Medical Physics for Nuclear Medicine

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الهيئة السعودية للتخصصات الصحية
Saudi Commission for Health Specialties

بسم الله الرحمن الرحيم

In The Name of Allah

PREFACE

- The primary goal of this document was to enrich the experience of postgraduate trainees by outlining the learning objectives and competencies necessary for them to become competent, independent future practitioners.
- This curriculum may contain sections outlining training regulations; however, such regulations must be sought from the “General Bylaws of Training in Postgraduate Programs” and “Executive Policies” published by the Saudi Commission for Health Specialties (SCFHS), which can be accessed online through the official SCFHS website. In the case of discrepancies in regulation statements, the one stated in the most updated bylaws and executive policies must be considered.
- As this curriculum is subject to periodic refinement, please refer to the electronic version posted online for an updated edition at www.scfhs.org.sa.

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III. COPYRIGHT STATEMENTS

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V. INTRODUCTION

1. Context of Practice

Medical Physics for Nuclear Medicine (NM) in the Kingdom of Saudi Arabia (KSA) has evolved alongside the expansion of gamma-camera services in the 1990s and 2000s coupled with the introduction of Positron Emission Tomography/Computed Tomography (PET/CT) and radionuclide therapy services over the last two decades, particularly in oncology, cardiology, endocrinology, and infection/inflammation imaging [1]. NM medical physicists in KSA work within multidisciplinary teams (NM physicians, technologists, radiochemists/pharmacists, radiation protection officers, and biomedical engineers) to assure image quality, quantitative accuracy, patient/staff/public radiation safety, and compliance with national regulations [2], [3]. Core responsibilities include commissioning and acceptance testing of imaging systems, routine Quality Assurance (QA), dosimetry and calibration standardization, radiation shielding assessment, and protocol optimization to ensure reliable and safe clinical performance [4].

The NM infrastructure in Saudi Arabia has experienced continuous growth. National surveys have reported an increasing availability of PET/CT and single-photon emission computed tomography/computed tomography (SPECT/CT) systems, with earlier data noting 21 PET/CT and 55 SPECT units. These numbers have since risen and expanded geographically. As of 2023, approximately 68 NM departments operate across 26 cities embedded within diverse healthcare institutions, including Ministry of Health hospitals, military and university centers, and private facilities [5]. Leading tertiary centers have established in-house medical physics divisions responsible for acceptance testing, commissioning, and routine QA [6].

Under the Saudi Vision 2030 Health Sector Transformation Program, the consolidation of services into regional clusters and increased privatization have driven the demand for rigorous QA, quantitative imaging expertise, and comprehensive radiation safety systems, wherein medical physicists are pivotal [3]. Regulatory oversight, including guidance for radiation-emitting medical devices and radiation protection programs, is provided by the Saudi Food and Drug Authority (SFDA) is aligned with global safety frameworks [2].

Oncology remains the principal driver of NM services, both in Saudi Arabia and globally, owing to the need for cancer staging, treatment response evaluation, and theranostics. The Saudi Health Council National Cancer Center Saudi Cancer Registry highlights the rising cancer incidence driven by population growth and aging, thereby fueling a greater demand for PET/CT imaging and radionuclide therapy.

Other key contributors to NM utilization include cardiovascular diseases, thyroid disorders, and infections or inflammation. These areas require advanced quantitative imaging techniques such as Standard Uptake Value (SUV) harmonization, dynamic imaging, and absolute quantification [1]. International guidelines underscore the essential role of medical physicists in maintaining instrumentation performance, dosimetric precision, and data reliability to ensure safe and effective service delivery [2], [3].

A residency program in Medical Physics for Nuclear Medicine in Saudi Arabia should prepare NM medical physicists for the following:

- Perform commissioning and periodic QA for SPECT, SPECT/CT, PET/CT, PET/MR (as available), and dose calibrators; verify correction methods (attenuation, scatter, randoms, dead time) and harmonize SUV measurements [1], [4].
- Patient-specific dosimetry for diagnostic and therapeutic radionuclides (e.g., I-131, Lu-177, and Y-90) incorporates internal dosimetry techniques and

uncertainty analysis aligned with International Atomic Energy Agency (IAEA) guidance.

- Implement radiation protection programs, including shielding design, As Low As Reasonably Achievable (ALARA) principles, contamination control, and staff monitoring in accordance with SFDA standards.
- Optimize imaging informatics, data quality, protocol optimization, and harmonization across regional healthcare clusters.
- Follow/adhere to radiation safety measures during hospital-based emergency preparedness and response efforts.

These competencies complement the SCFHS training framework and align with national educational tracks in diagnostic and therapeutic medical physics and radiology technology/NM, thus, supporting competency-based education [7].

The future needs and challenges of Medical Physics of Nuclear Medicine include the following:

- Workforce and distribution: As NM expands across regions, adequate numbers of qualified medical physicists (QMPs) and equitable distribution beyond the central hubs are needed.
- Quantitative imaging and multicenter harmonization: Clustered care models require harmonized QA, standardized quantitation (SUV bias control), and shared calibration networks across institutions.
- Theranostics growth: Expanding Lu-177 and other novel agents necessitates advanced internal dosimetry capabilities, traceable calibration, and clinical decision support tools—areas where physicists will spearhead implementation.
- Regulatory alignment and readiness: Ongoing updates to the SFDA radiation device/use guidance require physicist engagement to maintain compliance, incident learning, and a facility-level radiation-protection culture.

- Education and residency capacity: Services scale, residency positions, supervised clinical training sites, and faculty development must keep pace with SCFHS competency expectations and international residency guidelines.
- Emergency preparedness: Strengthening hospital response capabilities, with physicists trained for radiological emergencies.

2. Goals and Responsibilities of Curriculum Implementation

This curriculum aims to guide trainees to become *competent* Medical Physicists specializing in the field of NM, equipped with the appropriate scientific, technical, and professional skills necessary to support safe, high-quality diagnostic and therapeutic NM services. Accordingly, achieving this goal requires significant effort and coordination from all stakeholders involved in postgraduate training. As *"adult-learners,"* trainees must be proactive, fully engaged, and exhibit the following: a careful understanding of learning objectives, self-directed learning, problem solving, an eagerness to apply learning through reflective practice based on feedback and formative assessment, a growth mindset and self-awareness, and a willingness to seek support when needed. Program directors, clinical physicist trainers, accredited NM centers, and training stakeholders are vital in ensuring successful implementation of this curriculum. Moreover, training committee members, particularly program administrators and chief residents, significantly impact program implementation. Trainees should be called upon to share their responsibilities for curriculum implementation.

The strategic direction of the Saudi Commission for Health Specialties (SCFHS) applies a recognized competency model of training governance to achieve the highest training quality. Aligning with this model, postgraduate programs in Medical Physics for Nuclear Medicine are required to integrate research literacy, evidence-based practice, and applied clinical physics training—including imaging instrumentation, radiation dosimetry, quality assurance, and radiation safety. Additionally, academic affairs in training centers and regional supervisory training committees play key roles in training supervision and implementation. The Specialty Scientific committee guarantees that the curriculum content is regularly updated to align with the highest standards in postgraduate education across all trainee specialties.

The purpose of this curriculum is to define the training process and competencies required for award of the Saudi Board Certification in Medical Physics for Nuclear Medicine. After training, medical physics graduates will have the competencies required to work as a Qualified Medical Physicist (QMP) in NM, and emerge as an individual who is professionally certified and authorized to independently provide clinical medical physics services, ensure radiation safety, lead quality assurance programs, and uphold national and international standards in NM practice.

VI. ABBREVIATIONS USED IN THIS DOCUMENT

Abbreviation	Description
AAPM	American Association of Physicists in Medicine
ALARA	as Low as Reasonably Achievable
CAMPEP	Commission on Accreditation of Medical Physics Education Programs
CanMEDS	Canadian Medical Education Directives for Specialists
CBD	Case-Based Discussion report
CBE	Competency-Based Education
COT	Consultation Observation Tool
CPD	Continuous Professional Development
CT	Computed Tomography
DOPS	Direct Observation of Procedural Skills report
EYPT-Local	End of year progress test
IAEA	International Atomic Energy Agency
IPEM	Institute of Physics and Bioengineering in Medicine
ITER	In-Training Evaluation Report
KSA	Kingdom of Saudi Arabia
MCQs	Multiple-Choice Question Exam

Abbreviation	Description
Mini-CEX	Mini-Clinical Evaluation exercise
NM	Nuclear Medicine
NEMA	National Electrical Manufacturers Association
OSCE	Objective Structured Clinical Examination
OSATS	Objective Structured Assessment of Technical Skills
PACS	Picture Archiving and Communication System
PBL	Practice-Based Learning
PET	Positron Emission Tomography
PET/CT	Positron Emission Tomography/Computed Tomography
PT	Progress test
QA	Quality Assurance
QC	Quality Control
QMP	Qualified Medical Physicist
R1	(First) year of residency
R2	(Second) year of residency
R3	(Third) year of residency
RTC	Residency Training Committee
SCFHS	Saudi Commission for Health Specialties
SFDA	Saudi Food and Drug Authority
SMPS	Saudi Medical Physics Society

Abbreviation	Description
SOE	Structured Oral Exam
SPECT	Single-Photon Emission Computed Tomography
SPECT/CT	Single Photon Emission Computed Tomography/Computed Tomography
SUV	Standard Uptake Value
WBL	Work-Based Learning

VII. PROGRAM ENTRY REQUIREMENTS

Please refer to the executive policy of the SCFHS on admission and registration, and ensure that there is a statement advising candidates to refer to the SCFHS website.

VIII. LEARNING AND COMPETENCIES

1. Introduction to Competency-Based Education

Training should be guided by well-defined "*enabling competencies*" that are developed based on the "*competencies*" of a particular program to serve specialty needs. Enabling competencies are supposed to reflect the professional "*competencies*" and tasks that are aimed to be "*entrusted*" by trainees upon graduation. This ensures that graduates fulfill the expected demands of the healthcare system and patient care related to their particular specialties. *Competency-based education* (CBE) is an approach to "*adult-learning*" that is grounded in achieving *pre-defined*, *fine-grained,* and *well-paced* sub-competencies that are derived from complex professional competencies.

Professional competencies associated with healthcare are usually complex and contain a mixture of multiple learning domains (knowledge, skills, and professional behavior). CBE is expected to redefine traditional approaches to postgraduate education. For instance, although it is a precious resource, the time of training should not be considered a proxy for *competence* (e.g., the time of rotation in certain hospital areas is not the primary marker of competence achievement). Furthermore, CBE emphasizes the critical role of informed judgment in assessing a trainee's competency progress based on their staged and progressive performance, using data collected from multiple educational and assessment encounters, methods, and workplace-based observations. Several CBE models have been developed for postgraduate healthcare education. We used the CanMEDS framework of the Royal College of Physicians and Surgeons of Canada (RCPSC). The key concepts associated with CBE are as follows:

a. **Competency:** Competency refers to a healthcare professional's observable ability, which encompasses knowledge, skills, values, and attitudes/professional behaviors. It reflects the potential to perform efficiently in a given situation based on the standards of the profession, and involves the practical application of these components in real-world settings. Professional roles (e.g., medical experts, health advocates, communicators, leaders, scholars, collaborators, and professionals) are used to define competencies in a way that makes them adaptable for learning and assessment.

b. **Milestones**: Milestones represent stages of the developmental journey along the competency continuum. Throughout their learning journey, trainees from junior to senior levels assist in transitioning from novice/supervised to master/unsupervised practitioners. This should not undermine the role of supervisory/regulatory bodies with respect to the malpractice of independent practitioners. Milestones are expected to enhance the learning process by pacing training/assessment to match the trainees' developmental levels (junior vs. senior).

c. **Learning-Domains:** The categories or dimensions of learning encompass the development of a learner's abilities and attributes. These domains are commonly divided into the following three key areas: K = Knowledge, S = Skills, and A = Attitude (also known as professional behavior).

Principles of Competency-Based Medical Education (CBME)

These include the following:

1. **Focused Outcomes:** CBME emphasizes defining and achieving clear outcomes based on societal needs, and ensuring that graduates fulfill these standards.
2. **Competencies as a Framework:** The curriculum is developed around clearly defined abilities or competencies that integrate knowledge, skills, attitudes, and behaviors.
3. **Learner-Centered Approach:** It promotes individualized learning by allowing trainees to progress at their own pace and according to their ability to demonstrate competencies.
4. **Integrated Assessment**: It utilizes multiple assessment methods to comprehensively and continuously evaluate competencies.
5. **Flexibility in Learning Pathways**: It encourages adaptable learning experiences tailored to individual needs while fulfilling established competency standards.
6. **Focus on Real-World Application**: This emphasizes the ability to apply knowledge and skills in practical, real-world contexts.
7. **Supervision and Feedback**: This involves close supervision and regular feedback to promote continuous improvement and ensure safety.
8. **Emphasis on Lifelong Learning**: It prepares learners for ongoing self-directed learning and adaptation to a rapidly evolving healthcare environment.
9. **Accountability**: This ensures that training aligns with societal needs and the preparation of competent professionals.

The SCFHS endorses the CanMEDS for articulating professional competencies. The curriculum applies the principles of CBME. The CanMEDS is a globally accepted framework that outlines competency roles. Specifically, the "CanMEDS 2015" has been adopted in this section.

The following reference exemplifies a general outline of the same:

1- The CanMEDS competency (Frank, J. R., Snell, L., Sherbino, J., & Boucher, A. (2015). *CanMEDS 2015 Physician Competency Framework Series I*. Ottawa: Royal College of Physicians and Surgeons of Canada.);

2. Program Duration

Medical Physics for Nuclear Medicine is a 3-year residency program divided into two levels: junior level in the first two years (R1 and R2) and senior level in the final year (R3).

