

Mobile Phones and Health – The Wishaw Papers

1 Introduction

The “Wishaw” papers relate to concerns raised by Eileen O’Connor about the possible health effects of exposure to radiofrequency (RF) radiation arising from the use of mobile phones. She would appear to be principally concerned about exposures to radiofrequencies (RF) from base stations and that this might result in an increased incidence of cancer in those living nearby. Other issues are also raised in the papers. The documents provided include scientific papers, reviews, laboratory reports and newspaper cuttings and were passed to the National Radiological Protection Board (NRPB) for comment.

Up to 1 April 2005, NRPB had a statutory responsibility to give formal advice to Government on protection standards for exposure to ionising and non-ionising radiation, including radiofrequencies from mobile phone technology. From that date this responsibility now falls to the Health Protection Agency (HPA) within which the NRPB has been subsumed as its Radiation Protection Division (RPD).

It became apparent on review of the papers that it would not be practicable or useful to comment in detail on every study or review provided; rather it is preferable to consider issues raised by the documents and the extent to which they have been or are being addressed. I do not comment specifically on media coverage although I do refer to the need to provide informed advice to the public. In order to provide a systematic response to the material provided, I have started with the more general issues then looked at some specific issues.

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Finally, an Appendix gives more detail on the ICNIRP exposure guidelines.

2 *Mobile Phones and Health 2000*

The papers provided include copies of the report on *Mobile Phones and Health* issued in 2000. I am very pleased that Eileen O’Connor sees this report as making an important contribution to how the mobile phone issue has been addressed. The Independent Expert Group on Mobile Phones (IEGMP), who produced the report, under the chairmanship of Sir William Stewart, was set up by NRPB at the request of the then Public Health Minister, Tessa Jowell. The terms of reference of the Group were:

to consider present concerns about the possible health effects from the use of mobile phones, base stations and transmitters, to conduct a rigorous assessment of existing research and to give advice based on the present state of knowledge. To make recommendations on further work which should be carried out to improve the basis for sound advice.

These recommendations were interpreted broadly by the Expert Group. The Stewart Report, published in May 2000, included a comprehensive review of the scientific information then available and a series of recommendations that were designed to provide much more information to the public about this developing technology and to address public health concerns. The IEGMP was very aware of public concerns about mobile communications technology as they had held open meetings in London, Edinburgh, Liverpool, Belfast and Cardiff, at which the public were invited to raise issues that they felt were important.

The 34 recommendations that were made in the report by IEGMP included suggestions for further research (Section 3) but advice was also given to Government, industry and others on how to address concerns that had been raised. The report was seen as a milestone in the way scientific issues related to public health are addressed and substantial progress has been made in addressing the majority of the recommendations.

A principal conclusion of the report was that:

the balance of evidence to date suggests that exposures to RF radiation below NRPB and ICNIRP guidelines do not cause adverse health effects to the general population (paragraph 1.17).

however, it was also noted that:

there is now scientific evidence, however, which suggests there may be biological effects occurring at exposures below these guidelines (paragraph 1.18).

The report, therefore, recommended a *precautionary approach* to the use of mobile phone technologies until much more detail and scientifically robust information on any health effects becomes available.

This conclusion is similar to many that are reached by authors in the Wishaw papers and is a recommendation that the Government accepted in response to the Stewart Report.

The Stewart Report specifically considered information related to concerns about exposures of the public to RF from base station antennas (masts). This is considered further below (Section 8).

The follow on to the Stewart report is discussed below (Section 4) .

3 Research

A number of the documents provided in the Wishaw papers are scientific publications on various areas of research. Some of these papers suggest that biological effects can occur at low levels of exposure. As mentioned above, this observation was also made in the Stewart Report and related to results from a number of studies. These included volunteer studies on effects of RF radiation on brain function, studies on the function of cells in culture as well as some experimental studies.

While it remains the case that a number of observations of effects at levels at around or below national and international guidelines levels are not yet explained, a number of studies that have tried to replicate those noted in the Stewart Report have not been successful. The Stewart Report particularly noted effects on brain function in studies carried out in the UK and in Scandinavia. Although the effects noted generally suggested an improvement in brain function there was an argument that any effect was of concern and needed to be understood. Since that report was published, however, there have been attempts to repeat the earlier studies but these have not been successful.

