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# HEALTH HAZARDS FROM EXPOSURE TO MICROWAVES

*Report on an Evaluation Group convened by the Regional Office for Europe of the World Health Organization,* Copenhagen, 22–23 October 1973*

## 1. Introduction

Within the framework of its long-term programme in environmental pollution control, the WHO Regional Office for Europe convened an Evaluation Group in Copenhagen on 22 and 23 October 1973 to discuss the sector of non-ionizing radiation (NIR).

An earlier Working Group held in The Hague in November 1971 had recommended, *inter alia*, that the protection of man against health hazards arising from microwave radiation should be considered a priority activity in the field of NIR protection. The biologic effects and health hazards of microwave radiation were discussed in detail at an International Symposium on this subject, organized jointly by the Polish Government, the United States Government and WHO and held in Jadwisin, near Warsaw, Poland, from 15 to 18 October 1973. Over 50 scientists from 12 countries and representatives from 5 international organizations attended the Symposium. Thirty-nine papers were presented which covered the biologic effects and health applications of microwave exposure. Of these papers, nine were related to the physiopathology of the central nervous and neuroendocrine systems and seven each to epidemiologic surveys and energy absorption/measurement techniques. Other subjects referred to included cellular and molecular biophysics (5), ocular effects (4), thermal regulation (3), mammalian development (1), combined effects (1) and applications (2). The Proceedings of this Symposium will be published in 1974 by the co-sponsors.

The objective of the Evaluation Group, which immediately followed the International Symposium, was to discuss and analyse the papers presented at the Symposium, the deliberations that followed and the conclusions that were drawn, in order to advise the WHO Regional Office for Europe on measures which the Office could undertake for determining and reducing the risks to public health from microwave radiation.† A summary of the recommended activities and a list of participants are given in Annexes I and II respectively.

The Evaluation Group also discussed other aspects of exposure to microwaves, such as electromagnetic compatibility (EMC), as exemplified by interference between microwave energy and electronic life support and prosthetic devices (i.e. implanted cardiac pacemakers), and the differentiation between personnel exposure and product performance standards. In formulating its recommendations, the Group recognized that the Regional Office may be bound by certain constraints and that not all the suggestions put forward can be implemented by the Office. The Group felt, however, that the present situation is such that continuous study and surveillance of the literature, frequent discussions and constant vigilance are necessary in view of the continuing development and proliferation of microwave and radiofrequency generators on an international level. This is especially important from the public health point of view, since the mechanisms of biologic effects and public health aspects of microwave and radiofrequency exposure are not completely understood. Finally, the Group wished to draw attention to the fact that the measurement of microwave fields is complicated and from the public health point of view is still in a developmental stage.

## 2. Exchange of Information

Already before the International Symposium took place it was known that several groups in various parts of the world were working on both the physical and the biologic aspects of the effects of microwave radiation from the public health point of view. It was evident, however, that there had not been sufficient communication between these groups and a full understanding of the results and their implications was not always possible. The Symposium was thus an important step forward in increasing international contacts in this field.

The Evaluation Group recommended that WHO should be active in promoting such contacts and communication. This could, in part, be achieved by means of the measures suggested in the following sections. Furthermore, the establishment of such contacts should have very high priority in the work of WHO.

The Group considered it advisable that WHO should take the initiative by convening another interdisciplinary symposium as soon as was reasonably

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† The Evaluation Group restricted its discussion to microwaves (300 GHz–300 MHz) and radiofrequency radiation.

possible (at least within the next 2 yr) in order to present the general problems in this field and to introduce new data and concepts arrived at by laboratories involved in these studies.

### 3. Standardization of Nomenclature

In discussions concerning the biologic effects and health implications of exposure to microwave and radiofrequency energies, numerous uncertainties become evident, largely resulting from linguistic difficulties encountered not only in translating specific words but also in conveying shades of meaning. This concerns not only the description of effects and organism response but also the medical terminology, techniques and criteria used in assessing the physiopathologic reaction of the body. It is important, therefore, that the terminology and definitions used by different countries should be understood and agreed upon. The Evaluation Group felt that the WHO Regional Office for Europe was in a unique position to serve as the centre for establishing such uniformity.