3. Program Rotations

Stage	Training Year	Mandatory core rotations*		
		Rotation name	Duration	Setting
Junior	R1	• Hospital Orientation and Clinical Awareness	2 weeks	• As per hospital setting
		• Radiation Protection and Safety in Nuclear Medicine	6 weeks	• Radiation Safety Office
		• Radiation Detectors and Measurement Systems in Nuclear Medicine	6 weeks	• Nuclear Medicine Department
		• General Clinical Diagnostic Imaging Physics	8 weeks	• Diagnostic Imaging Department
		• Computers and Data Processing in Nuclear Medicine	8 weeks	• Nuclear Medicine Department
		• General Clinical Nuclear Medicine Physics	18 weeks	• Nuclear Medicine Department
	R2	• Gamma Camera with/without SPECT	12 weeks	• Nuclear Medicine Department
		• Radiopharmacy	4 weeks	• Nuclear Medicine Department
		• CT Scanners	8 weeks	• Medical Imaging Department
		• Non-Imaging Detectors & Counters	8 weeks	• Nuclear Medicine Department
		• Positron Emission Tomography	12 weeks	• Nuclear Medicine Department
		• Hybrid Modalities Imaging Systems	4 weeks	• Nuclear Medicine Department
Senior	R3	• General Clinical Radiation Oncology Physics	12weeks	• Radiation Oncology Department

Stage	Training Year	Mandatory core rotations*		
		Rotation name	Duration	Setting
		• Quantitative Measurements in Nuclear Medicine	8weeks	• Nuclear Medicine Department
		• Image Reconstruction	7weeks	• Nuclear Medicine Department
		• Patient Dosimetry	7weeks	• Radiation Oncology Department
		• Radionuclide Therapy	8 weeks	• Nuclear Medicine Department
		• Clinical Physics Practice, Clinical Project and Final Residency Report	6 weeks	• Nuclear Medicine Department

*(*__Mandatory core rotation__: Set of rotations representing the program's core components whose completion is mandatory.*

4. Mapping of Competencies, Roles, Assessment, and Educational Activities to Program Rotations

Rotation Descriptions:

This section aims to match the competencies and objectives for each type of rotation. Trainees and trainers should collaborate to achieve their objectives during teaching, learning events, educational activities, and formative assessments. Expectations should evolve as the training level progresses (e.g., training stage, level, and milestones).

Competency assessment: Map the competencies, roles, educational activities, and matrix assessment (See Appendix A)

R1 Medical Physics for Nuclear Medicine Rotations

Rotation 1: Hospital Orientation & Clinical Awareness

Introduction:

This rotation provides residents with the time and opportunity to complete all institutional induction requirements and become familiar with the NM department, along with its structure, workflow, policies, and safety procedures. Rotation ensures that residents understand the multidisciplinary environment of clinical practice and organizational systems within which NM services are delivered.

Learning Objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

- Complete all mandatory institutional safety, radiation protection, and operational training required by the NM department and affiliated hospital units. [K, S]
- Apply radiation safety and operational procedures to support safe NM clinical activities under supervision. [K, S, A]

Leader

Describe the leadership role of medical physicists in quality assurance and patient safety systems. [K, A]

- Participate in incident reporting and discuss outcomes during QA or safety meetings. [S, A]
- Manage time and resources efficiently in alignment with institutional standards (resource stewardship). [A]

Health Advocate

- Identify and report potential safety and workflow concerns that may affect patients or staff. [S, A]
- Promote radiation protection principles and safe practices for patients, staff, and the environment. [K, A]
- Support departmental initiatives that enhance patient safety and service quality. [A]

Collaborator

- Active participation in departmental and institutional meetings, educational sessions, and interprofessional orientations. [S, A]
- Demonstrate effective teamwork and communication with colleagues across disciplines. [S, A]

Scholar

- Recognize personal learning needs and reflect on educational and clinical practice issues to guide self-directed development. [S, A]
- Engage in ongoing learning related to new technologies, protocols, and safety practices. [K, A]

Professional

- Maintain patient confidentiality, privacy, and autonomy in all clinical and research contexts. [S, A]
- Demonstrate professional communication, appearance, and ethical conduct when interacting with patients, technologists, physicians, and staff. [S, A]
- Exhibit professional work habits including punctuality, accountability, and organization. [A]

Duration:

2 weeks

Setting:

Hospital setting within the NM department and supporting administrative or training facilities (e.g., orientation center, conference room, etc.).

Assessment

); Certificate checks (BLS, Fire Safety), and DOPS (PPE).

Rotation 2: Radiation Protection and Safety in Nuclear Medicine

Introduction:

This rotation equips residents with the knowledge and practical skills necessary to ensure safe use of unsealed radioactive materials and imaging equipment in NM. This encompasses local and international regulations, radiation protection principles, monitoring, and quality assurance to promote safe practices for patients, staff, and the environment.

Learning Objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

- Practically apply fundamental principles of radiation protection (time, distance, and shielding) in NM. [K, S]
- Describe internal and external exposure pathways and interpret applicable dose limits for workers and the public. [K]
- Perform shielding design and verification for hot labs, uptake rooms, and imaging suites. [K, S]
- Handle and dispose radiopharmaceuticals and radioactive waste safely and according to regulations. [K, S]
- Operate and evaluate contamination and radiation survey meters, and interpret the measurement results. [K, S]

- Manage personnel monitoring records and calibration certificates per institutional policy. [K, S]
- Apply national and international radiation safety regulations relevant to NM [K]
- Apply statistical principles in dose optimization and radiation safety auditing. [K, S]

Communicator

- Identify and acknowledge the limits of personal competence and seek guidance from supervisors, RSO, or senior physicists, when appropriate. [S, A].
- Communicate effectively during radiation incidents or safety briefings. [K, A]

Collaborator

- Collaborate with multidisciplinary teams (physicians, technologists, RSO, and maintenance staff) to maintain a safe environment. [S, A]
- Actively contribute to departmental radiation safety committee meetings. [A]

Scholar

- Reflect on professional experiences and identify areas for improvement in safety practices. [S, A]
- Contribute to educational sessions on radiation safety for staff and trainees. [A]

Health Advocate

- Apply ALARA principles to minimize the exposure of patients, staff, and the public. [K, S, A]
- Promote a culture of safety and radiation awareness in clinical practice. [A]

Professional

- Demonstrate integrity and adherence to ethical standards regarding confidentiality and safety. [S, A]

- Maintain professionalism in appearance, communication, and punctuality. [S, A]
- Exhibit accountability and diligence in all radiation safety tasks. [A]

Duration:

6 weeks

Setting:

Hospital environment within the NM and Radiation Safety/Health Physics units equipped with appropriate teaching and monitoring facilities.

Educational Activities:

Half-day activity, Journal Club

Assessment Tools:

DOPS (1. Handling and Disposal of Radioactive Materials; 2. Radiation Area Survey), CBD, logbook, MCQs, and SOE (Formative).

Rotation 3: Radiation Detectors and Measurement Systems in Nuclear Medicine

Introduction:

This rotation focuses on the fundamental principles, design, calibration, and applications of the radiation detectors and counting systems used in NM. Residents will gain practical experience with detection equipment for activity measurement, radiation monitoring, and quality control while focusing on performance evaluation and uncertainty assessment.

Learning Objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

- Describe the physical principles and operation of gas-filled, scintillated, and semiconductor detectors used in NM. [K]
- Differentiate among counting systems (dose calibrators, well counters, thyroid probes, and survey meters) and evaluate their calibration and performance. [K, S]
- Conduct measurements using portable and stationary detectors, analyze the consequent data, and evaluate its accuracy and precision. [K, S]
- Apply concepts of dead time, energy resolution, efficiency, and background correction. [K]
- Perform document calibration and constancy checks of the dose calibrators and well counters. [K, S, A]
- Evaluate statistical methods for data analysis and measurement uncertainty. [K, S]

Communicator

- Communicate the measurement results and uncertainties to physicians, technologists, and regulatory personnel. [S, A]
- Report deviations or equipment malfunction promptly and professionally. [A]

Collaborator

- **Collaborate with service engineers, technologists, and RSO to maintain calibration integrity and compliance. [S, A]**
- **Participate in QA meetings addressing instrumentation performance. [A]**

Scholar

- **Reflect on experimental data and identify opportunities for improvement in detector calibration and testing procedures. [S, A]**
- **Participate in in-service education sessions on instrumentation and radiation detection. [A]**

Health Advocate

- **Apply radiation safety principles to all detector-related activities to minimize exposure and contamination risks. [K, S, A]**

Professional

- **Maintain professional ethics in data handling, documentation, and equipment care. [S, A]**
- **Demonstrate consistency, accuracy, and reliability in performing measurements. [A]**

Duration:

6 weeks

Setting:

Hospital-based NM departments and Medical Physics laboratories equipped with radiation detection systems, calibrators, and QA instruments.

Educational Activities:

Half-day activity, Journal Club

Assessment Tools:

DOPS (1. Dose Calibrator Calibration 2. Contamination and background survey measurements); CBD; Logbook; and MCQs.

Rotation 4: General Clinical Diagnostic Imaging Physics

Introduction

This rotation introduces residents to the physical principles, instrumentation, and quality assurance techniques underpinning the diagnostic imaging modalities used in NM and radiology. It emphasizes dose optimization, image quality assessment, and radiation protection for both ionizing and nonionizing modalities.

Learning Objectives

By the end of this rotation, the resident will be able to:

Medical Expert

- Describe and justify the role of diagnostic imaging physicists and broader radiological teams in NM. [K]
- Identify major imaging modalities (SPECT, PET, CT, and MRI) and their physical principles. [K]
- Explain radiation detection and shielding concepts in imaging environments. [K]
- Perform and interpret basic image quality and performance tests on imaging equipment. [K, S]
- Evaluate patient radiation doses from hybrid imaging (SPECT/CT and PET/CT), and recommend optimization strategies. [K, S]

Communicator

- Recognize limitations in expertise and consult senior physicists or clinical supervisors as needed. [S, A]
- Demonstrate effective communication with technical and clinical staff regarding imaging performance or radiation dose concerns. [K, A]

Collaborator

- Collaborate with technologists, radiologists, and medical physicists to maintain optimal imaging performance. [S, A]
- Participate in departmental QA meetings and discussions. [A]

Scholar

- Reflect on learning and quality issues encountered during imaging QA. [S, A]
- Participate in educational/training sessions related to imaging physics. [A]

Health Advocate

- Promote the application of ALARA principles in diagnostic imaging, balancing image quality, and patient dosage. [K, S, A]

Professional

- Maintain confidentiality, integrity, and professionalism in all interactions. [S, A]
- Demonstrate ethical, punctual, and organized work behavior. [A]

Duration:

8 weeks

Setting:

Hospital setting within Diagnostic Imaging and NM departments with access to imaging suites and QA laboratories.

Educational Activities:

Half-day activity, , Journal Club

Assessment Tools:

DOPS (1. quality Control of Imaging Equipment, 2. Patient Dose Estimation in SPECT/CT or PET/CT); CBD; Logbook; and SOE (formative).

Rotation 5: Computers and Data Processing in Nuclear Medicine

Introduction:

This rotation covers the computational principles, image reconstruction, data analysis, and information systems essential for NM. It introduces software, algorithms, and an informatics infrastructure that support quantitative imaging, radiation dose estimation, and clinical workflow integration.

Learning Objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

- Describe the structure and function of NM computer systems, workstations, and PACS. [K]

- The principles of image digitization, filtering, and reconstruction (planar, SPECT, and PET) have been explained. [K].
- Apply image processing techniques for noise reduction, attenuation correction, and quantitative analysis. [K, S]
- Data transfer, archiving, and retrieval were performed using DICOM standards. [K, S]
- Utilize software tools for dosimetry, kinetic modeling, and image fusion. [K, S]
- Describe the principles of system security, patient data privacy, and backup procedures, and also demonstrate adherence to institutional policies. [K, A]
- Implement a reproducible image-processing workflow and verify the quantitative outputs using built-in QC tools. [K, S, A]

Communicator

- Present quantitative imaging results and statistical analyses effectively to multidisciplinary teams. [S, A]
- Document data processing workflows clearly and reproducibly. [A]

Collaborator

- Collaborate with IT staff, technologists, and physicians on troubleshooting data transfer and analysis issues. [S, A]
- Participate in software evaluation and selection for departmental use. [A]

Scholar

- Reflect on computational challenges and contribute to the continuous improvement of image processing workflows. [S, A]
- Engage in research or development projects using NM software tools. [A]

Health Advocate

- Promote safe handling of electronic medical information and support secure data practices. [K, A]

- Support optimization and automation processes that improve patient care efficiency. [K, S, A]

Professional

- Maintain ethical handling of patient data and respect confidentiality. [S, A]
- Demonstrate accountability, organization, and meticulousness in computational analyses. [A]

Duration:

8 weeks

Setting:

Hospital-based NM department, image processing work/unit, and IT-supported clinical workstations equipped with specialized software for quantitative and hybrid imaging.

Educational Activities:

Half-day activity, , Journal Club

Assessment Tools:

DOPS (1. SPECT/CT or PET/CT Image Reconstruction and Processing, 2. Dosimetry Software Application); CBD; Logbook.

Rotation 6: General Clinical Nuclear Medicine Physics

Introduction:

This rotation will provide residents with a comprehensive understanding of NM operations including imaging, radiopharmaceutical preparation, quality control, data analysis, and radiation safety. It integrates the clinical workflow, multidisciplinary collaboration, and physicists' role in ensuring safe and effective imaging procedures.

This rotation integrates previously acquired knowledge of radiation protection, instrumentation, and imaging physics into comprehensive clinical NM practice.

Learning Objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

- Describe and demonstrate the role and responsibilities of a NM physicist in a clinical team. [K]
- Describe the structure and workflow of diagnostic and therapeutic NM procedures. [K]
- Analyze the physical principles and performance parameters of SPECT, PET, and hybrid imaging systems. [K]
- Perform basic quality control tests for imaging systems, dose calibrators, and contamination monitors. [K, S]
- Contribute to patient dosimetry and radiopharmaceutical activity calculations. [K, S]
- Demonstrate the key elements of radiopharmaceutical preparation and quality assurance. [K]

Communicator

- Seek advice or escalate when clinical or technical issues exceed current competencies. [S, A]
- Communicate effectively within multidisciplinary NM teams. [K, A]

Collaborator

- Collaborate with NM physicians, technologists, radiopharmacists, and RSOs. [S, A]
- Contribute to clinical case discussions and departmental QA meetings. [A]

Scholar

- Reflect on learning outcomes from clinical activities and research exposure. [S, A]
- Engage in continuous professional development sessions. [A]

Health Advocate

- Promote patient and staff radiation safety in all aspects of NM practice. [K, S, A]
- Apply ALARA principles and dose optimization techniques during imaging and therapy. [K, S, A]

Professional:

- Uphold professional conduct, confidentiality, and ethical responsibility. [S, A]
- Demonstrate consistent professionalism, organization, and accountability. [A]

Duration:

18 weeks

Setting:

Hospital environment within the NM department including imaging units, hot laboratories, and data analysis facilities equipped for hands-on training and supervision.

