EDUCATIONAL RESOURCES

IAEA EDUCATION AND TRAINING ACTIVITIES IN MEDICAL PHYSICS

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Abstract— **The IAEA's core mission is to promote and verify the safe, secure and peaceful use of nuclear sciences and technologies with the aim of reaching peace, health and prosperity throughout the world. The IAEA specifically address the important topic of health through its Human Health programme, which aims at supporting Member States in building their capacity to prevent, diagnose and treat health problems by applying nuclear and radiation-based techniques in the most effective way. Consequently, medical physics, as the discipline that tackles optimization and quality assurance in medical applications of radiation, is an important area of expertise that must be supported and nurtured. The lack of adequate academic education and clinical training, as well as continuous professional development, is an important issue for the medical physics profession that affects many countries and that can lead to ineffective and sometimes harmful uses of radiation in diagnosis and therapy of patients. The IAEA is committed to support education, training and continuous professional development (CPD) of medical physicists worldwide to ensure the achievement of the highest level of quality and effectiveness of diagnostic and therapeutic procedures involving ionizing radiation. To achieve this goal, the IAEA offers to Member States a variety of education and training tools and activities with the drive of addressing specific situations through tailored intervention while harmonizing the overall level of medical physics applications worldwide. The ultimate achievement resides in guarantying to patients the same highest standard of diagnostic and treatment procedures employing ionizing radiation wherever in the world.**

Keywords— ***Medical physics, education and training, competency building, guidelines***

I. INTRODUCTION

Education and training are important components of the work of the International Atomic Energy Agency (IAEA) [1], since they represent a way to ensure the achievement of the highest level of effectiveness and safety in every application of nuclear technologies, including the protection of human health and the environment against ionizing radiation. Support to education directly originates from the IAEA's mandate linking to the strengthening and spreading of the safety culture in Member States. The IAEA's core role is to promote and verify the safe, secure and peaceful use of nuclear sciences and technologies with the aim of reaching peace, health and prosperity throughout the world. The IAEA's Member States (164 as of July 2015) can benefit from technical and specialized assistance and be supported in different ways, including education and training, in reaching their developmental goals through a peaceful, safe and effective use of nuclear technologies. The IAEA role includes support to Member States for the application of nuclear sciences and technologies in the most effective way, providing scientific guidance and fostering harmonization of procedures among countries. The IAEA is formally authorized by its Statute to "establish standards of safety for protection of health and to provide for the application of these standards". For this purpose, international safety standards are developed, published and disseminated, in an effort to achieve standardization and encourage best practices. As an example, the International Basic Safety Standards (BSS) for Protection against Ionizing Radiation and for the Safety of Radiation Sources aims at establishing basic requirements for protection against the risks associated with exposure to ionizing radiation and for the safety of radiation sources that may deliver such exposure [2]. These Standards have been developed from widely accepted radiation protection and safety principles, endorsed by the main partner organizations: the European Commission (EC), the Food and Agriculture Organization of the United Nations (FAO), the IAEA, the International Labour Organization (ILO), the OECD Nuclear Energy Agency (OECD/NEA), the Pan American Health Organization (PAHO), the United Nations Environment Programme (UNEP) and the World Health Organization (WHO). The BSS also provide an agreed on definition of the role and duties of medical physicists, an important point in the process of supporting the recognition of the medical physics profession worldwide. Health is a specific area of interest of the IAEA and through its Human Health programme [3], the IAEA responds to the needs of Member States, supporting the enhancement of their capacity to prevent, diagnose and treat health problems by applying nuclear and radiation-based techniques. Consequently, medical physics, as the discipline that tackles

optimization and quality assurance in medical applications of radiation, is one of the core topics included in this area of interest. Through the work of the Dosimetry and Medical Radiation Physics Section [4], the IAEA supports activities specifically related to medical radiation physics, focussing on clinical and highly specialized technical topics in radiotherapy and diagnostic imaging (nuclear medicine and diagnostic and interventional radiology). The spreading of the culture of quality and the technical support to medical physics are carried on in different forms including support to education, production of specific publications and training activities.

