Global cancer control: The role of the International Atomic Energy Agency and future perspectives

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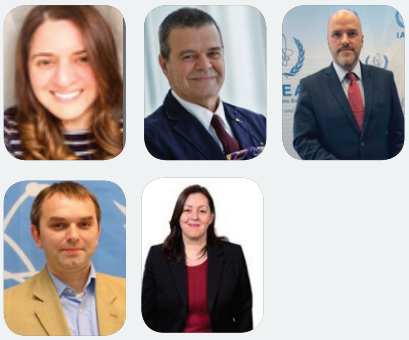


The global burden of cancer is rapidly growing worldwide and there is a low level of preparedness to assess the disease, especially in LMICs. The International Atomic Energy Agency (IAEA) is committed to providing all the required support, to introduce, expand and improve the peaceful use of radiation in medicine, through its inter-institutional partnerships and its different technological tools.

The global burden of cancer is rapidly growing worldwide *(1)*, with an estimated number of 18.1 million new cases and 9.6 million cancer deaths globally in 2018. These numbers are expected to rise to 24.1 million new cases and 13 million deaths by 2030 *(1)*. Among the global challenges in addressing this disease are its variability, differing epidemiology between regions and countries, multiple risk factors associated with different types of cancer, pressure on all components of national health systems from promotion, prevention, access to early diagnoses and treatment as well as the palliative care and survivorship programmes.

The International Atomic Energy Agency (IAEA) was created in 1957 as an independent, intergovernmental organization in the United Nations System with a main objective to "… seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose". (IAEA Statute) *(2)*.

As part of the achievement of this objective and in concordance with the sustainable development goals, the IAEA is committed to providing all the required support, to introduce, expand and improve the peaceful use of radiation, this includes the safe and sustainable use of radiation in medicine, including radiotherapy, diagnostic radiology, nuclear medicine and medical physics. Since its creation, the IAEA has strongly supported and advanced research, staff training and the design of quality radiation facilities for low- and middle-income countries (LMICs).

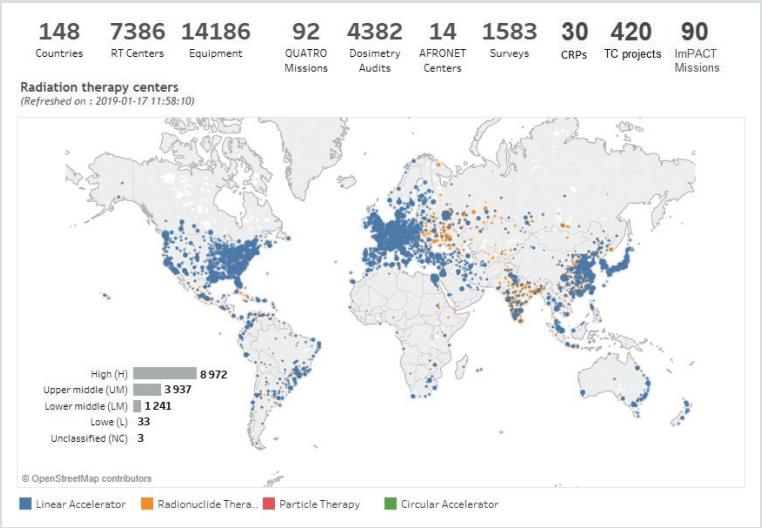
Over time the different approaches used to address the growing needs of Member States included the use and development of different technological tools to facilitate training and education of professionals in radiation medicine worldwide, as well as to create a collection of important data that can help identify and address gaps in a timely manner.

Coordination of efforts worldwide

The IAEA, aware of the growing burden of cancer worldwide, has coordinated efforts with different international institutions and other UN organizations to tackle the global challenges that need to be addressed. Cervical cancer is the second most common cancer in women in LMICs, where 80% of the cases occur. In response, seven UN agencies (IAEA, WHO, IARC, UNAIDS, UNFPA, UNICEF and UNWomen) have joined efforts to create the UN Joint Global Programme on Cervical Cancer Prevention and Control (UNJGCP), working together through joint missions, and supporting the development of joint work plans that address cervical cancer all the way from prevention and HPV vaccination, to diagnosis, treatment, and palliation *(3)*.

