IAEA RLA 6091: ENHANCING CAPACITY BUILDING OF MEDICAL PHYSICISTS IN LATIN AMERICA AND CARIBBEAN

Simone K. Renha[1], Leonel A. Torres Aroche[2], Graciela Velez[3], Peter Knoll[3], Virginia Tsapaki[3]

[1]Instituto de Radioproteção e Dosimetria, Commissão Nacional de Energia Nuclear, Rio de Janeiro, Brazil

[2]Centro de Isótopos (CENTRIS), Habana, Cuba

[3]International Agency of Atomic Energy, Vienna, Austria

Abstract: **In Latin America and the Caribbean, important investments have been made in high-tech and complex equipment. However, the number of qualified medical physicists (MP) remains insufficient to meet the current demand, especially in diagnostic radiology (DR) and nuclear medicine (NM). In addition, the lack of education and clinical programs in agreement with IAEA recommendations aggravates the problem. Considering this scenario, the project RLA6091, intends to improve the quality and safety of diagnostic and interventional radiology and nuclear medicine services through several activities, which include regional training courses, expert missions, workshops, and meetings. The project's expected outcome is to improve the knowledge and skills of MPs in the region. Project outputs will contribute to increasing competencies in medical physics that will impact the quality and safety of patient diagnosis and treatment.**

Keywords – medical physicist, education, clinical program, quality, safety

I. INTRODUCTION

In the last decade, the demand for medical physicists (MPs) increased significantly in Latin America and the Caribbean. Besides the growth of radiotherapy (RT), nuclear medicine (NM), and diagnostic radiology (DR) new departments, a significant technological advance was observed in the region. However, the number of MPs well qualified and updated needs to be increased to attend to this demand. Although many efforts have been made by International Atomic Energy Agency (IAEA) so far, many actions are still necessary to provide the quality and safety of patients submitted for diagnosis and treatment (1,2).

Concerning this current situation in the region, IAEA approved at the end of 2021 the project RLA 6091, "Enhancing Capacity Building of Medical Physicists to Improve Quality and Safety in Medical Practices." (https://www.iaea.org/projects/tc/rla6091). The overall objective is "To improve the quality and safety in medical practices with an emphasis on diagnostic and interventional radiology and nuclear medicine fields through building capacities and strengthening skills and competencies of MPs in the region." The project is expected to increase the medical physics workforce competencies in patient diagnosis and treatment over the years. In addition, focusing on the education and training in medical physics, the outcome expected is strengthening the knowledge and competencies, contributing to patient care improvement, and reducing potential risks of adverse effects of radiation. In the project, we are glad to have the following participants countries: Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Honduras, Mexico, Nicaragua, Paraguay, Peru, Uruguay, and Venezuela. Each country will select different numbers of hospitals.

In the context of medical physics for sustainable health care, the International Day of Medical Physics (IDMP) 2022 message of the International Organization for Medical Physics (IOMP) (https://www.iomp.org/idmp-2022/), it is foreseen that this project will contribute to building sustainable health care since all efforts will be made to improve health and well-being without exhausting natural resources or causing adverse ecological damage.

II. CURRENT BASELINE IN THE REGION

During the project design, several common problems were identified, which included an insufficient number of well-qualified MPs, especially in diagnostic radiology (DR) and nuclear medicine (NM), and a low number of academic and clinical training programs for MPs, among which few accomplished the new international recommendations and are updated to new technologies. In addition, in many countries, MPs are not recognized as health professionals and their presence, in general, is mandatory only in RT services. Consequently, few MPs have dedicated themselves to NM and DR. In addition, only a few countries have national radiation protection laws and standards updated to the new international recommendations and new technologies, especially in DR and NM fields (3). Although this survey was done in 2013, in the survey carried out in 2022, it was identified that many problems still remain and actions should be taken.

A special concern is identified specifically in education and training. The difference between clinical training and academic courses between countries include the syllabus, the theoretical and practical clinical training hours, the structure, and the MP evaluation process. Therefore, some points need to be verified, such as: Can we ensure that the MPs are clinically qualified? Are they well-prepared to assume their responsibilities independently after the clinical training? Did they acquire all the necessary skills to act as MPs in one of the chosen areas? All these questions can be answered as long as the entire education and training system is properly improved and meets the highest standards. Therefore, some activities will be carried out to achieve these goals.

Two surveys were carried out at the beginning of this project to update the information on the region, one for the official representative of the country in this project (counterpart) and one for participant hospitals. The countries which answered the survey before the first coordination meeting were: Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Cuba, Ecuador, Honduras, Paraguay, Peru, Uruguay, and Venezuela. A summary of the results is presented below.