Assessment Tools:

DOPS (1. Daily QC of Gamma Camera, SPECT/CT or PET/CT, 2. calculation of the Administered Activity and Dosimetry; and 3. Equipment Mechanical/Performance Test), CBD, logbooks, MCQs, and SOE (formative).

Annual Leave and Total Training Duration – R1

R1 includes 48 weeks of structured clinical training across six rotations.

- Annual Leave: 4 weeks
- Total Training Duration (R1): 52 weeks (including annual leave)

All activities were conducted under direct supervision, with R1 representing the foundational level of training.

R2 Medical Physics for Nuclear Medicine Rotations

R2 serves as a progressive stage that builds on the theoretical knowledge and foundational competencies developed in R1. During R1, residents acquired an essential understanding of radiation protection principles, detector systems, and fundamental clinical applications in NM. Thereafter, R2 advances this learning by engaging residents in more specialized and practice-oriented rotations to gain skills, including gamma camera performance, radio-precision, CT, positron emission tomography/computed tomography, and hybrid imaging systems. Through these experiences, residents are expected to enhance their technical proficiency, clinical judgment, and analytical capabilities, thereby enabling them to perform complex tasks with increased confidence and semi-independence.

Rotation 7: Gamma Camera with/without SPECT

Introduction:

This rotation covers technical aspects, components, and functions of gamma cameras with and without SPECT capabilities. Furthermore, it addresses the procedures for equipment selection, acceptance and reference testing, calibration, and quality assurance, as well as the annual performance evaluations required to ensure safe and effective clinical use in NM.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

Equipment Selection:

- Explain the components, operation, and clinical use of gamma cameras. [K]
- Describe the steps necessary to select a gamma camera, focusing on feature specification, performance specification, and clinical usage. [K]

- Identify the mechanical and architectural considerations important for installing a new nuclear imaging room. [K]
- Discuss the requirements and specifications of the system in meetings and select equipment. [K]

Acceptance and Reference Testing:

- Be familiar with local protocols for acceptance and reference testing informed by international guidance (AAPM, NEMA, IEC, and IAEA), including their scope and limitations. [K]
- Determine the tests to be performed during acceptance and reference testing. [K]
- Utilize the appropriate equipment required to perform acceptance and reference testing, including intrinsic, extrinsic, and SPECT tests. [K]
- Perform physical inspections of the equipment, including assessments of the adequacy of installation, detector level, and accuracy of angle indicators [K,S]
- Independently perform all recommended acceptance and reference tests (intrinsic, extrinsic, and SPECT) under QMP supervision, and prepare the final report for review and co-signature by the supervising QMP[K,S,A]

Calibration and Quality Assurance:

- Describe the principles of quality assurance and calibration required for a gamma camera, including SPECT systems. [K]
- Develop and monitor a calibration and quality control program for NM cameras, including SPECT systems (daily, weekly, monthly, and quarterly QC procedures). [K,S,A]
- Calibrate and perform routine quality control on planar and SPECT cameras. [K,S,A]

Annual Tests of a Gamma Camera:

- Analyze the relationship between acceptance tests and annual tests. [K]

- Perform annual planar and SPECT testing, analyze the test results, generate the testing report, and compare them to the initial (reference) results. [K,S,A]

Communicator

- Assess the limitations of their expertise and determine when it is appropriate to seek support or escalate it to seniors, QMP, or consultants in a timely manner. [S,A]
- Recognize challenging communication issues. [K,A]

Collaborator

- Communicate effectively with others to assess, plan, provide, and integrate patient care. [S,A]
- Interact in departmental meetings and physics meetings. [A]

Scholar

- Recognize and reflect upon learning and practice issues. [S,A]
- Engage in educational/training sessions. [A]

Health Advocate

- Apply ALARA principles in daily practice to justify the application of ionization radiation to patients and staff. [K,S,A]

Professional

- Demonstrate commitment to team ethics for confidentiality, resource allocation, and professionalism. [S,A]
- Express proper communication and professional appearance. [S,A]
- Demonstrate professional work habits such as being punctual, available, and organized [A].

Duration:

12 weeks

Setting

Hospital setting within the NM Department with designated teaching and training facilities.

Educational Activities:

Half-day activity, Journal Club

Assessment Tools:

- DOPS (1. Acceptance or annual testing of NM gamma cameras; 2. Quarterly ACR SPECT phantom test; 3. Gamma Camera Calibration)
- CBD
- Logbook
- MCQs
- SOE

Rotation 8: Radiopharmacy

Introduction:

This rotation introduces residents to nuclear pharmacy practices and the physics underlying radiopharmaceutical production. Training includes generator elution, quality control, activity assays, kit preparation, dosage calculations, and therapeutic dose preparation, along with mastery over the principles of reactors, cyclotrons, and radionuclide generators such as Mo-99/Tc-99m.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Physics for Nuclear Medicine Expert

Perform and document the following nuclear pharmacy procedures under supervision:

a. Generator elution [K,S],

b. Quality control of generator eluates [K,S],

c. Activity assays [K,S],

d. Radiopharmaceutical kit preparation [K,S],

e. Dosage calculations for administration [K,S], and

f. Preparation and verification of unit and therapeutic doses (including beta emitters). [K,S,A]

- Demonstrate knowledge of the physics underlying radionuclide production using reactors and accelerators, and of the operation of an in-house cyclotron. [K,S]
- Demonstrate knowledge of the physics of radionuclide generators and the physical and chemical principles underlying the Mo-99: Tc-99m generator. [K,S]

Communicator

- Assess the limitations of their expertise and judge when it is appropriate to seek support or escalate it to seniors, QMP, or consultants in a timely manner. [S,A]
- Identify and address communication challenges that affect coordination with NM team. [K,A]

Collaborator

- Communicate effectively with others to assess, plan, provide, and integrate care for patient. [S,A]
- Engage in departmental meetings and physics meetings. [A]

Scholar

- Recognize and reflect upon learning and practice issues. [S,A]
- Engage in educational/training sessions. [A]

Health Advocate

- Apply ALARA principles in daily practice to justify the application of ionization radiation to patients and staff. [K,S,A]

Professional

- Demonstrate commitment to team ethics for confidentiality, resource allocation, and professionalism. [S,A]
- Demonstrate proper communication and professional appearance. [S,A]
- Demonstrate professional work habits, such as being punctual, available, and organized. [A]

Duration:

4 weeks

Setting:

Hospital setting within the NM Department with designated teaching and training facilities.

Educational Activities:

Half-day activity, Journal Club

Assessment Tools:

- DOPS (1. generator elution, 2. kit preparation)
- CBD
- Logbook
- MCQs
- SOE

Rotation 9: CT Scanner

Introduction:

This rotation provides residents with core knowledge and hands-on skills in the principles, operation, and clinical applications of CT scanners, including PET/CT and SPECT/CT systems. The training will focus on acceptance testing, calibration, quality control, and performance evaluation, following international standards. By the end of the rotation, residents will be able to ensure optimal scanner performance, compliance with safety requirements, and high-quality imaging for patient care.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

Equipment Selection:

- Demonstrate knowledge of the components, operation, and clinical use of a CT scanner. [K]
- Describe the steps necessary to appropriately select a CT scanner, focusing on feature specifications, performance specifications, and clinical usage in the context of a system integrated with SPECT or PET system. [K]
- Identify the mechanical and architectural considerations important for installing a CT scanner integrated with SPECT or PET. [K,S,A]

Acceptance Testing:

- Determine the equipment required to perform CT acceptance tests. [K]
- Perform physical inspections of the equipment, including assessments of the adequacy of installation and shielding in relation to specified requirements. [K,S]
- Perform acceptance tests on the CT scanner, including dose evaluation. [K,S].

- Under the supervision of a QMP, independently perform all recommended acceptance tests related to the requirements for a system integrated with SPECT or PET. [K,S,A]

Calibration and Quality Assurance:

- Demonstrate knowledge of any required calibration for a CT scanner integrated with SPECT or PET. [K]
- Develop, perform, and/or monitor a calibration and quality control program for CT systems used in conjunction with SPECT or PET hybrid systems, including daily, monthly, and quarterly QC procedures. [K,S,A]
- Demonstrate familiarity with routine quality control tests performed by technologists and with those required for a CT scanner as part of an integrated system. [K,S,A]

Annual Testing:

- Perform annual tests of the CT scanner to ensure that the scanner is performing properly. [K,S,A]
- Perform the tests required to validate performance as part of an integrated system with SPECT or PET. [K,S,A]

Communicator

- Identify the limitations of their expertise and judge when it is appropriate to seek support or escalate it to seniors, QMP, or consultants in a timely manner. [S,A]
- Recognize challenging communication issues. [K,A]

Collaborator

- Work effectively with others to assess, plan, provide, and integrate care for patients. [S,A]
- Interact in departmental meetings and physics meetings. [A]

Scholar

- Recognize and reflect upon learning and practice issues. [S,A]
- Engage in educational/training sessions. [A]

Health Advocate

- Apply ALARA principles in daily practice to justify the application of ionization radiation to patients and staff. [K,S,A]

Professional

- Demonstrate commitment to team ethics for confidentiality, resource allocation, and professionalism. [S,A]
- Demonstrate proper communication and professional appearance. [S,A]
- Demonstrate professional work habits, such as being punctual, available, and organized. [A]

Duration:

8 weeks

Setting:

Hospital setting within the Diagnostic Imaging and NM Departments with designated teaching and training facilities.

Educational Activities:

Half-day activity, OSCE, Journal Club

Assessment Tools:

- DOPS (1. Acceptance or annual testing of a CT Scanner)
- CBD
- Logbook
- MCQs
- SOE

Rotation 10: Non-Imaging Detectors & Counters

Introduction:

This rotation will provide residents with the knowledge and skills necessary to work with non-imaging instruments such as dose calibrators, well counters, and uptake probes. The training emphasizes equipment selection, acceptance testing, calibration, quality control, and annual evaluations aligning with international standards to ensure accurate and reliable clinical use.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

Equipment Selection:

- Describe the design and operational characteristics of each type of non-imaging equipment. [K]
- Recognize the clinical use and limitations of each type of equipment. [K,S]

Acceptance Testing:

- Utilize relevant international guidance (e.g., AAPM, NEMA, and IAEA) for acceptance and routine testing, including recommended tolerances. [K]
- Determine the tests used to evaluate the performance of non-imaging equipment. [K]
- Perform acceptance tests on the equipment, including regulatory tests and measures of energy resolution, efficiency, accuracy, linearity, and sensitivity, as appropriate, and subsequently produce the testing report. [K,S,A]
- Perform tests for minimum detectable activity on counting systems, as appropriate. [K,S]

Calibration and Quality Assurance:

- Develop and monitor a quality control program appropriate for each piece of non-imaging equipment and demonstrate an understanding of the daily, monthly, quarterly, and annual tests required. [K,S,A]
- Perform calibration and routine quality control on each type of non-imaging equipment and produce a testing report. [K,S,A]

Annual Testing:

- Perform annual tests for each type of non-imaging equipment and produce a testing report [K,S,A].

Duration: 8 weeks

Setting:

Hospital setting within the NM Department with designated teaching and training facilities.

Educational Activities:

Half-day activity, , Journal Club

Assessment Tools:

- DOPS (1. Acceptance or annual testing of dose calibrator, 2. Uptake probe and well counter quality control and calibration)
- BD
- Logbook
- MCQs
- SOE

Rotation 11: Positron Emission Tomography

Introduction:

This rotation will provide residents with the knowledge and hands-on skills required to work with PET and PET/CT systems. Training includes scanner selection, acceptance testing, calibration, quality control, and annual performance evaluations with an emphasis on international standards (AAPM, NEMA, IEC, and IAEA). Residents will also learn about installation considerations, phantom scanning for accreditation, and the development of QC programs to ensure reliable performance, compliance, and high-quality patient imaging.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

Equipment Selection:

- Explain the components, operation, and clinical use of PET and PET/CT scanners. [K]
- Describe the steps necessary to select a PET or PET/CT scanner, focusing on feature specifications, performance specifications, and clinical use. [K,S]
- Discuss the mechanical and architectural considerations important in installing a new PET or PET/CT scanner (including scanner, uptake rooms, hot lab, and shielding). [K,S,A]
- Participate in meetings to define requirements and specifications for system selection. [K,S]

Acceptance Testing:

- Utilize available references (AAPM, NEMA, IEC, IAEA) for acceptance and routine testing and their limitations. [K]
- Demonstrate familiarity with NEMA tests. [K]
- Explain the tests to be performed during acceptance testing [K]
- Identify the equipment needed to perform acceptance testing [K]
- Perform acceptance tests for the scanner under the supervision, review, and approval of a QMP, and write the final report [K,S,A].

- Perform independent phantom scanning for accreditation (e.g., ACR) [K,S,A]

Calibration and Quality Assurance:

- Develop and monitor a calibration and quality control program for PET systems, including daily, monthly, and quarterly QC procedures [K,S,A]
- Perform annual tests of PET scanners to ensure it is performing properly. [K,S,A]

Annual Testing:

- Analyze the relationship between acceptance and annual tests, perform annual tests on a PET system, and generate reports to ensure that the PET scanner is performing properly [K,S,A].

