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Training Curriculum for Nuclear Medicine Physicians

IAEA
International Atomic Energy Agency

TRAINING CURRICULUM FOR NUCLEAR MEDICINE PHYSICIANS

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TRAINING CURRICULUM FOR NUCLEAR MEDICINE PHYSICIANS

ENDORSED BY THE
AFRICAN ASSOCIATION OF NUCLEAR MEDICINE,
ARAB SOCIETY OF NUCLEAR MEDICINE,
ASIA AND OCEANIA FEDERATION OF NUCLEAR MEDICINE AND BIOLOGY,
ASIAN REGIONAL COOPERATIVE COUNCIL FOR NUCLEAR MEDICINE,
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EUROPEAN UNION OF MEDICAL SPECIALISTS,
LATIN AMERICAN ASSOCIATION OF SOCIETIES OF NUCLEAR MEDICINE AND BIOLOGY
AND WORLD FEDERATION OF NUCLEAR MEDICINE AND BIOLOGY

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FOREWORD

Non-communicable diseases are on the rise globally, with the majority of new cases and associated deaths occurring in low and middle income countries. The increase in non-communicable diseases is related to several factors, including population growth, increased life expectancy and changes in lifestyle. The most frequent non-communicable diseases are cardiovascular diseases, cancer, chronic respiratory diseases and diabetes.

In recent decades, nuclear medicine techniques have become of paramount importance for the diagnosis and treatment of a wide range of health conditions, in particular non-communicable diseases. The cornerstone of safe, high quality clinical practice is adequate training of nuclear medicine physicians, and to reach full potential, these professionals need ongoing training throughout their careers. There is a need to harmonize training programmes for nuclear medicine physicians in order to raise the level of knowledge and competencies of nuclear medicine specialists worldwide. Because trainees come from diverse backgrounds and have different knowledge and experience, training programmes require an active, standardized approach to ensure compliance with the minimum standards needed to provide optimal clinical nuclear medicine care.

The present publication offers guidelines based on relevant medical publications, international recommendations and expert advice. It also presents the competencies required for a nuclear medicine trainee, as drawn from the syllabus for postgraduate specialization in nuclear medicine of the European Union of Medical Specialists (UEMS), the American Board of Nuclear Medicine, the Royal Australasian College of Physicians, the Joint Royal Colleges of Physicians Training Board and the Asian Board of Nuclear Medicine, among others. This publication puts forward a harmonized training programme for nuclear medicine physicians to allow trainees to develop the necessary knowledge, competencies and skills to practice this medical specialty, and to ensure the safe, high quality practice of clinical nuclear medicine.

The first draft of this publication was prepared during a meeting of external consultants and IAEA staff in Vienna in March 2017. This group included experts with experience not only in the education of medical specialists, but also in the preparation of guidelines and curricula for residency training in nuclear medicine. The manuscript was subsequently revised by internal and external reviewers familiar with the process of training nuclear medicine residents. The IAEA is grateful to all those who contributed to the drafting and review of the publication, and to the African Association of Nuclear Medicine (AANM), Arab Society of Nuclear Medicine (ARSNM), Asia and Oceania Federation of Nuclear Medicine and Biology (AOFNMB), Asian Regional Cooperative Council for Nuclear Medicine (ARCCNM), European Association of Nuclear Medicine (EANM), European Union of Medical Specialists (UEMS), Latin American Association of Societies of Nuclear Medicine and Biology (ALASBINM) and World Federation of Nuclear Medicine and Biology (WFNMB) for their contributions. The IAEA officers responsible for this publication were D. Paez, T. Pascual and F. Giammarile of the Division of Human Health.

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CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

There are two main challenges to consider before designing a nuclear medicine training programme: 1. prior knowledge and experiences of trainees vary, and 2. involvement of an active clinical practice of nuclear medicine in which a wide variety of procedures are performed is crucial. In that regard, it is essential to address these challenges through assessments and the inclusion of certain training fields. Firstly, as trainees' progresses are at different levels, frequent formative and summative assessments are required. These are based on daily observations, review of reports, and other methods of periodical assessments of performance. Ultimately, this approach will ensure support for the prescribed programme by catering to the individual needs of trainees. Secondly, an appropriate duration of training must be set aside for comprehensive inclusion of essential elements including physics, radiochemistry, and relevant pathophysiology for the entire field of nuclear medicine. Through this, the training programme is made more active and comprehensive in clinical practice.

At present there is huge heterogeneity amongst training pathways available worldwide for physicians practising nuclear medicine ranging from a three-month rotation as part of radiology specialty training to 4 to 5 years under nuclear medicine specialist training. Consequently, there is a need to define and harmonize the recommended basic minimum training requirements for nuclear medicine as a medical specialty, in order to ensure safety and quality of clinical practice.

1.2. OBJECTIVE

The goal of this outcome-based curriculum is to ensure the quality of training worldwide and to standardize nuclear medicine practice. This curriculum, therefore, assures up-to-date training for physicians with relevant knowledge, competencies and skills in clinical practice, scientific work, and management. All of which contribute to the best practice of diagnostic applications including all modalities related to hybrid imaging, as well as therapeutic applications in nuclear medicine, and the novel theranostic approach. Through this training, the overall quality of nuclear medicine can be enhanced, and the trainees can qualify for relevant national and international board certification.

1.3. SCOPE

This publication addresses the different components in which any well-trained nuclear medicine physician must be competent. It stresses the importance of providing support for the implementation of the prescribed programme, thus meeting the individual needs of trainees. Likewise, it emphasizes the appropriate duration of training necessary to acquire the competencies needed to provide adequate care to patients and ensure the safety and quality of clinical practice.
Moreover, the principles and practice of physics, radiochemistry, anatomy, physiology and clinical nuclear medicine, including hybrid imaging (PET/CT, PET/MRI, and SPECT/CT), are discussed.

1.4. STRUCTURE

Following the introduction, this publication is divided into five parts that carefully describe the recommended minimum requirements for training in nuclear medicine as a medical specialty.

This includes guiding principles for postgraduate training in nuclear medicine, institutional programme requirements, an overview of a three-year training programme, competencies expected to be acquired by nuclear medicine physicians, and suggested assessment methods.

The publication states that a three-year programme is considered to be the minimum training necessary for a medical doctor to acquire the knowledge, skills and competencies required to practice clinical nuclear medicine, ensuring the safety and quality of the service provided. It also acknowledges that, in several countries, training over the course of four or five years is implemented.

2. GUIDING PRINCIPLES ON THE CURRICULUM FOR NUCLEAR MEDICINE PHYSICIAN POSTGRADUATE TRAINING

2.1. PRINCIPLE 1: VISION FOR THE EDUCATION OF A PHYSICIAN IN NUCLEAR MEDICINE

A learning organization is committed to develop professional education of stakeholders by continuously reflecting on learning processes, as well as being inclusive of the social, political, and technological impacts on people.

The platform for teaching and learning should focus on the processes of learning rather than just the outcome. Learning-to-learn approaches aim to give the trainee the confidence to attempt novel approaches, the ability to undertake independent study, and the path to gain knowledge by working collaboratively [1].