III. BASELINE COLLECTED FROM EACH COUNTERPART

a) Clinical training program

Of the 13 countries surveyed, Barbados, Bolivia, Ecuador, Honduras, Paraguay, and Uruguay did not have a structured and supervised clinical training program, representing approximately 46% of the participant countries. The period of the training course also varies in the countries. In most clinical training, the duration of the training is one year (58 %), whereas only 25% of the duration is two years.

b) MP recognition

Another important result is the lack of recognition by law of the MP profession as a health professional in the region (61,5%). One strategy should be adopted to demonstrate the importance of this recognition which the International Labour Organization has already established.

c) Certification process

The certification process, essential to prove that the MP has the knowledge and skills and meets all the regulatory requirements to be a MP qualified, is not implemented in 77% of the countries. This result indicates that specific actions should be taken to change this current situation.

d) Staff

During routine procedures, the presence of a MP and radiation protection officer in the hospital is mandatory in 58% and 50 %, respectively. However, for radiologists and nuclear physicians, the presence is mandatory in 83%. In all RT centres, the radiation oncologist should be present during the procedures.

e) Regulatory framework

Regulatory bodies are in place in all participant countries, and laws and directives are established.

The MP presence in the hospital is mandatory in 53% of NM departments and 100% in radiotherapy. Only 58% of the countries require clinical training to consider the clinically qualified MP (6,7).

A quality control program is mandatory in 69% of DR services, 77% of NM, and 92,3 % of radiotherapy (RT). The patient dose assessment program is mandatory mainly in RT (61%), whereas in 38% of the countries is not mandatory in any area. Optimization of medical exposure is mandatory in 69% of NM and RT services and 54% of DR services. In more than 90% of the DR and NM services, establishing Diagnostic Reference Levels (DRL) is not mandatory.

A special concern is regarding education and training. The difference between clinical training and academic courses between countries is significant. The differences include the syllabus, the theoretical and practical clinical training hours, the structure, and the medical physicist evaluation process. Other points that should be answered are: Can we ensure that the medical physicists are clinically qualified? Are they well-prepared to assume their responsibilities independently after the clinical training? Did they acquire all the necessary skills to act as a medical physicist in one of the chosen areas? All these questions can be answered as long as the entire education and training system is properly improved and meets the highest standards. Therefore, some activities will be carried out to achieve these goals.

IV. BASELINE COLLECTED FROM HOSPITALS

All countries assigned one hospital to participate in the project, except Brazil, Cuba, and Paraguay, which assigned three. Most participating hospitals are public (79%) and provide DR, NM, and RT services. The specific data obtained for each department individually will be presented below.

Specific information from the DR department

a) Staff

Considering the different hospital dimensions in the DR departments, the number of radiologists presents a significant variation from 1 to 40. However, the number of physicists 'MPs varies from 1 (47%) to 12 (6,7%). A huge variation was also observed regarding the number of medical radiation technologists (from 1 to 80).

b) X-Ray Equipment

Most hospitals have conventional radiography and computed tomography (CT), but seven many hospitals do not have mammography equipment. Tomosynthesis and cone-beam CT are not in place in the majority of hospitals. Most hospitals have fluoroscopy equipment and C-arm systems.

c) Quality Assurance (QA)

In 66 % of the countries, there is a MP qualified in the DR department. However, many international requirements are not accomplished. In 73% of the hospitals, a QA program is implemented, protocols and guidelines are in place, and instrumentation and phantoms are available. However, 87% of the hospital did not implement programs for monitoring and managing patient radiation doses, and most did not have software for dose monitoring. In 80% of the DR services, Diagnostic Reference Levels (DRL) were not implemented, and 50% had no optimization program. Approximately 50% did not regularly participate in quality audit programs. Dedicated work is needed to solve these problems.

Specific information from the NM department

a) Staff

The number of nuclear physicians and MPs varies from 1 to 5 specialists, whereas the number of medical radiation technologists varies from 1 to 13. Only seven departments reported the presence of radiopharmacists (range 1-8). Most departments include 1 or 2 nurses in their staff to support NM activities.

b) Equipment

Most departments did not have Radioimmunoassay (RIA) or dedicated Positron Emission Tomography (PET). However, approximately 50 % have gamma cameras and single-photon emission computerized tomography (SPECT) systems in place. In around 60% of the departments, PET-CT and SPECT-CT equipment are available. Approximately 50% of the departments have at least one gamma probe. Radionuclides therapy is carried out in approximately 67% of the departments. However, the majority do not carry out internal dosimetry.

c) Quality Assurance (QA)

QA programs are implemented in 67% of the departments. Instrumentation and phantoms are available. Quality Control (QC) protocols and guidelines are established and implemented. However, 86.7% do not implement patient dose monitoring and management programs. Only 20% of the departments have tools for internal radiation dosimetry in patients. More than 93% of the services do not have DRL. Although 73% of the services have MP, in 60%, the optimization program is not in place. Radiopharmaceutical therapy is performed in 60% of the NM departments, but only in 36% is internal dosimetry performed. NM departments use mostly 99mTc, 18F, and I-131. More than 50% of the services do not regularly participate in any quality audit program. Dedicated efforts are needed to improve the NM services.