Communicator

- Assess the limitations of their expertise and judge when it is appropriate to seek support or escalate it to seniors, QMP, or consultants in a timely manner. [S,A]
- Recognize challenging communication issues. [K,A]

Collaborator

- Communicate effectively with others to assess, plan, provide, and integrate care for patient. [S,A]
- Engage in departmental meetings and physics meetings. [A]

Scholar

- Recognize and reflect upon learning and practice issues. [S,A]
- Engage in educational/training sessions. [A]

Health Advocate

- Apply ALARA principles in daily practice to justify the application of ionization radiation to patients and staff. [K,S,A]

Professional

- Demonstrate commitment to team ethics for confidentiality, resource allocation, and professionalism. [S,A]
- Express proper communication and professional appearance. [S,A]
- Demonstrate professional work habits such as being punctual, available, and organized. [A]

Duration:

12 weeks

Setting:

Hospital setting within the NM Department with designated teaching and training facilities.

Educational Activities:

Half-day activity, , Journal Club

Assessment Tools:

- DOPS (1. Acceptance or annual testing of the PET scanner, 2. Quarterly ACR PET phantom test; 3. PET calibrations)
- CbD
- Logbook
- MCQs
- SOE

Rotation 12: Hybrid Modalities Imaging Systems

Introduction:

This rotation will provide residents with the knowledge and skills necessary to work with hybrid imaging systems such as SPECT/CT and PET/CT. Training will cover scanner selection, acceptance testing, calibration, quality control, and annual performance evaluations of each component (CT, SPECT, and PET) as well as their integration. Emphasis is placed on image alignment, attenuation and scatter correction; compliance with international standards; and ensuring optimal clinical performance.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

Equipment Selection:

- Analyze the main components of a CT scanner and evaluate their impact on system performance. [K]
- Identify and assess the key components of SPECT or PET modality within a hybrid imaging system. [K]
- Explain and apply the operational principles and clinical use of the CT components of the hybrid system. [K]
- Demonstrate knowledge in the operation and clinical use of the SPECT or PET components of the hybrid system. [K]
- Appropriately select a SPECT/CT or PET/CT system, while focusing on feature specifications, performance specifications, and clinical needs. [K,S,A]
- Analyze and discuss the important mechanical and architectural considerations of installing hybrid systems. [K,S,A]

Acceptance Testing:

- Perform physical inspection of the equipment, including adequacy of installation and shielding. [K,S,A]
- Perform acceptance tests of the CT components (including CTDI dose evaluation). [K,S,A]
- Perform acceptance tests of the SPECT components. [K,S,A]
- Perform acceptance tests of the PET components. [K,S,A]

Calibration and Quality Assurance:

- Describe the required calibrations for CT, SPECT, and PET components (vendor-specific). [K]
- Develop, perform, and/or monitor a calibration and quality control program for CT, SPECT, and PET components, including daily, monthly, and quarterly QC. [K,S,A]
- Explain the routine QC tests performed by technologists for CT, SPECT, and PET. [K,S,A]

Annual Testing:

- Describe the purpose and scope of annual tests required to ensure proper performance of the CT, SPECT, and PET components. [K]
- Perform annual CT, SPECT, and PET component tests. [K,S,A]
- Validate the integrated performance of CT, SPECT, and PET as part of a hybrid system. [K,S,A]

Communicator

- Assess the limitations of their expertise and judge when it is appropriate to seek support or escalate it to seniors, QMP, or consultants in a timely manner. [S,A]
- Recognize challenging communication issues. [K,A]

Collaborator

- Communicate effectively with others to assess, plan, provide, and integrate care for patient. [S,A]
- Engage in departmental meetings and physics meetings. [A]

Scholar

- Recognize and reflect upon learning and practice issues. [S,A]
- Engage in educational/training sessions. [A]

Health Advocate

- Apply ALARA principles in daily practice to justify the application of ionization radiation to patients and staff. [K,S,A].

Professional

- Demonstrates commitment to team ethics for confidentiality, resource allocation, and professionalism. [S,A]
- Exhibit proper communication and professional appearance. [S,A]
- Demonstrate professional work habits, such as being punctual, available, and organized. [A]

Duration:

4 weeks

Setting:

Hospital setting within the NM Department with designated teaching and training facilities.

Educational Activities:

Half-day activity, , Journal Club

Assessment Tools:

- DOPS (1. Acceptance or annual testing of the PET/CT scanner, 2. Acceptance or annual testing of SPECT/CT scanners)
- CbD
- Logbook
- MCQs
- SOE

R3 Medical Physics for Nuclear Medicine Rotations

The R3 training year is the culmination of the Medical Physics for Nuclear Medicine residency program, and marks the transition from supervised, semi-independent performance (R2) to near-independent clinical practice. During their final year, trainees are expected to demonstrate mastery of core medical physics competencies, function confidently as primary physics contact in routine clinical situations, and manage most tasks with only indirect supervision. R3 residents should be capable of independently performing quality control procedures, supporting radiation safety programs, contributing to multidisciplinary clinical decision making, and troubleshooting imaging and dosimetry issues. By the end of this year, the trainee is expected to function at the entry-to-practice (QMP) level in NM and be prepared for professional certification and independent clinical responsibility.

Rotation 13: General Clinical Radiation Oncology Physics

Introduction:

This rotation will provide residents with a comprehensive overview of the functions and workflow of a typical radiation oncology department. This will include an understanding of the roles and responsibilities of the various professionals involved and the variety of tools and equipment used to image and treat patients in a safe and precise manner. This knowledge is critical for residents who will perform radionuclide therapy and for understanding radiation protection in NM.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

- Analyze the role of a radiation oncology physicist and related health specialists. [K]
- Differentiate radiotherapy systems (linear accelerators, brachytherapy units, and simulators). [K]
- Design basic quality assurance tests with dedicated devices and analyze the test results. [K,S]
- Participate in basic treatment planning. [K,S]
- Utilize radiation protection devices and their uses. [K]
- Analyze the workflow of radiotherapy (RT). [K]

Recognize the main areas covered in the R3 rotation: treatment planning, quality assurance, special radiation therapy techniques, and brachytherapy.

Communicator

- Recognize the limits of their expertise and judge when it is appropriate to seek support or escalate it to seniors, QMP, or consultants in a timely manner. [S,A]
- Recognize challenging communication issues. [K,A]

Collaborator

- Work with others to assess, plan, provide, and integrate care for patients. [S,A]
- Participate in departmental and physics meetings. [A]

Scholar

- Recognize and reflect upon learning and practice issues. [S,A]
- Engage in educational/training sessions. [A]

Health Advocate

- Apply ALARA principles in daily practice to justify the application of ionization radiation to patients and staff. [K,S,A]

Professional

- Follow team ethics regarding confidentiality, resource allocation, and professionalism. [S,A]
- Maintain patient confidentially, privacy and autonomy. [S,A]
- Demonstrate proper communication and professional appearance. [S,A]
- Demonstrate professional work habits, such as being punctual, available, and organized. [A]

Duration:

12 weeks

Setting:

Hospital setting within the radiation oncology department with designated teaching and training facilities.

Educational Activities:

Half-day activity, Journal Club

Assessment Tools:

- DOPS (1. Daily Quality Assurance Testing of a Linear Accelerator, 2. Radiation Treatment Planning of a Palliative Case, 3. Mechanical Test of a Radiotherapy Equipment)
- CBD
- Logbook
- MCQs
- SOE

Rotation 14: Quantitative Measurements in NM

Introduction:

This rotation will provide residents with a comprehensive understanding of the quantitative measurements and functional analyses of NM. These methods include the use of calculation methods, measurement techniques, and quality control procedures to obtain accurate organ function data. Residents will gain experience with the software tools and equipment used for quantitative studies, thereby ensuring that they understand both the technical aspects and clinical applications of functional measurements in patient care.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

- Apply mathematical models to measure organ function.

- Generate and evaluate time-activity curves from patient studies.
- Validate measurement accuracy using test phantoms.
- Optimize image quality factors that affect measurements

Communicator

- Interpret and clearly communicate measurement results to doctors.
- Cooperatively analyze measurement limitations and uncertainties with medical teams.
- Produce comprehensive technical reports with statistical data.
- Visualize complex data in easy-to-interpret formats

Collaborator

- Collaborate with cardiologists to optimize quantitative cardiac imaging and functional measurements.
- Coordinate with nephrologists to refine renal quantitative assessment protocols.
- Engage with gastroenterologists to support quantitative studies of gastrointestinal function.
- Co-develop innovative measurement methodologies in partnership with fellow medical physicists.
- Present findings at medical team meetings

Scholar

- Review research papers on measurement techniques.
- Evaluate different calculation methods.
- Analyze measurement errors and find solutions.
- Design and implement studies to test new measurement protocols.
- Contribute to research on imaging techniques.
- Apply statistical methods to check measurement quality

Health Advocate

- Promote accurate measurements for better diagnosis.
- Support standard measurement methods across hospitals.
- Monitor appropriate use of quantitative studies.
- Educate healthcare workers about functional measurements.
- Contribute to establishing normal value ranges for different populations

Professional

- Uphold professional, ethical, and scientific standards in quantitative measurement practice.
- Document quantitative results properly for quality tracking.
- Engage in continuous learning to remain current with emerging quantitative methodologies.
- Lead and evaluate quality programs for quantitative studies.
- Disclose methodological measurement limitations transparently in clinical reporting

Duration:

8 weeks

Setting

- Hospital setting within the NM Department with designated teaching and training facilities, quantitative analysis workstations, and specialized software laboratories.

Educational Activities:

- Half-day activity, , Journal Club

Assessment Tools:

- DOPS (1. Quantitative Analysis Software Operation, 2. ROI Analysis and Time-Activity Curve Generation)
- CBD

- Logbook
- MCQs
- SOE

Rotation 15: Image Reconstruction

Introduction:

This rotation will provide residents with a comprehensive understanding of image-reconstruction techniques and algorithms used in NM. This includes mathematical principles, computational methods, and quality factors that affect image formation from raw projection data. Residents will gain experience with reconstruction software, filtering techniques, and optimization methods, thereby ensuring that they understand both the technical implementation and clinical impact of different reconstruction approaches on diagnostic quality.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

- Apply mathematical principles of image reconstruction from projection data.
- Implement filtered back-projection and iterative reconstruction algorithms.
- Optimize reconstruction parameters for different clinical applications.
- Evaluate image quality factors including noise, resolution, and artifacts.
- Perform attenuation and scatter correction in reconstruction process.
- Compare different reconstruction methods and their clinical applications

Communicator

- Explain and discuss the reconstruction parameters, their effects on image quality, and related tradeoffs with medical teams and referring physicians.

- Prepare and present technical reports on reconstruction protocol optimization, including common artifacts and their solutions, to the clinical staff.
- Train and mentor technologists on selecting and applying appropriate acquisition and reconstruction parameters, and also collaborate with medical teams to optimize imaging protocols.

Collaborator

- Collaborate with radiologists and multidisciplinary teams to optimize image quality for interpretation and integrate reconstruction expertise into clinical decision making.
- Partner with IT specialists and equipment vendors to implement, update, and troubleshoot reconstruction software and algorithms.
- Engage with research groups to develop, evaluate, and translate advanced reconstruction techniques into routine clinical workflows.

Scholar

- Review research literature on reconstruction algorithm development.
- Compare performance of different reconstruction methods.
- Analyze factors affecting reconstruction quality and speed.
- Design validation studies for new reconstruction protocols.
- Contribute to research on advanced reconstruction techniques.
- Apply statistical methods to evaluate reconstruction performance

Health Advocate

- Promote reconstruction methods that improve diagnostic accuracy.
- Support standardized reconstruction protocols across institutions.
- Ensure optimal reconstruction parameters for patient diagnosis.
- Educate staff about the impact of reconstruction on patient care.
- Advocate for reconstruction techniques that reduce scan time

Professional

- Maintain high standards for reconstruction quality and accuracy.
- Document reconstruction parameters and protocols properly.
- Maintain continuous professional development in new reconstruction algorithms and techniques.
- Report reconstruction limitations and artifacts honestly.

Duration:

7 weeks

Setting:

Hospital setting within the NM Department with designated teaching and training facilities and image reconstruction workstations.

Educational Activities:

Half-day activity, Journal Club

Assessment Tools:

- DOPS (1. Reconstruction Software Operation, 2. Parameter Optimization and Quality Assessment)
- CBD
- Logbook
- MCQs
- SOE

Rotation 16: Patient Dosimetry

Introduction:

This rotation will provide residents with a comprehensive understanding of radiation dose calculations and patient dosimetry in the field of NM. This includes dose estimation methods, biological effects of radiation, and optimization techniques to minimize patient exposure while maintaining diagnostic quality. Residents will gain experience with dosimetry software, calculation models, and regulatory requirements to ensure that they understand both the theoretical principles and practical applications of radiation protection in patient care.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

- Calculate radiation doses to organs and tissues using MIRD methodology.
- Apply biokinetic models for radiopharmaceutical distribution and clearance.
- Estimate effective dose and organ-specific doses for different procedures.
- Perform dose calculations for pediatric and pregnant patients.
- Utilize dosimetry software and reference databases effectively.
- Optimize imaging protocols to reduce patient radiation exposure.

Communicator

- Explain radiation risks and benefits clearly to patients and families.
- Discuss dose estimates and safety measures with medical teams.
- Prepare radiation dose reports for regulatory compliance.
- Present dosimetry data in understandable formats for clinical staff.
- Inform referring physicians about radiation dose considerations.

Collaborator

- Work with NM physicians on dose optimization.
- Partner with radiation safety officers on patient release criteria.
- Coordinate with pediatric specialists on dose reduction strategies.
- Cooperate with medical physicists on dosimetry research projects.
- Share dosimetry expertise in radiation safety committees.

Scholar

- Review research literature on radiation dosimetry and biological effects.
- Compare different dose calculation methods and models.
- Analyze factors affecting dose estimates and uncertainties.
- Design studies to validate dosimetry calculations.
- Contribute to research on dose optimization techniques.
- Apply statistical methods to analyze dose data and trends.

Health Advocate

- Promote ALARA principles in all NM procedures.
- Support dose reduction initiatives without compromising diagnosis.
- Ensure appropriate use of NM studies.
- Inform healthcare providers about radiation dose optimization.
- Advocate for patient-specific dose calculation protocols.

Professional

- Maintain accurate records of patient dose calculations.
- Follow regulatory guidelines for dose reporting and limits.
- Maintain updated knowledge on new dosimetry methods and recommendations.
- Report dosimetry uncertainties and limitations transparently.