In the UK, the Mobile Telecommunications and Health Research (MTHR) Programme was set up by Government in response to the recommendation in the Stewart Report for further research. The Programme Management Committee of the MTHR programme has ensured that in any study

supported, the exposure assessment procedure is of the highest quality and that it is coupled with sound experimental design using standardised biological systems. The original MTHR programme, which commenced in 2001 and tackled the research agenda recommended in the Stewart Report, is now looking for a continuation of this programme. The Programme Management Committee has prepared a well-focussed research programme and it is hoped that further funding will come from Government and industry to support its continuation.

Recent reviews by NRPB in 2004 and by AGNIR in 2003 have also stressed the need for research to continue. Whilst the evidence available to date does not suggest any significant health risk from exposure to RF radiation below guideline levels, the application of RF for communications has been a very rapidly expanding technology with very large numbers of people exposed and so far with limited follow up.

The papers include a report of a study in Holland by Zwamborn et al (2003) suggesting possible effects on well being and cognitive function resulting from exposure to signals from third-generation, 3G, mobile phone base stations. The study has some limitations and further work in this area is needed. (AGNIR 2003, NRPB 2004). The Stewart Report had, however, previously identified the need for research on brain function and this is being taken forward through the MTHR programme.

Another series of studies quoted in the Stewart Report related to the effect of RF on nematode worms in culture. Some of the relevant papers are also included in the Wishaw papers. It was reported that these animals were particularly sensitive to RF radiation and that effects noted could not be attributed to heating. Following further work funded under the MTHR programme with a more rigorous experimental design the principal author of the papers has identified problems with the original experimental design and it now seems that the initial effects were in fact the result of heating, albeit to a small extent.

The Wishaw papers include a summary of work on exposure to EMFs that is being co-ordinated through the World Health Organization (WHO). Research in this area will continue to be essential for sometime and it is important that it is well co-ordinated so that research carried out in various countries is complementary. WHO plays a key role in this co-ordination and has worked hard to organise workshops on particular topics within the framework of its programme.

4 Reviews of Research

In examining the health effects of exposure to RF electromagnetic fields, it is important to take into account the totality of the science and not just consider specific studies that suggest there may be some effect. It is in this context that many groups, world-wide, having reviewed studies reporting effects that might have implications for health, stressed that it is essential such studies are replicated. Whilst there are suggestions in some of the Wishaw papers that there is no need to replicate such studies, this is not a sustainable position for systematic and authoritative reviews. It is vital that improvements in experimental design that have been made over recent years are continued and that good quality research is carried out, if necessary replicating both positive and negative findings that may relate to a better understanding of any health effects stemming from the existing body of evidence.

The Stewart Report in 2000 had recommended that there should be a further review of the science in 3 years time, or earlier if circumstances demanded it. The Government asked NRPB to carry this out and the Board of NRPB asked for this to be undertaken by the independent Advisory Group on Non-ionising Radiation. The report by AGNIR was issued in the *Documents of NRPB* in the 2003 volume. It concluded that:

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 exposure 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.

The Board of NRPB detailed the response to the Stewart Report recommendations in a report on *Mobile Phones and Health 2004*. That report, issued in January 2005, sought to provide further advice to address remaining public concerns about mobile phone technology as well as related technological developments. It also reviewed progress on implementing the recommendations in the Stewart Report. The report can be found on the web site of the Health Protection Agency (http://www.hpa.org.uk/radiation/publications/documents_of_nrpb/).

The subsequent report by the Board of NRPB on *Mobile Phones and Health 2004* emphasised that:

there is a lack of hard information showing that the mobile phones systems in use are damaging to health.

Nevertheless, a number of outstanding issues were identified for further work and it was stressed that this is a new technology being used by large numbers of people. The Board believed that the main conclusion reached in the Stewart report in 2000 still apply and that a precautionary approach to the use of mobile phone technologies should continue to be adopted.

The report included summaries of recent reviews carried out by Groups in the Netherlands, Switzerland, USA, Sweden, the Nordic Authorities and by the WHO. The main conclusions on the potential for health effects from exposure to RF from mobile phones and base stations in all these reports are little different from the Stewart Report in 2000, the AGNIR Report of 2003 and the NRPB Board report in 2004.