Specific information from the RT department

a) Staff

The number of radiation oncologists (RO) varies from 1 to 14, whereas the number of MPs varies from 1 (25%) to 12 (8,3%). A huge variation is also observed in the number of medical radiation technologists (from 4 to 30). In 40% of the services, there is only one dosimetrist.

b) Equipment

Only three departments have fluoroscopy equipment, but most of them have CT simulators available. The majority of the departments have two treatment planning systems. Only five departments have X-ray Superficial Therapy equipment, and four have equipment for Teletherapy with Cobalt-60.
Equipment such as gamma knife, tomotherapy, equipment for proton therapy, Low dose rate (LDR) Brachytherapy (Caesium-137), or Cyberknife is not present in the RT departments. Only one service has Pulsed Dose Rate (PDR) systems for brachytherapy (Iridium-192. Almost all departments have a Linear Accelerator (LINAC) capable of performing Intensity-modulated radiation therapy (IMRT), but just 4 departments have LINACs capable of performing ArcTherapy (VMAT). The majority of the departments have two LINACs in total. Intracranial SRS is provided in 46,2% of the departments, and only 30% provide stereotactic radiation therapy (SRT) and stereotactic body radiation therapy (SBRT) techniques. Most services have HDR Brachytherapy (Co-60) equipment.

c) Quality Assurance

The QA program is implemented in 92% of the services, and instrumentation and phantoms are available. Only 7,7% of the RT departments did not have a medical physicist trained and updated in the routine. Most of the departments regularly participate in quality audit programs.

V. PROBLEMS TO BE ADDRESSED

1) Lack of education and clinical training courses for MP in new technologies and imaging processing techniques
2) Necessity to develop educational and clinical training programs in RD and NM according to international recommendations
3) Need to improve the quality and safety of diagnosis and therapy in RD and NM, by implementing standardized quality assurance (QA) and quality control (QC) protocols, standardized dose assessment, monitoring and dose management, optimization programs, and individual clinical dosimetry methods for patient radionuclide treatment to maximize benefits for patients
4) Lack of doses registry systems in DR and NM to estimate absorbed doses to the target organs and healthy tissues.
5) Lack of regulations in the specifications that imaging equipment must meet.

VI. OUTPUT AND ACTIVITIES

Main Outputs:

- **Clinical training program in MP**. Efforts will be dedicated to updating the existing programs and supporting the creation of new ones through workshops, expert missions, and audits. In addition, support will be provided to review documents and proposed clinical training according to new IAEA recommendations (4) and also specific education regulations of the country
- **Network of reference hospitals with qualified MP**: to promote the quality and safety of medical applications, some hospitals will be carefully chosen to provide technical support for hospitals that requires special attention. These hospitals will demonstrate that all requirements were achieved, including establishing a quality assurance program, DRL, dose assessment, monitoring, and management, including patient's internal dose assessment methods in radionuclide treatment.
- **QC/QA procedures:** although some countries have already established QC/QA programs, the advent of new technologies has challenged many medical physicists in the region. Special protocols should be elaborated, and adequate instrumentation and phantoms must be available. In addition, special training courses could be necessary for many countries to prepare the medical physicist to carry out performance tests with accuracy and precision.
- **DRLs established**: DRLs are not implemented in any Latin American country. Standard protocols should be elaborated and presented in regional training courses. It is fundamental that all health professionals of the participant hospitals be aware of the importance of DRL in the optimization

process and that all should be committed to the establishment of DRL.

- **Number of MPs trained and updated in complex technologies increased**: To achieve this output, more than 50 activities are scheduled, such as a workshop, regional training course, and expert missions. Expert missions will support the regional training courses, especially in practical lectures, including measurements to establish DRLS. In addition, the expert mission will help to review the e-learning materials prepared by the working in Spanish and Portuguese. The main objective is to achieve medical physicists in remote places and consider different knowledge levels.

VII. EXPECTED RESULTS

This is the first-ever TC project specially designed for imaging medical physicists for the last 10 years. The training courses and all activities are tailored to meet the medical physicist's needs. It is expected to increase the number of well-trained medical physicists and reduce the inequality between countries and even in different regions of the same country. The main goal is to provide an accessible high-level of quality diagnostic and therapy for the patients independently of their geographic location. Therefore, the education and training of medical physicists should break these barriers. The number of clinical training centres in different regions should be stimulated and supported. Adequate work conditions for medical physics it also necessary to avoid leaving in search of better places to work. Safety culture, when well disseminated, can open more opportunities even in remote places.