II. HARMONIZATION OF MEDICAL PHYSICISTS' EDUCATION AND TRAINING

The roles, responsibilities and, consequently, clinical training requirements of medical physicists are still today very diverse among countries. The medical physics profession plays a key role in the safe and effective application of medical diagnostic imaging and therapy. Therefore, the IAEA is dedicated to work toward the definition of internationally endorsed roles and responsibilities of medical physicists, establishing harmonized requirements for education and supporting and promoting clinical training worldwide.

The lack of adequate academic education and clinical training, as well as continuous professional development, is an important issue for the medical physics profession that affects many countries. Medical physicists are health professionals with specialist education and training in the concepts and techniques of applying physics in medicine [2]. They are competent to practise independently in one or more of the specialties of medical physics and their responsibilities include as well being in charge of the maintenance of a correct quality management program of high technology medical equipment. Therefore, providing adequate education and training of medical physicists is an important point in the process of ensuring quality and effectiveness in the use of radiation in human health. Currently, a wide spectrum of different levels of education can be found in different countries, sometimes even inside the same country, as a result of lack of recognized and well-structured educational programmes. The IAEA directly addressed in a specific publication the recommendations for the academic education and training programmes of clinically qualified medical physicists, including guidelines for their accreditation, certification and registration, along with continuous professional development. This publication, "Roles and Responsibilities, and Education and Training Requirements for Clinically Qualified medical physicists" [5], has been jointly endorsed by the International Organization for Medical physics (IOMP) and the American Association of Physicists in Medicine (AAPM). The publication introduces the denomination of Clinical Qualified Medical Physicist (CQMP) which corresponds to the same level of training and education of "qualified expert in medical physics" defined in the BSS [2] and the "medical physics expert" defined by the European Council Directive 2013/59/Euratom [6]. In support to the previously described publication and in response to an increasing number of Member States seeking support to establish specific education paths in medical physics, the IAEA worked to provide guidelines for a postgraduate academic education programme for medical physicist, issuing "Postgraduate Medical Physics Academic Programmes", also endorsed by the International Organization for Medical Physics (IOMP) [7]. In addition to academic education, medical physics' students should be required to undertake specialized clinical training which needs to be monitored, properly structured and supervised. It is also recommended to put in place a formal mechanism for registration and/or accreditation or certification; this would help to maintain a verified level of professionalism, fostering the organization of continuous professional development (CPD) programs. A proper harmonization and certification is also a first step towards the adequate recognition of the profession of medical physicist, a common problem in many countries. To support the establishment of structured practical clinical training programmes for medical physicists, the IAEA has issued three Training Course Series publications (Figure 1), which provide references and guidelines to clinical training material for medical physicists specializing in radiation oncology (TCS-37 [8]), diagnostic radiology (TCS-47 [9]) and nuclear medicine (TCS-50 [10]).

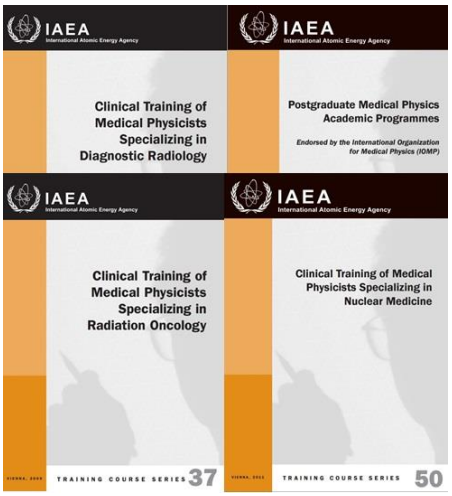

Fig. 15 IAEA Training Courses Series on education and training of medical physicists

III. DEVELOPMENT OF EDUCATIONAL AND TRAINING MATERIAL

Publications of guidelines represent an important tool for the dissemination and support of best practices in quality assessment and management. Furthermore, in the medical

physics area, special attention has been dedicated to the production of three comprehensive handbooks (Figure 2) in Radiotherapy Physics [11], Diagnostic Radiology Physics [12] and Nuclear Medicine Physics [13].