### 4. Survey of Biologic Effects

A recurrent theme in the literature on biologic effects, as well as in the presentations and discussions at the International Symposium, is the fundamental question whether injury from microwave and radiofrequency exposures is a threshold response, as opposed to a possible non-threshold manifestation of transient biologic danger. Linked with the threshold phenomenon are such considerations as multiple injury, recovery, cumulative long-term and possible delayed effects. If injury from microwave and radiofrequency exposure is a threshold phenomenon, then the problem of setting realistic protection standards that are globally compatible and acceptable is greatly simplified.

It was the opinion of the Evaluation Group that the available literature should be carefully surveyed and analysed for data concerning threshold phenomena; this survey should incorporate conceptual considerations relevant to the elucidation of such reactions in relation to injury. If it should prove that the available data does not permit a definitive evaluation of the phenomena, a working group could make recommendations for appropriate biologic investigations to ascertain the absence or presence of threshold responses.

### 5. Interaction Between Physical, Engineering and Biologic Scientists

The International Symposium provided an excellent milieu for formal and informal dialogue among physical, engineering and biologic scientists. The importance of such interaction cannot be overemphasized. Appropriate and meaningful test procedures which include field measurements and animal exposure as well as analysis of experimental results require close collaboration between physical and biologic scientists within the same investigation team.

It is recommended, therefore, that the Regional Office continue to foster exchanges and interaction between physical and biologic scientists from different laboratories and institutions. This could be implemented through a fellowships programme.

### 6. Promotion of the Development and Standardization of Dosimetry and Measuring Instruments

At the International Symposium about one-fifth of the papers were devoted to the problems of energy absorption, distribution and measurement. The authors of these papers were generally in complete agreement that the problems of measurement, both of the incident field and of the energy absorption, were multiple and that the requirements for significant biologic measurement could only be fulfilled to a small extent. This is in contrast to measurements in physical experiments, where precise and reproducible conditions can be selected.

The Evaluation Group discussed the problems involved in this area and suggested that WHO should attempt to promote a number of measures aimed at normalizing the measurement methods used by groups working in this field. In addition, WHO could develop standards for the measurement of microwave and radiofrequency fields and of the energy absorption, this being of significance for biology and public health.

The Group suggested the convening of a small working group of some 6–8 specialists working in this field to discuss the available instruments which permit the measurement of complex microwave fields, to evaluate the instruments and to give standardized descriptions of their selection and proper use, including calibration, standardization and comparison of calibrations.

Furthermore, the Group advised that WHO should convene a working group with a limited number of participants to discuss the problems of instrumentation that permits the measuring of microwave fields in biologic objects, both *in vitro* and *in vivo*. This group would also be expected to give a standardized description of the mode of operation when experimental material is radiated by microwaves or subjected to radiofrequency radiation.

### 7. The Evaluation of Ambient Electromagnetic Fields

The Evaluation Group was concerned at the lack of knowledge regarding the fields of electromagnetic radiation to which members of the general public are exposed, particularly in urban areas but also in certain rural areas.

These microwave and radiofrequency fields will be built up by a steadily increasing number of types of appliances in industrial places of work, and in the home. Insufficient knowledge regarding the size and distribution of the field is, however, partly due to the inadequacy of available measuring devices, as mentioned in the previous section.

There is some doubt whether low-frequency, long-wavelength radiation may have special public health significance. The Group suggests that WHO should take steps to ensure that measurements of this type are carried out and evaluated, that such evaluation is kept under constant surveillance and that the reason for any increase is identified. This could be done partly by a consultant who would collect and analyse existing information on field strength and on the development and incidence of use of microwave-emitting devices.

