Appendix III-C

Spanish Guide for the Training of Medical Specialists

*Nuclear Medicine**

* Taken from: España, Ministerio de Sanidad y Consumo, Consejo Nacional de Especialidades Médicas y Consejo Nacional de Especialidades Farmacéuticas. *Guía de formación de especialistas*. Madrid: Ministerio de Sanidad y Consumo; 1986. (Free translation). (An updated version of this Guide was published in 1996.)

1. Definition of the Specialty

Nuclear medicine is the medical specialty that uses radioactive *isotopes*, nuclear radiation, the electromagnetic variations of the components of the nucleus and related biophysical techniques for the prevention, diagnosis, and treatment of disease and for medical research

2. Nature of the Specialty

2.1 Scientific basis

Nuclear medicine utilizes knowledge from other basic sciences, such as physics, chemistry, mathematics, and biology, for medical purposes

2.2 Areas of activity

Prevention: In the area of prevention, nuclear medicine applies knowledge and techniques from the specialty to hygiene and to prophylactic and preventive medicine.

Research: Nuclear medicine is used in basic and applied research using radioactive ***isotopes*** and related biophysical techniques.

Diagnosis: Diagnostic nuclear medicine consists basically of functional, morphological, dynamic, morphodynamic, and radioanalytical tests performed in order to gain a better understanding of the function and structure of the human body, based on biological and physiopathological principles.

Treatment: Nuclear medicine is used in the treatment of various specific human pathologies (e.g., metabolic, endolymphatic, and intracavitary therapy).

2.3 Professional responsibility of the specialist

The specialist in nuclear medicine should be trained to carry out his/her professional functions in accordance with accepted practices in the specialty. He/she is expected to prescribe, execute, interpret, apply, and explain diagnostic and therapeutic procedures of the specialty in general, encompassing all its different areas. The objective of the training program is to produce a self-reliant medical specialist capable of independently practicing all facets of nuclear medicine at any medical care level, and, given the rapidly changing nature of the specialty, applying future developments in the field.

2.4 Specific areas of competence

Given the nature of the specialty, it is agreed that it should not be divided into subspecialties devoted to the application of the conceptual principles to specific organs or systems.

2.5 Relationship of Nuclear Medicine to the Basic Sciences

Because the collaboration of a multidisciplinary team of professionals is necessary in order to achieve superior development at the various care levels,

the specialist in nuclear medicine should collaborate with professional colleagues in the areas of biology, physics, chemistry, pharmacy, and information science applied to nuclear medicine.
The qualifications of these professionals will be defined subsequently.

3. Contents and duration of the training program

3.1 Overall duration of the program

The training of specialists in nuclear medicine should be completed over a four-year period and should include a balance between theoretical and practical instruction carried out simultaneously

3.2 Stages of training

a) Generic Training Stage:
Learn the fundamentals of mathematics, physics, chemistry, pharmacy, instrumentation, hygiene, and radiation protection and their practical applications in nuclear medicine.
Understand the physiological, physiopathological, and pathological mechanisms studied.

b) Specific training stage:
Learn to assume all professional responsibilities:
- Monitoring of patients and supervision of the laboratory
- Selecting appropriate tests, radiopharmaceuticals, instrumentation, reporting of results
- Maintaining bibliographic information
- Initiating and carrying out research projects

With regard to theoretical instruction, given the nature of teaching in the specialty and the small number of graduates undergoing training, it is preferable that theoretical instruction be imparted in tutorials to small groups.

Activities to be undertaken in each training stage

General overview of the program

a) First-year residents:
- Basic concepts: mathematics, radiation physics, radiation biology, radiation chemistry, radiopharmacy, hygiene, and radiation protection

b) Second-year residents:
- In vivo methodology
- In vitro methodology
- Instrumentation
- Participation in a program of radiation protection in order to obtain the *license* as a supervisor of installations utilizing radioactive materials. This will be done during the early years of residency.

c) Third- and fourth-year residents
- Clinical course (clinical nuclear medicine)

During the four years of their training, residents will have the option of participating in a six-month rotation in other services.

Objectives

General objective

The objective of the training is to produce a physician specialized in nuclear medicine (PSNM): A physician who contributes to diagnosis by means of techniques in which spontaneous or induced radiation associated with nuclear processes is used and who is trained to carry out treatment and follow up of patients who require the utilization of non-encapsulated radioactive ***isotopes***. In addition, the specialist in nuclear medicine may extend his/her sphere of action to include diagnostic, morphological, or functional techniques that use non-***ionizing*** physical agents.

