

A PROGRAMME ON NON-IONIZING RADIATION PROTECTION OF THE
WORLD HEALTH ORGANIZATION REGIONAL OFFICE FOR EUROPE

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Abstract

Increased and wider attention is being paid at present to a relatively new physical hazard, namely, non-ionizing radiation (NIR), arising from different devices. To promote the study of the health effects from NIR the WHO Regional Office for Europe has developed, within its long-term programme on environmental pollution control, a sector programme on NIR with activities extending to the year 1979. The mode of action for the control of NIR and the programme's priorities are based on the recommendations of a Working Group convened by this Office in November 1971.

Non-ionizing Radiation

During recent years there has been an increased development and use of equipment which can produce a number of types of radiation which may be hazardous both to the user and to the general public if necessary precautions are not taken, especially when large quantities of energy are being transmitted. None of these radiations can, after absorption, transmit enough energy to produce ion pairs, as is the case with the ionizing radiations. Free radical formation has been observed after exposure to ultrasound, and photochemical effects may be observed after exposure to ultraviolet radiation, but in most cases the energy absorption tends to be manifest in the form of heat. The differences in modes of production and in areas of use are, however, so great that it is necessary to discuss each type of radiation separately. The differences in energy even within a single type of radiation are of particular importance for the evaluation of the hazards from exposure to NIR. The ability to penetrate into the human body and the places of absorption of the radiation will depend on this characteristic and will differ from one type of radiation to another.

The NIR devices are finding an ever increasing use in industry, engineering, telecommunication, medicine, research, education, and by the general public. This gives rise to a number of questions:

- How serious are the problems linked with NIR, what are their dimensions and what acute and/or chronic effects on the human body are involved?
- How adequate is our present knowledge about occupational risks and public health hazards from these radiation types?
- How can the radiation exposure be reduced?

- How can better regulations be drafted and enforced to reduce the exposure to NIR?

Moreover, while the implications to occupational personnel and the general public from the use of these devices may be mainly limited to developed countries, it is important to start as soon as possible, preferably on an international basis:

- to collect and evaluate informative data in a systematic manner,
- to support further investigations into the health hazards involved,
- to discuss possible biologic criteria for damage,
- to develop guides and criteria for health protection, and
- to assist in the establishment of rules and regulations and the proper means of enforcing them.

Ultraviolet Radiation. This has been used extensively for sterilization of equipment and air, and in different types of medical apparatus. The use appears at present to be somewhat declining, but a certain risk to the occupational worker in rooms supplied with open ultraviolet sources is still present. The damage will be localized to the eye and to the skin, but with a certain long-term risk for ultraviolet carcinogenesis. It is evident that the largest exposed group is that of persons working in open air and attention should be drawn to protective cosmetics. This stands true also for entertainers as an occupational group. No quantitative knowledge of dose-effect relationship and of latency periods is available as far as human cancer is concerned. The ultraviolet lamps for private use are widely disseminated among the public and should be supplied with appropriate warnings.

Infrared Radiation. Exposure to this light can occur in almost any industry from direct infrared sources as well as from other heat sources, and the risks under certain working conditions are well known. Still unsolved is the question as to whether infrared radiation can produce cataract. In any case, the presence of well developed temperature sensors in the skin around the eye represents a good biological warning system.

Microwave Radiation. The recent great expansion in use of microwave ovens presents a new serious health hazard. The damage will affect the eye (cataract formation) and the skin and other locations by heating. In certain instances genetic effects may perhaps result. The risk from big radar installations emitting much energy should also be considered. Microwaves are recognized as the type of NIR which represents the largest risk. At present there exists no possibility for adequate measurements of absorbed dose and the special measuring problems of near and far fields cannot be neglected. In general, the thermal type of effects has been considered the most important one. However, additional effects, such as those on the nervous system, have been reported and require further attention.

Lasers. The risks from lasers must receive much attention with their increasing use. The emitted light can give rise to damage to the eye and the skin, and under certain conditions perhaps also to more deep lying organs. A special risk appears to be connected with lasers emitting non-visible light where unnoticed temperature gradients may be produced. The difficulties of evaluating the risks from lasers are partly due to the lack of agreement in the translating of animal experiments to the human eye. In the case of pulsed exposure the differences of effectiveness of heat transfer from different localities will decide the biologic effects in connexion with the duration of the pulses, but existing experiments are not too convincing. Also the question of a risk of shock waves from a pulsed laser is not sufficiently well studied to be fully understood.