2.2. PRINCIPLE 2: EDUCATIONAL PHILOSOPHIES

- Learning is a search for meaning [2]. In the context of training programmes, the search for meaning, aside from the acquisition of information, must be fostered;
- "Andragogy" is the art of teaching and learning in the adult situation. The most valuable adult learning arises when the learners are i) responsible for their own learning; ii) collaborative, supportive, and cooperative; iii) accountable for their own learning; and iv) encouraged by the learner-centred process [3,4]. "Heutagogy", a form of adult learning which focuses on self-directed learning, should be the learner-focused direction within the training programme;
- A nuclear medicine physician (NMP), who is an adult learner, enters a training programme to have the opportunity to acquire new knowledge or skill sets through the training activities. This would enhance the physician's professional development;
- Nuclear medicine physicians who enter a training programme come with different personalities, learning styles, and learning characteristics which influence their learning needs. The training programme planners may not fully address individual differences, but it is helpful to consider these differences in the planning processes to ensure that optimal learning happens for all learners;
- It is important to be mindful of how inborn intelligence influences learning approaches of different learners [5]. The fact that each person learns differently from other people in the group makes them who they are and their contribution unique. Therefore, the trainer needs to offer different learning and teaching methods to accommodate different learning approaches;
- There are three kinds of learners. First, the practical learners that learn better by acting and learning from their mistakes. Second, the analytical learners that learn better by thinking, developing an overview of a topic, and discovering new insights from basic principles. Third, observant learners that learn better by listening, watching, and sitting quietly;
- Developers of training programmes must ensure that cultural and linguistic differences among trainees are taken into consideration. Attention should also be given to the existence and availability of different teaching methods and tools for delivery;
- Training programmes can present challenges to programme planners depending on the structure of the organization, sophistication of equipment, level of institutional support, availability of human and material resources, intensity of interaction with colleagues

from other departments, and other factors that facilitate or constrain the training programme;
— The duration, complexity, and requirements of training programmes have impacts on the desired competencies of trainees.

2.3. PRINCIPLE 3: NATURE OF THE TRAINING PROGRAMME

The training programme should be aimed at encouraging physicians to explore new content for themselves and to be involved in training activities. Trainees are encouraged to closely interact with clinicians in departments from which most referrals for NM procedures originate. By doing so, trainees are provided with optimal guidance on the role of nuclear medicine procedures in the management of patients and gain insight into optimal practices of health delivery.

This training curriculum is designed to meet quality standards of training in clinical nuclear medicine and to acquire knowledge, competencies and skills needed by a NMP.

2.4. PRINCIPLE 4: GOALS OF THE TRAINING PROGRAMME

The overall goal is to define a standardized nuclear medicine training programme to produce competent nuclear medicine physicians by:

— Training physicians in all aspects of clinical nuclear medicine to provide nuclear medicine services in their practice;
— Developing knowledge and skills of trainees in ways that can be applied to clinical decision making;
— Engaging trainees in developing research projects which will contribute to the growth of the field of NM.

2.5. PRINCIPLE 5: ENTRY REQUIREMENTS & PATHWAYS

Nuclear medicine is a medical specialty requiring at least 3 years of core NM training which is open for physicians who have appropriately completed medical training and hold a license to practice medicine. Specific requirements are as follows:

— Trainees must have at least 1 year of clinical training (may include an internship);
— Trainees must have obtained related prior training and clinical experience in recognized, reputable institutions with appropriate certification from an accredited certifying board (if applicable); or, at a minimum, with a letter of certification from the pertinent training office of said institution;
— Trainees are willing to and are interested in providing patient care and enhancing the capabilities of countries to address needs related to the diagnosis and treatment of diseases through the application of NM techniques.

Physicians with complete training in a clinical specialty (e.g. internal medicine, radiology, oncology, cardiology, endocrinology) may be given credit for up to one year towards completion of NM training.

3. INSTITUTIONAL PROGRAMME REQUIREMENTS

A NMP training programme requires teaching facilities, equipment, and a diversity of examinations and therapies.

Trainees can rotate between categories 1, 2, and 3, below as needed.

The number of NMPs is related to the equipment available. Centres with training programmes must have at least one NMP certified for training.

The minimum requirements (cases per year) for NMP training according to categories include the following:

3.1. CATEGORY 1: NUCLEAR MEDICINE PRACTICE WITHOUT PET/CT

- Minimum of one SPECT camera;
- Nuclear medicine therapy facility for thyroid diseases;
- Centralized radiopharmacy (level 1);
- Minimum of 2,300 cases of NM examinations per year;
- Minimum of 100 cases of NM therapies per year.

3.2. CATEGORY 2: NUCLEAR MEDICINE PRACTICE WITH PET/CT

- SPECT or SPECT/CT camera, and PET/CT;
- NM therapy facility;
- Radiopharmacy (level 1, 2 or 3);
- Minimum 2,900 cases of NM examination per year;
- Minimum of 100 cases of NM therapies per year.

3.3. CATEGORY 3: ADVANCED NM PRACTICE

- SPECT or SPECT/CT camera, PET/CT, cyclotron (optional);
- Nuclear medicine therapy facility;
- Radiopharmacy (level 1, 2 or 3);
- Medical physics;
- Research facility;
- Minimum 3,300 cases of NM examinations per year;
- Minimum 150 cases of NM therapies per year.

Table 1 compiles the type and number of minimum institutional requirements per year according to the category of the nuclear medicine department.

TABLE 1. MINIMUM INSTITUTIONAL REQUIREMENTS OF NUCLEAR MEDICINE EXAMINATIONS AND THERAPIES PER YEAR ACCORDING TO CATEGORIZED NUCLEAR MEDICINE PRACTICE OF THE INSTITUTION

	CV	ENDO	GI	GU	ONC	CNS	PUL	BONE	PET	MIX	THER	**SUM**
C1	400	400	100	250	150	50	50	700	0	100	100	**2,300**
C2	400	400	100	250	50	50	50	700	700	100	100	**2,900**
C3	400	400	100	250	50	50	50	700	1,000	150	150	**3,300**

4. OVERVIEW OF THE THREE-YEAR CURRICULUM-NUCLEAR MEDICINE TRAINING PROGRAMME, TO BE ACHIEVED OVER THE DURATION OF THE TRAINING PERIOD

In the Curriculum-Nuclear Medicine Training programme, focus is given on the increasing depth of knowledge and experience gained through different aspects of the nuclear medicine training.

4.1. YEAR 1

4.1.1. Basic Science

4.1.1.1. Basic Physics

- Fundamentals of radioactivity, radiation, nuclear and atomic physics;
- Natural radioactivity;
- Artificial radioactivity:
    - Production in generators;
    - Production in reactors;
    - Production in cyclotrons.
- Quantitative laws of radioactivity:
    - Activity, radioactive decay, half-life, specific activity.
- Interaction of radiation with matter;
- Radioactive parents and daughters: equilibrium.

4.1.1.2. Mathematics & Statistics

- Mathematics:
    - Logarithms, exponentials;
    - Use of spreadsheets.
- Statistics:
    - Statistics of counting;
    - Average, variance, standard deviation.

4.1.1.3. Instrumentation

- Detectors:
    - Scintillation detectors;
    - Solid-state detectors.
- Imaging instruments:
    - Gamma camera;
    - Single Photon Emission Computed Tomography (SPECT);
    - Positron Emission Tomography (PET);
    - X-ray (static and fluoroscopy);
    - Computed Tomography (CT);
    - Magnetic Resonance Imaging and Spectroscopy (MRI, MRS);
    - Ultrasound, including doppler;
    - Dual Energy X-ray Absorption (DEXA) (optional);
    - Hybrid imaging (SPECT/CT, PET/CT, PET/MR).
- Principles of computing:
    - Acquisition and management of image processing;

    - Attenuation correction;
    - Reconstruction from projections;
    - Recognition of pitfalls and artefacts.
- Theoretical and practical aspects of image formation.

