Development of Radiation Protection Guidelines for Nuclear Medicine Facility in Burundi

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1. Introduction

Nuclear medicine, encompassing diagnostic techniques such as Single-Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET), as well as therapeutic procedure using radionuclides like Iodine-131(I-131) [1]. Medical imaging is becoming increasingly important in routine clinical practices. Molecular imaging techniques such as Single-Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET) offer significant benefits to medical practice [2]. The introduction of hybrid imaging technologies, including Positron Emission Tomography/Computed Tomography (PET/CT) and Single-Photon Emission Computed Tomography (SPECT/CT), has resulted in the combination of traditional nuclear medicine approaches with X-ray-based techniques, causing the distinction between them to blur [1, 3]. While there are clear advantages to using ionizing radiation in nuclear medicine, it is essential to adhere to radiation protection guidelines to ensure that the benefits outweigh the health risks. Burundi is establishing its first nuclear medicine facility to address the rising incidence of various types of cancer in the nation. This initiative requires comprehensive radiation protection guidelines to safeguard workers, patients, and the public.

The successful implementation of these guidelines depends on a strong commitment from licensees, personnel, and the national radiation protection regulatory authority.

2. Methods and Results

The Burundi nuclear law (Law No. 31- September 16th, 2022), the International Atomic Energy Agency Specific Safety Guides (SSG-46), the IAEA General Safety Requirements Part 3, and IAEA publications for radiation protection in nuclear medicine serve as the basis for the development of these guidelines.

2.1 Burundi Nuclear Law

Burundi's legal framework regarding nuclear technologies, although still under development, reflects an increasing commitment to radiation protection consistent with IAEA guidelines. The law focuses on regulating ionizing radiation in medical applications. A fundamental aspect of this regulatory structure is the creation of a competent authority (Burundi Radiation Protection and Nuclear Safety Authority) responsible for

Table I: Comparison of Burundi Nuclear Law and IAEA

Burundi Nuclear Law	IAEA GSR Part 3
Regulates peaceful use of nuclear technologies, safety and security of nuclear energy, national focus.	Establish international basic safety standards for protection against ionizing radiation in all exposure situations.
Provides detailed legal definitions relevant to Burundi.	Provides extensive glossary and standard definitions.
Establishes ARSBU (Autorité de Radioprotection and de la Sûréte Nucléaire du Burundi) as an independent nuclear and radiation protection regulatory authority with clear power.	Requires establishment of an independent nuclear and radiation protection regulatory body with legal authority and competence.
Justification, optimization, dose limits, monitoring, emergency measures.	10 Safety principles, justification, optimization (ALARA), dose limitation, protection of future generations, emergency preparedness.
Requirement on authorization for nuclear activities; licensing framework.	Defines notification, registration, licensing, exemptions, clearances, graded approach.
Regulates export/import, physical protection, and transport per international norms.	Sets standards for transport, storage, security; references IAEA Transport Regulations.
Specifies criminal sanctions, fines, imprisonment for infractions.	Does not prescribe penalties; expects national implementation.

licensing, inspections, and enforcement activities. The legal framework imposes stringent controls over the importation, storage, utilization, and disposal of radiopharmaceuticals to reduce radiation exposure for patients, healthcare professionals, and the public at large. The law prioritizes the implementation of justification and ALARA (As Low As Reasonably Achievable) principle in clinical environments and mandates that all practices in nuclear medicine be justified and optimized.

2.2 Personnel Training

The effective implementation of radiation protection measures in nuclear medicine facilities relies on a competent and well-trained workforce, encompassing nuclear medicine physicians, radiologic technologists, medical physicists, nurses, and other support staff. Human resources in this context include not only technical expertise, skills, and creativity but also the professional values and safety-conscious attitudes that ensure adherence to radiation protection protocols.

The training curriculum for Burundi nuclear medicine facility should include the following core components:

- Radiation Physics and Radiobiology: Understanding the properties of radionuclides used in nuclear medicine (e.g., Tc-99m, F-18, I-131), including their emission characteristics, half-lives, and biological effects on human tissues.
- Radiation Protection Principles: Application of the ALARA (As Low As Reasonably Achievable) principle, justification, and optimization to minimize exposure to patients, staff, and the public.
- Safe Handling of Radiopharmaceuticals: Procedures for the preparation, dispensing, and administration of radiopharmaceuticals, including the use of shielding devices (e.g., L-Blocks, syringe shields) and contamination prevention techniques.
- Radiation Detection and Monitoring: Practical training on the use of radiation survey meters, contamination monitors, and personal dosimeters, including calibration and interpretation of results.
- Emergency Preparedness: Protocols for responding to radiation incidents, such as spills, loss of radioactive sources, or overexposure, in accordance with IAEA.
- Regulatory Compliance: Familiarity with Burundi's Nuclear Law (Law No. 31, 2022) and IAEA General Safety Requirements Part 3 (GSR Part 3), including licensing, reporting, and documentation requirements

Given Burundi's limited infrastructure, partnerships with international organizations, such as the IAEA, World Health Organization (WHO), or regional nuclear medicine associations, are crucial for building training capacity. These partnerships can facilitate train-the-trainer programs, equipment donations (e.g., radiation detectors for training), and exchange programs with established nuclear medicine facilities in neighboring countries. By integrating these elements, Burundi can develop a sustainable training framework that supports the safe operation of its nuclear medicine facilities.