Duration:

7 weeks

Setting:

Hospital setting within the NM Department with designated teaching and training facilities, dosimetry calculation workstations, and radiation safety laboratories.

Educational Activities:

Half-day activity, Journal Club

Assessment Tools:

- DOPS (1. Dose Calculation Software Operation, 2. MIRD Model Application and Validation)
- CBD
- Logbook
- MCQs
- SOE

Rotation 17: Radionuclide Therapy

Introduction:

This rotation will provide residents with a comprehensive understanding of the therapeutic application of radioactive materials in NM. These include treatment planning, dose calculations, patient-management protocols, and safety procedures for various radionuclide therapies. Residents will gain experience with therapeutic radiopharmaceuticals, isolation procedures, and posttreatment monitoring, thereby ensuring that they understand the clinical applications and radiation safety aspects of NM therapy.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Physics for Nuclear Medicine Expert

- Calculate therapeutic doses for different radionuclide treatments.
- Apply treatment planning principles for targeted radiotherapy.
- Implement patient-specific dosimetry for therapy optimization.
- Perform radiation safety calculations for patient release.
- Utilize therapeutic radiopharmaceuticals safely and effectively.

- Monitor treatment response using quantitative imaging methods.

Communicator

- Explain treatment procedures and side effects to patients and families.
- Discuss radiation safety precautions with patients and caregivers.
- Prepare detailed treatment reports and follow-up recommendations.
- Present therapy outcomes and complications to medical teams.
- Inform healthcare staff about therapeutic radiation safety.

Collaborator

- Work with oncologists and endocrinologists on treatment planning
- Partner with radiation safety officers on isolation protocols
- Coordinate with nursing staff for patient care during isolation
- Cooperate with medical physicists on dose optimization studies
- Share therapy expertise in multidisciplinary tumor boards

Scholar

- Review research literature on new therapeutic radiopharmaceuticals.
- Compare effectiveness of different therapeutic approaches.
- Analyze factors affecting treatment outcomes and toxicity.
- Design studies to evaluate therapy protocols and optimization.
- Contribute to research on novel therapeutic applications.
- Apply statistical methods to analyze treatment response data.

Health Advocate

- Ensure appropriate patient selection for radionuclide therapy.
- Promote evidence-based therapeutic protocols.
- Support access to effective radionuclide treatments.
- Inform patients about treatment benefits and risks.
- Advocate for optimal therapy facilities and resources.

Professional

- Maintain highest standards of safety in therapeutic procedures.
- Follow regulatory requirements for therapeutic radionuclides.
- Document treatment procedures and outcomes accurately.
- Stay updated on new therapeutic agents and techniques.
- Lead implementation of new therapeutic protocols safely.

Duration:

8 weeks

Setting

Hospital setting within the NM Department with designated teaching and training facilities, therapy administration rooms, isolation units, and radiation safety laboratories.

Educational Activities

Half-day activity, , Journal Club

Assessment Tools:

- DOPS (1. Therapeutic Dose Calculation and Administration, 2. Patient Isolation and Safety Protocol Implementation)
- CBD
- Logbook
- MCQs
- SOE

Rotation 18: Clinical Physics Practice & Research Project

Introduction:

During the final rotation, the resident will independently manage daily clinical physics tasks in the NM Department and provide expert support, troubleshooting, and consultations. The resident will lead the clinical physics research project and prepare a comprehensive report detailing the project's methodology, results, and clinical implications. (Appendix D).

The residents are expected to work on the project alongside their clinical work.

Learning objectives:

By the end of this rotation, the resident will be able to:

Medical Expert

- Provide clinical physics support with minimal supervision in the NM Department. [K,S,A]
- Perform, analyze, and make decisions regarding QA tests and compliance. [K,S,A]
- Serve and assist with the acceptance test (if available) and physics 2nd check tasks. [K,S,A]
- Recognize the ethical requirements of research and demonstrate an understanding of responsible use of informed consent Evaluate research practices to ensure ethical conduct and proper implementation of informed consent. [K,A]
- Practice appropriate methods for writing research proposals, manuscripts, data collection, result analysis, and discussions. [S]
- Maintain current knowledge of research topics and emerging trends in NM and Medical Physics through a critical review of scientific literature. [K,S]

Communicator

- Demonstrate effective and respectful communication with stakeholders (consultants/dosimetrists/radiologists/physicists/receptionists/patients) during the QA process. [S,A]
- Realize the limitations of their expertise and judge when it is appropriate to seek support or escalate it to seniors, QMP, or consultants in a timely manner. [S,A]

- Address challenging communication issues effectively. [S,A]
- Support and educate others (residents, dosimetrists, radiologists, and nurses) regarding the knowledge and practice of clinical physics. [S,A]
- Communicate and collaborate effectively with a research supervisor to conduct research. [S,A]
- Present the clinical project at a medical physics residency-training session, departmental seminar, or conference and participate in public discussions. [K,S,A]

Collaborator

- Work effectively with others to assess, plan, provide, and integrate care for patient. [S,A]
- Meaningfully participate in committees and meetings (M&M; Patient reviews). [S,A]
- Identify, consult, and collaborate with appropriate experts, research institutions, and/or organizational bodies to facilitate research. [S,A]

Leader

- Organize and lead in committees and meetings. [S,A]
- Assist in training and teaching junior residents, patients, and other health specialists. [K,A].
- Supervise junior residents in QA and treatment planning. [S,A]
- Identify an area of research interest and secure a research supervisor to support scholarly work in scientific inquiry and dissemination. [S,A]
- Utilize available resources and regularly meet with an identified research mentor. [S,A]
- Set realistic priorities and manage time effectively to optimize professional performance. [S,A]

Health Advocate

- Apply ALARA principles in daily practice to justify the application of ionization radiation to patients and staff. [K,S,A]
- Identify opportunities for advocacy regarding patient safety and quality improvement. [S,A]
- Identify patient and safety events in NM, report events in internal/hospital reporting systems, and participate in the analysis of safety events. [K,S,A]
- Recognize the contributions of scientific research in improving the health of patients and communities. [K]

Scholar

- Recognize and reflect upon learning and practice issues. [S,A]
- Engage in educational/training session. [K,S,A]
- Support and educate others (residents, radiologists, and nurses) regarding the knowledge and practice of clinical physics. [S,A]
- Undertake and lead a collaborative clinical/physics research project with a medical resident, medical consultant, or QMP. [K,S,A]
- Produce a written report upon completion of the clinical project. This manuscript is expected to be submitted for publication in a peer-reviewed journal. [K,S,A]
- Identify research limitations and areas for further research. [K]

Professional

- Adhere to professional ethics regarding confidentiality, resource allocation, and professionalism [S,A]
- Respect and protect patient confidentiality, privacy, and autonomy. [S,A]
- Demonstrate proper communication and professional appearance. [S,A]
- Demonstrate professional work habits, such as being punctual, available, and organized. [A]

- Uphold ethical and professional expectations of research consistent with institutional review board guidelines, including the maintenance of meticulous data and undertaking ethical research. [A]
- Demonstrate personal responsibility for setting research goals and working with a supervisor to set and achieve research timeline objectives. [A].
- Appropriately attribute authorship and contributions when publishing research. [A]
- Disclose potential financial conflicts of interest (including speaker fees, consultative relationships, etc.) as appropriate when engaging in and disseminating research results. [A]

Duration:

6 weeks

Setting:

Hospital setting within a NM Department with designated teaching and training facilities.

Assessment Tools:

DOPS (1. Independent Clinical Physics Consultation, 2. Quality Assurance Program Management, 3. Radiation Protection, and 4. NM shielding calculations).

IX. CONTINUUM OF LEARNING

Domain	R 1-2 (Junior Level)	R 3 (Senior Level)	Consultant
Level of Practice	Dependent/supervised practice	Semi-dependent/supervised practice	Independent practice/provide supervision
Knowledge	Obtain fundamental knowledge related to nuclear medicine physics, including radiation interactions, imaging instrumentation, radiopharmaceutical characteristics, and regulatory frameworks.	Apply knowledge to provide appropriate clinical practice including image quantification, dosimetry, instrumentation, and protocol optimization.	Integrate and synthesize cutting-edge knowledge and contribute to specialty advancement (e.g., theranostics, AI-assisted quantification).
Clinical Skills	Apply clinical/practical skills such as QC tests, dose calibrator checks, and gamma camera uniformity, while presenting problems and procedures of the specialty.	Analyze and interpret findings from nuclear medicine medical physics assessments—including image quality metrics, quantitative uptake values, and patient-specific dosimetry—to support appropriate differential diagnoses and optimize the patient's management plan in collaboration with the clinical team.	Manage complex clinical physics services, lead commissioning and acceptance testing, design QA programs, and provide expert consultation for radionuclide therapy, novel technologies, and equipment procurement.
Professionalism and Patient Safety	Demonstrate professional conduct, follow radiation protection rules, and comply with SCFHS, SFDA, and institutional policies under supervision.	Apply radiation safety, ethics, and regulatory frameworks independently while promoting a culture of safety in the nuclear medicine department.	Role model for professionalism, quality assurance, and patient safety leadership.

Domain	R 1-2 (Junior Level)	R 3 (Senior Level)	Consultant
Decision-Making	Contribute physics input to clinical decisions (e.g., QC failures, imaging protocol selection) under direct supervision.	Make independent decisions with oversight for routine and moderately complex NM medical physics issues.	Lead interdisciplinary decision-making and strategic clinical planning.
Supervision/Teaching Role	Learn from supervision and accept feedback.	Begin peer teaching and provide feedback under supervision.	Offer formal supervision, mentorship, and system-level educational input.

This includes the learning that should occur at each key stage of progression within a specialty. At this stage, trainees are reminded of lifelong Continuous Professional Development (CPD). Trainees should remember the necessity of CPD for every healthcare provider to fulfill the evolving demands of their vital professions. The following table elucidates how each role is expected to progressively develop throughout the junior, senior, and consultant levels of practice.

X. EDUCATIONAL ACTIVITIES

(TEACHING AND LEARNING STRATEGIES AND METHODS)

Teaching & Learning

Clinical, Academic, and Scholarly Content of the Program-Specific Learning Activities:

The educational process for the Medical Physics for Nuclear Medicine residency program was based on the principles of adult learning theory. Residents are expected to be aware of the importance of learning and to play active roles in the content and process of their own learning. Training programs implement the adult learning concept in each feature of the activities, where residents maintain responsible for their own learning requirements. Whenever applicable, core specialty topics should include workshops, team-based learning (TBL), and simulations to develop skills for core procedures

Medical Physicists will achieve the competencies described in curriculum using a variety of learning methods. The program comprises training to acquire cognitive and technical skills and understand how they relate to physics, applied anatomy, pathology, and physiology of radiation in medicine. Moreover, training involves practical procedures and interpretation methods taught in a sequential and integrated manner through lectures, tutorials, seminars, and apprenticeships that provide hands-on experience.

Formal training time would include the following five teaching activities:

- Program Specific Academic Activities
- Practice-Based Learning
- Skills Training and Procedures
- Scholarly Projects
- Professional and Personal Development

1. Program-Specific Academic Activities

Program-specific activities are educational interventions specifically designed and intended for teaching of trainees during their training period. Residents are required to attend these activities, and noncompliance can result in disciplinary actions. It is advisable to link attendance and participation in these activities with formative assessment tools (see the formative assessment section below). Program administration should support these activities by providing protected time for residents to attend and allowing them to participate.

Program Academic Half-Day:

Every week, at least 2–4 hours of formal training (commonly referred to as an "academic half-day") should be reserved. Formal teaching time is planned in advance by coordinating with the assigned tutor(s), time slots, and venue. Notably, formal teaching excludes hands-on clinical teaching. The academic half-day covers fundamental topics determined and approved by the specialty's scientific council, and are aligned with specialty-defined competencies and teaching methods. The core specialty topics ensure that the important clinical problems of the specialty are highlighted. It is recommended that lectures be conducted using an interactive, case-based discussion format. The learning objectives for each core topic must be clearly defined and it is preferable to use pre-learning materials. Regional supervisory committees—in coordination with academic and training affairs, program directors, and chief residents—should ensure the planning and implementation of academic activities, as indicated in the curriculum. The trainee should be actively involved in the development and delivery of topics under faculty supervision; this involvement might be in the form of delivery, content development, or research, to name a few. The trainee's supervisor should ensure that the discussion on each topic is stratified into three categories of learning domains: knowledge, skill, and attitude, whenever applicable.

The academic half-day should:

- Provide the knowledge, technical skills, and experience necessary for residents to interpret and correlate their clinical findings.
- Promote effective communication and sharing of expertise with peers and colleagues.
- Promote the development of investigative skills to better operate technical skill processes as these apply to both individual patients and the general patient population.
- Advise colleagues from their specialty and other specialties regarding problems related to medical physics.
- Enable residents to recognize the humanistic and ethical aspects of a medical physics career.
- Enable residents to examine and affirm their personal and professional moral commitments.
- Enable residents to apply their knowledge in clinical reasoning and equip them with the necessary interactive skills to apply this insight, knowledge, and reasoning to human clinical care.

The recommended number of half-days that should be conducted annually is 40 sessions per academic training year, with time reserved for other forms of teaching methods such as journal clubs and clinical/practical teaching. The residency training committee, program directors, and chief residents—in cooperation with academic and training affairs and regional supervisory committees—should ensure that academic activities are planned and implemented as indicated in the curriculum. This should be done efficiently by utilizing the available resources with an optimal exchange of expertise. Appendix (B) provides an example of an academic half-day.

Educational Component Layout:

Several core courses will be organized for residents to augment their training in various important areas. These courses should typically be offered on academic half-days.

R1	General Review	Radiation Therapy Physics	Anatomy & Physiology	Radiobiology	Ethics	Informatics	Research Methodology
	10 w	12 w	4 w	4 w	3 w	3 w	4 w
R2 & R3	Selected topics in Nuclear Medicine Physics						
	40 w						

Refer to APPENDIX (B) for course contents.

2. Practice-Based Learning (PBL):

Training exposure during clinical and other work-related activities, including courses and workshops (e.g., simulations and clinical teaching), represents excellent learning opportunities. Residents are expected to use these opportunities to build their capacities through self-directed learning.