The Programme of Action for Cancer Therapy (PACT) was created in 2004 as an IAEA global initiative to confront the cancer crisis, with the vision of a global public-private

Figure 1: **A dashboard representing the different information available for radiotherapy decision-making, as an example of the use of the technological tools available**



partnership and fund, a joint programme for cancer control in collaboration with the Word Health Organization (WHO) the International Agency for Research on Cancer (IARC), the Union for International Cancer Control (UICC) and other key international organizations was developed, with the main objectives of building a global partnership of interested organizations committed to address the challenge of cancer in LMICs; to mobilize resources to assist LMICs in the development and implementation of their radiation medicine capacities, within a national cancer control programme (NCCP); and to ensure the effective and sustainable transfer of radiation medicine technologies and technical knowledge to LMIC Member States.

As a tool to achieve all these goals the IAEA, in coordination with WHO and IARC, have established the ImPACT Review Missions, to help LMICs with a baseline situation analysis as well as a set of recommendations to help them prioritize and guide their decisions and the cancer control planning from the establishment of a cancer registry, prevention, early detection, diagnoses, treatment and palliative care. Since 2005, IAEA has conducted over 90 ImPACT review missions to its Member States. Recent published data *(4)* summarize some of the results obtained from these ImPACT review missions.

Diagnosis and treatment for paediatric cancers is another issue the IAEA has taken on. In June 2018, a new cooperation agreement between Childhood Cancer International (CCI) and the IAEA was signed, to ensure the best possible access to treatment and care for children with cancer worldwide. CCI brings together 188 organizations in 93 countries, representing parents and young cancer survivors working to promote best practices. Together with other institutions, the IAEA has joined WHO to strengthen the diagnosis and treatment in paediatric radiation oncology to support this especially sensitive group of patients.

Knowing the geographic distribution of radiotherapy centres, nuclear medicine and radiology equipment available worldwide helps to clearly identify the population-based shortfalls in equipment and staffing. With its already well-established role in providing technical guidance at every step involved in the implementation and use of radiation medicine, the IAEA has maintained a Directory of Radiotherapy Centres (DIRAC) since 1968, with an online edition available since 1995. Data on facilities is obtained from several sources and is being continuously updated, including 7,269 radiotherapy centres in 147 countries, with 12,000 teletherapy machines. There is a similar database for nuclear medicine facilities, NUMDAB, and current inter-institutional efforts are being made to establish a radiology database.

The IAEA also encourages research in Member States by creating a framework that supports scientific and technical exchanges between countries, bringing together research institutions from high-income countries and LMIC to research topics of common interest for both. The results of the Coordinated Research Projects (CRPs) are available to Member States as well as the international scientific community through dissemination in the IAEA's scientific and technical publications and in other relevant international or national journals.

IAEA CRPs in human health have a broad scope, ranging from quality assurance *(5-7)*, radiation biology *(8,9)* and diagnostic imaging *(10)* to hypofractionated treatments in head and neck cancers *(11-13)*, central nervous system tumours *(14-15)*, lung cancer *(16)*, cervical carcinoma *(17, 18)* among other pathologies, as well as educational CRPs, focusing, for example, on the global evaluation of an electronic blended tool for contouring *(19)*. Current CRPs include new technological approaches, such as Stereotactic Body Radiation Therapy (SBRT). The IAEA is developing a new secure data management and repository system, called International Research Integrated System (IRIS), that will allow the IAEA not only to monitor every step of data collection to ensure high-quality data from its CRPs, but will also provide a dynamic schema that allows further analysis of the data and mega data collection as a step towards a medical artificial intelligence tool.

Artificial intelligence

The use of artificial intelligence is increasing rapidly around the world and the IAEA has embraced this new development

and is working to improve some of its processes by the implementation and integration of artificial intelligence systems in the working rhythm of the IAEA's Dosimetry Laboratory (DOL), that would allow it to predict better the time windows between receipt and delivery of the Dosimetry sets and the final receipt at DOL, with an expected improvement in the scheduling of the deliveries and a continuous workflow allowing no delays in the results.

