INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

WORKSHOP REPORT

ICNIRP/WHO International Workshop on Non-Ionizing Radiation (NIR) Protection in Medicine

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International Workshop on Non-Ionizing Radiation Protection in Medicine

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An international workshop brought together a range of stakeholders to consider protection from non-ionizing radiation used in medicine, research and cosmetics. Presentations on specific topics were followed by a general discussion on possible improvements in protection. Participants considered that adherence to science-based, harmonized exposure guidelines to limit exposures for clinical staff and other workers was a key prerequisite to safety in all situations. In addition, to engender an awareness of the risks involved to both the patient as well as the operator, equipment should be operated only by suitably qualified persons who have received appropriate training in the safe use of that device. This training should be carried out under the auspices of an accredited safety provider, and preferably offer a recognized qualification. Specific advice included the necessity for correct eye protection with higher power optical radiation sources, and avoiding the use of ultrasound for all exposures without medical benefit. Finally, the possibility of a harmonized approach to safety for both non-ionizing and ionizing radiation was considered worthy of further discussion. © *2013 American Association of Physicists in Medicine*. [http://dx.doi.org/10.1118/1.4824921]

Key words: bio-electromagnetics, ultrasonics, non-ionizing radiation

1. INTRODUCTION

Ionizing radiation, in the form of x-rays, γ-rays, and radioactive isotopes, has been used to great benefit in the diagnosis and treatment of numerous medical conditions. For example, x-rays are used in radiography, fluoroscopy, and computed tomography to provide detailed information about internal structures of a body. While medical exposures are generally below thresholds to cause immediate harmful effects, such as skin burns or radiation sickness, they may carry a very small increased risk of cancer later in life. However, other imaging and diagnostic methods have been developed, such as magnetic resonance imaging (MRI) and ultrasound, which do not use ionizing radiation, but instead employ non-ionizing radiation (NIR) or acoustic energy. These modalities are considered less harmful than ionizing radiation but uncertainties remain about the risks of exposure to both the patient and healthcare worker.

This report provides a summary of the presentations of an international workshop on protection against the hazards of exposure to NIR and ultrasound as used in medicine for diagnosis and therapy, and also for their uses outside medicine. The main purposes of the workshop were to bring together experts and users of NIR or ultrasound in clinical care and medical research with other relevant stakeholders in order to review the current status of radiation protection, including exposure guidelines and safety regulations.

The one-day workshop was organized by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and co-sponsored by the World Health Organization (WHO). It was hosted by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), and chaired by Rüdiger Matthes (ICNIRP). The full program, with the affiliations of the speakers, is given in the Appendix.

2. PRESENTATIONS

2.A. WHO perspective

Adriana Velazquez Berumen presented the WHO perspective on access to safe medical devices using NIR or ultrasound. Medical devices were defined as instruments used in the prevention, diagnosis, or treatment of illness or disease, or used to detect or correct the structure or function of the body for health purposes. They are considered indispensable for healthcare, although many people worldwide still have no access to the essentials.

Following approval of the health technologies resolution WHA60.29 in 2007, the WHO collected information from its Member states on the number and distribution of high cost medical devices, as well as on the regulations and policies governing their use. This baseline information has allowed the WHO to discover the gaps and produce guidelines to ensure the effective use of resources through proper planning, rational selection, acquisition and management. The information has been published as technical reports and data sheets and is available at www.who.int/medical_devices/gfmd_report_final.pdf.

In general terms, it was stressed that any health technology should be "available, accessible, affordable, and appropriate," as well as being safe and effective. In practice this requires good installation, calibration, and maintenance of the equipment, as well as ongoing support from the manufacturer for spare parts and necessary updates. Continuous user training was also considered essential, as was adherence to the appropriate guidelines or regulations.

In addition, specific advice was presented to increase the safe use of medical devices. For example, MRI (and other technologies) should be performed only when the clinical advantages outweigh any possible risks, and these risks should

be compared with those posed by other diagnostic techniques. Also if MRI examinations form part of a research project, there should be prior approval by an appropriate ethics committee and informed consent obtained from the participants.