Specific objectives

Basic Sciences

After completing the training program, the PSNM will be able to do the following in the disciplines listed below:

Mathematics and Statistics:

- Give mathematic descriptions of linear, exponential, and logarithmic functions.
- Explain the basic concepts of compartmental analysis and name its most important clinical applications.
- Apply the basic concepts of statistics and correlation techniques, evaluating the significance of the results.

Physics:

- Describe the atomic and nuclear structure of matter.
- Name the characteristics of the following elementary particles: ***electron***, ***proton***, ***neutron***, positron, and neutrino.
- Define the following concepts: atomic mass, atomic number, ***nuclide***, and ***radionuclide*** (RN).
- Distinguish between isotopic, isobaric, isotonic, and isomeric elements.
- Interpret nuclear stability in relation to mass defect, atomic number, and atomic mass.
- Describe the principal methods and systems used to produce artificial ***radionuclides***.
- Describe the cyclotron and list the cyclotron products normally used in nuclear medicine.
- Describe ***radiation*** and the particles emitted by radioactive nuclei.
- State and apply the law of ***radioactive decay***.
- Explain the meaning of the following terms: decay constant, physical ***half-life***, biological ***half-life***, and radioactive equilibrium.
- Illustrate the following processes: ***beta*** emission, electronic capture, internal conversion, and isomeric transition.

- Interpret the energy spectra associated with the aforementioned processes.
- Explain the interaction of radiation with matter and describe the basic characteristics of the photoelectric, Compton, and pair-production effects.
- Describe the interaction of charged and neutral particles with matter.
- Define the following radiological quantities: ***activity***, ***exposure***, ***absorbed dose***, ***equivalent dose***, as well as their units. Describe the basis for the various components of a detection and measurement chain.
- Describe and explain the operation of the equipment used in nuclear medicine.
- Identify and describe the physical properties of the RN used in nuclear medicine.
- Explain the basic principles of image production and the factors that modify it in the various systems used in nuclear medicine services.

Information Management:
- Explain the basic physical components (hardware) of a computer.
- Describe operating systems (software).
- Describe the input/output units (peripherals) of a computer.

Radiation Biology:
- Explain the mechanisms of direct and indirect action of ***ionizing radiation***.
- Define linear energy transfer (LET) and relative biological efficiency (RBE).
- Explain the action of radiation on DNA.
- Explain the action of radiation on cells and the cellular cycle. Explain the mechanisms that intervene in cellular repair. Define the concept of radiosensitivity and list factors that modify it.
- Explain the factors and mechanisms that modify the action of radiation: fractionation.
- Describe somatic and genetic effects in general: irradiation syndrome.

Radiopharmacology:
- Define the term "radiopharmacology."
- Distinguish between the terms radiopharmaceutical, ***radionuclide*** (RN), and radiotracer.
- Evaluate which ***radionuclides*** and radiopharmaceuticals are most suitable for each specific procedure.
- Describe the different ways in which the various radiopharmaceuticals are administered, metabolized, and eliminated.
- Describe the mechanisms for localizing radiopharmaceuticals and their application in the design of nuclear medicine studies.
- Define and distinguish between chemical, radiochemical, and radioactive purity.
- Define the isotonic, apyrogenic, sterile, pH, toxic, and biological suitability characteristics of a radiopharmaceutical.
- Define the terms "synthesis" and "labeling."

- Describe the general methods of labeling
- Recognize the factors that can affect the purity and stability of labeled compounds.

Radionuclide Generators in Nuclear Medicine:
- Define the concept "***generator***" and describe its elements and characteristics.
- Name the most commonly used ***generators*** and select the most appropriate ***generator*** system for each use.
- Analyze the problems that can arise with ***generator*** use.

Molybdenum-Technetium Generator:
- Describe the Mo-Tc ***generator*** and analyze its various characteristics.
- Describe the principal characteristics involved in the radiochemistry of technetium-99m (oxide-reduction reactions, presence of Mo-99).
- Describe the various Tc-99-labeled compounds used in nuclear medicine.