Ultrasonic Radiation. This type of radiation is a relatively new energy source and its versatility has led to its widespread employment in various industrial, medical and scientific products for measurement and control applications and to modify the material by the dissipation of energy. While the possible damage to the human eye has already been observed, the rapidly expanding use of ultrasonic power calls for further study of levels and other biologic effects of stray radiation. Ultrasound can be produced in a large spectrum. It is partly made safe by its inability to pass an air-water interface. However, whether potential adverse effects exist from immersion of hands in ultrasonic fields during cleaning are not known. It is not definitely solved whether chromosome aberrations can be produced but the evidence tends to be negative. So far no major adverse effects have been recognized from diagnostic exposure of children in utero.

The Long-term Programme

It was the favourable acceptance of the Office's long-term programme on environmental pollution control and its approval by the Regional Committee of the European Region at its 19th session in Budapest in 1969 that eventually led to the development of a programme on NIR protection. The first activity on the subject was the convention of a Working Group in The Hague in November 1971, held to discuss the health effects of ionizing and non-ionizing radiation. The members of that Working Group reviewed and assessed the situation prevailing in Europe, studied trends and developments, discussed needed activities of special importance, and recommended actions and projects to be undertaken. The Working Group's deliberations were summarized in a report published by the Regional Office which also included detailed conclusions and recommendations.¹

The first half of the Working Group's recommendations deal with NIR in general and touch on needed health studies, the establishment of reference centres, the preparation of model codes of practice, education and licensing, while the second half concentrates on the specific types of radiation. Noting the lack of regular action on NIR protection by any international agency or committee, the Working Group urged the WHO to initiate the setting-up of an organ with terms of references in the field of NIR similar to those of the ICRP and ICRO in the area of ionizing radiations (recommendation 8). Recommendation 5 is also of much interest, as it calls for the establishment of an international reference centre which should, among other activities, co-ordinate badly-needed studies on an international level. Many of the Working Group's recommendations have been transformed into a working plan as shown in figure 1. This working plan identifies the various activities which are expected to be carried out by the WHO Regional Office for Europe. Because of their inter-regional nature (i.e. concerning more than one WHO regional office) some recommendations of the Working Group cannot be implemented at the regional office level but may be carried out only through WHO headquarters. For example, this would be the case for the establishment of an international reference centre.

The NIR sector within the long-term programme can be divided into six activity components, namely, review, survey, study, manual, education and evaluation. The activities which have already taken place, or those in progress, are described in more detail in the coming sections. With respect to field and laboratory studies planned for 1974 to 1978, their objectives will be more closely identified following the recommendations from the various NIR scientific meetings already planned to discuss specific sources. In 1979, when the present series of planned activities will have been exhausted, a meeting will take place to evaluate the work already done and make recommendations on further needed action within the NIR sector of the long-term programme to the

implementation of which the WHO Regional Office for Europe can contribute (Fig.2).

Range Limits of NIR. At the conclusion of the first Working Group's meeting, the inconsistency of the range limits of the various types of NIR as defined by different investigators could not be overlooked. It is, of course, recognized that any such limits were approximations, as no exact end-point can be defined. However, to advance future fruitful discussions and collaborations at an international level, the various NIR ranges have now been fixed and are being adhered to by WHO for its own activities on NIR (table 1). Thus, for example, the microwave radiation range with the given limit of 300 GHz to 300 MHz has been adopted for use by the forthcoming International Symposium on Biologic Effects and Health Hazards from Microwave Radiation to be held near Warsaw, 15 - 18 November, 1973.

Survey of Institutions. The worldwide identification of the existing institutions and the affiliated scientists active, at least to some extent, in the study of the biologic effects and health hazards from NIR and in the development of appropriate dosimetry and protection measures is a must if progress is to be expected in the establishment of internationally agreed units and procedures for dose measurement and analysis of results. Moreover, such agreements are necessary for the comparison of, for example, epidemiological studies of long-term effects from exposure to all types of NIR, and in general, for the meaningful collaboration between the various institutions on exchange of information, correlation of findings, joint research projects and the development of internationally accepted safety guidelines and protection standards.