Ultrasound imaging should be used only for medical diagnosis and imaging and be performed by staff who have been fully trained and have an awareness of the risks. Further, examination times should be kept as short as possible and use the lowest output level to produce a useful diagnostic result. It was suggested that the operator should keep within guidelines recommended for scan times, especially for obstetric examinations, and scans in pregnancy should not be carried out for the sole purpose of producing keepsake images.

Neonatal jaundice (hyperbilirubinemia) is a frequent issue in newborns. However, phototherapy using high power LEDs that emit light in the blue-green part of the spectrum (430–490 nm) is an effective treatment, which works by breaking down the excess bilirubin. It is important that the eyes of the babies being treated are covered correctly to avoid the possibility of retinal damage. To ensure the correct dosage is received, the phototherapy lamps should not be positioned closer to the infant than the distances recommended by the manufacturer, and only one baby should be treated in one cradle at any one time. It is also essential that only authorized lamps emitting the correct wavelengths are used, otherwise the treatment would be ineffective.

Various types of lasers are used for diagnosis and surgery including CO_2 lasers, diode lasers, dye lasers, and optical parametric oscillators (for a full description see http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/SurgicalandTherapeutic/ucm115910.htm). High energy lasers can cause eye damage if viewed directly or from a highly reflective surface and also cause damage to the skin (for additional information see http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/LaserProductsandInstruments/default.htm). Increased risks occur when the operator does not follow appropriate protocols or does not handle the equipment correctly through a lack of training or knowledge, or when the equipment has not been maintained. The availability of appropriate safety goggles designed to protect against the specific wavelengths for the laser(s) being used is essential.

General problems encountered with health technology using NIR include a lack of training in the safe use of a device, absence of funding for appropriate calibration and maintenance, or when spare parts and support from the manufacturer are not readily available. In addition, it was emphasized that it was important to engender an awareness of all aspects of safety in users of medical devices.

Finally, it was proposed that the information prepared by ICNIRP should be included in health technology meetings and disseminated in medical technology documents, and that this information should be shared with engineers and others responsible for the procurement and use of medical devices. It was also proposed that the information from ICNIRP should be used by ministers in formulating health policies.

2.B. Electrochemotherapy

Lluis M. Mir considered the appropriateness of applying population-based exposure limits for NIR in medicine. He argued that restrictions designed to prevent adverse effects in healthy individuals should not be used to obstruct the development of technologies in medicine, if it can be shown through careful research and development that a new technology offers advantages to the patient. This was illustrated by considering a recently developed NIR-based therapy for the treatment of tumors in the skin or subcutaneous tissues that involves minimal heating of tissues.

Electroporation is a well-established technique to increase the permeability of a cell membrane using an intense electric field (delivered as a train of electric pulses via electrodes). Antitumor electrochemotherapy (ECT) combines this technique with administration of anticancer drugs or otherwise nonpermeant molecules to treat and control solid tumors.

Preclinical studies with ECT showed that the viability of cancer cells *in vitro* could be greatly reduced following combined electric pulse treatment with bleomycin compared with treatment using the antibiotic alone. Similar results were obtained *in vivo* using mice models bearing implanted skin tumors. It was shown that the electric pulses had no adverse effects on the animals and that bleomycin was well tolerated and was toxic only to the tumor cells in an area defined by the electrodes.[1] These studies enabled the characteristics of the electric pulses as well as the dosage of bleomycin to be optimized for use in clinical trials.