5 Exposure Guidelines

Up to 1 April 2005 the NRPB had the responsibility for advising the UK Government on standards of protection for exposure to non-ionising radiations, including radiowaves from the use of mobile telecommunications systems. Following the publication of the Stewart Report the NRPB was asked by the Department of Health to review its advice on exposure guidelines for exposure to EMFs. The review particularly examined the issues of uncertainty in the science and aspects of precaution. NRPB staff conducted a comprehensive review of the published literature. They also undertook an extensive consultation exercise involving national and international experts, held an open meeting for the public and published a consultation draft on the NRPB web site. Formal advice, published in May 2004 was that the UK should adopt the exposure guidelines recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). Exposure guidelines for workers recommended by ICNIRP are similar to those previously recommended by NRPB in 1993 but the guidelines recommend lower exposures for the public, by a factor of about 5. At radiofrequencies this is to reflect the potentially greater sensitivity to heating effects in members of the public than people who are occupationally exposed.

The then Minister for Public Health, Melanie Johnson, welcomed this new advice (22 July 2004).

6 ICNIRP Guidelines

The ICNIRP guidelines for limiting exposure of people to electromagnetic fields (EMF) are intended to provide a framework for a system of protection by recommending:

- Limits on exposure, termed basic restrictions, to avoid the adverse health consequences of exposure
- Other measures for reducing the risk of adverse effects

In addition, ICNIRP provides reference levels. These are expressed as field and electric current quantities in order to enable the investigation of compliance with the basic restrictions in specific practical exposure situations. ICNIRP's advice has not been prescriptive with regard to setting field

limits. This allows the health and safety professional to use the most up-to-date measurement and computational techniques in assessing compliance with ICNIRP's recommended basic restrictions. This system has proved effective in practice and has been adopted by a number of national advisory bodies.

The principles and the methodology by which ICNIRP develops its advice on limiting exposure to EMFs is published (ICNIRP 2002) and the guidelines are summarised in Appendix A.

The Wishaw papers include reference to the ICNIRP guidelines and comment critically on their basis, which for RF radiation are developed to prevent damage from heating due to whole or partial body exposure.

ICNIRP's exposure guidelines derive from extensive reviews of the science, including consideration of uncertainties in the scientific data, carried out in partnership with the World Health Organization. Its advice on exposure restrictions requires judgements to be made by experts covering the different scientific disciplines involved. Much of this work is carried out by ICNIRP's four Scientific Standing Committees and in consultation with other experts, often through scientific seminars and workshops.

In practical terms this ultimately requires judgements to delineate between those adverse health effects that can be considered as having been demonstrated to be caused by exposure to EMFs and where supporting scientific data are sufficient to be able to quantify appropriate basic restrictions on exposure, and those adverse effects that can be considered as having been demonstrated as being associated with EMF exposure but where the scientific data are insufficient to make a judgement on causality nor to quantify appropriate basic restrictions on exposure.

In common with other expert bodies, ICNIRP has concluded that there are scientific data that demonstrate the need to prevent adverse health effects of heating caused by exposure to RF – either whole or partial body. The nature of these effects and the underlying mechanisms are well understood and the quantitative limits on exposure (basic restrictions) advised by ICNIRP are derived from data on these effects.

Knowledge of effects associated with RF exposure, but where the scientific data are insufficient to make a judgement on causality nor to quantify appropriate exposure restrictions, derive principally from epidemiological studies and from some experimental studies. The main, but not sole, subject of such studies has been cancer. The results of such studies have been reviewed extensively by international and national expert groups. ICNIRP has concluded that currently the results of these studies on RF and health, taken individually or collectively are insufficient to derive quantitative basic restrictions on exposure to EMFs (ICNIRP 2001). They do however provide a pointer to the need to consider further aspects of precaution with regard to RF exposure and the need for additional research.

The ICNIRP guidelines have been accepted by many countries in Europe and world-wide. The Wishaw papers refer to different approaches from a number of other countries. The limits on exposure to environmental RF issued by Italy, Switzerland, Belgium and some other countries are more restrictive than ICNIRP. What is unclear, however, is the scientific rationale for the choice of the limiting values and how they work in practice. From consideration of the Italian law and regulations it is clear that the framework law is based on matters other than the scientific evidence in that it refers to the Precautionary Principle and environment and landscape protection. Such approaches do not consistently draw on the scientific evidence for adverse health effects. The independent reviews in the UK have not recommended arbitrary reductions to the exposure guidelines.