Towards this goal, the European Regional Office has embarked on a survey of institutions and specialists in the field of NIR which, when completed, will provide the information for a Directory of Institutions. Meanwhile, a preliminary survey has revealed that only in a relatively small number of countries are there institutions dealing with NIR. In addition to the two countries long involved, namely, the USA and the USSR, only less than twenty or so other countries in the world may have institutions which are concerned with the study of NIR. Of these, about half are European countries. Over twenty institutions have already identified themselves in the USA. They include the National Institute of Environmental Health Sciences and the Bureau of Radiological Health, both of the Department of Health, Education and Welfare, the Environmental Protection Agency, research centres of the three branches of the armed forces, various universities and a few industrial corporations.

Survey of Legislation. A second survey is now under preparation by the WHO Regional Office for Europe and is expected to bring forward, in a concentrated orderly form, the detailed legislation and the administrative regulations which govern the manufacturing, licensing, use and maintenance of NIR devices in the various countries related to employees, patients and the general public, at national, regional and local levels.

Study of Health Effects. As part of its discussions, the Working Group did, of course, review the possible health effects from specific NIR sources. However, a more elaborate study on this subject was considered necessary. Consequently, a report was drafted for the WHO Regional Office for Europe on the potential hazard to human health from the exposure to microwaves, lasers, and radiofrequency-type radiation. In this report attention has been given equally to work published in the USA, Western Europe, the USSR and Eastern Europe. This report is now under review by a number of well-known experts and will be discussed, together with the review comments received by future working groups, and eventually serve as an input for the Manual on NIR Protection.

Health Effects from Microwave Radiation. WHO, together with the US Department of Health, Education and Welfare, and the Polish Scientific Council to the Minister of Health and Social Welfare, are sponsoring the forthcoming International Symposium on Biologic Effects and Health Hazards from Microwave Radiation. This symposium which will meet in Warsaw, 15-18 November, 1973, will serve as the first international forum for the personal exchange of research information and professional experience. The symposium sessions will include papers on thermal and biologic effects, influence on the nervous system and behaviour, effects on the cellular and molecular level, measurements of the radiation and the biologic effects, occupational exposure and public health aspects.

The material submitted to this symposium and the conclusions to be drawn from its discussions will be the subject of a special evaluation meeting which should provide the feed-back into the NIR sector of the programme of the European Regional Office. Moreover, it is anticipated that during this evaluation meeting the research gap and the need for complementary information on the study of microwave radiation will be identified, and possibly taken up through an expansion of the presently foreseen activities.

Health Effects from Laser Radiation. To study the health effects from lasers, a Working Group will be convened by the WHO Regional Office for Europe in May 1974. This meeting will discuss and make recommendations on hazards to the eye and skin, risks from the use of lasers for engineering, industry, medicine, research and education, dose measurement and analysis of results, development of international standards, needs for additional investigations, and legislation and administrative regulations. This Working Group will also finalize the draft chapter on lasers for the Manual on NIR Protection.

Manual on NIR Protection. All the printed material resulting from the work on NIR will be incorporated into one manual, which should then serve as a comprehensive reference volume. To ensure that the manual has the maximum impact at all levels of governmental administration, it will be divided into two parts. The first part, addressed to senior administrators (i.e. decision-makers and appropriators of funds) is a short part containing well-integrated summaries of the following chapters and emphasizing the points which should be taken into consideration when promoting a NIR protection programme, namely, principles, available methodology, approaches and possible alternatives. The second part, comprising of the detailed chapters themselves, will provide the background and detailed information on the respective subjects, references, present practice, etc. Although this manual is being prepared by the Regional Office for use in Europe, it could, of course, also be adapted for use by countries outside the European Region. In its final form the second part of the manual may contain the following chapters:

- Directory of institutions,
- Potential hazards to human health from exposure to ultraviolet radiation, lasers, microwaves, radiofrequency radiation and ultrasound,
- Health criteria and guides,
- Occupational risks and public health hazards,
- Model code of practice for the safe handling of NIR sources,
- Existing laws and regulations,
- Licensing of NIR sources and law enforcement measures.

International Health Criteria and Protection Standards

At the conclusion of the United Nations conference on the Human Environment in Stockholm, 1972, the WHO was entrusted with the enormous task of developing international health criteria and standards. In a meeting in Geneva, the scope of such a programme and its priorities were discussed.² To enable the preparation of the criteria documents, among others on NIR, it was considered essential to first prepare critical reviews of the existing knowledge on health effects from microwaves (as part of the category of first priority) and from ultraviolet radiation, lasers and ultrasonic radiation (as part of the category of second priority).