The first successful clinical trials were performed in 1991 and demonstrated that ECT could be very effective against cutaneous carcinomas of the head and neck.[2] Other successful trials followed, leading to the development of a commercial device that could be used in a clinic. Four cancer centers participated in the European Standard Operating Procedures for Electrochemotherapy (ESOPE) project that defined and validated the standard operating procedures for this technology. Over 100 centers in the EU are now equipped to carry out ECT, and the numbers that have been treated has steadily increased, with about 1100 patients being treated in 2009. ECT is considered the treatment of choice for inoperable tumors or tumors resistant to conventional chemotherapy. Further refinement is possible through feedback from the growing database of users and their experience with patients, as well as from empirical and theoretical studies.[3]

The peak electric fields used in ECT exceed the reference levels recommended by ICNIRP for the general public. However, these levels are highly conservative and are designed to prevent acute effects on peripheral nerve function following exposure of the whole body or substantial parts of it. In this instance, with highly localized and controlled exposures under medical supervision, it was suggested that any risks to the patient were clearly outweighed by the benefits.

2.C. MRI safety

Paul Glover reviewed the biological effects of exposure to the electromagnetic fields associated with MRI. He noted that

the severity of any effect depends on the magnitude of the field, and the trend in medicine has been towards machines with ever-higher field strengths, from 0.1 T in 1977 to 3 T today, with fields of 7 T or more often used in research. The increasing use of interventional methods is also increasing the likelihood of exposure of clinical staff.

In MRI, a pulsed radiofrequency (RF) field used for the excitation of atomic nuclei in the tissues being imaged results in the generation of heat in those tissues. Restrictions are set to avoid the adverse effects of heating by limiting the rate of energy absorption.[4,5] Absorption of RF energy outside the bore of the scanner is likely to be negligible, so presents no problems for medical staff.

Switched magnetic field gradients are used for the spatial encoding of the image. They have a wide frequency range, from around 100 Hz to 100 kHz or more. Peripheral nerve stimulation (PNS) is the most likely consequence of exposure to these gradients[6] and restrictions are set to avoid PNS. Induced electric fields of around 3 V m^{-1} or more are required to cause PNS in a typical person, but the ability to predict the threshold for PNS for any person is poor, possibly due to macroscopic differences in anatomy between individuals. Nevertheless, field gradients can be adjusted to avoid PNS. While an operator at the end of the bore is unlikely to experience PNS, it may occur in someone conducting an interventional procedure in a region with a very high rate of change of magnetic field amplitude, and this would affect their ability to safely perform the procedure.

A static magnetic field is used to align the nuclei in the exposed tissues. However, movements through this field, including those associated with blood flow and autonomic functions, will induce low frequency currents. Linear translations through a field gradient or rotations in a uniform field can induce currents in the head or body, and people often experience a metallic taste after head movements in fields of 3 T or more, and vertigo or feelings of disorientation are common when working in and around the bore of the magnet.[7] The latter is attributed to field-induced effects on the vestibular system and is usually experienced more as a vague perception rather than as a definite feeling of motion. In recent experiments, subjects were slowly pushed in total darkness into a magnetic field while their involuntary eye movements (nystagmus) were monitored. It was found that there was a perception of clockwise rotation while going into the magnet, and that this reversed on removal. The threshold for this effect was around 5 T with a rate of change of 0.2 T s^{-1}, although the threshold for the detection of (slow-phase) eye movements was lower. Each showed an adaptive response, which was considered evidence of higher order processing in the brain. Roberts and colleagues[8] first reported that magnetic field-induced vertigo may derive from Lorentz force pressure resulting from interaction between the static magnetic field and the naturally occurring ionic currents in the endolymph of the vestibular system. It was suggested that this pressure pushes on the cupula of the semicircular canals, leading to nystagmus and vertigo.

It was concluded that none of these biological effects is indicative of adverse health effects. The occurrence of vertigo is more problematic, although operators learn and adapt their behavior. It was recognized that PNS could affect the ability of an interventional radiologist to perform a procedure on a patient in a magnet, although field gradients could be designed to avoid the occurrence of PNS.

Regarding future developments, it was suggested that while high fields systems were useful for research purposes, most imaging systems were likely to remain operating at 3 T, and that the operators of these systems were unlikely to experience any effects under normal use (and this included being at the end of the bore). Interventional systems did not present any issues if they were used as a conventional imaging system (except for the problems of acoustic noise) but a need was identified for further design for "work within imaging volume" systems.

