in vitro* experiments, and dosimetry studies. Difficulties are encountered since many studies of radiofrequency radiation (RFR) are not specific to that generated by mobile phone technology, they may cover whole-body exposure rather than local exposure, and they vary in the intensities and levels of exposure investigated and are thus not comparable.

## ***Cancer***

Since RFR is non-ionising (ie cannot break down bonds between atoms), it is unlikely that it could directly induce a carcinogenic process, however, there is anxiety that it might possibly promote or progress it. The consensus is that current scientific evidence indicates that exposure to RF fields is unlikely to induce or promote cancers.<sup>3,5,8,20,21</sup> Those studies that have found positive results<sup>22</sup> require replication and their applicability to humans needs to be evaluated. There have been reports of DNA fragmentation which could be relevant to malignancy<sup>23</sup> but these have not been confirmed independently and are subject to much dispute. The International Agency for Research into Cancer is conducting a study that aims to address these uncertainties (see table on page 8).

## ***Reproductive system***

Since developing embryos or foetuses are vulnerable to environmental hazards at lower levels than adults, assessing the possible effects of RF fields on fertility and development should be a priority area. The Stewart Group concluded that studies on rodents have not found any convincing evidence of risks to the foetus or male fertility, but one study<sup>24</sup> of female rodents found a decline in their fertility at low level RF exposure. The Group recommended this study be repeated under controlled conditions (absent in the original study) so that conclusions can be drawn.

## ***Effects on the eye***

The eye has limited capability to dissipate heat and is not protected by bone like the brain. Hence, the Royal Society of Canada<sup>8</sup> has concluded that the possibility of adverse effects to the eye by RFR should be treated with caution and concern. Studies have demonstrated that high level (thermal) exposure to RFR may produce adverse effects in the eye, particularly in the retina, iris and cornea, although no definitive conclusions can be reached since the studies have used intensities of pulsed RF fields “well above the SAR and specific absorption that could occur in the eye from the use of current mobile phones”.<sup>3</sup>

## ***Cognitive effects***

There has been concern that RFR may effect cognitive functions such as memory, reaction times, and sleep processes. One study has reported a decrease in reaction times in people exposed to RFR,<sup>25</sup> a finding that has been replicated by an independent group.<sup>26</sup> The same study failed to find evidence for memory loss or attention deficiency. Hydration levels were not considered to be a confounding factor.<sup>27</sup> Studies on sleep processes have demonstrated that exposure to RFR both before and after sleep onset enhances the intensity of the brain’s electrical signals (EEG) during sleep.<sup>28, 29</sup> Other studies have concluded that RFR exposure may shorten the time to sleep onset,<sup>30</sup> and may reduce the amount of waking after sleep starts.<sup>29</sup> The NRPB writes that the few studies that have investigated these issues do not suggest the existence of an obvious health scare.

## ***Children***

Children are amongst the keenest users of mobile phones: ownership levels are now at 16% for primary school children and almost 59% for secondary school children in England, Wales and Northern Ireland.<sup>31</sup> Due to their developing nervous systems, greater absorption of energy in the tissues of the head, and their longer lifetime exposure, children may be more vulnerable to the effects of RFR. Unfortunately, the epidemiological studies that have focused on children and their reactions to electromagnetic radiation have been ecological in design, lacking any individual level data for either exposure or potential confounders.<sup>8</sup> Consequently these studies are not particularly informative about potential RF health risks. The Stewart Report<sup>3</sup> advised that children under 16 years of age should be discouraged from using mobile

phones for non-essential calls, and in addition, that the mobile phone industry should refrain from promoting the use of mobile phones by children.

Children are particularly likely to use mobile phones for text messaging, a use that has increased exponentially, with over 900 million messages being sent in the UK in January 2001 alone.<sup>32</sup> Since the handset is normally held near to waist level for this activity, research is necessary into whether mobile phone radiation may effect different parts of the body in different ways, and hence whether there are any additional possible health risks associated with text messaging.

### ***Subjective disorders***

Mobile phone users have complained of short term adverse effects including headaches, dizziness, and unpleasant heating or tingling in the head or behind the ear.<sup>33</sup> One epidemiological study suggested that users experienced such symptoms in a dose dependent fashion, with symptoms increasing with greater phone use.<sup>34</sup> There have been very few studies that have looked systematically at such users, so firm conclusions cannot be drawn, although one review<sup>5</sup> concluded that existing evidence does not support the conclusion that microwave radiation (part of RFR) can induce headaches. To end the uncertainty, the Stewart Report<sup>3</sup> recommended that a large cohort study of long term mobile phone users be conducted in the UK, that double-blind studies be undertaken to assess the relationship between mobile phone use and these symptoms, and a significant research programme be initiated so that “the impact of mobile phone technologies on well-being in its broadest sense” can be determined.