4.1.1.4. Basic Radiation Biology

- Molecular and cellular effects;
- Sensitivity of foetus to radiation;
- Deterministic effects;
- Stochastic effects.

4.1.1.5. Dosimetry

- General principles of radiation exposure from internal and external sources;
- Quantitation of radiation exposure;
- Diagnostic radiopharmaceuticals;
- Therapeutic radiopharmaceuticals;
- The pregnant and breast-feeding patient.

4.1.1.6. Radiation Protection

- Practical handling of radioactive material:
    - Time;
    - Distance;
    - Shielding;
    - Prevention of contamination;
    - Monitoring.
- Sources of human exposure:
    - Natural origin;
    - Artificial origin.
- Types of exposure:
    - External;
    - Internal.
- Impact of natural and artificial exposures:
    - Natural human exposure;
    - Natural radioactive aerosols.
- Influence of human activities on the levels of exposures;
- Radiation dose limits and As Low As Reasonably Achievable (ALARA) principles;
- Radiation protection: International Commission on Radiological Protection (ICRP) and Basic Safety Standards (BSS);
- Protection of nursing and pregnant women.

4.1.1.7. Basic Radiopharmacy Principles

- Criteria for selection of radionuclides used in nuclear medicine;
- Regulatory environment:
    - Good laboratory practice;
    - Current good manufacturing practice.

4.1.1.8. Safety Rules and Regulations

- Informed consent and human subject consideration;
- Regulatory organizations national and international, e.g. BSS, ICRP, National Council on Radiation Protection & measurements (NCRP), committee on the Biological Effects of Ionizing Radiation (BEIR), Nuclear Regulatory Commission (NRC).

4.1.1.9. Administrative and Regulatory Aspects of Nuclear Medicine

- Administrative and technical means of procuring radionuclides;
- Radioprotection facilities: collective, individual;
- Procedures for radiation protection and waste management;
- Storage and disposals of radioactive waste.

4.1.2. Diagnostic Clinical Nuclear Medicine

The focus of learning clinical NM in the first year is to become familiar with the most common studies and the mechanism of action and normal biodistribution of radiopharmaceuticals. For each of the studies, the trainee should understand the physiology and anatomy of the specific organ/region being studied, as well as cross-sectional imaging, commonly-used tracers and its preparation. The trainee is expected to learn the principles of radiopharmaceutical imaging with scintillation gamma cameras. He/she should also be familiar with the description of relevant findings and appropriate interpretation.

During the second and third years, there will be time to study and understand these procedures in greater depth.

4.1.2.1. Clinical Application (see Appendix I)

4.1.2.2. Dedicated Cross-Sectional Imaging Rotation (2 months)

4.2. YEAR 2

Includes the requirements of Year 1 with more focus on clinical NM and with additional clinical training in oncology, neurology, cardiology, and paediatrics.

4.2.1. Basic Science

These are more advanced levels of the topics covered in the first year (4.1.1).

4.2.1.1. Mathematics and Statistics

- Errors and distributions;
- P values;
- Sensitivity, specificity, positive predictive value, negative predictive value;
- Bayes' theorem;
- ROC curves;
- Clinical trial design and analysis.

4.2.1.2. Instrumentation

- Spectrometry;

— Gas detectors;
— Film badges, TLD and OSL;
— Personal dosimeters.

4.2.1.3. Principles of Radionuclide Therapy

— Relationship between absorbed dose and exposure;
— Relative biological effectiveness;
— Concept of dose equivalence;
— Internal dosimetry.

4.2.1.4. Natural, Medical and Professional Radiation Exposures

— Elements of radiation toxicity;
— Nuclear accidents and incidents, mitigation, and consequences.

4.2.1.5. Principles of Tracer Kinetics

— Data acquisition in nuclear medicine;
— Compartmental analysis;
— Non-compartmental analysis;
— Fitting models (parameter optimization).

4.2.1.6. Basic Radiopharmacy and Radiochemistry

— Production of radioactive isotopes:
    - Bombardment with neutrons;
    - Bombardment of charged particles.
— Generators;
— Cyclotron production of radioisotopes;
— Compounding and dispensing radiopharmaceuticals.

4.2.1.7. Principles of Quality Management Systems

— Preparation of standard operating procedures;
— Regulatory and compliance requirements;
— Clinical audits.

4.2.1.8. Quality Control and Regulatory Issues of Radiopharmaceuticals

— Compounding;
— Quality control (QC) testing including equipment (e.g. dose calibrator) and generators;
— QC of radiolabelled blood cells;
— Quality assurance programme;
— *In vitro*, including radioimmunoassay, if available.

4.2.2. Diagnostic Clinical Nuclear Medicine

For each study, the trainee should have a detailed understanding of the physiology and anatomy of the specific organ/region being study, as well as cross-sectional imaging, all available tracers,

methodology, and preparation. The trainee should fully understand the relevant findings and be able to formulate an appropriate differential diagnosis.

4.2.2.1. Clinical Application (see Appendix I)

4.2.2.2. Dedicated Cross-Sectional Imaging Rotation (2 months)

4.2.3. Therapeutic Nuclear Medicine

The trainee should understand the general principles of treatment using radiopharmaceuticals. Therapy using unsealed radioactive sources includes the theranostic approach, for personalized medicine.

4.2.3.1. Clinical Application (see Appendix I)

4.3. YEAR 3

4.3.1. Diagnostic and Therapeutic Nuclear Medicine

At this point, a trainee should be competent in all aspects of routine diagnostic and therapeutic nuclear medicine. For each study, the trainee should fully understand the implications of the findings and be able to recommend the next step in the patient's workup or management.

4.3.1.1. Clinical Application (see Appendix I)

4.3.1.2. Dedicated Cross-Sectional Imaging (2 months)

4.3.2. Additional Competencies

- Legal and regulatory requirements;
- Quality management apply to nuclear medicine;
- Departmental and hospital operations;
- Education and training.

4.3.3. Complementary Skills

- Communication skills (e.g. negotiation, public speaking);
- Teamwork;
- Patient support and advocacy;
- Analytical thinking and summarising;
- Public presentation;
- Medical writing.

4.4. ADDITIONAL YEARS

A three-year programme is considered to be the minimum training necessary for medical doctors to acquire the knowledge, skills and competencies required to practice clinical NM, ensuring the safety and quality of the service provided. However, in several countries or to acquire additional competencies, training extending to four or five years exists. In this section, a dedicated programme for these additional years is included.

At this point, a trainee should be perfectly competent in all aspects of diagnostic and therapeutic nuclear medicine. Additional training should be directed towards acquiring a deeper understanding of clinical research and management skills such as the following:

- Advanced understanding of the clinical context of nuclear medicine studies;
- Participation and presentation at interdisciplinary meetings;
- Academic activities: research and teaching;
- Introduction to pre-clinical imaging;
- Radiation accident preparedness;
- Financial management (budgeting, billing, accounting, planning);
- Research protocol design and funding;
- Leadership skills;
- Grant and scientific paper preparation skills.

4.5. CONCLUSION

Upon completion, postgraduate trainees must be able to plan, perform, process, analyse, compare to other imaging modalities, report and archive any type of diagnostic NM procedure.

The trainee must complete a minimum requirement of 2,500-3,000 documented diagnostic procedures, including at least 150 diagnostic procedures in paediatric patients and extensive experience with hybrid imaging when possible. If not available, image fusion should be mandatory (Table 2).