Workshop participant Rianne Stam (National Institute for Public Health and the Environment, the Netherlands) noted that nausea and vertigo have also been reported in people who are motionless in a magnetic field and asked whether the Lorentz force pressure was compatible with this. Dr. Glover replied that the Lorentz force mechanism has a static component which is proportional to the magnitude of the field.

2.D. RF safety in medicine

High power RF energy is used in healthcare facilities: in surgery for the ablation of tumors or cardiac tissues and in MRI for diagnostic imaging. RF fields are used for the local interrogation of brain function and RF diathermy is used for deep tissue heating. James Lin described RF safety problems of these applications.

In recent years, therapeutic thermal tissue ablation has experienced a high rate of growth. It has provided special opportunities in the areas of cardiac and tumor ablation that require only the insertion of an antenna or electrode into the body. Microwave ablation uses fields of 915 or 2450 MHz at 200 W, while RF ablation uses fields of 500–750 kHz at 500 W. Both methods aim to heat the target tissues to 65–98 °C. Thermal ablation of a number of tumor types, including liver, breast, thyroid, and prostrate tumors, has a success rate of 95% for a single treatment, with a 3 year overall patient survival rate of 90%. While this technology is minimally invasive and is intended to cause only the local ablation of target tissues with minimal damage to overlying structures or surrounding tissues, there are concerns about possible collateral damage to normal structures adjacent to the desired zone of ablation.

Guidelines have been produced by ICNIRP (Ref. 9) to limit the exposure of patients to static and RF fields during MRI procedures. The recommendations depend on the type of examination undertaken, with relaxation for controlled exposures under direct medical supervision or for experimental exposures granted specific ethical approval. The RF guidelines are set to avoid excessive elevation of core body temperature or local temperature in the head, trunk, or extremities by restricting the specific energy absorption rate (SAR). However, recent calculations using the Visible Women voxel phantom[10] suggest that using the International

Electrotechnical Commission (IEC) algorithm[11] to calculate whole-body and partial body SARs may result in the peak SARs in the head, trunk, and extremities being exceeded during imaging with a birdcage MRI coil at 1.5 T, although the whole-body average SARs may remain within guidelines.[12]

Transcranial magnetic stimulation (TMS) is widely used in medicine and in physiological studies of motor function. TMS is also used to study cognitive processes in the brain by causing a temporary disruption of normal function over a targeted cortical area. Typically, TMS uses a figure eight coil which is placed against the head over the region of particular interest. Exposure can consist of either a single 100 μs pulse at 10 kHz or, in the case of repetitive TMS, a train of pulses. Although the site of maximal stimulation corresponds to the cross-over point between the two circular coils, there are secondary peaks off to the side of the coil. Thus a larger volume of neural tissue could be affected than desired, and there are concerns that sensitive regions of the brain could be over-exposed.

Lastly, RF diathermy is used to heat muscles to relieve strain, and to stimulate blood circulation and reduce inflammation. Microwave diathermy at 2450 MHz is used for superficial heating, UHF diathermy at 433 MHz is used to treat osteoarthritis of the knee and to reduce pain, and shortwave diathermy at 27 MHz is most widely used in physical medicine and in rehabilitation for the deep heating of muscles and joints. While the intention is to cause local hyperthermia in selected tissues by deposition of RF energy at exposures above guideline levels, there is concern that under some circumstances other tissues could receive exposures that exceed local guideline values for the general public. It is also possible that members of staff could exceed the occupational limits on exposure when operating or standing close to shortwave diathermy machines.

It was noted that the exposures of patients undergoing medical diagnosis and treatment or volunteers in medical research are permitted to be higher than occupational levels because of risk and benefit considerations. Exposures to medical RF fields of the public are typically low and well within relevant exposure guidelines. Guidelines limiting occupational exposures to electromagnetic fields have been published by international scientific advisory bodies including ICNIRP (Refs. 4 and 13) and the Institute of Electrical and Electronics Engineers.[5,14] The WHO has strongly promoted the use of international guidelines, although some countries maintain the need to develop or refine their own standards (for a list of those used in different countries, see www.who.int/peh-emf/standards/framework/en/).