### **Base stations**

Base stations may contain more than one transmitter and the outputs of each transmitter are fed to the antenna on top of the mast. Each transmitter gives rise to a maximum radiated power of approximately 10W at the antenna and each base station may have up to 8 transmitters – thus maximum powers radiated from the antenna are in the region of 80W. The antenna are located up to 50m above ground level and the main RF beam is angled slightly downwards so that it reaches ground level typically between 50 and 300m from the foot of the mast (see figure 2). Hence, whilst exposures close to the antenna and *directly* in front of the beam can exceed guidelines, power density decreases with distance from the antenna and calculations have shown that exposure levels fall below NRPB and ICNIRP public guidelines at distances greater than 3.1m and 8.4m respectively.<sup>13</sup> There is, nevertheless, a practice, and recommendation by the Stewart Group, of defining and marking exclusion zones around the antennas.

The NRPB measured radiowave signal strengths at 118 locations of public access near base stations and found that the maximum exposure at any location measured was 0.023% of the NRPB guideline and 0.18% of the ICNIRP reference level. The exposures were therefore well within the guidelines and not considered hazardous. This included exposure to signals from other sources, eg radio, TV and pagers; however, such exposures were found to be very variable, and could make it difficult to isolate the health effects of signals from base stations in any population-based epidemiological study.

A base station measurement audit and database recommended by the Stewart Group is being taken forward by the Radiocommunication Agency of the Department of Trade and Industry to ensure that exposures of people in the vicinity of them are within guidelines. It is anticipated to be ready and on-line by summer 2001.<sup>35</sup>

The Stewart Report<sup>3</sup> concluded “the balance of evidence indicates that there is no general risk to the health of people living near to base stations on the basis that exposures are expected to be small fractions of guidelines. However, there can be indirect effects on their well-being in some cases”, such as anxiety about the possible effects, or possibly a reduction in the value of property. In terms of schools, it has been recommended that the beam of greatest intensity from the masts should not fall on the site without the agreement of the school and the parents, and it should be recognised that exposure may be less with a mast placed on top of the buildings due to the way the RF waves spread out.

### **Further research**

Research is being conducted on a worldwide scale, largely according to the WHO agenda for further research ([www.who.int/peh-emf](http://www.who.int/peh-emf)), and individual countries and academic researchers are contributing to the larger scale programmes. The WHO has established an on-line research database ([www.who.int/peh-emf/database.htm](http://www.who.int/peh-emf/database.htm)) which contains details of published and on-going research. The UK Department of Health has established a multi-million pound programme of research that will be 50% funded by industry. An independent panel of experts will co-ordinate the research. The following table summarises the main programmes, and individual UK projects that are contributing to these.

### **Summary**

The most recently published reviews of the literature have concluded that whilst there are small physiological effects within the existing guidelines, there are no definite adverse health effects from mobile phones or their base stations. However, all the main professional organisations have called for more research to be conducted, since the possibility that radiofrequency radiation may cause adverse effects cannot be ruled out on the currently available data. Clearly there are large gaps in the knowledge that need to be addressed. The Stewart Group recommended the precautionary approach be adopted until more detailed and scientifically robust information on any health effects becomes available, and the WHO listed recommendations for countries to follow until the conclusive research is published in 2-3 years time. The table (on page 8 and 9) details the current on-going and planned research.