The mobile phone systems used throughout most of the world are based upon essentially the same technology. Exposures from base stations or from the use of phones would be expected to be very similar in any country in which a service is provided.

7 Electromagnetic Sensitivity

The issue of sensitivity to exposure to EMFs has been frequently raised, and is the subject of a number of the Wishaw papers. As described in the papers, the symptoms that are reported to arise in some individuals exposed to RFs include skin problems, headache, sleep disruption, nausea, dizziness, depression, discomfort and visual disruptions. Similar concerns were also raised at the open meetings held by the Stewart Group in 1999/2000 and this was also raised with NRPB during an open consultation on its advice on exposure guidelines for EMFs in 2003.

The subject was also examined in the NRPB Board report on Mobile Phones and Health 2004. Although no firm conclusions were drawn it was considered that the issue of electromagnetic sensitivity needs to be carefully examined in the UK. The Board also supported the strengthening of work designed to understand the reasons for this reported sensitivity in some people. It noted that electromagnetic sensitivity is being addressed in the MTHR research programme and that NRPB has commissioned a review of the subject, which will be published during 2005.

8 Base Stations

The Independent Expert Group on Mobile Phones (IEGMP, 2000) considered exposures from base stations (masts). Its principle conclusion was that:

we conclude that 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 adverse effects on their well-being in some cases (paragraph 1.33).

In coming to its conclusions about exposures from base stations, the IEGMP drew on the results of the then fairly limited number of measurements that have been made by a number of bodies including those made by the National Radiological Protection Board (NRPB). This evidence was published by NRPB in June 2001 (NRPB-R321) – *Exposure to Radio Waves near Mobile Phone Base Stations* (S Mann et al). Measurements had been made at 118 locations at which members of the public would have access around 17 base stations. Exposures were in all cases small fractions of guidelines. The maximum exposure at any location was 0.18% of the international reference level for the public recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) whilst the average level of exposure was about 0.002%.

A recommendation in the report was that there should be an independent random, ongoing audit of all base stations to ensure that guidelines are not being exceeded. The Radiocommunications Agency (now Ofcom) has undertaken this task and up to the end of 2004 about 450 base stations had been surveyed. In all cases exposures of the public in situations where they may have access were very small fractions of guidelines. Similar conclusions have been found for measurements of about 60 base stations that have now been made by NRPB (now RPD of the HPA). In addition many European countries now have a measurement programme. Results are consistent with measurements undertaken in the UK. These measurements support the conclusions of the Expert Group in 2000. Information on some of these surveys is given on the HPA web site (www.hpa.org.uk/radiation).

As indicated above, IEGMP was concerned that as a result of concerns about base stations there could be indirect adverse effects on people's well-being in some cases. In particular they considered that it was important to provide much better information to the public about this developing technology and in particular about the siting of base stations. Changes in planning guidance, the provision of leaflets from the Department of Health and a number of other measures detailed in the *Mobile Phones and Health 2004* report illustrate how this has been approached by Government and others.

The 2004 report also noted that whilst the Ofcom web site does provide "Sitefinder", that allows people to find out about base stations in their area, and the results of the base station audit the

details provided are difficult to access. It was recommended that information on the web site should be much more readily accessible, easily interpretable by members of the public, and kept up to date.

It was also recommended that it is timely for there to be set in place a much clearer and more readily understandable template of protocols and procedures for local authorities and phone operators to follow. This should aim to address continuing public concerns about the planning process.

9 Terrestrial Trunked Radio (TETRA)

A number of the Wishaw papers refer to TETRA systems that are emergency service radios primarily being deployed for use by the police. The main concern raised has been that the signals from the base stations are pulsed and that this may cause adverse health effects.

The Stewart Report provided some information on Terrestrial Trunked Radio (TETRA) and separately noted some contradictory results when examining the biological effects of radiofrequency emissions which are pulsed at or near a frequency of 16 Hz. In practice TETRA operates at 17.6 Hz. While no obvious health effect was suggested a precautionary approach was recommended.