In conclusion, Professor Lin emphasized the risks of unintended overexposure of patients and the concerns about collateral damage to normal tissue structures, and the potential for occupational overexposure while working with diagnostic or therapeutic RF equipment or devices. In some cases, recent developments have focused on system performance improvements which are often accompanied by ever-increasing levels of exposure to RF fields, not only for patients and healthcare providers, but also for workers engaged in equipment development, testing and manufacturing.

2.E. Optical radiation safety

Bruce Stuck discussed safety issues of lasers and other sources of optical radiation associated with medical and cosmetic uses.[15,16] The properties of laser radiation present many opportunities for improved healthcare, and lasers are now used in most medical specialties, from ophthalmology and dermatology to oncology and gynecology, in order to heat, coagulate, ablate or cut tissues either directly or via an endoscope. It is possible to deliver high radiant exposures, yet laser radiation can be readily controlled and focused to a desired spot size. Laser radiation is also used for many purposes in cosmetics. These include removing unwanted hair, reducing the appearance of wrinkles on the face, and reducing cellulite. Many of these applications have moved from hospitals to "medical spas" in shopping malls, being performed without direct clinical oversight. Some of these applications require exposures that exceed ICNIRP recommendations.

The widespread use of lasers in medical spas suggests that there could be a potential safety issue for both staff and patients. Because a large number of diverse systems may be available in any location, it is necessary to establish administrative and engineering controls for each use, and to ensure that there is appropriate staff training and awareness of the risks: the need for correct eye protection must be emphasized, as well as the use of appropriate signs and labels. Maintenance, calibration, and scheduling are particularly important when several clinicians use the same system. However, it is recognized there has not been a large number of reported accidents, perhaps reflecting the (low) probability of transpupil exposure (although it may also raise important questions about the regulations governing reporting of such accidents).

ICNIRP produces information about new optical applications and devices, publishes detailed evaluations about the effects of NIR on health and well-being, and provides scientifically based advice on NIR protection, including the provision of guidelines to limit exposure.[17] These guidelines are used by the WHO, International Labour Organization and many other organizations, but exposure guidelines alone are not sufficient to ensure safety: control measures must be implemented and followed to minimize risk to staff. Mr. Stuck considered that while these measures may exist in medical facilities, they are perhaps less likely in a medical spa.

The long-term effects of repeated or chronic exposures to optical radiation are not well understood. Work with molecular and genomic assays might be used to determine the consequences of long-term low level exposure, or whether there are effects from long-term exposures that produce a minimal acute response. Further epidemiological investigations that explored adverse events and injury cases with optical radiation were also highlighted.

In conclusion, Mr. Stuck stressed the ubiquitous use of optical radiation in medicine and cosmetics posed a challenge. Science-based, harmonized exposure limits are critically important for the safe and effective use of the technology, and ICNIRP will contribute by providing exposure limit updates as needed. The safety of workers must be assured by training, protection and control measures: patient, and particularly

medical spa client, protection must be given more attention. The wide variety of sources and applications means that hazards need to be assessed on a case-by-case basis.

2.F. Ultrasound safety

Marvin Ziskin considered the safety aspects of high power ultrasound for medical, cosmetic, and souvenir purposes. Overall, he considered that ultrasound had been remarkably safe in clinical practice, with no documented evidence of any adverse effect resulting from its use in diagnostic examinations. This does not mean that ultrasound is risk-free: immediate damage to exposed tissues will occur at sufficiently high intensities, while prolonged exposures may induce harm at lower intensities. Because the safety of ultrasound cannot be assured, he recommended that the use of ultrasound for keepsake pictures of the fetus and other exposures without medical benefit should be avoided. This is consistent with the policy statements of national and international ultrasound organizations.[18–20]