## Currently planned and on-going research into possible adverse effects of mobile telephone technology

<i>Organisation</i>	<i>Research details</i>	<i>Funding details available</i>	<i>Estimated completion</i>
World Health Organization (WHO)	The International EMF project aims to initiate and co-ordinate research worldwide into the possible health effects of EMF including RF fields emitted by mobile phones and their base stations to produce a well-founded response to public concerns. Collaborating organisations include 8 international agencies, over 40 national authorities, and 8 WHO collaborating centres. The research agenda is available on <a href="http://www.who.int/peh-emf/database.htm">www.who.int/peh-emf/database.htm</a>	US\$600,000 per year	2005
International Agency for Research into Cancer (IARC)	Co-ordinating a multi-national case control study to identify whether there is a link between mobile phone use and cancer of the brain and salivary glands. There are 13 countries involved including the UK.	Funded by World Health Organization and a grant from the EU	2004
Leukaemia Research Fund Centre, Leeds University	Multi-centric UK case control study of the aetiology of adult brain tumours. Its aim is to test a number of hypotheses associating brain cancers with exposure to various agents including the use of mobile phones. This study will contribute to the IARC study.	EU funded	2004
Medical Physics University Research Centre, Bristol	The main objectives of the research are the dosimetry of the head from GSM mobile phones and examination of the mechanism of cognitive and other changes. Specific studies are: <ul style="list-style-type: none"> <li>Minimally invasive E-field dosimetry of target organs in a complex head phantom</li> <li>Effect of mobile phone radiofrequency exposure on the permeability of human placentas</li> </ul> Three other projects are lodged with the Department of Health in conjunction with Burden Neurological Institute and National Physics Laboratory.	£45,000 from DTI  £15,000 from charitable trustees & MRC	Sept 2001  Sept 2001



<b>Organisation</b>	<b>Research details</b>	<b>Funding details available</b>	<b>Estimated completion</b>
European Commission	<p>Under the Fifth Framework Programme 1998-2002 Quality of Life Key Action 4, the following studies are being conducted:</p> <ul style="list-style-type: none"> <li>• Combined effects of electromagnetic fields with environmental carcinogens</li> <li>• International case-control studies of cancer in relation to mobile telephone use (IARC)</li> <li>• <i>In vivo</i> research on possible health effects related to mobile telephones and base stations (carcinogenicity studies in rodents)</li> <li>• Risk evaluation of potential environmental hazards from low-energy electromagnetic field (EMF) exposure using sensitive <i>in vitro</i> methods</li> <li>• Development of advice to the EC on the risk to health of pulsed electromagnetic fields</li> </ul>	<p>980k euros</p> <p>3,850k euros</p> <p>2,050k euros</p> <p>2,050k euros</p> <p>58k euros</p>	All projects will be complete by 2004
National Radiological Protection Board (NRPB)	<ol style="list-style-type: none"> <li>1. Development and application of anatomically realistic computational phantoms to measure the interaction of magnetic and electrical fields with the human body.</li> <li>2. Study to address the possible effects of RF radiation on the induction of chromosomal damage in human lymphocytes.</li> <li>3. UK National Study conducted jointly with the Institute of Occupational Health at Birmingham University to investigate occupational exposure to RF EMF and radiation from various sources including broadcast transmitters and telecommunications. Commenced November 1998.</li> <li>4. A working group is examining the implication of the Stewart Report's recommendation that ICNIRP guidelines are adopted for SAR.</li> </ol>	<p>–</p> <p>–</p> <p>£600,000 industry contribution</p> <p>–</p>	<p>–</p> <p>–</p> <p>2002</p> <p>–</p>
UK Department of Health	An extensive research agenda including: effects on brain function; consequences of exposure to pulsed signals; improvements in dosimetry; the possible impact on health of sub-cellular and cellular changes induced by RFR; psychological and sociological studies related to mobile phone use; epidemiological and human volunteer studies including the study of individuals who might be more susceptible to RFR; emerging communication technologies (that is, 3G phones), including an epidemiological study of 3G users.	£7 million Government : industry 50 : 50	2004/5
Industry	<p>UK cellular operators do not conduct their own scientific research. However, they set up a committee in 1999 (Scicom) to direct funding to research projects in the UK when approached by researchers.</p> <p>The worldwide GSM Association set up the Electromagnetic Compatibility and Bioeffects Review Committee to consider the research that should be funded by GSM members.</p>	<p>50% of Department of Health's programme</p> <p>£3 million for the 5 years</p>	<p>2004/5</p> <p>2004/5</p>

## Cars and road safety

Of all the aspects of mobile phones and health that were examined by the Stewart Group, the only one that resulted in conclusive evidence of a substantiated risk was an increased incidence of motor vehicle accidents when drivers use mobile phones.

### The evidence

There is strong experimental evidence that those engaging in mobile phone conversation have an impaired ability to react to potentially hazardous situations.<sup>36,37</sup> Epidemiological studies have also indicated an association between phone conversation whilst driving and an increase in the risk of involvement in an accident, although causality cannot be attributed.<sup>38,39</sup> This finding appears to be unaffected by whether a hands-free kit (HFK) is used or not. For this reason, the Stewart Group concluded that the effect is most likely to be due to the distracting nature of the conversation, and drivers should be dissuaded from using either hand-held or hands-free phones while on the move.