Following a request to the National Radiological Protection Board (NRPB) by the Home Office, the issue of possible health effects caused by exposure to signals from TETRA base stations was comprehensively addressed in a report by the AGNIR. The report was published in 2001 on the NRPB web site (www.nrpb.org). A supplementary report was also issued in November that gave more details on TETRA signals. The full report has been published in the *Documents of the NRPB* (*Doc NRPB, 12(2), 2001*). The report notes that the signals from TETRA base stations are not pulsed whereas those from the mobile terminals (handsets) and repeaters (mounted on vehicles) are.

There is, therefore, no reason to believe that signals from TETRA base stations should be treated any differently from other base stations. In the NRPB *Mobile Phones and Health 2004* report the Board of NRPB recommended that:

until much more information becomes available the Board considers that it would be premature to rule out the possibility of health effects on users of TETRA based equipment and believes that a precautionary approach should be adopted.

Research on TETRA is being supported through the MTHR programme and by the Home Office.

10 Powerlines

A number of the Wishaw papers refer to potential effects from exposure to extremely low frequency (ELF) electric and magnetic fields (EMFs) from powerlines (50 Hz in the UK). These additional papers are not appropriate for consideration in the context of exposure to RF as the interaction of EMFs with the body depends critically upon the frequency and wavelength. These papers are therefore discussed only briefly.

Some papers refer to work related to the possibility that ELF EMFs might cause Alzheimer's disease, breast cancer or motorneurone disease. A report was issued by NRPB in 2001 that considered ELF electromagnetic fields and neurodegenerative disease (*Doc NRPB, 12(4), 2001*). That report concluded that there are no good grounds for thinking that exposure to ELF EMFs can cause Parkinson's disease and only very weak evidence suggests that it could be a cause of Alzheimer's disease. The evidence of people employed in electrical occupations having an increase risk of developing amyotrophic lateral sclerosis is substantially stronger but this could be because they run an increased risk of having an electric shock rather than any effect of long-term exposure to the fields *per se*.

11 Melatonin and Breast Cancer

A number of papers referred to the possible health implications of changes in melatonin secretion caused by exposure to EMFs. The majority of these papers relate to exposure to ELF electric and magnetic fields from powerlines. It should be noted that a Sub-Group of the AGNIR is bringing to a close a comprehensive review on this topic. The report should be published before the end of 2005.

12 NRPB Income and Role

The NRPB, now RPD of the HPA, is an independent body with a remit to give advice on protection standards for ionising and non-ionising radiations. It also carries out research to underpin this advice and provides commercial services for which it can make a charge. A number of the Wishaw papers refer to the work of NRPB and the sources of funding.

In 2003/04 about 40% of the income of NRPB came as core funding from the Department of Health, with a contribution from the Scottish Executive. Some campaigners have claimed that much of the remainder was a direct grant from the mobile phone industry. This is incorrect. The remainder came from carrying out contract research and providing technical services and training courses in relation to both ionising and non-ionising radiation. Included in services work are surveys of base stations carried out for local authorities, schools or other organisations. Surveys are not carried out for the mobile phone industry. Some research is carried out in conjunction with industry in relation to understanding how telecommunications equipment functions, particularly in relation to new and developing technologies. This allows the organisation to be in a position to comment on new equipment that comes onto the market and is an essential element of horizon scanning that must be undertaken by an advisory body. The total income received directly from the mobile phone industry has never exceeded 1% of the total annual budget. The NRPB now the RPD of the HPA has not, and will not act as a representative of the mobile phone industry in any forum.

Conclusion

The Wishaw papers provide an interesting collection of scientific papers and other publications relevant to concerns about possible effects of radiowaves from mobile phone technology on human health. The issues raised by the papers have generally been addressed in other publications, including the Stewart Report in 2000 and the NRPB Board report in 2004 as well as by many other national and international organisations. In assessing the potential effects of radiowaves on health, it is important to consider the totality of the information available. In the most recent 2004 report the NRPB Board concluded that there is a lack of hard information showing that the mobile phone systems in use are damaging to health. They emphasise this crucial point.