In view of the potential hazards connected with the use of emitters of NIR, especially whenever large amounts of energy are transmitted, it is felt that international rules for the use of these radiations are urgently needed. The rules should cover the construction, handling, licensing and maintenance of the equipment used for the production of the radiations. At present laws covering the protection of both workers and the general public against the different types of NIR exist only in the USA and USSR and are expected to be promulgated shortly in a few other countries. It is, however, evident that in most countries definite regulations concerning the manufacture of apparatus emitting NIR are deficient. It should be stated that before workable international rules for maximum exposure and regulations for manufacture can be set up, a number of conditions have to be fulfilled. Most important of these conditions is the adequate agreement on the level of exposure that represents the lowest hazardous dose to man. On the basis of this knowledge, it should be possible to formulate standards with a sufficiently large margin of safety which would then be the protection guidelines.

It is evident that the most general expression for the result of energy deposition after radiation is that of a thermal nature. It is however, very difficult to give in all cases a satisfactory description of the distribution of energy inside the body due to differences in absorption in different tissues the occurrence of interference or resonance in a single organ or at interfaces between tissues, and for other reasons. A principal reason for the lack of information is the lack of proper instruments for measurement at the biologically appropriate place. This problem is of great importance in all types of NIR, but is probably felt strongest in the study of microwave absorption. Therefore, in order to obtain the maximum amount of reliable information, it will be necessary to plan the necessary studies as multidisciplinary collaborative studies in which representatives from the following disciplines could participate: physicists and engineers well grounded in the theory of the types of radiation under study and in electronics; biologists experienced in disciplines such as physiology, biochemistry, pathology, genetics and biostatistics; and in some cases, knowledge of ophthalmology, behavioural science and human and veterinary medicine, and if possible, a biophysicist would be useful.

References

1. World Health Organization Regional Office for Europe, Health Effects of Ionizing and Non-ionizing Radiation, Copenhagen 1972. (Report on a Working Group, The Hague, 15 - 17 November 1971, WHO document EURO 4701)
2. World Health Organization, The WHO Environmental Health Criteria Programme Geneva, 1973. (Report on a WHO meeting, Geneva, 20 - 24 November 1972, WHO document EP/73.1)

Table 1: CHARACTERISTICS AND SOURCES OF ELECTROMAGNETIC TYPE RADIATIONS

Type of radiations	Frequency range*	Wave-length range*	Energy range per photon	Typical source
Ionizing	above 30 000 THz	below 10 nm	above 124 eV	Electronic tubes, nuclear decay, nuclear fission
Ultraviolet	30 000 THz to 790 THz	10 nm to 380 nm	124 eV to 3.3 eV	Sun, gas discharge tubes
vacuum	3 000 THz to 1 600 THz	100 nm to 190 nm	12.4 eV to 6.5 eV	
far	1 600 THz to 1 000 THz	190 nm to 300 nm	6.5 eV to 4.1 eV	
near	1 000 THz to 790 THz	300 nm to 380 nm	4.1 eV to 3.3 eV	
non-ionizing portion	1 800 THz to 750 THz	170 nm to 400 nm	7.3 eV to 3.1 eV	
Visible	790 THz to 400 THz	380 nm to 750 nm	3.1 eV to 1.6 eV	Sun, thermally excited atoms
Infrared	400 THz to 300 GHz	750 nm to 1 mm	1.6 eV to 1.2 meV	Sun, hot bodies
near	400 THz to 100 THz	750 nm to 3 μ m	1.6 eV to 0.4 eV	
middle	100 THz to 10 THz	3 μ m to 30 μ m	0.4 eV to 41 meV	
far	10 THz to 300 GHz	30 μ m to 1 mm	41 meV to 1.2 meV	
Laser	1 500 THz to 15 THz	200 nm to 20 μ m	6.2 eV to 62 meV	
Microwaves	300 GHz to 300 MHz	1 mm to 1 m	1.2 meV to 1.2 μ eV	Klystron, Magnetron
EHF**	300 GHz to 30 GHz	1 mm to 10 mm	1.2 meV to 0.1 meV	
SHF**	30 GHz to 3 GHz	10 mm to 100 mm	0.1 meV to 12 μ eV	
UHF**	3 GHz to 300 MHz	100 mm to 1 m	12 μ eV to 1.2 μ eV	
Radar	56 GHz to 220 MHz	5.4 mm to 1.3 m	0.2 meV to 0.9 μ eV	
Radio-frequencies	300 MHz to 300 kHz	1 m to 1 km	1.2 μ eV to 1.2 neV	Tubes, transistors and tuned circuits

* The given ranges are only approximations, as no exact end-point can be defined.