He/she must also complete 100 therapeutic procedures (these therapies should be distributed between benign and malignant conditions).

Some flexibility should be accepted; although the total number of procedures for diagnostic and therapeutic studies should be completed.

TABLE 2. MINIMUM NUMBER OF PROCEDURES DURING THE TRAINING PROGRAMME

	Oncology SPECT	Oncology PET*	Bone & Joint	Cardio vascular	Endocrine	Neurology	Pulmonary	Urinary	Gastro intestinal	Others**
Total	150	650	600	400	300	200	100	100	100	500

* when available
** or additional from the table

5. EXPECTED COMPETENCIES AND SUGGESTED ASSESSMENT METHODS

The emergence of competency-based models from the Accreditation Council for Advanced Medical Education (ACGME) and the Royal College of Physicians and Surgeons of Canada (CanMEDS) meant a change in process-based medical education. The main attribution of these models is the ability to improve the assessment component of medical training programme curriculums. This explains firstly, the support of national medical education councils for these models and secondly, the willingness for these models to be utilized by post-graduate medical education councils or national specialty programme directors [6,7]. This section offers suggested assessment methods and schedules that are designed to achieve the expected competencies within the nuclear medicine training programme.

TABLE 3. PARALLEL ASSESSMENT TOOLS TYPICALLY ADMINISTERED IN THE RESIDENCY TRAINING PROGRAMME IN NUCLEAR MEDICINE. ASSESSMENT TOOLS

ADAPTED FROM ACGME [6,7]

<table>
<tr><th rowspan="2">Timeline</th><th colspan="2">Home institute</th><th colspan="2">Certifying body/ Local board</th></tr>
<tr><th>Common assessment tools used</th><th>Desired demonstrated competencies (ACGME)</th><th>Common assessment tool</th><th>Desired demonstrated competencies (ACGME)</th></tr>
<tr><td rowspan="7">Year one
Year two
Year three</td><td>• Written exam
• Multiple choice questions (MCQ)</td><td>• Medical knowledge
• Practice-based learning and improvement</td><td>• Exam MCQ, yearly</td><td>• Medical knowledge
• Practice-based learning and improvement</td></tr>
<tr><td>• Oral exam</td><td>• Medical knowledge
• Practice-based learning and improvement</td><td rowspan="6">• Research paper criteria</td><td rowspan="6">• Professionalism
• Patient care
• Practice-based learning and improvement</td></tr>
<tr><td>• Procedure or case logs</td><td>• Patient care
• Practice-based learning and improvement</td></tr>
<tr><td>• Direct observation</td><td>• All competencies in CanMeds and ACGME</td></tr>
<tr><td>• 360 Global rating</td><td>• Professionalism
• Patient care
• Practice-based learning and improvement</td></tr>
<tr><td>• Portfolios</td><td>• Practice-based learning and improvement</td></tr>
</table>

	• Checklist	• Patient care • Systems-based practice		
	• Patient survey	• Patient care		
	• Objective structured clinical examination	• Professionalism • Patient care • Practice-based learning and improvement		
Board examination			• Exam MCQ • Oral exam • OSCE	• Medical knowledge • Patient care • Professionalism • Practice-based learning and improvement

TABLE 4. SCHEDULE AND TYPES OF ASSESSMENTS USED. CORRESPONDING COMPETENCIES, AS INDICATED BY ACGME, ARE ALSO SHOWN. THE FREQUENCY ASSESSMENT IS DEPENDANT ON THE OBJECTIVES AND AVAILABLE RESOURCES [8]

	Assessment tools	Context	Domain assessed or implied	Competency demonstrated/ suggested
Daily	• Oral exam, short	• Daily reading sessions • Formative assessment	• Cognitive	• Medical knowledge • Patient care • Practice-based learning and improvement • Professionalism
	• Procedure or case logs • Updates	• Patients encountered • Reflective activity • Formative assessment	• Cognitive • Psychomotor • Affective/ attitude	• Patient care • Practice-based learning and improvement
Weekly	• Written exam • Short quizzes	• Weekly exams depending on rotation focus • Formative assessment	• Cognitive	• Medical knowledge • System-based practice • Practice-based learning and improvement
	• Procedure or case logs • Updates	• Patients encountered • Reflective activity • Formative assessment	• Cognitive • Psychomotor • Affective/ attitude	• Patient care • Practice-based learning and improvement

Monthly or quarterly intervals	• Written exam • Oral exam	• Monthly exams depending on rotation focus • Formative assessment	• Cognitive	• Medical knowledge • System-based practice • Professionalism • Practice-based learning and improvement
	• Procedure or case logs • Updates	• Patients encountered • Reflective activity • Formative assessment	• Cognitive • Psychomotor	• Patient care • Practice-based learning and improvement
	• Checklist	• Competency assessment and self-assessment of skills achieved	• Cognitive • Psychomotor • Affective/ Attitude	• Medical knowledge • Patient care • Professionalism • System-based practice • Interpersonal and communication skills • Practice-based learning and improvement
Yearly	• As a whole or in blocks: • Written exam • OSCE/ simulations and models • Standardized patient • Oral exam	• Yearly exam • Summative assessment • In-service examination	• Cognitive • Psychomotor • Affective/ Attitude	• Medical knowledge • Professionalism • Practice-based learning and Improvement • System-based practice
	• 360 Global rating • Checklist	• Performance • Review evaluation by superiors, hospital staff, patients • Summative assessment	• Mainly affective/ attitude • Psychomotor	• Medical knowledge • Patient care • Professionalism • System-based practice • Interpersonal and communication skills • Practice-based learning and improvement

	• Procedure or Case Logs • Updates	• Patients encountered • Reflective activity • Formative/ summative assessment	• Cognitive • Psychomotor	• Patient care • Practice-based learning and improvement
	• Portfolios	• Literature review and reflection • Products of learning • Written assignments on topics • Video-audio recordings documenting what has been learned • Formative and summative assessment	• Cognitive • Psychomotor • Affective	• Professionalism • Patient care • System-based practice Practice-based learning and improvement

APPENDIX I

LIST OF EXAMS

I.1. ENDOCRINE DISEASES

I.1.1. Thyroid

- Hyperthyroidism:
  - Clinical, US and biological evaluation;
  - Radioiodine treatment;
  - Other treatments.
- Other benign thyroid conditions;
- Differentiated and non-differentiated thyroid carcinoma:
  - Clinical, radiological and biological evaluation;
  - Therapeutic of well-differentiated thyroid cancer;
  - Radioiodine treatment of thyroid cancer;
  - Clinical management and follow-up of thyroid patient.

I.1.2. Parathyroid

- Hyperparathyroidism, parathyroid adenoma and hyperplasia:
  - Detection and localization (ectopic, transplanted glands);
  - Intraoperative probe localization.

I.1.3. Adrenal Gland

- Pheochromocytoma and neuroblastoma;
- Characterization of adrenal masses.

I.2. ONCOLOGY

I.2.1. Generalities

- Diagnosis;
- Staging;
- Response evaluation;
- Follow-up/recurrence/progression;
- Multidisciplinary approach;
- Radiation treatment planning;
- Principles and practice of theranostics;
- Radio-guided surgery.