### The law

According to the Royal Society for the Prevention of Accidents (RoSPA),<sup>40</sup> there have been at least 14 deaths on Britain's roads since 1994 where mobile phone use has been implicated. There may be many more, but precise figures are impossible to obtain since use of a mobile phone while driving is not a specific offence, but rather is incorporated into other offences such as causing death by dangerous driving, careless or inconsiderate driving, and not having proper control of the vehicle. If the use of a mobile phone causes careless or dangerous driving then prosecution may result, ranging from an unlimited fine and disqualification, and up to two years imprisonment.<sup>41</sup> Currently the police are happy with their powers of prosecution, but if drivers continue to use their phones, the Government will review whether specific legislation is necessary.

In early 2000 the DETR<sup>41</sup> launched a national campaign against the use of a hand-held phone whilst driving, and again in December 2000 in its "Think!" campaign.<sup>42</sup> Advice included:

- Never use a hand-held phone while driving;
- It is safer not to use a hands-free phone while driving...If you have to receive a call, say that you are driving and keep the conversation brief;
- Use a message service and take regular breaks.

However, in light of the above evidence, it might be advisable for the DETR to revisit its campaign and alter its guidance about hands-free phones so that it is in line with that for hand-held phones, that is, "Never use a hands-free phone while driving". The Highway Code now contains guidance on mobile phone use in vehicles: "You **MUST** exercise proper control of your vehicle at all times. Never use a hand-held phone or microphone when driving. Using hands-free equipment is also likely to distract your attention from the road. It is safer not to use any telephone while you are driving – find a safe place to stop first". This guidance could also be adjusted accordingly.

### Potential risks for other road users

Cyclists and pedestrians may also be at risk of an increased involvement in accidents, either through using a mobile phone themselves, or as a result of their use by drivers of motor vehicles. However, there are no figures available to date which record such information, and this is an area where research is needed.

# Sociological implications

Mobile telecommunication technology has been embraced by society at an astounding rate. The current uncertainty over possible adverse health effects has been discussed, but as with all new developments in society, there are also sociological implications, both positive and negative, that need to be addressed.

## Negative implications

### *Electromagnetic compatibility problems*

#### *Interference with medical devices*

The Medical Devices Agency<sup>43,44</sup> has investigated a range of mobile communications including mobile phones to determine whether they may cause any electromagnetic interference (EMI). Medical devices suffered EMI in 23% of tests, of which 43% would have had a direct impact on patient care. Some categories of devices had high susceptibility to interference, with the most severely affected being physiological monitors, or devices incorporating them, such as defibrillators or external pace makers, while some makes of infusion pumps were also affected. However, the type of radio handset made a large difference to the likelihood of EMI, with mobile phones (both analogue and digital) at a distance of 1m causing interference to only 4% of devices, with less than 0.1% being serious. It was also concluded that EMI from base stations was unlikely unless the medical devices were particularly sensitive.

In light of these findings a number of recommendations regarding mobile phones were made:<sup>45</sup>

- Mobile phones should always be switched off in operating theatres and treatment areas where sensitive devices may be used; by the patients' bedsides when the patient is connected to any electromedical device; and in other designated areas where there is a perceived risk.
- Since the handset communicates periodically with the base station to signal its location, mobile phones should not be left in standby mode in the designated areas.
- Users, patients, and visitors should be informed of restrictions on use, restricted areas should be clearly signed, and staff should be aware of the possibility of EMI from mobile phones affecting medical devices.

The Stewart Report<sup>3</sup> stated that health authorities and health boards should issue guidance for the use of mobile phones, and ensure that all hospitals comply with them. This guidance should include the placing of visible warning signs at entrances to buildings to indicate that mobile phones should be switched off.

*Pacemakers and hearing aids* – mobile phones used close to these devices may possibly cause interference.<sup>5</sup> If there is any concern, technical specifications of both the mobile phone and the device (hearing aid or pacemaker) should be obtained from the product literature, and advice sought from the Medical Devices Agency.