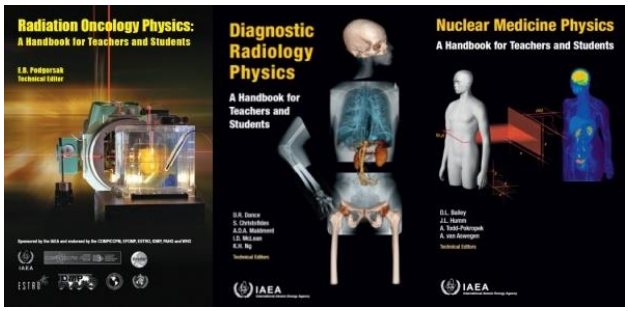

Fig. 2 IAEA freely downloadable handbooks

These handbooks, produced by international leading scientists, aspire to serve as primary text for medical physics students and reference support for lecturers and professionals. For the Radiotherapy Physics and the Diagnostic Radiology handbook, freely downloadable PowerPoint slides are also offered (currently in preparation for Nuclear Medicine Handbook) to ease the use of these Handbooks by teachers. To promote the diffusion of the highest level of education in an affordable way, all of the handbooks and related material are made available for free download from the IAEA website [14].The IAEA also aims at supporting the everyday work of medical physicists in hospitals, providing help in standardizing it according to international and widely accepted best practice. For this reason, the IAEA issues publications that can be used as guides for applications in a clinical environment and that are available on the website [15]. These publications address major broad topics or more specialized ones, which are relevant for the medical physics community. These needs are identified by the IAEA through consultancies with professional societies and international experts, with the aim of addressing the most relevant topics in a comprehensive way. Special attention is dedicated to commissioning and quality assurance, since these activities are important for the application and maintenance of quality management procedures in the use of nuclear science and radiation technologies for human health. Furthermore, standardizing these procedures will help to harmonize quality and efficiency in the use of radiation for diagnosis and treatment worldwide. Guidelines and technical reports on acceptance testing, commissioning and quality assurance (QA) procedures are available for both equipment and patient-related procedures in radiotherapy [16, 17, 18, 19], radiology physics [20, 21, 22, 23] and nuclear medicine physics [24, 25, 26, 27]. Specific codes of practice are also published for radiotherapy dosimetry [28, 29, 30], as well as publications on clinical dosimetry [31], publications on dosimetry in X-ray diagnostic radiology [32, 33, 34] and radioactivity measurements in nuclear medicine [35]. Specific publications are also available to provide support in the application of best practices during the process of planning and setting up clinical radiation facilities [36, 37, 38, 39].In the case of centres planning a change or transitioning to new technologies, publications are issued to offer guidance and expert advice for the process [40, 41]. All publications can be freely downloaded from the IAEA's website [15].

IV. Guidance, training, competency building and research activities in medical physics

In addition to publications and guidelines, the IAEA is committed to practically support their clinical application, fostering the maintenance and implementation of quality procedures worldwide. The IAEA also offers support through its dosimetry audit services to Member States, for example by providing postal dose verification of radiotherapy beam outputs. Through the IAEA Dosimetry Laboratory, located in Seibersdorf, in the framework of the IAEA/WHO Network of SSDLs [42], support in the correct application of guidelines and dosimetric measurements is provided to Secondary Standards Laboratories (SSDLs) and radiation therapy centres in Member States on regular basis, for applications in radiotherapy, diagnostic radiology and radiation protection. Thermoluminescent dosimeters (TLD) are sent to participating radiotherapy centres and SSDLs who request the services, irradiate under specific conditions by the participants, then return them to the IAEA for readout and analysis. The dose received by the TLD is compared with the intended dose stated by the staff of a participating institution. When discrepancies are detected, the IAEA establishes a follow-up programme for quality improvement, including on-site visits by local or international experts, as required. In response to requests by Member States, the Agency provides this way dose quality audits to over 1500 end-user institutions in regions that have no other means to participate in a dose verification process. Member States can receive different types of direct support and training by the IAEA through the specific Technical Cooperation (TC) programme [43]. The TC programme supports transfer of know-how and technology through the procurement of equipment, training and expert missions, and operates in four geographic regions: Africa, Asia and the Pacific, Europe and Latin America. Through TC, the IAEA directly supports medical physicists worldwide, responding to Member States' requests in different and customized ways: providing guidance from international experts for specific tasks, helping organize on-the-job training, granting fellowships to professionals working in medical physics for well-defined training. Support is also provided for building competencies on a large scale, for example, setting-up national medical physics education and clinical training programs in Member States. Through TC, the IAEA offers for example the possibility of a comprehensive audit to assess the whole radiotherapy