I.2.2. Clinical Oncology

- Primary tumours of the central nervous system;
- Head & neck cancers;
- Lung cancer;
- Breast cancer;
- Oesophageal cancer;
- Gastric carcinoma;

- Gastrointestinal tumours including stromal tumours;
- Pancreatic adenocarcinoma;
- Cholangio- and gallbladder carcinomas;
- Colorectal cancers;
- Kidney cancers;
- Ovarian cancer;
- Germinal tumours;
- Lymphomas;
- Melanoma;
- Neuroendocrine tumours;
- Sarcomas (soft tissue and bone);
- Cancer of unknown primary;
- Sentinel lymph node mapping;
- Primary and secondary bone cancers.

I.3. BONE AND JOINTS DISEASES

- Rheumatological diseases;
- Trauma;
- Prostheses;
- Infection;
- Metabolic disease.

I.4. CARDIOLOGY

- ECG interpretation;
- Myocardial perfusion studies:
    - Coronary artery disease;
    - Cardiomyopathy;
    - Congestive heart failure.
- Stress tests:
    - Exercise;
    - Pharmacological.
- Gated blood pool studies:
    - Cardiotoxicity (chemotherapy, radiotherapy and immunotherapy);
    - Congestive heart failure.
- Inflammation;
- Other nuclear medicine techniques for cardiovascular diseases:
    - First pass studies, including right ventricular ejection fraction.
- Other modalities:
    - Computed tomography angiography;
    - Coronary angiography;
    - Ultrasound;
    - Cardiac magnetic resonance imaging.

I.5. LUNG DISEASES

- Ventilation-perfusion scintigraphy:
    - Pulmonary embolism;
    - Pulmonary hypertension;

- Preoperative evaluation.

— Other nuclear medicine techniques for lung diseases:
  - Vascular permeability studies;
  - Shunt studies;
  - Inflammatory disorders.

I.6. GASTROINTESTINAL DISEASES

I.6.1. Salivary Gland

— Obstruction;
— Sjogren's.

I.6.2. Oesophagus

— Reflux;
— Motility.

I.6.3. Stomach

— Gastroparesis;
— Post-operative;
— Search for ectopic gastric mucosa:
  - Meckel's diverticulum.

I.6.4. Small and Large Bowel

— Gastrointestinal bleeding.

I.6.5. Hepatobiliary

— Acute and chronic cholecystitis;
— Biliary leak;
— Biliary dyskinesia;
— Neonatal hyperbilirubinemia.

I.7. NEPHRO- UROLOGY

— Dynamic scan:
  - Evaluation of hydronephrosis and obstruction;
  - Furosemide - various protocols;
  - Split and differential function;
  - Renal graft evaluation;
  - Acute or chronic renal failure;
  - Renovascular hypertension;
  - Quantitative and qualitative interpretation;
  - Vesicoureteral reflux.
— Cortical renal scintigraphy:
  - Urinary tract infections;
  - Malformation pathology;
  - Parenchymal infarction.
— Direct and indirect cysto-scintigraphy:

- Reflux;
- Urinary leak.

I.8. NEUROLOGY

— Brain perfusion:
  - Epilepsy;
  - Dementia;
  - Brain death.
— Neurotransmission:
  - Movements disorders.
— Cerebrospinal fluid studies:
  - Shunts;
  - Leaks;
  - Normal pressure hydrocephalus.

I.9. HAEMATOLOGY

— Evaluation of bone marrow;
— Splenic tissue detection.

I.10. INFECTION/INFLAMMATION

— Musculoskeletal infections:
  - Acute and chronic bone infection;
  - Soft tissue infection.
— Cardiovascular infections:
  - Vascular graft infection;
  - Infectious endocarditis;
  - Infection of cardiac implantable electronic devices.
— Inflammatory bowel disease;
— Sarcoidosis;
— Fever of unknown origin.

I.11. PAEDIATRICS

— General concepts of handling children;
— Physiologic, anatomic considerations (organ maturation, growth, etc.);
— Specific aspects of different pathologies;
— Dosimetric considerations.

I.12. MISCELLANEOUS

— Dacryoscintigraphy;
— Peripheral lymphoscintigraphy;
— Radionuclide venography;
— Testicular studies;
— Intraperitoneal distribution.

I.13. THERAPY

- Thyroid:
  - Hyperthyroidism;
  - Thyroid cancer.
- Bone:
  - Palliative treatment of painful bone metastases.
- Neuroendocrine tumours:
  - Peptide receptor radionuclide therapy.
- Lymphomas:
  - Radioimmunotherapy.
- Liver metastasis;
- Prostate:
  - Alpha therapy;
  - Lutetium 177 PSMA.
- Radiosynovioarthesis;
- Others (e.g. brain tumours).

I.14. *IN VITRO* ASSAYS

- Radioimmunoassay:
  - Hormone assays;
  - Tumour markers.
- Clinical:
  - Glomerular filtration rate;
  - C-14 (and optional C-13) urea breath test.

APPENDIX II

EXPECTED COMPETENCIES AND SUGGESTED ASSESSMENT METHODS

II.1. OVERVIEW OF COMPETENCIES AND SUGGESTED ASSESSMENT METHODS

The following competencies are adapted from ACGME's six clinical competencies, initially published in 2002 [9]. A well-trained trainee in any of the medical specialties is expected to have attained these competencies. More competencies for nuclear medicine trainees are presented below [10].

II.1.1. Patient Care

- Provide patient care that is compassionate, as well as, appropriate and effective towards the treatment of health problems and the promotion of health;
- Obtain patient-informed consent for required procedures according to rules, regulations, and institutional policies;
- Educate the patient on pre-procedural preparation and post-procedural care effectively and demonstrate caring, respectful, and ethical behaviours when interacting with the patient, family, physicians, and other health care professionals;
- Make informed decisions about diagnostic and therapeutic procedures under the direction of the supervising physician and based on patient information and preferences, up to date scientific evidence, and clinical judgment;
- Gather and evaluate essential information, including correlative studies, about the patient and arrange follow-up as necessary under the direction of the supervising physician;
- Obtain history and perform physical examination;
- Evaluate findings for contraindications to testing and for indicators of additional patient pathology;
- Consult with the ordering physician as needed;
- Counsel the patient and family as indicated to determine and implement a plan of care;
- Use professional judgment to recommend or adapt protocols for procedures to improve diagnostic quality and outcome;
- Consult with the supervising physician or appropriate health care provider to determine a modified action plan when necessary;
- Report findings to the supervising physicians and the patient per protocol;
- Provide supportive medical management including basic life support and advanced life support.

II.1.2. Medical Knowledge

II.1.2.1. *Objectives:*

Trainees are expected to demonstrate knowledge of existing, evolving, and emerging biomedical, clinical, epidemiological, and social and behaviour related sciences, as well as the application of this knowledge in patient care. These skills and objectives can be achieved flexibly over the duration of a minimum of three years.

II.1.3. Interpersonal and Communication Skills

Trainees must demonstrate soft skills such as interpersonal and communication skills that result in the effective exchange of information and collaboration with patients, their families, and health professionals.

II.1.3.1. *Key Competencies:*

- Communicate effectively with health-related agencies, patients, families, and the public, indiscriminate of socioeconomic and cultural backgrounds;
- Work effectively as a member or leader of a health care team or other professional group;
- Advise other physicians and health professionals;
- Maintain comprehensive, timely, and legible medical records, if applicable.

II.1.4. Professionalism

Trainees must demonstrate a commitment to carrying out professional responsibilities and an adherence to ethical principles.