#### *Mobile phones on aircraft*

The Civil Aviation Authority (CAA), in response to anecdotal evidence of interference with aircraft instrumentation from mobile phones, conducted their own research<sup>45</sup> which found evidence of false cockpit warnings, aircraft system malfunction, interference in pilots' headsets, and the crew making mistakes due to distraction by the phones. Therefore, the ban on mobile phones in UK-regulated aircraft that has been implemented since mobile phone technology was introduced, remains. Research is planned by the CAA for later this year (2001) into how the aircraft instruments are affected, and which are the most susceptible.

### *Environmental issues*

Perhaps one of the most common complaints made about the use of mobile phones after health concerns, is the amount of noise pollution they generate; on public transport, in restaurants, theatres, cinemas and other public places. In May 2000 a House of Commons Early Day Motion with 45 signatures was passed deploring the “willingness with which many mobile phone users on trains divulge intimate details of their domestic and business affairs to their fellow passengers”. A train company was congratulated on its introduction of Quiet Zones on its trains for passengers who wish to work and/or travel in peace. The Government was called upon to encourage the rail operators to designate mobile phone free zones on all trains, “following the precedent established by smoking and non-smoking sections”. As mobile phone technology evolves and becomes even more widespread, the BMA recommends that the Government consider issuing guidelines for establishing ‘quiet zones’ in public places.

Base stations have an environmental impact: wherever possible operators locate them on existing buildings, but otherwise, purpose-built structures usually over 15m high are erected that are painted, or if appropriate, disguised as windmills or trees, to limit their impact. Mast sharing is encouraged between operators where that is the optimum solution in the individual circumstances, although this may result in taller structures to accommodate the antennas. With the emergence of 3G phones, the number of masts required for full coverage will increase significantly.

The current planning procedure for masts was criticised in the Stewart Report,<sup>3</sup> particularly since masts below 15 metres are not subject to full planning procedure. The DETR has recently announced changes to this situation that will be implemented at the ‘earliest opportunity’.<sup>35</sup> This includes strengthening public consultation requirements on mast proposals of 15 metres and below so that they are exactly the same as applications for planning permission. The operators have simultaneously launched their own initiative, comprising ten commitments that they expect to achieve by early 2002, to address public concerns in relation to the siting of base stations.

### *Crime*

Recorded Crime Statistics in England and Wales (1999-2000)<sup>46</sup> shows an increase in robberies of 26.1%. The majority of these robberies were of personal property, mainly muggings which have increased by 28%. It has been suggested in the media that this rise might be due to an increase in theft of mobile phones. Metropolitan Police figures indicate an increase in street crimes since 1998 in which only mobile phones were stolen (suggesting they were actively targeted). The suspects and victims of these possibly targeted thefts are younger than other street crime suspects and victims; over 20% of the victims are aged 14 or 15, and the peak suspect age is 16, compared to 20 for other street crimes. As many as 10,000 mobile phones are stolen each month in London.

Positive action that mobile phone owners can take is to note their handsets’ electronic security number (ESN), which can be found by typing in \*#06#. A 15 digit code, unique to that handset, will appear on the screen. Should the phone be stolen, the service provider can be given this code to block the handset. Even if the thief changes the SIM card, the phone will remain useless, and hence impossible to use in future. In addition, owners should use their phone’s security lock code if it has one, and put their postcode on the phone and battery to help police identify stolen ones.<sup>47</sup>

### ***Children's use***

In schools, theft of mobile phones and bullying via text messaging is an area of concern. The Department for Education and Employment (DfEE) is working with the Home Office to produce a strategy document for tackling crime for both schools and the police,<sup>48</sup> which will touch on the issue of theft of mobile phones. Schools will be advised that through dialogue with local education authorities, school governors, parents and the police, protocols can be devised for controlling mobile phone use in the school environment, and also for raising awareness among parents. Balance needs to be achieved between the benefits of children being able to contact their parents with the consequences of bullying and theft in the playground, and possible disruption in the classroom. In terms of health effects, the DfEE has recommended that each school should bear in mind the advice from the Stewart Report when considering their policies on the use of mobile phones in the schools.<sup>49</sup>

### **Positive implications**

#### ***Benefits to the medical profession***

In 1999 the NHS Executive launched its *Zero Tolerance Zone* nationwide campaign<sup>50</sup> to stop violence against staff working in the NHS. Part of this campaign involved an assessment of risk of violence and aggression faced by staff; those judged to be at such risk may be issued communication devices to help reduce it, such as mobile phones. Such a method to minimise any risk to their safety can only be a benefit.