Ultrasound may affect biological tissues by thermal and nonthermal (mechanical) mechanisms. Thermal effects occur because ultrasound imparts energy as it traverses biological materials, which causes an increase in tissue temperature. Although tissues are very good at handling small temperature increases, elevations greater than 43 °C lead to protein denaturation and cell death. The duration of the temperature elevation is also important, with 40 °C being tolerated by tissues for about an hour without injury, and 39 °C being considered safe. Rapidly dividing cells are at most risk from thermal effects, and the most important consequence of temperature rise relates to the creation of fetal abnormalities, especially when the temperature elevation occurs in the first trimester, the period of organogenesis.[21–23] Nonthermal effects arise because of the pressure associated with an ultrasound wave. Cavitation is the most important mechanical effect. It results from the growth and collapse of bubbles in an ultrasound beam and is greatly amplified in the presence of gas bubbles contained in ultrasound contrast agents. High temperatures and pressures are produced at the moment of collapse, with the production of free-radicals increasing the potential for biological effects. Cavitation is employed in lithotripsy in which high power ultrasound is used to break up kidney and gall bladder stones. Hind-limb paralysis and pulmonary and intestinal hemorrhage in animal models exposed to ultrasound have been attributed to this mechanism. Other effects attributed to nonthermal mechanisms include capillary bleeding in the lungs, an increase in the number of premature ventricular contractions in the presence of contrast agents, and accelerated wound healing.[24]

Manufacturers of ultrasound imaging instruments have been encouraged to provide safety indices updated in real-time to help sonographers in maximizing the safety of diagnostic clinical examinations. There are two safety indices: the TI or Thermal Index, which denotes the maximum temperature elevation anticipated under reasonable worst-case conditions; and the MI or Mechanical Index, which indicates the likelihood of an adverse effect due to cavitation or another mechanical mechanism. The indices allow sonographers to employ an "as low as reasonably achievable" (ALARA) approach during an examination: the values of both indices can be minimized while maintaining adequate visualization so as to avoid compromising the diagnostic accuracy of the examination. The risk benefit ratio has to be carefully considered in the case of therapeutic applications of ultrasound, because the exposures are intentionally greater in order to achieve the desired effect.[18–20]

The increase in popularity of ultrasound to provide keepsake or souvenir images of the fetus was acknowledged by Professor Ziskin. However, he emphasized that an obstetric ultrasound examination is not a frivolous thing, but should only be taken where there is a medical indication and then be carried out in a clinical setting under the supervision of a physician or trained sonographer. This view has been endorsed by a number of professional bodies: for example, the World Federation for Ultrasound in Medicine and Biology (WFUMB) makes it clear that it disapproves of the use of ultrasound for the sole purpose of providing keepsake images of the fetus.[18] It also recommends that the use of ultrasound solely to determine the gender of a fetus is inappropriate and contrary to responsible medical practice. WFUMB does, however, suggest that the provision of keepsake images or videos of the fetus may be acceptable if undertaken as part of the normal clinical examination, provided that it does not increase exposure to the fetus.

3. SUMMARY OF DISCUSSION

The final part of the workshop was devoted to a discussion on future challenges for NIR protection in medicine led by a panel consisting of the speakers plus an additional four experts (see the Appendix for details).

The first topic considered the need for exposure guidelines for patients and whether it was justifiable to have one set of guidelines for medical staff and another for workers in other industries. The panel agreed that the availability of (ICNIRP) guidelines for limiting exposures of patients during MRI examinations and from optical radiation sources provide additional information to clinicians about any particular risks to their patients, and information about other devices would be useful. The need for specific guidelines for medical staff is less clear-cut. It is not possible to give a definitive answer for every application or exposure situation. Some industries have produced exposure standards for their own staff, but generally such standards can be criticized for a lack of independence and objectivity, and their development runs counter to recent trends to harmonize guidelines.