Diagnostic Ultrasound:
- Define the concept of diagnostic ultrasound.
- List, apply, and describe the physical processes by which ultrasounds interact with matter.
- Relate the frequency, penetration, and resolution of ultrasound waves. Relate the amplitude and attenuation of ultrasound waves.
- Describe the various types of diagnostic ultrasound and list their applications in medical diagnosis.
- Explain the basic principles of image production and the factors that modify it in the various systems used in diagnostic ultrasound.

Nuclear Magnetic Resonance:
- Explain the physical basis of nuclear magnetic resonance.
- Describe the block diagram of a nuclear magnetic resonance unit.
- Describe the imaging and spectroscopy possibilities of nuclear magnetic resonance.

In Vitro Studies

Radiochemical Analysis:
- Define the concept of radiochemical analysis and state the theoretical principles on which it is based
- Define competition, activation, and substitution analysis.
- Describe the various types of competition analysis (protein, RIA, IRMA, ELISA, and hormone receptors).

RIA:
- Give a general description of RIA.
- Define monoclonal and polyclonal antibodies, antigens, haptens. Define the binding capacity and affinity of an antibody.

- Explain the basic principles and characteristics of the antigen-antibody reaction. Assess the various factors that influence this reaction.
- Explain the various methods of labeling in RIA.
- Draw and interpret a standard curve.
- Select the best method for automatic calculations.
- Perform ***quality control*** of the elements used in RIA
- Prescribe and plan the stimulation and suppression tests used in nuclear medicine.
- Monitor and clinically assess the results obtained by RIA.

Autoradiography:
- Describe the principal autoradiography techniques.
- Describe and explain the basic principles of autoradiography.

In Vivo Techniques

After completing the training program, the physician specialized in nuclear medicine (PSNM) will be able to:

- Describe all the studies used in the examination of each organ or system, including:
  · Patient preparation
  · Radiopharmaceuticals and ***doses*** to be used
  · Views to be used
  · Technical data on instruments
  · Need for auxiliary equipment
  · ***Risks*** of the study and their prevention and treatment
- Plan the study, taking into account the clinical data on the patient, including:
  · Clinical information on the patient:
    Physical and psychological condition
    Results of previous studies
    Socioeconomic status
  · Instruments and equipment available:
    Own equipment
    Equipment belonging to another facility (regional)
  · Current availability (extent of equipment use, waiting list, stock of radiopharmaceuticals).
- Correlation with other diagnostic techniques in the facility.
- Identify and describe the anatomical structures imaged, the normal variants, the artifacts and/or parameters of normalcy and their variations in morphofunctional studies.
- Assess ***activity***/time curves and quantitative data obtained in functional studies.
- Identify and describe pathological findings and their semiologic characteristics.
- Process the analog and digital data obtained from the study in order to carry out the necessary calculations to quantitatively determine the parameters for defining the function studied.

- Make timely decisions in order to resolve medical emergencies that may occur in the nuclear medicine service.
- Produce a report of the findings of the study, always including diagnostic guidance.
- Define the possibilities, limitations, and ***risks*** of nuclear medicine studies.
- Calculate the diagnostic efficiency and cost-benefit ratios for each study.

Therapeutic Applications of Nuclear Medicine

After completing the training program, the PSNM will be able to:

- Describe the radiopharmaceuticals utilized in nuclear medicine therapy as well as their pharmacological and pharmacokinetic properties.
- Describe the radiobiological basis for the therapeutic action of the ***radionuclides*** utilized in nuclear medicine therapy.
- Describe the natural history (etiology, pathogenesis, clinical course, etc.) of diseases susceptible to treatment with nuclear medicine.
- Establish the diagnosis and prognosis, monitoring the evolution of pathologies susceptible to treatment with nuclear medicine.
- Formulate the treatment prescription and describe the nuclear medicine techniques to be used with pathologies susceptible to treatment with nuclear medicine.
- Make the necessary calculations (volume, ***activity***, ***dose***) for nuclear medicine therapy.
- Diagnose and assess pathologies deriving from the therapeutic application of ***radionuclides*** in nuclear medicine.
- Determine when other associated treatment modalities should be used.