Virtual tumour boards

The shortage of radiation professionals, added to the scarcity of access to new evidence-based approaches in clinical practises in some isolated centres in LMICs, encouraged the IAEA to look for a different solution that could fit their needs. The implementation of virtual tumor boards (VTB) started in 2012 as a response for those isolated centres, with limited access to up-to-date publications or difficult cases with no access to a second opinion or further case discussions. The Africa Radiation Oncology Network (AFRONET), started as a pilot telemedicine project that included 14 centres. To date, more than 70 sessions have been organized with a presentation of cases, as well as evidence-based data and expert opinions. AFRONET provides an electronic, easy to install, cost-free application that allows the interaction of all the participants and strengthens the bonds among the participating countries. The IAEA is in the process of expanding this successful project, with the creation of other VTBs in francophone Africa, Asia-Pacific, Latin America and Russian-speaking countries.

IT-based education

Taking in to account the need to facilitate the access to already available learning material, the IAEA created the Human Health Campus *(20)*, now available through desktop and mobile devices. The Human Health Campus is an electronic tool designed to work as an essential informative resource for all health professionals in nuclear medicine, radiopharmacy, radiation oncology, medical physics, nutrition. Having access to a modern learning environment that allows users to download the learning material available, that includes a wide variety of different types of publications: from a set of technical guidelines on setting radiotherapy infrastructure *(21-23)*, guidelines for the treatment of common malignancies *(24-27)*, recorded webinars in nuclear medicine and radiotherapy, atlases for nuclear medicine and radiology *(28-29)*, updated educational syllabi for professionals in radiation medicine *(30-34)* and digital training material *(35-44)*. All these learning materials are constantly being updated and are freely downloadable.

The IAEA's Cyber Learning Platform for Network Education and Training (CLP4NET) is a machine learning environment, that allows easy access from anywhere in the world to the broad collection of educational material available. It provides an interactive online learning platform that allows users to find educational resources easily. It contains distance-assisted training online, with instructor-led courses and e-learning self-study resources to enhance the self-directed learning experience and expand it to a wider audience. The use of the IAEA's platform is provided as a cost-free service by the IAEA.

Among the learning material available is a distance-learning course in Applied Sciences of Oncology (ASO)*(45)*. The ASO provides the learner with an introduction to the applied sciences of oncology. It is designed to supplement textbooks with practical information and examples, and to give an overview of knowledge not easily gained from any one textbook. The course has been produced for the IAEA to provide cancer education for doctors and other radiotherapy professionals in countries where there is little currently available. The course covers eight subject areas and within each subject there are a few individual modules. The materials include interactive text and illustrations that require the students to answer questions before they can progress to the next module. Another distance learning course available is the Advanced Medical Physics Learning Environment (AMPLE) another IAEA-developed platform that provides medical physicists with guided learning materials and remote mentorships to enhance their clinical training in hospitals, as the lack of clinical training in Medical Physics has been identified as a weakness in the Medical Physicist curricula in several LMIC. AMPLE was initially launched in 2004 and since then it has been widely used in Asia and the Pacific, providing a structured, instructor-led learning environment focused on key competencies, in the different areas of medical physics (radiation medicine, nuclear medicine, diagnostic radiology and radiotherapy).

The IAEA launched the TNM cancer staging application in 2015. With it, the user can select characteristics of the disease, such as presence of metastases in the lymph nodes, and the application would provide the correct staging via their mobile devices.

Automated remote quality assurance

Knowing that in every process a good quality assurance system is mandatory to guarantee the expected results, to assess this important keystone of radiation medicine the IAEA has worked overtime in the development of quality assurance guidelines for radiotherapy (QUATRO) *(46)*, nuclear medicine (QUANUM) *(47)*, and radiology (QUAADRIL) *(48)*. These tools have been broadly used in expert missions carried out by the IAEA and have been adopted in several countries as a national framework for internal audits *(49)*.

Since 1969, the IAEA/WHO introduced a postal dosimetry audit system for radiotherapy centres offered to Member

States eligible for TC programme support. It is a cost-free service to participants and it checks the calibration of megavoltage machines (Cobalts and Linacs) with small dosimeters sent by mail, providing the results within eight weeks. The centre receives a certificate if the results are within the 5% tolerance limit. Outliers receive another set of dosimeters and are contacted if additional verifications are needed *(50)*.