II.1.4.1. *Key Competencies:*

- Compassion, integrity, and respect for others;
- Responsiveness to patients need that supersedes self-interest;
- Respect for patient privacy and autonomy;
- Accountability to patients, society, and the profession;
- Sensitivity and responsiveness to a diverse patient population, including but not limited to diversity in gender, age, culture, race, religion, disabilities, and sexual orientation.

II.1.5. Practice Based Learning and Improvement

Trainees must demonstrate the ability to investigate and evaluate their care of patients, to appraise and assimilate scientific evidence, and to continuously improve patient care based on constant self–evaluation and lifelong learning.

II.1.5.1. *Key Competencies:*

- Identify strength, deficiencies, and limit in one's knowledge and expertise;
- Set learning and improvement goals;
- Identify and perform appropriate learning activities;
- Systematically analyse practice using quality improvement methods and implement changes with the goal of quality improvement;
- Incorporate formative evaluation feedback into daily practice;
- Locate, appraise, and assimilate evidence from scientific studies related to their patient's health problems;
- Use information technology to optimize learning;
- Participate in the education of patients, families, students, trainees, and other health professionals.

II.1.6. System-Based Practice

Trainees will be expected to demonstrate an awareness and responsiveness to the system of health care implemented, as well as the ability to call effectively on resources in the system.

II.1.6.1. *Key Competencies:*

- Work effectively in various healthcare delivery settings and system relevant to their clinical specialty;
- Incorporate consideration of cost-awareness and risk-benefit analysis in patient and/or population-based care as appropriate;
- Advocate for quality patient care and patient care systems;
- Work in interprofessional teams to enhance patient safety and improve patient care quality;
- Participate in identifying system errors and implementing potential systems solutions.

II.2. EXPECTED COMPETENCIES FOR FIRST YEAR NUCLEAR MEDICINE TRAINEES

First year nuclear medicine trainees are expected to attain the following competencies:

II.2.1. Patient Care

- Critically review patient charts and interview patients to obtain relevant histories, physical findings, and diagnostic data to provide a basis for interpretation of basic nuclear medicine studies;
- Determine that the nuclear study is indicated based on the clinical information about the patient;
- Demonstrate a basic understanding of electronic patient information systems;
- Demonstrate the ability to use the Internet as an educational instrument to expand medical knowledge;
- Prepare and present cases at regular follow-up conferences;
- Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees.

II.2.2. Medical Knowledge

- Demonstrate a general knowledge of clinical indications, procedures, radiopharmaceuticals, and scintigraphic findings for basic nuclear medicine studies;
- Identify the isotopes (including physical and chemical properties) that are used routinely in the compounding of radiopharmaceuticals;
- Recognize the normal and abnormal appearance of images, mode of radiopharmaceutical uptake, normal variants, and common artefacts encountered;
- Begin to learn the contraindications for studies, modifications for special patients, and the selection of appropriate procedures;
- The trainee will learn the basic principles of radionuclide therapy, treatment of hyperthyroidism, thyroid cancer, and metastatic bone pain as well as parathyroid disease;
- Become familiar with radiation biology, Radiation protection, and waste management protocols. Understand the effects of high and low levels of radiation;
- Demonstrate general knowledge of basic physics and mathematics;

— Implement knowledge of anatomy with a minimum of 2 months dedicated to rotations in full-body CT, where the trainee will participate by actively dictating studies.

II.2.3. Interpersonal and Communication Skills

— Dictate reports using appropriate terminology with clear delineation of the relevant history and findings and a succinct, pertinent interpretation;
— Provide direct communication to the referring physician or appropriate clinical personnel when interpretation reveals an urgent or unexpected finding and document this communication in the radiologic report;
— Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees.

II.2.4. Professionalism

— Demonstrate altruism and compassion for patients;
— Be honest with patients and all members of the health care team, and interact with others without discriminating based on religious, ethnic, sexual or educational differences;
— Demonstrate positive work habits, including punctuality and professional appearance;
— Demonstrate an understanding of broad principles of biomedical ethics;
— Demonstrate principles of confidentiality with all information transmitted during a patient encounter;
— Discussion of conflicts of interest and the ethics of conducting research during departmental or institutional conferences and daily clinical work;
— Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees.

II.2.5. Practice-Based Learning and Improvement

— Attend weekly follow-up conferences where trainees are expected to present one or more cases;
— Attend the nuclear medicine journal club;
— Maintain a procedure log of radioactive therapies;
— Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees and by results of the in-training examination.

II.2.6. Systems-Based Practice

— Demonstrate awareness of necessities for coding and billing;
— Attend and participate in division and departmental conferences;
— Attend and participate in division and departmental follow-up conferences where there is discussion of the imaging evaluation of specific diseases and most appropriate and cost-effective methods for establishing a diagnosis;
— Attend departmental or institutional presentations on health care funding and regulation;
— Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees.

II.3. EXPECTED COMPETENCIES FOR SECOND YEAR NUCLEAR MEDICINE TRAINEES

Second year nuclear medicine trainees are expected to obtain the following competencies:

II.3.1. Patient Care

- Critically review patient charts and interview patients to obtain relevant histories, physical findings, and diagnostic data to provide a basis for interpretation of basic nuclear medicine studies;
- Determine that the nuclear study is indicated based on the clinical information about the patient;
- Demonstrate a basic understanding of electronic patient information systems;
- Demonstrate the ability to use the Internet as an educational instrument to expand medical knowledge;
- Prepare and present cases at regular follow-up conferences;
- Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees.

II.3.2. Medical Knowledge

- Demonstrate a general knowledge of the clinical indications, procedures, radiopharmaceuticals and imaging findings for diagnostic nuclear medicine studies;
- Identify the isotopes (including physical and chemical properties) that are used routinely in the compounding of radiopharmaceuticals for the studies listed in Year 1 above;
- For radioiodine treatment of hyperthyroidism: Understand the clinical indications and contraindications and side effects, perform a history and physical examination, and compute the required dose and observe administration of the dose;
- Understand the patient conditions and patient monitoring requirements for exercise and pharmacologic stress cardiac studies;
- Discuss the basic physical principles of nuclear medicine imaging, instrumentation, and image processing;
- Be familiar with radiotracer kinetics;
- Understand the linear hypothesis and threshold hypothesis of biological response to low levels of radiation;
- Be familiar with the effective equivalent and the calculation of radiation dose from radiopharmaceuticals;
- Implement knowledge of anatomy with a minimum of 2 months dedicated to rotations in full-body CT, where the trainee will participate by actively dictating studies.

II.3.3. Interpersonal and Communication Skills

- Demonstrate skills in obtaining informed consent for radioiodine therapy of hyperthyroidism, including effective communication to patients of the procedure, alternatives, and possible complications;
- Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees and their dictated reports.

II.3.4. Professionalism

- Demonstrate altruism and compassion for patients;
- Be honest with patients and all members of the health care team, and interact with others without discriminating based on religious, ethnic, sexual or educational differences;
- Demonstrate positive work habits, including punctuality and professional appearance;
- Demonstrate an understanding of broad principles of biomedical ethics;
- Demonstrate principles of confidentiality with all information transmitted during a patient encounter;
- Discuss the conflicts of interest and the ethics of conducting research during departmental or institutional conferences and daily clinical work;
- Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees.

II.3.5. Practice-Based Learning and Improvement

- Attend weekly follow-up conferences where trainees are expected to present one or more cases;
- Attend the nuclear medicine journal club;
- Maintain a procedure log of radioactive therapies;
- Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees and by results of the in-training examination.

II.3.6. Systems-Based Practice

- Demonstrate understanding of the need for authorization prior to the initiation of certain imaging studies and procedures;
- Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees.