Radiation Protection (RP) and Safety in the Workplace

After completing the training program, the PSNM will be able to:

- Describe the physical principles of RP.
- Describe the biological principles of RP.
- Describe radiobiological phenomena and prevention of the harm caused by the radiation emitted by ***radionuclides***.
- Put in place the radiation protection measures provided for in current legislation on nuclear medicine services
- Establish special protective measures in each case for the management of ***radionuclides*** in solid, liquid, or gas form.
- Evaluate protective measures for the management of ***radioactive waste***.
- Establish radiation protection and safety measures at work for diagnostic and therapeutic applications of nuclear medicine.
- Plan radiation protection and safety measures at work for potentially exposed persons of ***members of the public*** and general population.
- Establish and carry out ***emergency plans*** in the event of ***accidents*** involving ***radionuclides***.

Psychomotor Objectives

After completing the training program, the PSNM will be able to:

- Collect qualitative and quantitative data and process them with a computer in order to solve applied statistics problems.
- Correctly handle non-encapsulated ***radioisotopes*** and ***generators***, employing optimal radiation protection measures and consistently ensuring:
  · Desired dilutions and/or concentrations.
  · Dose extraction.
  · Measurements of the ***activity*** to be administered
  · Administration of the ***dose*** to the patient by the appropriate route.
  · Safe handling of waste.
- Correctly utilize ***radionuclide*** decay tables.
- Operate a ***gamma camera*** in order to obtain the best possible information on the object under study for morphological and morphodynamic studies.
- Establish and carry out, with appropriate frequency, ***quality control*** tests of the ***gamma camera***, checking:
  · Homogeneity
  · Spectrometry
  · Linearity
  · Resolution
- Handle automatic and manual gamma counting systems to obtain the most exact results possible in terms of:
  · Voltage adjustment
  · Photo-peak determination
  · Handling of scalers, analyzers, counting rate meters, and plotters.
  · Handling of scintillation probes and well counters
  · Determination of measurement times and number of counts.
- Utilize, calibrate, and periodically check monitoring systems for the protection of personnel and areas.
- Use the nuclear medicine computer to:
  · Make extensive use of programs devoted to nuclear medicine
  · Use operating system resources related to nuclear medicine programs.
- Handle the laboratory materials necessary for the use of commercial equipment.
- Establish and carry out ***quality control*** tests of:
  · Radiopharmaceutical labeling
  · Radiochemical purity
  · Validation of RIA methods
- Perform radiopharmaceutical labeling.
- Perform cell labeling.
- Carry out by him/her-self, with the necessary collaboration, the techniques of NM.
- Monitor systems of protection and excreta disposal in areas in which patients are treated with ***radionuclides***.
- Handle and complete the required legal documentation.
- Establish and carry out ***quality control*** tests of diagnostic ultrasound.

Affective Objectives

After completing the training program, the PSNM will be able to:

- Train the personnel assigned to the various functional units of the service.
- Promote professional and human relations within the workplace.
- Adequately inform patients and their family members of the characteristics of studies, their ***risks***, and the benefits that justify them.
- Participate actively in the preparation of patient follow-up plans.
- Critically evaluate treatment outcomes, employing all available scientific means of verification, and complete the information acquired using all the resources available to him/her professionally.
- Collect, organize, and transmit data from studies, following the most appropriate method to contribute to scientific progress
- Identify opportunities for utilizing applied research in his/her work.
- Promote scientific meetings and participate in them.
- Update his/her knowledge and abilities, utilizing the necessary sources.
- Systematize the sources necessary for periodic review of the data acquired from patients.
- Inform the public of the type and magnitude of the potential ***risks*** associated with nuclear medicine activities.
- Assess cost-effectiveness and cost-benefit ratios in choosing among possible test options, selecting the safest, most sensitive, and most specific test available at the least economic cost.
- Monitor the application of radiation protection measures and measures taken to prevent the ***contamination*** of people, installations, and the environment
- Monitor the administration of ***radioactivity*** doses for diagnostic purposes to ensure that the best possible information is obtained with the lowest possible total ***dose*** and the lowest potential ***risk***.
- Organize a secondary/tertiary-level radiology installation.

Quantitative objectives

1. *Morphofunctional studies*
   By the end of the training period, the nuclear medicine specialist will have interpreted a minimum of 2,000 morphofunctional studies
2. *In vitro studies*
   The specialist will have carried out 150 radioimmunoassays, utilizing at least 10 different techniques.
3. *Therapeutic applications*
   The specialist will have administered and monitored a minimum of 25 radiation therapy treatments during the four years of training.