The possible future inclusion of email and video cameras on third generation mobile phone systems may assist in diagnosis or rapid treatment of patients who, for example, are in transit to a hospital, or who have been injured in a remote location. If clinical information from a patient in an ambulance can be transferred to a doctor at a hospital, valuable time in assessment of the condition may be saved.

#### ***Use of mobile phones to make calls to emergency services***

Research in Australia has shown that there appears to be widespread use of mobile phones in rapidly reporting emergencies.<sup>51</sup> If this results in ambulances arriving more quickly at the scene of a car accident for example, this must be viewed as a positive application of the technology. With the advent of the new generation of mobile phones with location technology, the benefits of a handset in an emergency will increase.

#### ***Personal safety***

Data from 2000 showed that nearly two thirds of all UK mobile phone users considered their mobile phones to be a necessity, rising to 71% for the over 65s<sup>52</sup> indicating that they may provide an added sense of security to vulnerable sectors of the population. In terms of child safety, parents and guardians are often reassured that they can be contacted by their children if they are in a difficult situation.

# Protective devices

The debate over possible adverse health effects of mobile phones has resulted in the production and use of devices that aim to reduce or block the radiation emitted by the handset and hence that absorbed by the user. There are two main categories: hands-free kits (HFKs), and shields and attachments.

## Hands-free kits

Great public confusion has been generated by the conflicting results of studies that have investigated these devices. Below we briefly outline the main findings from the studies:

- April 2000: UK Consumers' Association<sup>12</sup> reported that the earpiece wire on HFKs may act as an aerial, channelling three times as much radiation into the user's head. Recommendations included reducing mobile phone use, and ceasing use of HFKs.
- May 2000: The Stewart Report<sup>3</sup> concluded that there is insufficient published information about the measurement methods used in the research to date to form a clear view, and recommended that the Government establish a national system which enables independent testing of shielding devices and HFKs to be carried out, and allows clear information to be given about the effectiveness of these devices. A kite mark or equivalent should also be introduced.
- August 2000: Australian Consumers' Association<sup>14</sup> concluded that HFKs can reduce exposure to electromagnetic radiation. Recommendations included purchasing a HFK, avoidance of mobile phone contact with the body, and minimisation of phone usage.
- August 2000: The Department of Trade and Industry's (DTI) study<sup>15</sup> concluded that "in what would be considered their normal mode of use, personal hands-free kits offer very substantial reductions in SAR compared to the normal use of the phone against the head". With a kit in use, the maximum body absorption depends on where the phone is placed – SAR levels are reduced when the phone is placed with the keypad pointing towards the body. Recommendations to reduce exposure as a precautionary measure included letting the ear-piece cable hang down naturally from the ear, keeping the cable away from the phone's antenna and not placing the phone directly against the body.
- November 2000: Further UK Consumers' Association research<sup>16</sup> concluded that all HFKs they tested could lower the levels of radiofrequency emissions, but they could also increase them by anything from 50% to 250% (although still within the ICNIRP guidelines). This depends on the phone, the kit, the height of the user, and where the phone is positioned. In particular the distance between the handset and the earpiece was found to influence RF emission from the earpiece, although it is not possible for an individual to work out the best position to minimise the effect. The report noted that a potential solution to the higher level of emissions would be the fitting of a ferrite ring (metallic/ceramic compounds designed to absorb electromagnetic fields) on the HFK wire below the ear as this seems to reduce the levels of radiation measured in the ear. The report recommended that the Government devise a new standard for testing HFKs, and that the quantity and duration of calls be kept to a minimum whether a kit is used or not.

The DTI does not know for certain why the differing results have emerged, and plans to study the UK Consumers' Association methodology in more detail.<sup>53</sup> Differences in the methodology used in the different laboratories can go some way to explain the conflicting results, for example:

- i. There is no standard for testing HFks, hence the DTI and Australian Consumers' Association measured SAR, whilst the Consumers' Association measured electromagnetic emissions. The DTI argues that SAR is the rational and scientific way to proceed, and that emissions say little about absorption in the head which is the key health risk factor.
- ii. The UK Consumers' Association identified potential problems with the SAR test used by the DTI, including the rig hindering the wire from hanging straight down as it would in normal use and where their own tests identified the highest RF emissions, and potential problems with interference from other electrical systems in the environment (electromagnetic compatibility problems).