II.4. EXPECTED COMPETENCIES FOR THIRD YEAR NUCLEAR MEDICINE TRAINEES

Third year nuclear medicine trainees are expected to obtain the following competencies:

II.4.1. Patient Care

- Demonstrate knowledge of the levels of ionizing radiation related to specific imaging procedures and employ measures to minimize radiation dose to the patient;
- Actively participate in journal clubs to determine the effectiveness of diagnostic imaging for specific diagnostic questions;
- Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees.

II.4.2. Medical Knowledge

- Demonstrate a general knowledge of the clinical indications, procedures, radiopharmaceuticals, and imaging findings for diagnostic nuclear medicine studies;

— Demonstrate the ability to use all relevant information resources to acquire evidence-based data;
— Learn the basics of DEXA and know the guidelines for the use of bone densitometry; Understand the pathophysiology of osteoporosis and the factors influencing bone density (optional);
— Be familiar with the latest appropriate use clinical guidelines;
— Know how patients should be prepared for therapy and choose the appropriate therapy according to the disease;
— Explain the treatment and obtain consent with special reference to the female patient's concern about fertility and contraception;
— Understand the physiologic and radiobiological mechanisms by which different radioisotope therapies are effective;
— Evaluate clinical criteria for radionuclide therapy, including expected biodistribution of radiotherapies;
— Arrange appropriate follow-up and further management of the patient;
— Explain in detail the process, guidelines, and timelines for the radioisotope therapy regimen according to institutional policy and guidelines;
— Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees;
— Implement knowledge of anatomy with least 2 months of cross-sectional imaging experience where the trainee will actively participate by reporting studies;
— Demonstrate the knowledge and willingness to comply with the rules and regulations governing the use of radioisotopes;
— Understand the legal framework for the safe administration of radiopharmaceuticals including the general instruction for ionizing radiation and those specific to the practice of nuclear medicine;
— Understand the methodology of clinical audit and scientific researches;
— Critically evaluate studies and research to determine the appropriateness of the type of research conducted and its relative validity.

II.4.3. Interpersonal and Communication Skills

— Same as in previous years.

II.4.4. Professionalism

— Demonstrate knowledge of issues of impairment (i.e. physical, mental, and alcohol and substance abuse), obligations for impaired physician reporting, and resources and options for care of self-impairment or impaired colleagues;
— Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees.

II.4.5. Practice-Based Learning and Improvement

— Assist less-experienced trainees to understand and interpret nuclear medicine studies;
— Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees.

II.4.6. Systems-Based Practice

- Demonstrate understanding of the need for authorization prior to the initiation of certain imaging studies and procedures;
- Demonstrate the ability to design cost-effective care plans based on knowledge of best practices;
- Demonstrate knowledge of basic health care reimbursement models;
- Performance will be evaluated by written feedback from the attending physicians based on their direct observation of the trainees.

II.5. FIRST YEAR NUCLEAR MEDICINE TRAINEE EVALUATION FORM

Name of trainee: _____

Rotation: _____

Dates of rotation: _____

KEY: 1 (Lowest, does not meet expectations) ……. 3 (meets expectations) ……. 5 (Highest, exceeds expectations)

PATIENT CARE

1. Become familiar with the operations of a nuclear medicine clinic, including evaluation of the clinical request, planning and monitoring of the procedure, interpretation of the study, and dictation of the final report after faculty review.

   1 2 3 4 5

2. Learn basic radiation safety.

   1 2 3 4 5

3. Learn how to interview thyroid therapy patients, calculate therapeutic radioiodine doses, and obtain informed consent.

   1 2 3 4 5

4. Begin to participate in the stress portion of myocardial perfusion studies.

   1 2 3 4 5

5. Begin patient procedure logs to document participation in nuclear cardiology, thyroid therapy, antibody therapy, bone therapy (^{89}Sr and ^{153}Sm), and PET and CT studies.

   1 2 3 4 5

MEDICAL KNOWLEDGE

1. Learn basic physics of nuclear medicine.

   1 2 3 4 5

2. Learn basic radiopharmacy and quality control (preferred: dedicated radiopharmacy rotation).

   1 2 3 4 5

3. Learn basic nuclear medicine instrumentation and quality control (preferred: hands-on experience).

   1 2 3 4 5

4. Learn appropriate radiopharmaceuticals, procedures, and basic interpretations for the most common nuclear medicine studies (bone scans, thyroid studies, lung scans, cardiac studies, hepatobiliary scans, renal scans, gastric emptying studies, and ^{18}F-FDG studies).

1 2 3 4 5

5. Begin critical review of the major nuclear medicine literature (journal club participation).

1 2 3 4 5

INTERPERSONAL AND COMMUNICATION SKILLS

1. Use digital dictation/voice recognition systems as appropriate for the institution.

1 2 3 4 5

2. Learn the appropriate format for a nuclear medicine report.

1 2 3 4 5

3. Begin to formulate a concise, meaningful, and accurate nuclear medicine report.

1 2 3 4 5

4. Learn to use Word and PowerPoint for presentations.

1 2 3 4 5

5. Understand the need and style for oral communication of results to referring physicians.

1 2 3 4 5

6. Begin participation in clinical settings (intra- and interdepartmental conferences).

1 2 3 4 5

PROFESSIONALISM

1. Begin to understand how to be a committed, ethical, and professionally responsible nuclear medicine physician who is sensitive to a diverse socioeconomic health care system (patient and health care team).

1 2 3 4 5

2. Understand patient privacy issues.

1 2 3 4 5

3. Pursue membership and involvement in organized nuclear medicine societies.

1 2 3 4 5

PRACTICE-BASED LEARNING AND IMPROVEMENT

1. Use computer technology and the Internet as tools for the acquisition of evidence-based medical knowledge from existing published and online educational resources.

1 2 3 4 5

2. Begin patient follow-up as related to nuclear medicine procedures, including radiopharmaceutical therapy.

1 2 3 4 5

SYSTEMS-BASED PRACTICE

1. Learn to use nuclear medicine computer systems, radiology information systems, and picture archiving and communication systems workstations.

1 2 3 4 5

2. Begin a scholarly research project to present at a state, regional or national meeting or for publication in a peer-reviewed journal.

1 2 3 4 5

3. Present one didactic departmental nuclear medicine lecture.

1 2 3 4 5

4. Understand basic billing and coding issues in nuclear medicine.

1 2 3 4 5

OVERALL PERFORMANCE

1 2 3 4 5

COMMENTS: (An overall impression resulting in not meeting expectations or exceeding expectations requires narrative comment.)

Faculty: _____

Signature: _____

Date: _____

Trainee: _____

Signature: _____

Date: _____

II.6. SECOND YEAR NUCLEAR MEDICINE TRAINEE EVALUATION FORM

Name of trainee: _____

Rotation: _____

Dates of rotation: _____

KEY: 1 (Lowest, does not meet expectations) ……. 3 (meets expectations) ……. 5 (Highest, exceeds expectations)

PATIENT CARE

1. Begin to assume clinical responsibility for and supervision of the operations of a nuclear medicine clinic, including quality control issues.

   1 2 3 4 5

2. Understand NRC regulations as applied to nuclear medicine and patient safety (preferred: dedicated experience with the Radiation Safety Office or its equivalent).

   1 2 3 4 5

3. Assume increasing responsibility and understanding in the therapeutic uses of unsealed radiopharmaceuticals, including the following: radioiodine; painful bone disease; radiolabelled antibodies; malignant effusions; and therapy of hematologic, endocrine, and metabolic disorders.