process [44, 45] or imaging modalities [46, 47]. These comprehensive peer-review missions aim at evaluating the effectiveness and quality of all components of the practice at the institution, including safety, as well as professional competences and training activities. IAEA activities also include the organization of workshops, conferences and meetings at a national, regional and international level to address specific subjects and topics of interest for the worldwide medical physics community. Furthermore in the Laboratories in Seibersdorf, the IAEA has also set up a gamma camera laboratory, which is used to develop and implement practical courses on topics considered essential for practical training of medical physicists specializing in Nuclear Medicine. The request of support by the IAEA through the TC programme is based on formal requests that have to be completed on-line [48] and submitted to the IAEA through the relevant national authorities. Requests for fellowships and scientific visits, and for participation in meetings, workshops and trainings, should be related to an on-going IAEA TC project, and must be channelled through the National Liaison Officer of the applicant's country. The IAEA also encourages research in medical physics through dedicated Coordinated Research Activities (CRAs). These projects aim at transferring knowledge and know-how among the participants while achieving specific research and development objectives consistent with the IAEA programme of work. Most of the CRAs are carried out under Coordinated Research Projects (CRPs), which bring together experts from high income to lower and middle income countries to work and collaborate on topics of common interest. Examples of ongoing CRP in medical physics are Doctoral CRP in "Advances in Medical Imaging Techniques" [49] and "Development of Quality Audits for Advanced Technology (IMRT) in Radiotherapy Dose Delivery" [50]. The CRP participants prepare the project work plan, regularly meet and review the ongoing work, thus creating a network that often favours new collaboration and leads to new developments. The IAEA ensures that the end results of the research and collaboration activities are freely available to all its Member States. This is usually achieved through the publication of the results in the form of a technical document, an IAEA report or in the open literature. To participate in the CRAs, proposals should be prepared by institutes in IAEA Member States and submitted to the Research Contracts Administration Section [51].

V. Human health campus website

The IAEA, besides its general website, also offers an entire web platform dedicated to learning, the Human Health Campus [52]. On this platform (Figure 3), different areas of science applied to human health are covered, including medical radiation physics.

Fig. 3 IAEA Human Health Campus website

This web space has been created by the IAEA with the aim of becoming a free reference virtual resource centre for professionals and students who work in health, providing coverage for the main topics related to every relevant scientific area and selected link to useful documents. Under the medical physics section, educational material and references can be found for the three main subspecialties (Diagnostic Radiology, Radiotherapy and Nuclear Medicine). For each subspecialty, a wide offer of selected references is available, including links to IAEA publications but also international references and journal articles. A special chapter is dedicated to the medical physics career, professional roles and responsibilities, continuing professional development (CPD) and the educational and training requirements.

VI. Conclusions

Medical physics plays an important role in the effectiveness and quality of clinical applications of radiation therapy, nuclear medicine and diagnostic radiology; this is more and more evident considering the fast and major improvements of technology. Treatment and diagnosis are intertwined with technology and computer tools, and are becoming increasingly complex. The medical physicist is called to verify and ensure the correct functioning of these high tech systems and, at the same time, to favour the link between technology and medicine. The work of a medical physicist is then constantly evolving. Multiple diverse skills are requested and must be acquired, maintained and developed. The IAEA, as an international hub, collect inputs from all over the world and identifies the gaps and needs for assistance, especially in training and continuous education. At the same time, the world situation is very diverse and it is then necessary to customize the support. The IAEA is working to support and harmonize the medical physicist work worldwide, providing tools, responding to immediate needs and, at the same time, planning on long term actions to achieve improvements in efficacy and safety of medical application of radiation for the benefit of patients worldwide.

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