In contrast, practice-based learning allows educators to supervise residents to become competent in the practical skills required by the program, which ensures that learners achieve the intended knowledge, psychomotor, and/or attitude learning outcomes. Each resident must maintain a logbook documenting records of both supervised and independent clinical training.

The following list constitutes examples of Practice-Based Learning (PBL):

- Clinic-based Learning
  - Discuss the differential and management plans with colleagues.
  - Discuss the need for any special procedures with the attending physicists.
  - Supervise the resident's notes, orders, and interpretation and discuss the report results with attending physicists.

3. Skills Training and Procedures

As a national supervising body, the SCFHS has initiated a shift towards integrating simulations into residency training programs.

Clinical simulations involve creating artificial clinical scenarios from which residents can learn. This process has educational advantages, such as learning and practicing how to address rare and/or high-risk clinical scenarios and conduct rare procedures, while in a controlled, standardized environment with immediate, effective feedback. This has a significant positive impact on knowledge, skills, and attitude.

Simulation scenarios must be as close as possible to real clinical situations, including those involving team members, equipment, and the environment. This should be followed by prompt and effective feedback.

The use of simulations in postgraduate training programs is currently necessary, especially in competency-based curricula. Current postgraduate programs aim to create skilled, competent, and independent physicians while maintaining focus on quality and patient safety. In practice, substantial variability may exist in how simulation is used to implement competency-based curricula, with specialty-specific factors likely contributing to this variability. Establishing standardized needs assessment methods for simulation may pose a challenge to any national organizational body dealing with numerous ongoing postgraduate training programs.

4. Scholarly Project

As part of teaching and learning within the residency program, residents were required to complete a structured scholarly project that progressively builds research competence across R1–R3. In R1, residents attend a designated research course to establish foundational knowledge, submit a course attendance certificate, and identify a feasible project topic aligned with program priorities. In R2, residents formalize the scholarly project by preparing a brief project description and a full research proposal, along with securing IRB approval, and initiating data collection and analysis; progression at this stage is verified through documented committee approval. In R3, residents complete the remaining data collection and analysis, and produce a completed manuscript as a mandatory deliverable, with encouragement to disseminate outcomes through conference abstract/poster submissions or journal publications when feasible. The final review and approval of the manuscript by the committee confirms completion of the scholarly project requirements, supports evidence-based practice skills, and contributes to the residents' academic development and promotion readiness. Refer to APPENDIX (D) for the research requirements.

5. Professional and Personal Development

- Guest speakers on core specialty topics
    - Increase medical physicist staff and resident knowledge and skills, and ultimately improve patient care.
    - Recognize and apply current practice guidelines in the field of medical physics.
    - Describe the latest advances in the field of medical physics and research.

- Identify and explain areas of argument in the field of medical physics.

- Tutorial
  - Tutorials provide strong foundational knowledge in the skill of radiological interpretation.
  - To discuss and review imaging findings and approaches toward the diagnosis of various radiological conditions.
  - To develop a sense of confidence in handling clinical discussions.
- Courses and Workshops
  - Attending national and international conferences.
  - Forming a network with other medical physicists in the community.
  - Exchange of ideas.
  - Targeting courses based on the interests of residents and their involvement in specific departmental projects.
- Self-directed Learning
  - Maintenance of a personal portfolio (self-assessment, reflective learning, and personal development plans).
  - Achieving personal learning goals beyond the essential, core curriculum.
  - Reading, including web-based material.
  - Auditing and conducting research projects.
- Discussion (logbook)
  - Formulate a list of all problems identified in the medical physics board examinations.
  - Develop a proper solution for each problem.
  - Present a follow-up of the problem.

Universal Topics

Universal topics are educational activities developed by the SCFHS and intended for all specialties. Priority is given to topics possessing the following qualities:

- High value
- Interdisciplinary and integrated
- Require expertise that might be beyond the availability of the local clinical training sites

Universal topics developed by the SCFHS are available through e-learning with personalized access for each resident. Each universal topic has a self-assessment at the end of the module. As indicated in the "executive policies of formative assessment and annual promotion," universal topics are a mandatory component of the criteria for the annual promotion of residents from their current level of training to the subsequent level. Universal topics were distributed throughout the training period.

Table for Universal Topics distributed over residency years:

Training Year	Modules		Topics name	
	Number	Name	Number	Name
R1	Module-1	Medical Fundamentals	Topic-2	Hospital acquired infections
	Module-2	Cancer	Topic-6	Principles of management of cancer
	Module-2	Cancer	Topic-7	Side effects of chemotherapy and radiation therapy
	Module-2	Cancer	Topic-8	Oncologic emergencies
	Module-2	Cancer	Topic-9	Cancer Prevention
	Module-4	Medical and Surgical Emergencies	Topic-18	Management of Hypotension and Hypertension
	Module-5	Acute Care	Topic-22	Post-Operative Care
	Module-5	Acute Care	Topic-23	Acute Pain Management
			Topic-24	Chronic Pain Management
R3	Module 6	Frail & Elderly	Topic-30	Care of the Elderly
	Module 7	Ethics and Healthcare	Topic-31	Occupational Hazards of Healthcare Workers
	Module 7	Ethics and Healthcare	Topic-33	Patient Advocacy
	Module 7	Ethics and Healthcare	Topic-34	Organ Transplantation
	Module 7	Ethics and Healthcare	Topic-35	Autonomy and Treatment Refusal
	Module 7	Ethics and Healthcare	Topic-36	Role of Doctors in Death and Dying

XI. ASSESSMENT AND EVALUATION

1. Purpose of Assessment

Assessments play a vital role in the success of postgraduate training. Assessments aim to guide trainees and trainers in achieving defined standards, learning outcomes, and competencies. Simultaneously, they provide feedback to learners and faculty regarding curriculum development and implementation, teaching methods, and quality of the learning environment. A reliable and valid assessment is essential for examining curriculum alignment with respect to objectives, learning methods, and assessment tools. Finally, assessment ensures patients and the general public that health professionals are safe and competent.

Assessment serves the following purposes:

a. **Assessment for learning**: Also known as formative assessment; trainers utilize information from trainees' performance to diagnose their learning needs and tailor instructions for improvement. This enables faculty members and educators to use information on the trainees' knowledge, understanding, and skills to deliver prompt, specific, and constructive feedback. Additionally, it fosters the development of trainees' metacognitive and practical skills, encourages reflection and self-regulated learning, and ultimately helps them become lifelong learners.

b. **Assessment of learning:** Also referred to as summative assessment. This approach is designed to evaluate whether trainees have achieved their intended learning outcomes. It is typically scored and contributes to highstakes decisions including the progression, certification, and completion of training.

c. **System of assessment:** Also known as Program of Assessment; it represents the relationship between multiple collated assessment methods, where formative and summative assessments are integrated, complementary, and aligned throughout a specialty training program. It's blueprint is mapped against the curriculum roles, competencies, and outcomes. The overall system blueprint, which differs from the exam blueprint, articulates how diverse assessment tools collectively provide evidence of competence. It may include varying levels of detail according to its purpose and is also known as "assessment mapping." This mapping outlines the competencies to be assessed by all types of assessment methods to build a comprehensive, balanced, and fit-for-purpose assessment strategy, and helps identify areas where assessment is lacking or needs strengthening.

d. **Feedback and evaluation** As assessment outcomes, these represent quality metrics that enhance the learning experience. Moreover, this can be utilized for training progression and determining the suitability of undertaking different levels of summative assessment. High-quality feedback should be specific, actionable, longitudinal, and promote self-assessment. Narrative and meaningful feedback on trainees' performance in work-based assessments and evaluation forms should inform structured action plans, support deliberate practice, and facilitate trainee improvement and progression.

For the sake of the organization, assessments will be further classified into two main categories: *Formative* and *Summative*.

2. Formative Assessment

2.1 General Principles

Formative assessment should be integrated into the curriculum design, grounded in best practices and evidence-based approaches, and aligned with stated competencies and appropriate tools.

2.1.1. Purpose of formative assessment:

Formative assessment aims to actively support trainees' growth by guiding learning, verifying progression, and ensuring that they acquire competencies essential for high-quality professional practice across all health disciplines. Briefly, formative assessment should:

- Enhance learning by offering trainees opportunities to practice, receive immediate feedback, measure their performance, and identify areas for further development and improvement.
- Drive learning and optimize the training process by clarifying the expectations of trainees and motivating them to actively pursue suitable training and experience.
- Provide robust and comprehensive evidence that trainees are progressing toward fulfilling curriculum standards throughout the training program.
- Ensure that trainees are acquiring the required competencies across all domains of effective healthcare practice.
- Verify that trainees possess the essential foundational knowledge, skills, and professional attitudes required for their specialty.
- Confirm that trainees are advancing appropriately in their performance relative to their training stage.

As adult learners, trainees should actively seek feedback and use it to develop their performance throughout their journey from "novice" to "mastery" levels of competence. Formative assessment (also referred to as continuous or ongoing assessment) is a component of assessment deliberately distributed across the academic year to provide trainees with prompt, meaningful, and actionable feedback that drives learning and improvement.

Specified time should be allocated for trainees to meet with their program director or review performance reports and logs (e.g., ITER, logbook, and workplace-based assessment tools). Trainees are expected to assume ownership of their development through self-directed learning. The input from the formative assessment tools is integrated at the end of the year to inform decisions on whether individual trainees will advance to the next training level. The formative assessment instruments are periodically reviewed and updated as needed to ensure alignment with the SCFHS guidelines and standards.

Consistent with best practices in health education, formative assessments will have the following features tailored to the targeted competencies:

a. Multisource: Select all appropriate tools, including relevant workplace-based assessments, according to competency, training level, and rotation.

b. Comprehensive: Cover all learning domains (i.e., knowledge, skills, and attitude; core elements of professional behavior).

c. Relevant: Focus on workplace-based observations for performance in authentic practice settings.

d. Milestone-oriented competency: This reflects trainees' expected competencies that match their developmental level.

2.2 Formative Assessment Tools

Trainees should actively seek feedback during training, and trainers should provide timely and formative assessments. The SCFHS provides an e-portfolio system to enhance the communication and analysis of data from formative assessments. Trainers and trainees are expected to follow the recommendations of the scientific council regarding the updated forms, frequency, distribution, and deadlines related to the implementation of evaluation forms.

The candidate must complete the compulsory requisition of all selected formative assessment tools to attain the optimum training level outcome.

2.2.1. Work-based assessment:

Work-based assessment (WBA) is occasionally used interchangeably with workplace-based assessment (WPBA), which refers to the direct observational assessment of a trainee in a real work environment. This has recently been referred to as a supervised learning event (SLE).

WBA is among the most recognized and widely utilized approaches for enhancing learning through formative assessment and feedback.

WBA tools assess a range of competencies, including communication and consultation skills, clinical decision-making and reasoning, and patient management in the contexts of diagnostic uncertainty, resource constraints, and public health considerations. Moreover, WBA tools facilitate the assessment of more complex domains, including professionalism, procedural skills, and the ethical and legal aspects inherent to clinical practice, which may not be adequately evaluated using traditional assessment methods.

2.2.2. Educational Activity (EA) (Non-WBA assessment)

EA is a part of the trainee training program that involves teaching and learning activities to acquire specialty competencies. Examples of contributions to EA can be, but are not limited to, presenting in journal clubs, lectures, morbidity and mortality rounds, grand rounds, and research and scholarly activities.

All formative assessment tools used for formative assessment purposes MUST abide by the **Scoring Categories and Scaling Definitions** in the SCFHS policies.

Doesn't Meet Expectation	Borderline	Meets Expectation	Exceeds Expectation
(<50%)	(50–69.99%)	(>70–89.99%)	(>90%)

To attain the optimum training outcome, the candidate must complete the compulsory requisition of all selected formative assessment tools.

The following table summarizes the formative assessment tools that trainees must complete (mapping learning objectives and competency roles into program rotations).

Program			Medical Physics for Nuclear Medicine									
Level	Rotation	Duration (weeks)	Knowledge Skills Attitude									
			Workplace-based assessment			Educational Activity (Non-WBA assessment)						
			DOPS	mini-CEX	CbD	Academic Activities	Logbook	PT	SOE	OSCE	Research	ITER
R1	1. Hospital Orientation	2	(x2)			√		√	√			√
	2. Radiation Protection & Safety	6	(x2)		(x2)	√	√	√	√			√
	3. Radiation Detectors	6	(x2)		(x2)	√	√	√	√			√
	4. NM Imaging Devices	8	(x2)		(x2)	√	√	√	√			√
	5. Computers in NM	8	(x3)		(x2)	√	√	√	√			√
	6. General Clinical NM Physics	18	(x3)		(x2)	√	√	√	√			√
R2	7. Gamma Camera with/without SPECT	12	(x5)		(x2)	√	√	√	√	√		√
	8. Radiopharmacy	4	(x5)		(x2)	√	√	√	√	√		√
	9. Scanners	8	(x5)		(x2)	√	√	√	√	√		√
	10. Non-Imaging Detectors & Counters	8	(x5)		(x2)	√	√	√	√	√		√

Program			Medical Physics for Nuclear Medicine									
Level	Rotation	Duration (weeks)	Knowledge Skills Attitude									
			Workplace-based assessment			Educational Activity (Non-WBA assessment)						
			DOPS	mini-CEX	CbD	Academic Activities	Logbook	PT	SOE	OSCE	Research	ITER
	11. Positron Emission Tomography	12	(x5)	(x3)	(x2)	√	√	√	√	√		√
	12. Hybrid Modalities	4	(x5)	(x3)	(x2)	√	√		√	√		√
R3	13. General Clinical Radiation Oncology Physics	9	(x5)	(x3)	(x2)	√	√	√	√	√		√
	14. Functional Measurements & Quantitative in NM	7					√	√	√			√
	15. Image Reconstruction	6					√	√				√
	16. Patient Dosimetry	8				√	√	√				√
	17. Radionuclide Therapy	8	(x5)	(x3)	(x2)	√	√	√	√	√		√

Program			Medical Physics for Nuclear Medicine									
Level	Rotation	Duration (weeks)	Knowledge Skills Attitude									
			Workplace-based assessment			Educational Activity (Non-WBA assessment)						
			DOPS	mini-CEX	CbD	Academic Activities	Logbook	PT	SOE	OSCE	Research	ITER
	18. Clnical Physics Practice, Clinical Project and Final Residency Report	8	(x5)	(x3)	(x2)	√	√	√	√	√	√	√

DOPS: Direct observation of procedural skills **Mini-CEX:** Mini-Clinical Evaluation exercise **CBD:** Case-based Discussion **MCQs:** Multiple-choice Question Exam **SOE**: Structured Oral Exam **OSCE:** Objective Structured Clinical Examination **ITER:** In-Training Evaluation Report **PT**: Progress Test

* Four weeks for annual leaves

Description Table of Formative Assessment Tools (R1, R2, R3)

Performance Evaluation and Requirements	Formative Assessment Tools	Important details (Description & frequency related to the tool/ Academic Year)
Workplace Based Assessment (WBA)	DOPS	- DOPS is used to assess the trainee's procedural, practical and technical skills while being observed by a trainer/instructor in a workplace setting. - R1 residents are required to perform a minimum of 2–3 DOPS per rotation, i.e. a total of 11 in the academic year. - R2 and R3 residents are required to perform a minimum of 5 DOPS per rotation. - (see program rotation details) - Results are for formative feedback purposes.
	Mini-CEX	- Mini-CEX is used to directly assess resident's clinical skills while being observed by a trainer/instructor in a workplace setting. - R2 (starting from Rotation 7) & R3 residents are required to do a minimum of 3 mini-CEX per rotation, i.e. a total of 6–9 mini-CEX per academic year per level. - Results are for formative feedback purposes.
	CBD	- CbD is used to evaluate the resident's clinical decision-making and reasoning skills (higher order thinking and synthesis). - R1 residents are required to do a minimum of 2 CbD per rotation (except hospital orientation rotation), i.e. a total of 8 CbD per academic year. - R2 & R3 residents are required to do a minimum of 2 CbD per rotation. i.e. a total of 6 CbD per academic year per level. - Results are for formative feedback purposes.