   1 2 3 4 5

4. Continue to maintain patient procedure logs.

   1 2 3 4 5

MEDICAL KNOWLEDGE

1. Increase depth of understanding of basic sciences, including physical science, instrumentation, radiobiology and radiation protection, mathematics and statistics, and radiopharmaceutical chemistry.

   1 2 3 4 5

2. Learn the guidelines for conducting and interpreting more complex studies, including the following: the spectrum of musculoskeletal, cardiac, endocrinologic, gastrointestinal, hematologic, oncologic, neurologic, pulmonary, and genitourinary studies, non-^{18}F-FDG PET agents; receptor and peptide imaging studies; and non-imaging studies.

   1 2 3 4 5

3. Participate in radiology conferences in the basic principles of CT, ultrasound, and MRI.

1 2 3 4 5

4. Learn to understand and interpret co-registration and fusion studies, including learning to interpret CT studies (preferred: dedicated rotations in radiology).

1 2 3 4 5

5. Understand a PET radiopharmacy (preferred: dedicated rotation).

1 2 3 4 5

6. Learn to process for display and review basic nuclear medicine studies, such as myocardial perfusion, radionuclide ventriculography, gastric emptying, and thyroid uptake.

1 2 3 4 5

7. Routinely present at and participate in journal clubs.

1 2 3 4 5

INTERPERSONAL AND COMMUNICATION SKILLS

1. Interpret and generate a preliminary report of nuclear medicine studies before faculty review.

1 2 3 4 5

2. Actively participate in nuclear medicine consultation with clinicians.

1 2 3 4 5

3. Present at intra- and interdepartmental conferences.

1 2 3 4 5

PROFESSIONALISM

1. Be a committed, ethical, and professionally responsible nuclear medicine physician who is sensitive to a diverse socioeconomic health care system (patient and health care team).

1 2 3 4 5

2. Adhere to patient confidentiality.

1 2 3 4 5

3. Maintain membership and involvement in organized nuclear medicine societies.

1 2 3 4 5

PRACTICE-BASED LEARNING AND IMPROVEMENT

1. Begin to perform self-reflection in identifying patient care and practice deficiencies, be able to formulate an intervention and deficiency reassessment.

1 2 3 4 5

2. Participate in the nuclear medicine peer review process.

1 2 3 4 5

3. Become familiar with recommended practice performance guidelines.

1 2 3 4 5

4. Routinely follow up radionuclide therapy patients.

1 2 3 4 5

5. Begin a quality assurance project.

1 2 3 4 5

SYSTEMS-BASED PRACTICE

1. Prepare a scholarly research project for presentation or publication.

1 2 3 4 5

2. Present at least two didactic nuclear medicine departmental lectures.

1 2 3 4 5

3. Begin to understand resource allocation as related to cost-effectiveness in nuclear medicine.

1 2 3 4 5

OVERALL PERFORMANCE

1 2 3 4 5

COMMENTS: (An overall impression resulting in not meeting expectations or exceeding expectations requires narrative comment.)

Faculty: _____

Signature: _____

Date: _____

Trainee: _____

Signature: _____

Date: _____

II.7. THIRD YEAR NUCLEAR MEDICINE TRAINEE EVALUATION FORM

Name of trainee: _____

Rotation: _____

Dates of rotation: _____

KEY: 1 (Lowest, does not meet expectations) ……. 3 (meets expectations) ……. 5 (Highest, exceeds expectations)

PATIENT CARE

1. Deliver diagnostic and therapeutic nuclear medicine procedures that are compassionate, appropriate, effective, and cost conscious and that contribute to patient care over a diverse socioeconomic population.

1 2 3 4 5

2. Become sufficiently competent to independently be responsible for the supervision and operations of a nuclear medicine clinic as related to triage procedures, health care provider consultations, and supervision and interpretation of diagnostic studies. The supervising faculty, however, should be readily available for consultations.

1 2 3 4 5

3. Become sufficiently competent to independently and appropriately evaluate patients for therapy.

1 2 3 4 5

4. Complete required patient procedure logs.

1 2 3 4 5

MEDICAL KNOWLEDGE

1. Acquire established and evolving biomedical, clinical, and cognitive evidence-based medical knowledge in the specialty of nuclear medicine.

1 2 3 4 5

2. Routinely critically review the major nuclear medicine and related literature with continued participation in journal clubs.

1 2 3 4 5

3. Demonstrate knowledge related to CT and MRI.

1 2 3 4 5

INTERPERSONAL AND COMMUNICATION SKILLS

1. Interpret and generate a preliminary report of nuclear medicine studies for faculty review.

1 2 3 4 5

2. Routinely use effective verbal and nonverbal communication skills as they apply to patient care.

1 2 3 4 5

3. Become a presenter and lead case discussions in intra- and interdepartmental conferences regarding nuclear medicine procedures and topics.

1 2 3 4 5

PROFESSIONALISM

1. Be a committed, ethical, and professionally responsible nuclear medicine physician who is sensitive to a diverse socioeconomic health care system (patient and health care team).

1 2 3 4 5

2. Maintain membership and involvement in organized nuclear medicine societies.

1 2 3 4 5

PRACTICE-BASED LEARNING AND IMPROVEMENT

1. Develop active critical reflection and improvement as applied to patient care.

1 2 3 4 5

2. Complete and submit a quality assurance project.

1 2 3 4 5

3. Become familiar with the certification process for implementation after completion of the nuclear medicine training.

1 2 3 4 5

SYSTEMS-BASED PRACTICE

1. Submit a scholarly research project for presentation or publication.

1 2 3 4 5

2. Present two didactic nuclear medicine departmental lectures.

1 2 3 4 5

3. Understand the complexity of the health care system and develop the ability to use health care resources for optimal and cost-effective patient care in nuclear medicine procedure.

1 2 3 4 5

OVERALL PERFORMANCE

1 2 3 4 5

COMMENTS: (An overall impression resulting in not meeting expectations or exceeding expectations requires narrative comment.)

Faculty: _____

Signature: _____

Date: _____

Trainee: _____

Signature: _____

Date: _____

II.8. FINAL EVALUATION FORM

FINAL CONFIDENTIAL EVALUATION FORM

I. Name (type or print): _____

II. Dates of training: from _____ to _____

III. Do you verify that the trainee has demonstrated sufficient competence to enter practice without direct supervision?

Yes ___ No ___

IV. Evaluation

This evaluation should be based on performance demonstrated when evaluated against levels of training and experience.

	Poor	**Fair**	**Good**	**Excellent**
Basic medical knowledge				
History and physical examination				
Record keeping and case presentation				
Patient management and care				
Professional judgment				
Physician-patient relationship				
Demonstrated responsibility and ethical conduct				
Cooperativeness, ability to work with others				
Professional appearance				
Timely communication with health care team				
Commitment to continuous learning and practice improvement				
Ability to practice in and improve systems of care				

V. During the time noted in item I, has this physician ever been subject to any disciplinary action, specifically reprimands, probation, suspension, or dismissal?

Yes ____ No ___

If the answer is YES, please elaborate in item VII or in a separate attachment.

VI. Recommendations

1. Recommended ___
2. Not recommended ___

If '2.' is checked, please elaborate in item VII or in a separate attachment.

VII. Comments (notable strengths and weaknesses or explanation of above answers)

_____
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I have read the foregoing information and have had an opportunity to discuss it with the evaluator.

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