At a later date, if the ambient field is increasing, it may be appropriate to convene a working group to discuss what steps should be taken to reduce this field if the increase appears to be of significance for public health.

### 8. Establishment of Criteria for Epidemiologic Surveys

Epidemiologic studies have in the past found effects without establishing a clear indication of the actual levels of microwave or radiofrequency exposure responsible for these effects. This has resulted in widespread uncertainty concerning the microwave and radiofrequency exposure levels that are safe for man. The relative interest in and importance of epidemiologic studies can be appreciated by the fact that about one-fifth of the papers presented at the International Symposium dealt with this subject.

In view of the limited populations at risk, and the ill-defined endpoints, epidemiologic surveys have to be approached with extreme caution. Epidemiologic surveys are expensive and may have a low productivity, yet they can be of considerable use in assessing hazards to man from exposure to microwave and radiofrequency energy. It was recommended that a small working group, including epidemiologists and statisticians, should be convened to identify populations at risk and compare them with appropriate and compatible controls. Careful consideration should be given to the size and distribution of these populations and the possibility of appropriate dosimetry. The working group should make recommendations regarding the study procedures and criteria to be utilized and the appropriate statistical examination and analysis of the data.

### 9. Protection Guides and Standards

It should be remembered that two quite different standards will be under consideration: the personal exposure standard and the product performance standard of the microwave-emitting instruments.

#### 9.1 *Personal exposure standards*

Protection guides and standards have been recommended or introduced into the legislation in various parts of the world. There is, however, a lack of uniformity and, in many cases, either misinterpretation or a lack of understanding of some of these standards. Whereas in the field of ionizing radiations such groups as the ICRP and the ICRU have effectively brought order and agreement into the field on an international scale, this is not true with regard to microwave and radiofrequency exposure. At its last meeting in Washington, D.C. in September 1973, the IRPA gave consideration to NIR as part of its programme.

The Evaluation Group recommended that co-ordination of microwave protection guides and standards should be fostered; in this the Regional Office could play an important role.

#### 9.2 *Product performance standards*

Because increasing numbers of microwave-emitting devices are being used for industrial application (drying ovens) and commercial as well as consumer use (food preparation) it is essential that the amount of permissible leakage from these units be kept down to levels that are not injurious. Product performance standards to ensure such safety have already been established in some countries. Other countries, however, have not established official standards, but a number of non-governmental standards exist. The Group recommended that the Regional Office should undertake a survey of product performance standards for microwave-emitting devices, with a view to achieving consistency with personal exposure standards and standardization, whether official or non-governmental.

#### 9.3 *Compatibility between microwave radiation and medical electronic equipment*

The Evaluation Group was concerned with the problem of the compatibility of electromagnetic fields from microwaves and related radiations and electronic devices now used in medicine, in some cases after implantation. The foremost instrument in this

respect is the implantable electronic cardiac pacemaker, but other lifesaving devices can be visualized. The number of persons using these devices will in a few years probably amount to between 200,000 and 300,000, which would make the problem a very significant one.

It is known that shielding of the unit to some extent prevents this interference. Wires outside the shielding can, however, act as antennae, but the introduction of by-pass filters has minimized this interference.

The Group recommended that WHO should convene a small working group to study this problem, to determine the maximum permissible size of electromagnetic fields that will not interfere with the proper use of these devices and to make suggestions for improving such instruments.

### 9.4 *The significance of diathermy*

The Evaluation Group discussed the widespread use of diathermy, including diathermy for diseases in the head region. Taking into consideration the papers presented at the International Symposium describing changes in both lens and retina following occupational microwave exposure, the Group felt that WHO should take steps to evaluate the risk/benefit relation of this type of treatment.

The Group suggested that WHO should convene a working group, including specialists in physical medicine, ophthalmologists and neurologists, to evaluate the risks involved in this connexion and to make suggestions on whether an epidemiologic survey of groups of patients exposed to high levels of microwaves or other electromagnetic radiations could contribute to knowledge concerning the tolerance level of the human eye and brain.