Performance Evaluation and Requirements	Formative Assessment Tools	Important details (Description & frequency related to the tool/ Academic Year)
Non-WBA	Logbook & Portfolio	- A logbook is used to document and assess the residents' enrolment and daily activity, while portfolio is used for providing evidence of teamwork, assessing complex competencies as a lifelong learning. - All residents (R1–R3) are required to maintain a logbook to be presented during the supervisor/program director meetings and at the end of rotation. - R1 residents are encouraged to develop a portfolio that maintain records and document all academic activities (e.g., procedures, lectures, meetings, training courses, workshops, symposia, and presentations) undertaken during each rotation and seek feedback from a mentor. - R2 residents are required to include in the portfolio for the quality assurance rotation that demonstrate background, methodology, results, and analysis and conclusion of quality tests and measurements used. - R3 residents are required to include in the portfolio for the special techniques rotation that demonstrate background, methodology, results, and analysis and conclusion of each special technique. - Logbook and portfolio are to be reviewed during the supervisor meetings for formative feedback purposes and progress check. See Appendix C for list of activities requirements.
	Progress Test (PT)	- The progress test assesses the knowledge level that is expected from the trainees' benchmarked against the practitioner's general and fundamental knowledge base. - The PT consists of 50–100 MCQs of general & fundamental medical physics questions (i.e. R1 level).

Performance Evaluation and Requirements	Formative Assessment Tools	Important details (Description & frequency related to the tool/ Academic Year)
		- All residents from all level are required to attend this PT held at the beginning of the academic year. - The results are used for formative feedback.
	SOE	- SOE is used to assess the resident's knowledge and as a practice/mock exam for the final exam. - All residents (R1–R3) are required to attend at least 2 SOE sessions per level per academic year, held at mid and end of academic year. - The minimum number of SOE station(s) is 4 stations. - The results are used for formative feedback.
	OSCE	- OSCE is used to assess the resident's clinical/practical performance and application of knowledge skills and as a practice/mock exam for the final exam. - R2 and R3 residents are required to attend at least 1 OSCE session per level per academic year. - The minimum number of OSCE station(s) is 3 stations. - The results are used for formative feedback.
	Annual Written Promotion exam (EYPT-Local)	- The promotion exam is required for R1 residents and is to be held once in the last quarter of the first year. - The exam consists of a minimum 100 MCQs in accordance to the Promotion Exam Blueprint. - Scores expressed in numbers will be translated to SCFHS categories. - The results are used for formative feedback.

Performance Evaluation and Requirements	Formative Assessment Tools	Important details (Description & frequency related to the tool/ Academic Year)
	Research Activities	- A clinical research project is required to be completed during the final residency rotation. - R2 trainees are expected to submit a research proposal with the IRB approval or TPC by the end of the academic year - R3 residents are required to meet at least one of the following for their research project: submit a publication in a peer-reviewed journal; submit the research according to SCFHS criteria.
	Weekly report	**Weekly report:** The weekly report is a review session with the resident's primary supervisors. This is a common practice in residency programs, with varying purposes and focuses. The goals of the weekly reports are to ensure that the student is achieving the required case presentation skills, allow discussion of the management of interesting cases, and enhance problem-solving and multidisciplinary team skills.
	ITER	ITER are related to the discipline and rotation objectives. It is also related to the stage and level of training. The ITER report must be completed after repeated observations and feedback of the trainee's performance, within two weeks after the end of each rotation.

Refer to the SCFHS "Formative Assessment Tools List" for the description and conduction instructions of each Tool at www.scfhs.org.sa.

Example of R1 Progress test Blueprint:

Category	Proportions
Radiological Physics & Radioactivity	20%
Principles of Imaging	20%
Radiation Therapy Physics	10%
Anatomy and Physiology	10%
Radiobiology	15%
Ethics	5%
Informatics	10%
Research Methodology	10%

Refer to the commission website, www.scfhs.org.sa, for updated examination details and blueprint.

2.3. Promotion of the trainee:

The trainee must demonstrate compliance by completing the necessary WBA and EA on time and in accordance with curriculum requirements. Furthermore, failure to comply will result in disciplinary consequences for the trainee, including repeating the entire academic year or a portion thereof.

The trainee should be promoted from one level to the next if they satisfy the following requirements:

A. Achievement of the minimally required compliance of selected WBA and EA.

B. The annual training evaluation report (AITER) is to be completed by the program director, which incorporates compliance of the WBAs and EA, along with the comments and feedback collected by concerned educators. Recommendations from the program director should be included. Furthermore, the Program Training Committee reviews the A-ITER and assessment evidence, and subsequently recommends one of three outcomes by majority vote, with one of the following options:

1. Unconditional promotion to the next level
2. Conditional promotion to the next level with remediation program during the promoted year
3. Not endorsing promotion with the recommendation of repeating the current year level, along with a remediation program

2.4. Final In-Training Evaluation Report (FITER)

FITER is a comprehensive final evaluation required at the end of training to determine trainees' readiness for independent practice. Its format and content are governed by the SCFHS regulations and may evolve over time. Submission of the FITER is part of the process for certification eligibility in accordance with the SCFHS requirements.

3. Summative Assessment

3.1. General Principles

Summative assessment is the assessment component primarily designed to make informed decisions regarding trainees' competence and readiness to progress or enter independent practice. Unlike formative assessment, it does not principally aim to provide constructive feedback but rather to judge whether the required standards have been fulfilled. For additional details, please refer to the General Bylaws and Executive Policy of Assessment (available online at www.scfhs.org).

To be eligible to sit for final examinations, trainees will be issued a "Certification of Training Completion" upon successful completion of all training rotations in accordance with the SCFHS regulations.

3.2. Certification of Training-Completion

To be eligible for the final specialty examinations, each resident is required to obtain a "Certification of Training Completion." Based on the General Bylaws of Training in Postgraduate Programs and executive policy (please refer to www.scfhs.org), residents will be granted the "Certification of Training-Completion" once the following criteria are fulfilled:

1. Successful completion of all training rotations
2. Completion of the training requirements (e.g., research, others) outlined in FITER, as approved by the Scientific Committee
3. Clearance from SCFHS training affairs ensuring compliance with tuition payments and completion of universal topics
4. Passing the first part examination (whenever is applicable)

The "Certification of Training Completion" will be issued and approved by the supervisory committee or its equivalent according to the SCFHS policies.

3.3. First Part Medical Physics for Nuclear Medicine Examination

The first part of the board is a written multiple-choice question (MCQs) exam open to R2 residents. Passing this exam permits residents to be promoted from junior to senior training levels. The number of examination items, eligibility, and passing scores are established in accordance with the Commission's training and examination rules and regulations.

Example of Part-1 Exam Blueprint:

Section	Proportions
Radiation Safety & Regulations	25%
Ethics & Informatics	5%
Radiation Detectors	10%
General Diagnostic Imaging Physics	20%
Computers & Data processing	10%
General Clinical NM Physics	30%

Refer to the commission website, www.scfhs.org.sa, for updated examination details and blueprint.

3.4. Final Medical Physics for Nuclear Medicine Examinations

The final specialty examination is a summative assessment component that grants residents a specialty certification. It has two elements:

1. **Final written exam:** Residents are required to have obtained the "Certification of Training Completion" to be eligible for the written exam. The examination assessed residents' theoretical knowledge base (including recent advances) and problem-solving capabilities regarding NM Physics. It is held annually and has a multiple-choice format.
2. **Final clinical/practical exam:** To be eligible for the final clinical/practical exam, residents were required to pass the final written exam, with a score of at least 70%. The clinical and practical examination assesses the residents' clinical skills, decision-making, and capabilities to perform NM Physics tasks. The exam is held annually in the objective structured clinical examination (OSCE) and structured oral examination (SOE) formats.

The number of exam items, exam format, eligibility, and passing scores are in accordance with the commission's training and examination rules and regulations. The updated details of the examination and blueprints have been published on the commission's website: www.scfhs.org.sa.

Example of Final Written Exam Blueprint:

Section	Proportions
Dosimetry methods, quantities, units and regulations	25%
Non-imaging Equipment	25%
Performance Testing of imaging Equipment	30%
Imaging Reconstruction	5%
Radiopharmacy Practice	15%

Example of Final Clinical Exam Blueprint:

Section	Proportions
Dosimetry methods, quantities, units and regulations	20%
Non-imaging Equipment's	30%
Performance testing of imaging equipment	30%
Image Reconstruction	20%

DOMAINS FOR INTEGRATED CLINICAL ENCOUNTER	DIMENSIONS OF CARE: Dosimetry methods, quantities, units and regulations 1±1 Station(s)	Non-imaging Equipment's 4±1 Station(s)	Performance testing of imaging equipment 3±1 Station(s)	Image Reconstruction 1±1 Station(s)	# Station(s)
Patient Care 1±1 Station(s)		1	1		2
Patient Safety and Procedural Skills 3±1 Station(s)	1	1	1	1	4
Communication and Interpersonal Skills 2±1 Station(s)		1	1		2
Professional Behaviors 0±2 Station(s)		1	1		2
Total Stations	1	4	4	1	10

For further details on the final exams, please refer to the general bylaws of training in postgraduate programs and general assessments (available online: www.scfhs.org).

Table of Summative Assessment Tools

Learning Domain	Summative Assessment Tools	Passing score
Knowledge	• Part-1 Written Examination • Final Written Examination	• At least borderline pass in each tool according to the standard setting method used by the executive administration of assessment
Skills	• Objective Structured Clinical Examinations (OSCE) • Structured Oral Examinations (SOE)	• At least borderline pass in each tool according to the standard setting method used by the executive administration of assessment.
Attitude	• FITER	• Each resident should obtain a clear pass on FITER from the Program Director at the end of the training period.

XII. PROGRAM AND COURSE EVALUATION

The SCFHS applies various measures to evaluate the implementation of this curriculum. The training outcomes of this program were reviewed using the quality assurance framework endorsed by the Central Training Committee of the SCFHS. The trainee assessment results (formative and summative) were analyzed and mapped against the curriculum content. Additional indicators incorporated into the evaluation process included the following:

- Annual trainees' satisfaction survey reports.
- Reports from trainees' evaluation of training rotations.
- Annual survey data from program directors.
- Reports gathered from direct field communications with trainees and trainers.
- Quality reports and metrics from the Standard & Quality Departments (e.g., Scientific Council reports, Training Center Reports, Code Blue data and reports, and related surveys).

Goal-Based Evaluation: Achievement of the intended outcomes or competencies will be evaluated at the end of each stage to assess the effectiveness of curriculum delivery. Any deficiencies will be addressed in the subsequent stage by utilizing the time allocated to trainee-selected topics and professional sessions.

In addition to expert subject matter input and best practices drawn from benchmarked international programs, the SCFHS will apply a robust approach to ensure that this curriculum incorporates all the relevant data available at the time of its future revisions.

XIII. POLICIES AND PROCEDURES

This curriculum outlines the means, materials, and learning objectives that trainees and trainers will use to achieve the identified educational outcomes. The SCFHS maintains a comprehensive set of “General Bylaws of Training in Postgraduate Programs” and “Executive Policies” published on the official SCFHS website that governs all training-related processes. These include, but are not limited to, general bylaws of training, assessment, and accreditation as well as executive policies on admission, registration, formative assessment and promotion, examination, trainees’ representation and support, duty hours, and leaves, all of which are examples of regulations that must be implemented. Under this curriculum, trainees, trainers, and supervisors are required to adhere to the most current versions of these bylaws and policies, which are accessible online through the official SCFHS website.