It is a challenge we have to face, but it is feasible when the knowledge is disseminated equally, and so are the opportunities. At the end of the project, we expect to provide medical physics for sustainable health care, to benefit the care of patients, reduce inequalities and improve the health service offered to the population.

VIII. ACTIVITIES IN 2022

1. Regional Training Course (RTC) on Structured and Supervised Clinical Training Programmes in Medical Physics, 24 to 28 October, Brazil.

Fifteen countries and 50 medical physicists participated in the course. The IAEA's new recommendations were presented. The event aims to train the participants on establishing and carrying out structured and supervised clinical training in alignment with the Guidelines for Academic and Clinical Training Programmes for Medical Physics in Latin America. As a result, it is expected to bring more quality and safety to the medical practices that undertake ionizing radiation by strengthening clinical training centres, developing capacities, and strengthening the skills and competencies of medical physicists in the region. Only a few countries have a structured clinical training program.

The training provided theoretical lectures, which included useful educational tools and practical exercises to assist in implementing clinical training programs, and a technical visit to the National Cancer Institute (Inca). The course concentrated all effort on giving the necessary support to update the current clinical training programs and the programs in the implementation phase.

2. RTC on Quality Assurance and Dosimetry in general radiography (conventional and digital), fluoroscopy, and interventional radiology, 14-18 November 2022, Costa Rica

The purpose of the training course was to train participants on all aspects related to physics, technology, quality assurance, quality control, and dosimetry in general radiography (conventional and digital), fluoroscopy, and interventional radiology, and the learning objectives were the following:

1. To update the knowledge on dosimetry in radiography, fluoroscopy, and interventional procedures
2. To become familiar with the latest image quality metrics in radiography, fluoroscopy, and interventional procedures
3. To understand the role of quality assurance in upgrading the radiology service and in avoiding incidents and accidents

4. To learn about the role of dose monitoring and how to perform efficient patient dose surveys
5. To become familiar with the concept of automated quality control and artificial intelligence in radiography, fluoroscopy, and interventional procedures

The course had a theoretical part with lectures and a practical part with quality control and dosimetry exercises in small groups.

3. RTC on Internal Dosimetry: Activity Quantification and Dosimetry Formalisms 5-9 December 2022, Cuba

The event aims to train the participants on image quantification and internal dosimetry. Molecular radiotherapy has demonstrated unique therapeutic advantages in treating many cancer types. Such treatments can deliver high-absorbed doses to specific targets (tumour lesions) and healthy organs (organs at risk) and, thus, require a patient-specific dose assessment. This would help to optimize the amount of radioactivity to be administered and to reduce the risk of under or over-dosing patients, otherwise observed when using empirical approaches to activity determination.

IX. WORK IN PROGRESS

After the first coordinating meeting, work groups were established to elaborate protocols and e-learning materials at the beginning of this year.
In diagnostic radiology, the thirteen groups established were divided between developing the following documents: harmonized QA/QC and dose assessment, monitoring and dose management protocols for complex technologies, good practices protocol based on new recommendations, DRL protocols for mammography, tomosynthesis, CT, fluoroscopy, interventional, Dental, cone-beam CT and digital systems, e-learning material with emphasis on complex technologies. In addition, one group should define the requirements to be a reference centre, select the essential instrumentation for reference centres and software, and adapt the audit QUADDRIL focus on MP.
In nuclear medicine, eleven groups are divided between working on the following subjects: harmonized QA/QC, dose assessment, monitoring, and dose management protocols for complex technologies, protocols harmonized and updated, harmonized dose assessment protocol for patient radionuclide therapy, Paediatric DRL, Hybrid techniques (PET/CT, SPECT/CT), e-learning material with emphasis on complex technologies (NM), to select the essential instrumentation for reference centres and software. (NM)requirements to be a reference centre, to define good practices in NM based on new recommendations, and to adapt the audit QUANUM (5), an IAEA tool for NM audits focused on MP

X. CONCLUSIONS

For the first time, one project dedicated to the education and training of medical physicists, with a special focus on diagnostic radiology and nuclear medicine, will certainly be a great milestone for strengthening these areas in the region. Increasing the number of medical physicists updated and well-prepared for new technologies will bring expressive benefit to the patients and to the healthcare systems.

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Contacts of the corresponding author:

Author: Simone kodlulovich Renha

Institute: Instituto de radioproteção e Dosimetria, Comissão nacional de Energia Nuclear

Street: Av. Salvador Allende, 3773 - Barra da Tijuca, 22780-160

City: Rio de Janeiro - RJ

Country: Brazil

Email: simonekodlulovich@gmail.com