## 10. Training Programmes

The International Symposium having clearly demonstrated the difficulties in measuring field strengths and in evaluating other physical and biologic parameters, the Evaluation Group agreed that some type of training programme in the public health evaluation of microwave and radiofrequency radiation was urgently needed. Since most of those responsible for the public health aspects would be conversant with the problems of measuring ionizing radiation, it was felt that the differences were so large that an education programme was a necessity in order to avoid mistakes due to the unfamiliar physical situation that pertains to measurements of electromagnetic fields.

The Group therefore recommended that WHO should set up a course for health physicists and public health personnel responsible for the evaluation of microwaves and radiofrequency radiation. Such a course should make the participants conversant with the physical, biologic and regulatory aspects of the problem.

## Annex I

*Summary of recommended activities*

1. *Symposium on microwave biophysics, biology and potential health hazards*

The subject matter in general and the new work and concepts in particular should be presented to a larger group of scientific, technical and public health workers.

2. *Standardization of nomenclature*

The terminology and definitions used in different countries should be compared and standardized:

(a) directly, through a consultant study;

(b) indirectly, through co-operation with reference centres or international organizations concerned.

3. *Survey of biologic effects*

The available data concerning the acceptance or rejection of threshold phenomena should be surveyed and evaluated and suggestions made for further activities on this subject (2–3 consultants and a working group).

4. *Interaction between physical, engineering and biologic scientists*

This interaction should be promoted by means of a fellowships programme.

5. *Measurement of complex microwave fields*

The available instruments which permit the measurement of such fields should be discussed and evaluated. A standard description for selection and use should be given, including calibration and suggestions for international comparison of calibration (a working group).

6. *Instrumentation for measuring microwave fields in biologic objects*

Instrumentation for such measurement *in vitro* and *in vivo* should be discussed and a standardized description given of the mode of operation when experimental material is radiated (a working group).

7. *Evaluation of ambient electromagnetic fields*

The measurement of such fields should be encouraged and the results surveyed and evaluated. The reason for any increase should be identified (a consultant study, followed, if any serious increase is found, by a working group).

8. *Epidemiologic studies*

Epidemiological studies of microwave exposure and possible pathologic effects should be promoted by identifying appropriate groups at risk and by determining study procedures (a working group).

9. *Protection guides and standards*

Co-ordination in the setting-up of protection guides and standards, at present lacking, should be encouraged (a working group).

10. *Product performance standards*

Existing product performance standards (or guidelines) for microwave-emitting devices should be surveyed with a view to achieving consistency with personal exposure standards (a consultant study and a working group).

11. *Compatibility between microwave radiation and medical electronic equipment*

The levels of electromagnetic fields that are compatible with the safe functioning of medical electronic devices should be studied and evaluated and suggestions made regarding possible improvements to such devices (a working group).

12. *The significance of diathermy*

The risk from certain types of diathermy should be evaluated and suggestions made as to whether an epidemiologic survey of such patients could contribute to the existing knowledge (a working group).

13. *Training programme*

A course for health physicists and public health personnel should be set up to make them conversant with the field (a course with up to 20 participants, to be repeated every 2 yr, if necessary).

## Annex II

*List of participants*

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*Note*—This report has been prepared by the Regional Office for Europe of the World Health Organization for distribution to the governments of Member States in the Region and to all those who participated in the Evaluation Group, Copenhagen, and the International Symposium on Microwave Radiation, Poland. A limited number of copies are available for persons officially or professionally concerned with this field of study from the WHO Regional Office for Europe, Copenhagen.

The views expressed are those of participants in the Evaluation Group and do not necessarily reflect the policy of the World Health Organization.

The designations employed and the presentation of the material do not imply the expression of any opinion whatsoever on the part of the Director-General of the World Health Organization concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.