XIV. APPENDICES

A. Assessment Mapping of Junior & Senior level competencies

B. Academic Half-Day Topics

C. Logbook Requirements

D. Research Requirements

E. References

Appendix A: Competency-Assessment Mapping: To map Competencies, Educational Activities, and Formative and Summative Assessments (Systems of Assessment)

Assessment mapping

Appendix A

Competency-Matrix: To map Competency, Learning domain, and Milestones

level	*Competency-Roles* (with annotation of learning domains involved: K: knowledge, S: Skills, A: Attitude)	Activities Related to Specific Rotation				
		Hospital Orientation, clinical awareness and patient care	Radiation Protection and Safety	General Clinical Radiation Oncology	General Clinical Nuclear Medicine	General Clinical Diagnostic Imaging physics
R1	Medical Expert	- Describe the radiologic anatomy and physiology. - Recognize appropriate clinical dress code. K, S.	- Identify regulatory requirements and guidelines. - Identify radiation dose limits. K.	Recognize systems in radiation treatment units. K.	Recognize the dosimetry and protection differences between nuclear medicine and radiology. K, S.	Propose actions to improve image quality. S.
	Communicator	- Manage interactions between patients and staff. S, A.	Effectively communicate with patients and team members. S, A.	Effectively communicate with team members and engineers. S, A.	Effectively communicate with team members and engineers. S, A.	Effectively communicate with team members and engineers. S, A.

level	*Competency-Roles* (with annotation of learning domains involved: K: knowledge, S: Skills, A: Attitude)	Activities Related to Specific Rotation				
		Hospital Orientation, clinical awareness and patient care	Radiation Protection and Safety	General Clinical Radiation Oncology	General Clinical Nuclear Medicine	General Clinical Diagnostic Imaging physics
	Collaborator	Illustrate interactions, duties, and responsibilities of multidisciplinary care-giver team. A.	Illustrate collaboration and team work, and distribute awareness and knowledge. S, A.	Demonstrate collaboration and seek consultation from senior physicists when needed. A.	Demonstrate collaboration and seek consultation from senior physicists when needed. A.	Demonstrate multidisciplinary team work and seek support from senior physicists when needed. S, A.
	Advocate	Ensure good patient experience. S, A.	Define radiation protection principles. K.	Describe the role of a radiation oncology physicist. K.	Explain the role of medical physicist in Nuclear Medicine. K.	Explain the role of medical physicist in diagnostic imaging. K.
	Leader	Manage responsibilities and tasks. S, A.	Manage time, responsibilities, and tasks. S, A.	Manage time, responsibilities, and tasks. S, A.	Manage time, responsibilities, and tasks. S, A.	Manage time, responsibilities, and tasks. S, A.
	Scholar	Identify types of medical images. K.	Exercise application of statistics in radiation and medical imaging. K, S.	Demonstrate advanced methods in radiotherapy. K, S.	Define the physics of SPECT, SPECT/CT, and PET/CT equipment. K.	Describe the imaging equipment's hardware and software design. K, S.

level	*Competency-Roles* (with annotation of learning domains involved: K: knowledge, S: Skills, A: Attitude)	Activities Related to Specific Rotation				
		Hospital Orientation, clinical awareness and patient care	Radiation Protection and Safety	General Clinical Radiation Oncology	General Clinical Nuclear Medicine	General Clinical Diagnostic Imaging physics
	Professional	Attend to patient needs, privacy, and confidentiality. S, A.	Select appropriate Personal Protective Equipment requirements. S.	Demonstrate quality assurance methods in radiotherapy. K, S.	Demonstrate the QC procedures used in nuclear medicine. K, S.	Demonstrate the QC procedures used in diagnostic imaging modalities. K, S.

	Competency-Roles (with annotation of learning domains involved: K: knowledge, S: Skills, A: Attitude)	Professional Activities Related to Specific Rotation					
R2		Gamma Camera with/without SPECT	Radio-pharmacy	Computed Tomography	Non-Imaging Equipment	Positron Emission Tomography	Hybrid Modalities
	Medical Expert	- Identify radiation exposure control techniques. K, S. - Illustrate methods of identifying and isolating common artifacts. K, S.					
	Communicator	- Effectively communicating with team members, radiographers, and engineers. S, A.					

level	*Competency-Roles* (with annotation of learning domains involved: K: knowledge, S: Skills, A: Attitude)	Activities Related to Specific Rotation				
		Hospital Orientation, clinical awareness and patient care	Radiation Protection and Safety	General Clinical Radiation Oncology	General Clinical Nuclear Medicine	General Clinical Diagnostic Imaging physics
	Collaborator	- Demonstrate multidisciplinary team work and seek support from senior physicists when needed. S, A.				
	Advocate	- Present advantages and disadvantages of the diagnostic imaging techniques based on technical and scientific data to non-physicist healthcare decision makers and patients. K, S.				
	Leader	- Manage responsibilities and tasks efficiently and promptly. S, A.				
	Scholar	- Describe the complete radiographic imaging chain. K. - Explore new technology and techniques. K. - Explain methods of exposure control. K, S.				
	Professional	- Perform acceptance and periodical compliance testing for medical imaging devices. K, S. - Estimate radiation dose. K, S.				

R3	*Competency-Roles* (with annotation of learning domains involved: K: knowledge, S: Skills, A: Attitude)	Professional Activities Related to Specialty		
		Patient Dosimetry	Radionuclide Therapy	Clinical Physics Practice, Clinical Project & Final Residency Report

<table>
<tr><th rowspan="2">level</th><th rowspan="2">Competency-Roles (with annotation of learning domains involved: K: knowledge, S: Skills, A: Attitude)</th><th colspan="5">Activities Related to Specific Rotation</th></tr>
<tr><th>Hospital Orientation, clinical awareness and patient care</th><th>Radiation Protection and Safety</th><th>General Clinical Radiation Oncology</th><th>General Clinical Nuclear Medicine</th><th>General Clinical Diagnostic Imaging physics</th></tr>
<tr><td rowspan="7"></td><td>Medical Expert</td><td colspan="5">- Identify imaging artifacts and challenges. K, S.
- Propose methods to eliminate image artifacts. K, S.</td></tr>
<tr><td>Communicator</td><td colspan="5">- Demonstrate effective communicating with team members, radiographers, and engineers. S, A.</td></tr>
<tr><td>Collaborator</td><td colspan="5">- Work in Multidisciplinary team and Seek support from senior physicists when needed. S, A.</td></tr>
<tr><td>Advocate</td><td colspan="5">- Conduct end-to-end tests for new treatment protocols. S,A</td></tr>
<tr><td>Leader</td><td colspan="5">- Manage responsibilities and tasks efficiently and promptly. S, A.</td></tr>
<tr><td>Scholar</td><td colspan="5">- Explore new technology and techniques in medical imaging. K.
- Lead a departmental QA audit. K</td></tr>
<tr><td>Professional</td><td colspan="5">- Perform acceptance and periodical compliance testing for medical imaging devices. K, S.</td></tr>
</table>

Appendix B (Academic Half-Day Topics)

The following is a table with sample topics illustrating half-day activities as they span over one year (or a cycle of teaching if more than one year is required to cover all topics):

The following is for illustrative purposes only. Details of topics/cases, frequency, levels, and years must be clearly outlined and aligned with the mapping.

Academic Week	*Rotation*	*Section*	*Sessions*
1	All Levels	Introduction to Medical Physics	Welcome to the Program
			Topic 1: Historical Background
			Topic 2: International Policies and procedures in Med. Physics
2	All Levels	Radiation Production & Safety	Topic 3: International Bodies in Radiation
			Case-based study
			Topic 5: National Agencies and References Devices
3	All Levels	Medical Physics Tools	Topic 6: Phantom
			Case-based study
			Topic 31: Calibration Devices
4	All levels	Imaging & Health Informatics	Journal club*
			Case-based study
			Topic 23 Basic information system in Radiology

- Journal club could be done in the evening or during the half-day
- ** Case-based study could be done in the evening or during the half-day

Appendix-C (Logbook Requirements)

The following is for illustrative purposes only. Details of cases/logs, frequency, levels, and years must be clearly outlined and aligned with the mapping.

Top Conditions and Procedures in the Specialty

(R1) Logbook				
Date	Activity		Comments	Mentor signature
	Procedures	Frequency		
	1. Perform basic phantom scan in different X-ray machine. 2. Perform dosimetry measurements using ionization chambers and other detectors. 3. Perform patient specific dose verification measurements. 4. Perform measurement and/or calculation of individual patient dose. 5. Perform TLD, OSL & RPL dosimeters and calculation methods 6. Attend QC measurements for X-ray equipment. 7. Perform radiation survey/ contamination equipment.	- Three for different X-ray equipment. - Three for different X-ray equipment. - Three for different X-ray procedure. - Three for each X-ray procedure. - Three for different sources - Three for different X-ray equipment. - Three for different sources.		

(R2) Logbook				
Date	Activity		Comments	Mentor signature
	Procedures	Frequency		
	1. Perform advanced phantom scan and parameters manipulation in different SPECT/CT and PET/CT Scanner 2. Perform calibration and verification of SPECT/CT and PET/CT equipment. 3. Perform QC measurements for NM equipment including plan, SPECT/CT, PET/CT, Dose calibrator, Gamma Counter, and BMD. 4. Perform acceptance and commissioning procedures for SPECT/CT and PET/CT equipment. 5. Attend preventive and corrective maintenance for SPECT/CT and PET/CT equipment. 6. Perform patient specific dose verification measurements. 7. Perform measurement and/or calculation of individual patient dose. 8. Perform phantom scan and parameters manipulation in different SPECT/CT and PET/CT scanner. 9. Perform QC test of generator, AL Breakthrough, purity, chemistry, and labelling efficiency percentage of radiopharmaceuticals.	- Minimum of three times for different NM equipment. - Minimum of three times for different NM equipment. - Minimum of three times for different NM equipment. - Minimum of three times for different NM equipment. - Minimum of three times for each NM equipment. - Minimum of three times for each NM procedure. - Minimum of three times for each NM procedure. - Minimum of three times for each CT procedure. - Minimum of three times of each.		

(R3) Logbook				
Date	Activity		Comments	Mentor signature
	Procedures	Frequency		
	1. Perform dosimetry measurements using ionization chambers and other detectors. 2. Perform calibration and 3. verification of NM equipment. 4. Perform QC measurements for NM equipment 5. Perform acceptance and commissioning procedures for NM equipment. 6. Attend preventive and corrective maintenance for NM equipment. 7. Perform measurement and/or calculation of individual patient dose. 8. Perform measurement and/or calculation of I-131 Capsules for patients' therapy 9. Perform measurement and/or calculation of other radionuclides for patients' therapy.	- Minimum of three times for different NM equipment. - Minimum of three times for different NM equipment. - Minimum of three times for different NM equipment. - Minimum of three times for different NM equipment. - Minimum of three times for different NM equipment. - Minimum of three times for different NM equipment. - Minimum of five times for different patients. - Minimum of five times for different patients.		

Appendix D (Research Requirements)

The following is for illustrative purposes only. Additional details of frequency, levels, and years must be clearly outlined and aligned with the mapping.

2.2.6 RESEARCH ROTATION

Reporting to the	Level of Expected	step: What to submit for research	training committee
R1	- Attend the course - Choose a project topic	- Certificate of course attendance	Certificate
R2	- Choose a project topic - IRB approval - Proposal writing - Data collection - Data analysis	- A brief description of the project - Final project proposal	Committee approval letter
R3	- Data collection - Data analysis - Completed Manuscript - Approach journals - Abstract/poster - submission to conferences	- Manuscript (Mandatory) - Conference certificate as speaker or journal citation (Optional)	Manuscript approval and promotion

MEDICAL EXPERT

Goals:

- To demonstrate the basic principles of research design, methodology, data analysis, and clinical epidemiology. Addition, they have both advantages and disadvantages from the perspective of medical physics in NM.
- To familiarize themselves with the ethical requirements of the research and demonstrate an understanding of the responsible use of informed consent.
- To practice appropriate methods for writing research proposals, manuscripts, data collection, and result analysis and discussion.

- To demonstrate the awareness of current research topics in medical physics in NM using available medical informatics systems.
- To skillfully present scientific presentations and participate in public discussions.

Training Methods

- Specify the period appropriately dedicated to research or full-time rotation of the research to be conducted.
- Attendance in dedicated courses or workshops that enhance research skills may be required for the program.
- This project is expected to last 2 months. Therefore, the completion of this study should align with subsequent rotations.
- The trainee must select a supervisor to help access essential resources that allow appropriate utilization of research skills and periodically discuss progress.
- The trainee must finish the research proposal by the end of the first six months, which must then be accepted by the institutional review board.
- The oral abstract of the study results should be presented at a specified time point (e.g., the end of the final year before entering the final exam) on Specialty's Research Day.
- The research paper should be sent at least two weeks before Specialty's Research Day.
- It is highly desirable for trainees to present their research results at national and/or international meetings and publish their work in indexed journals.

Evaluation

1- Attendance in designated courses/lectures/workshops will be monitored and incorporated into annual evaluation scores.

2- Panel scoring of the research abstract presentation will be conducted at the end of the pre-specified year on Specialty's Research Day. This counts toward the rotation score for that month.

COMMUNICATOR

- Demonstrate skills in conveying and discussing scientific research to scientific communities through posters, abstracts, teaching slides, manuscripts, or other scientific communication modalities.
- Communicate and collaborate effectively with the research supervisor to conduct the research.

COLLABORATOR

- Identify, consult, and collaborate with appropriate experts, research institutions, and/or organizational bodies to conduct the research.

LEADER

- Identify an area of research interest and find a research supervisor to support scholarly work in scientific inquiry and dissemination.
- Utilize available resources and regularly meet with an identified research mentor.
- Set realistic priorities and effectively use time to optimize professional performance.
- Utilize healthcare resources cost-effectively.

HEALTH ADVOCATE

- Recognize the contributions of scientific research in improving patient and community health.

SCHOLAR

- Pose appropriate research questions, recognize and identify gaps in the knowledge and expertise pertaining to the question, and formulate an appropriate study design to answer them.
- Conduct research as outlined in the proposal.
- Collect and analyze data utilizing appropriate methods.
- Prepare abstracts and manuscripts suitable for publication in peer-reviewed journals and/or international scientific meetings.
- Identify research limitations and areas for further research.

PROFESSIONAL

1- Uphold ethical and professional research expectations consistent with the Institutional Review Board guidelines, including maintaining meticulous data and conducting ethical research.

2- Demonstrate personal responsibility for establishing research goals and working with supervisors to set and achieve research timeline objectives.

3- Appropriately attribute authorship and contributions when publishing research.

4- Disclose potential financial conflicts of interest (including speaker fees and consultative relationships) when engaging in and disseminating research results.

Appendix-E

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