2.3 Facility Design

Nuclear medicine facilities should integrate radiation protection principles from the initial design phase, given the use of high-energy photon-emitting radionuclides (e.g., F-18, Tc-99m, I-131. A controlled area is a designated zone where the radiation protection officer (RPO) may restrict the entry or exit of persons and radionuclides, or may require compliance with specific safety regulations, to ensure radiation safety.

It includes a location where radioisotopes are distributed and injected, as well as an imaging room, which should be managed as a radiation control area. For PET procedures, a dedicated resting room for patients administered F-18 is required, with a waiting period of approximately one hour to allow for radiopharmaceutical uptake. This room should be strategically located near the injection area, with dedicated exit pathways to minimize patient movement and exposure to others.

To enhance security, facilities should be situated in areas with restricted public access to radioactive sources, such as radionuclide generators and dispensing equipment. Storage areas for radioactive materials should be equipped with robust locking mechanisms and located near authorized personnel to facilitate a rapid response to security incidents. Storage areas must include robust locking mechanisms and be positioned for rapid access by authorized personnel during security incidents.

2.4 Radiation Shielding

Shielding in a nuclear medicine facility should be carefully designed to fulfill the requirements for optimized radiation protection and safety. This design must take into account the classification of various areas within the facility, the nature of the procedures to be conducted, and the specific radionuclide and their activity levels intended for use. Both structural shielding and supplementary protective barriers should be incorporated during the facility's design phase.

Ideally, shielding should focus on the source itself rather than the entire room or personnel. Both structural elements (like walls, floors, and ceilings) and additional barriers should be evaluated during the design phase, especially for high-exposure areas like therapy or PET–CT rooms. Rooms containing sensitive instruments (e.g., gamma cameras, PET scanners) may require special wall shielding to maintain low background radiation levels. Structural shielding (e.g., concrete walls, lead-lined doors) and supplementary barriers (e.g., L-Blocks, syringe shields) should be optimized to

maintain dose of worker below regulatory limits (e.g., 1 mSv/year for the public, 20 mSv/year for worker)

2.5 Radiation Monitoring

Workplace monitoring in nuclear medicine facilities should encompass both external radiation exposure and radioactive contamination. Imaging rooms and other areas where unsealed radioactive sources are used must be systematically monitored for external radiation levels and surface contamination. Controlled and supervised areas should undergo periodic checks using survey meters, contamination monitors, or through wipe testing. Radiation survey instrument shall be periodically calibrated to verify their accuracy and operational integrity in accordance with the manufacturers' instrument.

Nuclear medicine physicians, other specialist doctors, medical radiation technologists and the radiation protection officer should be subject to individual monitoring. This also extends to all staff involved in the preparation, dispensing, and administration of radiopharmaceuticals for diagnostic or therapeutic purposes. Staff responsible for managing radioactive waste, biomedical and clinical engineers, maintenance and service technicians, as well as nursing and other personnel who either work in controlled areas or provide care to nuclear medicine patients, should also be considered for individual monitoring. Monitoring encompasses more than the mere collection of radiation measurements; it also involves the interpretation of results, assessment of potential risks, investigation of anomalies, and documentation of findings. Regulatory authorities typically define the monitoring interval, that is, the duration for which dosimeters are worn, within a range of about three months.

2.6 Radioactive Waste Management

Nuclear medicine generates short-lived radioactive waste (e.g., Tc-99m, half-life 6 hours; F-18, half-life 110 minutes), which can often be stored until decayed to background levels. To ensure compliance with regulatory standards, a formal system with strict control procedures should be established to govern the release of such materials from regulatory oversight once they are no longer classified as radioactive waste. The procedures are a formal waste management system, including segregation, storage, and disposal protocols. A dedicated, secure storage room with shielding and access control is required for interim waste storage. Detailed records must be maintained to ensure traceability, including radionuclide type, activity, and disposal date. Once decayed to clearance levels (as defined by IAEA SRS-44), waste may be released from regulatory control [5].

Gaseous waste (tritium, noble gases, radioiodine) and liquid waste (Contaminated waste water from the patient care, spills, equipment washing containing I-131 and TC-99m) are managed through containment measures aimed at preventing their uncontrolled release into the environment. Treatment of radioactive wastewater typically involves processes such as evaporation, filtration, or ion exchange to effectively remove radionuclides. After being assessed and confirmed as safe, these wastes are disposed of following established regulatory protocols.

3. Conclusions

The radiation protection guidelines presented in this paper provide a comprehensive framework for establishing Burundi's first nuclear medicine facility. The guidelines address personnel training, facility design, radiation shielding, radiation monitoring and radioactive waste management.

However, more sensitization activities of political leaders and policymakers on the benefits of establishing an effective regulatory framework are required. Given Burundi's limited infrastructure, international collaboration through the IAEAs Technical Cooperation Program and partnerships with the World Health Organization is critical for building training capacity. This cooperation between the government of Burundi and international organizations might continue to support the country in this process. The continuous development of the national regulatory framework is the basis for ensuring safety use of ionizing radiation for medical purpose.

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