** Extremely high frequencies, Super-high frequencies, Ultra-high frequencies

Conclusions and Recommendations of a WHO Working Group on NIR*

Health Studies

(1) The knowledge of the noxious effects of NIR is scattered and incomplete. The Working Group felt that our knowledge concerning low level effects and the possibility of cumulative effects is very defective.

IT IS RECOMMENDED THAT the World Health Organization should organize the collection of case-histories of accidental exposure to all types of NIR in order to make it possible to give a better description of the clinical disorders to be expected after such exposure.

(2) With the growing use of NIR, the populations at risk will be increasing in size. Due to the continuous introduction of new procedures in which NIR is used, the populations at risk will also be changing both in size and distribution, which means that new groups may present previously unrecognized health problems.

IT IS RECOMMENDED THAT the World Health Organization should initiate appropriate surveys into the size and distribution of populations at risk, among both workers directly concerned and the general public.

(3) In view of the lack of quantitative information on possible late effects of NIR in man, further information is urgently needed.

IT IS RECOMMENDED THAT the World Health Organization should encourage and co-ordinate both prospective and retrospective long-term epidemiological studies on groups of workers exposed to NIR.

(4) When considering the available equipment, which generates NIR, the degree of its use and the potential hazard involved, research priorities for the study of health hazards from NIR must be given to lasers and microwaves.

IT IS RECOMMENDED THAT the World Health Organization should encourage such most urgently needed research.

Reference Centres

(5) In order to co-ordinate such studies and to correlate the findings and in general to act as observers in the field of NIR, centres of outstanding quality should be selected as international and national reference centres, both for the total field of NIR and wherever possible for the single types of radiation also.

IT IS RECOMMENDED THAT the World Health Organization should establish appropriate international reference centres to undertake these tasks, and encourage the setting up of similar centres at national level.

* Taken from the report on a Working Group convened by the Regional Office for Europe of the World Health Organization, The Hague, 15 - 17 November 1972 ¹

Dose measurements and units

(6) For such studies, it is necessary to collect groups of exposed persons, for whom sufficient physical information on the exposure dose is available, in order to act as a basis for future epidemiological and other studies.

IT IS RECOMMENDED THAT the World Health Organization should encourage the development and use of measuring equipment for the registration of exposure to doses from NIR in exposed persons.

(7) It is felt that there is a need to extend the collaboration between centres active in health protection against NIR into the field of units and measurements also.

IT IS RECOMMENDED THAT the World Health Organization should initiate collaboration between such centres in order to harmonize the units used in dose measurements.

(8) It was evident from the discussions of the Working Group that the work of the International Commission on Radiological Protection and the International Commission on Radiation Units and Measurements, in introducing the concepts of normal man and of the maximum permissible dose and in classifying dose definition and dose measurements, has been fundamental in the control and protection of workers against ionizing radiation. In order to develop the understanding of the hazards of NIR, an organ with similar terms of references in the field of NIR is urgently needed.

IT IS RECOMMENDED THAT the World Health Organization should initiate the setting up of such an organ, either within its own organization or through international collaboration.

Safety guidelines and protective standards

(9) The use of NIR is rapidly expanding. The Working Group surveyed present safety codes and guidelines and found the guidelines in general sufficient to prevent injury under present conditions. It is doubtful, however, whether they will be adequate in the future, in view of the expected growth in the use of all types of NIR due not only to increased production of the types of equipment already in use but also to the constant introduction of new techniques using NIR.

IT IS RECOMMENDED THAT the World Health Organization should survey the field of health protection from NIR with the long-term goal of producing model codes of practice for this field, both for workers directly concerned and for the general public.

Education and licensing

(10) The number of apparatuses able to produce NIR is increasing rapidly in both industry and medicine. The number and types of such apparatus offered to the general public is also increasing. This increase in use requires technical personnel for construction, operation, maintenance and control. For all these groups, adequate training will be needed in the use of the equipment and in protection against the radiation emitted.