The Government considers that use of HFks is a matter of personal choice: the public has been supplied with relevant information so that they can make an informed choice, as recommended by the Stewart Report.<sup>3</sup> However, with no standard testing procedures or standards, and no regulatory requirements for the manufacturers of the HFk, the decision to use one, and which one to purchase is difficult to make. The DTI are "taking forward" the recommendation from the laboratory that conducted their research that the European CENELEC draft standard<sup>54</sup> for testing human exposure to EMFs should be developed for HFk measurement.

## **Shields and attachments**

Shields are cases or attachments for mobile phone handsets and their antennae that aim to reduce the exposure to electromagnetic emissions. The Stewart Report<sup>3</sup> concluded that in practice there would be very little reduction in the exposure received by most users through the use of a shield, and that all but one shield that they tested had no physical basis for their proposed effects. The Consumers' Association<sup>12</sup> concluded that although two of the three shields they tested did reduce emissions, this would result in the phones having to increase their power to maintain their RF signal to the base station. For this reason, phones' reception could be impaired when they were a long way from a base station or in buildings, cars, etc. The Stewart Report<sup>3</sup> predicted that widespread use of shields could have adverse effects on the environment since more base stations would need to be erected to maintain the quality of communication in phones whose optimum signals were reduced.

The Government has confirmed that research into shields and other absorption devices will be conducted. They do not recommend the use of any devices that have not been thoroughly and independently tested. The Federation of the Electronics Industry, the 'voice of the UK electronics industry' (FEI) states that it is a matter of consumer choice to use a HFk or shield. Devices which have not been approved by the mobile phone manufacturers for use with mobile phones, might impair the operating efficiency of the phone, so the FEI advises users to consult their dealer about suitable kits for their model of phone.

# The way forward

## The precautionary approach

The Stewart Report<sup>3</sup> concluded that the gaps in knowledge about radiofrequency radiation (RFR) and health are sufficient to justify a precautionary approach. The Government has accepted this need, and the BMA supports its adoption while scientific evidence remains inconclusive. In the meantime, the measures that Government, industry, consumers and the public can implement based on the best available scientific advice will be essentially voluntary.<sup>55</sup>

## Information for the public

The Department of Health has produced two informative leaflets for the general public about both mobile phones and base stations, available at the point of purchase. The provision of such information is a positive step. More information should also be provided by mobile phone manufacturers, for example, the power/radiation output from specific handsets. As our knowledge of the health effects increases, it will be important for the general public to understand the principles of risk assessment, that science can never provide a guarantee of zero risk but it may offer reassurance that risks are small in comparison with other risks in our lives. This will assist their interpretation of the data and evaluation of the facts. The BMA has previously addressed this issue in its policy report *The BMA Guide to Living with Risk*.<sup>56</sup>

Individuals using mobile phones who are concerned about the implications to their health and the health of others should take a precautionary approach to reduce their exposure to RFR as follows:

- Limit call duration
- Limit children's use of mobile phones
- Don't drive whilst using a mobile phone
- Show consideration to others

## Research

The BMA welcomes the international commitment to research into the possible adverse health effects of mobile phone technology, and particularly the contributions from UK organisations and academics. In addition to the extensive international research agenda into the current digital technology, research must be conducted to investigate potential adverse effects of third generation phones (covered in the Department of Health's research agenda), and whether models of handsets and masts can be designed to further minimise any potential risk. Research is also necessary to investigate any potential risks associated with text messaging, due to the different positioning of the handset during this activity, compared to using the handset conventionally.

## Interim recommendations

- The precautionary approach should be adopted while research remains inconclusive.
- The BMA supports the international commitment to research currently being conducted and planned into possible adverse health effects.
- The BMA endorses the Department of Health's policy to issue information on mobile phone technology direct to the public which should help them understand and assess the possible risks to their health.
- The Government should consider issuing guidelines for establishing 'quiet zones', restricting the use of mobile phones in some public places.
- Consideration should be given to introducing a standard test and kite mark for hands-free kits and shields.



- Mobile phone manufacturers should provide an indication of the power/radiation output from their handsets. We understand that a European standard is being established at present by CENELEC, with agreement forecast for mid 2001; the industry will subsequently utilise this measurement.
- Hospitals and other healthcare premises should issue guidance and use signs advising patients, visitors and staff to switch off their mobile phones in treatment/sensitive areas.
- The DETR should revisit its campaign about mobile phone use and driving indicating that a driver should not use **any** phone when driving – drivers should find a safe place to stop first.

### **Sources of further information**

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- Medical Devices Agency  
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