However, the 2004 report also noted studies that do suggest there could be possible effects on health of exposure to radiowaves from mobile phones and that it is not possible at present to say that exposures to radiofrequency radiation (RF), even at levels below national guidelines is totally without potential adverse health effects and that the gaps in knowledge are sufficient to justify a precautionary approach. The research programme in the UK funded principally through the MTHR programme, has set the standard for independent high quality health related research on RF exposure and the Board recommended that Government and industry should continue to provide support for a continuation of the programme.

There remain concerns about possible health effects of exposure to RF fields from base stations although measurements have demonstrated that exposures of the public, in normally accessible locations, are very small fractions of guidelines and should not cause any direct effects on health. It is clear though that some people are concerned about exposures, that this can affect their well-being, and that these are important issues that need to be addressed. The Board has recommended that information provided to the public should be made much more readily accessible, easily interpretable by members of the public, and kept up-to-date.

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References

- AGNIR (2001a). Possible health effects from terrestrial trunked radio (TETRA). Report of an independent Advisory Group on Non-ionising Radiation. *Doc NRPB*, **12**(2), 5–86.
- AGNIR (2001b). ELF electromagnetic fields and neurodegenerative disease. Report of an independent Advisory Group on Non-ionising Radiation. *Doc NRPB*, **12**(4), 5–24.
- AGNIR (2003). Health effects from radiofrequency electromagnetic fields. Report of an independent Advisory Group on Non-ionising Radiation. *Doc NRPB*, **14**(2), 5–177.
- ICNIRP (2002). International Commission on Non-Ionizing Radiation Protection. General approach to protection against non-ionizing radiation. *Health Phys*, **82**, 540–8.
- IEGMP (2000). Mobile phones and health. Report of an Independent Expert Group on Mobile Phones. The report is also available on the Expert Group website: www.iegmp.org.uk.
- NRPB (1993). Restrictions on human exposure to static and time varying electromagnetic fields and radiation: scientific basis and recommendations for the implementation of the Board's Statement. *Doc NRPB*, **4**(5), 7–63.
- NRPB (2004). Mobile phones and health 2004. *Doc NRPB*, **15**(5), 5–114.
- NRPB (2004). Advice on limiting exposure to electromagnetic fields (0-300 GHz). *Doc NRPB*, **15**(2), 1–35.
- NRPB (2004). Review of the scientific evidence for limiting exposure to electromagnetic fields (0-300 GHz). *Doc NRPB*, **15**(3), 3–215.

Appendix A

Radiofrequency fields (100 kHz-300 GHz)

There are well documented biological effects linked to excessive temperature elevation in this frequency range. Such effects have been observed from exposure to radiofrequency (RF) radiation resulting from whole body or local heating. Compliance with the basic restrictions will prevent harmful effects due to heating, electric shocks and radiofrequency RF burns. In establishing its exposure guidelines, ICNIRP (1998) reviewed the scientific literature on observed short-term as well as long-term biological effects including those relevant to cancer.

Basic restrictions

In the frequency range 100 kHz to 10 GHz, the basic restrictions on exposure are specific in terms of limiting whole body or partial body specific energy absorption rate (SAR). The basic restriction of the whole-body SAR of 0.4 W kg^{-1} provides adequate protection for occupational exposure. An additional reduction factor of 5 is applied for the general public. Localised SAR restrictions of 10 W kg^{-1} and 2 W kg^{-1} for occupational and public exposure, respectively have been chosen, to be averaged over any 6 minute interval and any 10 g of contiguous tissue of head and trunk. However, it should be noted that in the frequency range 100 kHz to 10 MHz restrictions on both SAR and induced current density apply (ICNIRP 1998).

For the frequency range 10 to 300 GHz, the basic restrictions are set out in terms of power density in the unit watt per square metre to prevent excessive heating in tissue at or near the body surface.

Special considerations

Special consideration should be given to the protection of people having an implanted medical device.

The sensitivity of a person to burns and shocks associated with radiofrequency radiation depends on the sensitivity of the involved part of the body and personal characteristics including the age and sex of the person. For occupational exposure, protective measures such as wearing protective shoes or gloves can prevent excessive contact currents.

For special exposure conditions, for example working with RF dielectric heaters and sealers, limits of exposure for limb currents are provided in (ICNIRP/WHO/ILO 1998).

Reference

ICNIRP 1998. International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time varying electric, magnetic, and electromagnetic fields (up to 300 GHz). *Health Phys*, **74**, 494–522.

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