The panel agreed that specific training in the safe use of particular devices using NIR is necessary for all medical and healthcare workers, and it is essential for those using (Class 3 or 4) lasers in the cosmetics industry. Training should be carried out under the auspices of an accredited safety provider and offer a recognized qualification. Of course not every country can offer this training to the same degree, but the WHO is working with industry to harmonize the approach.

Several areas were suggested where gaps in knowledge exist. These included short-term exposures to millimeter waves from security scanners, and whether there are effects from the combined exposures to NIR and ionizing radiation that are increasingly common in medicine. Although research is limited, ICNIRP does not consider that exposures from security scanners posed any particular hazard because exposures are well below public guidelines [see ICNIRP (Ref. 25)]. Another gap was the lack of a validated technique to readily allow measurement of ultrasound output at low frequencies (20–100 kHz). While it was possible to calculate the output, this was not a trivial exercise, and an appropriate technique would be welcomed.

The panel considered whether the three principles of protection against ionizing radiation (consisting of justification of a practice; optimization of protection; and the application of dose limits) could be usefully applied to NIR. ICNIRP recommends that exposures are kept below the threshold for the critical effect (with an adequate margin of safety) and also endorses the justification for medical practices (since ultrasound or MRI is less harmful than alternatives that use ionizing radiation). Cosmetic applications of NIR may not be justifiable since they have risk without tangible medical benefit. ICNIRP will consider further the possibility of a harmonized approach to protection against NIR and ionizing radiation.

The next question addressed the issue of compliance of medical devices with safety regulations. All medical devices used in developed countries must comply with relevant regulations and safety standards, but this is not necessarily true of equipment used for cosmetic purposes. For example, it was not clear whether skin burns associated with the cosmetic use of ultrasound were due to the equipment being capable of producing inappropriate outputs, or attributable to a lack of staff training.

Finally, options to improve communication about the risks of medical and other uses of NIR were discussed. It was agreed that this is a complex subject and producing definitive information is not easy. Nevertheless, it should be possible to produce clear, effective messages. Experience indicates that a one-size-fits-all approach would not be successful, and specific messages should be targeted at identified stakeholders. It was also suggested that these messages should be nested within information about related topics and include appropriate input from the relevant stakeholders.

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APPENDIX: INTERNATIONAL WORKSHOP ON NON-IONIZING RADIATION PROTECTION IN MEDICINE

Co-sponsored by WHO, hosted by BMU, Bonn Germany, 02.12.2012

Workshop Chair: Rüdiger Matthes, ICNIRP; Rapporteur: Zenon Sienkiewicz, ICNIRP

Opening of the workshop

Rüdiger Matthes, ICNIRP Chairman and Federal Office for Radiation Protection, BfS, and Christian Greipl, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, BMU, Germany

Access to safe use of medical devices: a WHO perspective

Adriana Velazquez Berumen, Essential Medicines & Health Products, World Health Organization

The application of non-ionizing radiation in medicine: an advantage for the patient

Lluis Mir, CRNS and Paris-Sud XI University, France

Occupational and patient safety aspects associated with increasing static magnetic field strengths and low frequency fields using MRI as an example

Paul M Glover, The Sir Peter Mansfield Magnetic Resonance Centre, University of Nottingham, United Kingdom

RF safety problems in medicine

James C Lin, ICNIRP, University of Illinois, United States of America

Safety aspects of high power ultrasound for medical, cosmetic/lifestyle and souvenir purposes

Marvin Ziskin, Center for Biomedical Physics, Temple University School of Medicine, United States Of America

Safety problems of optical radiation in medicine and cosmetics

Bruce Stuck, ICNIRP

Panel discussion: NIR a future challenge for radiation protection in medicine?

Chaired by Emilie Van Deventer, Radiation and Environmental Health, WHO Panel

Leonardo Longo, International Academy for Laser Medicine and Surgery, Italy

Jimmy Estenberg, Swedish Radiation Protection Authority, Sweden

John Parrish-Sprowl, Indiana University, USA

Birgit Keller BMU, Germany and speakers

Close of workshop

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