IT IS RECOMMENDED THAT the World Health Organization should conduct a survey of existing training programmes and courses on the use of NIR in order to ensure adequate international standards of education.

(II) To ensure the proper handling of equipment emitting NIR, a licensing system may be appropriate for manufacturers, engineers, physicians and technical personnel.

IT IS RECOMMENDED THAT the World Health Organization should investigate whether adequate licensing procedures for operation and maintenance are available and encourage the international formulation of the requirements for such licensing.

(I2) The population at risk is that part of the general population which may be exposed either by the use of equipment emitting NIR or by accidental contact with the radiation emitted and is increasing with the growing use of such equipment. In order to minimize the risk involved, it will be necessary to educate the general public in the use of such equipment and inform them of the dangers which may be involved.

IT IS RECOMMENDED THAT the World Health Organization should encourage the dissemination of such information on the safe use and the hazards of NIR to the general public.

Ultraviolet radiation

(I3) For the setting of proper standards for protection, an unambiguous dose-effect relationship for the production of skin cancer is urgently needed.

IT IS RECOMMENDED THAT the World Health Organization should encourage quantitative work on UV skin carcinogenesis.

(I4) The evidence suggesting the possibility of cataract formation from UV radiation is not too convincing.

IT IS RECOMMENDED THAT the World Health Organization should encourage studies into possible cataract formation from UV radiation.

Infrared radiation

(I5) The knowledge concerning possible long-term effects of IR radiation is inadequate.

IT IS RECOMMENDED THAT the World Health Organization should encourage studies into possible cataract formation and carcinogenesis from IR radiation.

(I6) The significance of the effect of ambient climate on the possible damage from IR radiation is not yet very well understood.

IT IS RECOMMENDED THAT the World Health Organization should encourage studies into the relation between damage from IR radiation and the temperature, moisture and other environmental factors.

Microwaves

(I7) Agreement must be reached on how to establish common criteria for assessing the action of microwaves on man. Only this would make the accurate comparison of results of scientific research from different laboratories possible, and thus allow guidelines for the protection of health to be established.

IT IS RECOMMENDED THAT the World Health Organization should take steps to develop the relevant recommendations for criteria of microwave effects on man.

(I8) The need for better personal dosimetry for the measurement of absorbed doses both by an integrating dosimeter and by a small implantable dosimeter for in vivo measurements in animals is felt very strongly in the case of microwaves.

IT IS RECOMMENDED THAT the World Health Organization should stimulate research on the development of accurate dosimeters for both near-field and far-field energy determination, including the development of implantable dosimeters.

Lasers

(I9) Insufficient knowledge is available for a complete description of the effect of laser radiation on the human eye.

IT IS RECOMMENDED THAT the World Health Organization should initiate a collaborative study on the effects of laser radiation on the human eye.

(20) Lasers are at present manufactured and sold in kits for home construction without appropriate licensing to purchasers, who may not understand the risks involved.

IT IS RECOMMENDED THAT the World Health Organization should take steps to introduce international standards for control of such sales.

Ultrasound

(21) Although the Working Group knew of no reports of accidents or well-established damage arising from occupational exposure to ultrasound, the scientific evidence on this subject was felt to be inconclusive. It is uncertain at present whether adequate provisions exist for reporting occupational injuries in such a manner that ultrasonic exposure could be identified as a cause.

IT IS RECOMMENDED THAT the World Health Organization should encourage the systematic and meaningful reporting of such injuries.

(22) At present there is no knowledge of the acoustic intensity levels in human tissues resulting from occupational exposure to ultrasound, although adequate measuring techniques for this purpose exist.

IT IS RECOMMENDED THAT the World Health Organization should encourage the determining and reporting of such exposure levels in typical occupational situations.

(23) A conflict of opinion exists in the literature concerning the possibility that exposure to ultrasound could lead to biological changes of a mutational nature.

IT IS RECOMMENDED THAT the World Health Organization should encourage the critical scientific review of this topic and, if necessary, additional definitive experimental studies.

Sound

(24) There are strong indications that sound levels, which are safe from the viewpoint of possible decrease of hearing level, may produce other somatic or functional effects or unfavourably influence the quality of sleep.

IT IS RECOMMENDED THAT the World Health Organization should promote international collaboration between the few institutes in the world active in this field.