Aware that all beams used to treat cancer patients should be verified by an independent national, regional or international auditing organization, as well as the scarcity of auditing centres, in 2010 the IAEA stablished a Dosimetry Audits Network Database (DAN) *(51)*, to be able to provide a network of the available centres to exchange information and compare results, and also to provide countries the opportunity to identify the available auditing centres. Through this network, the IAEA has identified that there are still not enough auditing centres and encourages the setting up of more auditing centres.

Efforts have been made by the IAEA also in the field of radiology to establish methodology and guidelines *(52)* from a remote quality control on planar imaging, that allows those centres with no regular availability to a Medical Physicist to perform the quality control on a regular basis, with a mechanism that allows a remote and automated regular quality control.

The IAEA, through its Human Health Division, understands the need to take advantage of the multiple data available, as well as the new technological advances that present themselves as a tool for decision-making, an engine for the identification of new opportunities, and an opportunity to reach out to those countries in need through the different networks and applications available. ■

Dr Lisbeth Cordero-Mendez, MD, is a Consultant in the Applied Radiation Biology and Radiotherapy Section (ARBR) of Human Health Division of the International Atomic Energy Agency. She is a radiation oncologist, who finished training in 2004 at The National Institute of Cancer (INCAN) in Mexico, and started working in Costa Rica's public health system at Hospital Mexico. Since then, she has worked on the transition from 2D to 3D and IMRT, as well as 3D Brachytherapy. She has participated as an expert in ImPACT missions since 2014. Dr Cordero-Mendez has been Head of the Radiotherapy Department since 2017, improving the radiotherapy workflow and established 24-hour shifts, decreasing waiting time for treatment.

Yaroslav Pynda, MSc, is an IT Systems Engineer, in the Division of Human Health, Department of Nuclear Sciences and Applications International Atomic Energy Agency in Vienna, Austria. He has over 20 years of technical experience in software development and engineering, with a solid foundation in database development including On-Line Transaction Processing (OLTP), Decision Support Systems (DSS) and Data Warehouse / Business Intelligence (BI) solutions. Throughout his career he has acquired extensive experience in conceptual data integration processes, complex data transformations and migrations. He is currently exploring a set of NoSQL concepts that allow the rapid and efficient processing of data sets with a focus on performance, reliability and agility. An advanced University Degree (MSc) in Applied Mathematics and a solid foundation in Software Engineering enable him to successfully identify and analyse business requirements and develop appropriate technological solutions accordingly.

Dr Eduardo Zubizarreta, MD, is Head of the Applied Radiation Biology and Radiotherapy Section (ARBR) at the International Atomic Energy Agency (IAEA). He specialized in radiation oncology in Buenos Aires, Argentina, after obtaining his MD degree from the University of Buenos Aires in 1980. He moved to Uruguay in 1989, where he obtained the degree of Doctor in Medicine from the University of the Republic in 1990. In 1995, he was Fellow at the Mallinckrodt Institute of Radiology, Washington University in St Louis, USA. After a career of 26 years as a radiation oncologist in Argentina and Uruguay he joined the IAEA in 2006. He has been responsible for 100 technical cooperation projects worldwide and for many technical publications, and has conducted several research projects. He collaborated with the GTFRCC and is actively engaged in several global health projects.

Dr Alfredo Polo, MD, PhD is a radiation oncologist with 20 years of clinical practice in the field. His main interest is brachytherapy, cervix, prostate, breast cancer and soft tissue sarcomas. He has experience designing and implementing quality management systems in the clinical environment. He joined the IAEA in 2015, after serving during several years as an expert in field missions and training courses. He is currently working on implementation research and health economics studies in radiotherapy.

Dr May Abdel-Wahab, MD, FASTRO, FACR, is Director of the Division of Human Health at the IAEA and has over 30 years of experience in patient care, teaching and research. She has served on various committees, including as former Chair of the ASTRO Committee for Healthcare Access and Training, former Co-Chair IHE-RO planning committee; and she is currently a Steering Committee Member of the UN Joint Global Programme on Cervical Cancer Prevention Control and Member of the UN Interagency Task Force (UNIATF) on Non-Communicable Diseases, among others.

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