Training program for supervisors of installations utilizing radioactive materials

Total duration: four weeks (160 hours)

A) *Theory component (46 hours)*

1. ***Radioactivity*** (6 hours):

- Fundamental concepts
- ***Radioactivity***
- Basic principles of the interaction of ***particles*** and ***radiation*** with matter
- Properties and interaction of ***particles*** with matter
- Properties and interaction of ***gamma rays*** with matter

2. Detection and measurement of ***radioactivity*** (5 hours):
   - Gas-***ionization*** detectors
   - Scintillation counters and semiconductor detectors
   - Errors in the measurement of ***radioactivity***
3. Radiation protection (10 hours):
   - Dosimetry
   - ***Dose*** calculation
   - Radiation protection
   - Maximum permissible ***doses***
   - Radiation protection techniques
   - Safety criteria for installations that utilize radiation ***sources***
   - ***Shielding*** calculations
   - Effects of radiation on the human body
4. Safe production and handling of ***radionuclides*** (8 hours):
   - ***Radionuclide*** production
   - ***Radioisotope*** handling without ***risks***
   - Design and construction of installations that utilize radioactive materials
   - Preparation of radioactive samples
5. Legislation and regulation (8 hours):
   - Spanish legislation
   - ***Licensing*** of installations that utilize radioactive materials
   - Inspection of installations that utilize radioactive materials
   - Analysis of safety regulations
6. Calculation problems (9 hours).

B) *Practical training component (100 hours)*

1. ***Radioactivity***. Detection and measurement (40 hours):
   - ***Contamination*** and radiation dosimeters
   - Counter resolution time
   - Sources of error in the measurement of ***activity***
   - NaI (Tl) scintillation counters
   - Particle and radiation absorption
   - Calibration of liquid-type scintillation counters
   - ***Beta particle*** back-scattering.

2 Radiation protection and safe handling of ***radionuclides*** (40 hours):
   - Operation and calibration of equipment
   - Attenuation of radiation as it passes through matter
   - Delimitation of work areas
   - Warning sign placement and control of operations with encapsulated ***sources***
   - Control of operations with non-encapsulated ***sources***

- Handling of ***beta*** emitters.
- Handling of ***gamma*** emitters
- Preparation of samples from precipitates
- Preparation of encapsulated ***gamma sources***

3. Legislation (20 hours):
   - Preparation of documentation for the establishment of installations utilizing ***radioactive*** materials
   - Practical applications

C) *Seminars and colloquia (14 hours)*

Appendix III-D

Curriculum for the Course of Study Leading to the Degree of

*Professional Diagnostic Imaging Technologist**

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* Taken from: Ministerio de Educación y Ciencia. Currículo del Ciclo Formativo de Grado Superior correspondiente a Técnico Superior en Imagen para el Diagnóstico. Real Decreto Español. Abril 1995. *Boletín Oficial del Estado* 1995;133(12). (Free translation).

Curriculum for the Course of Study
Leading to the Degree of Professional Diagnostic Imaging Technologist
Spanish Royal Decree, April 1995

ROYAL DECREE 557/1995, issued 7 April, establishing the curriculum for the training of professional diagnostic imaging technologists.

Royal Decree 545/1995, issued 7 April, established the degree of Diagnostic Imaging Technologist and its corresponding minimum instructional requirements, in consonance with Royal Decree 676/1993, issued 7 May, which in turn set the general guidelines for professional training and the minimum instructional requirements to obtain the degree.

In accordance with Article 4 of Organic Law 1/1990, enacted 3 October, on the general organization of the educational system, it is the responsibility of educational administrations or, where appropriate, the Government to establish the curriculum for training programs in their respective spheres of action. The principles relative to the academic system, its organization, and the instruction imparted in accordance with the curriculum of the training program established in the present Royal Decree are the same as those set forth in the preamble of Royal Decree 548/1995, issued 7 April.

By virtue of the foregoing, in accordance with a proposal of the Minister of Education and Science, and having examined the report of the National Academic Council and consulted with the Cabinet at its meeting on 7 April 1995,

I HEREBY DECREE:

Article 1:

1. The present Royal Decree determines the curriculum for the course of study leading to the degree of diagnostic imaging technologist. Reference to the productive system is established in Royal Decree 545/1995, issued 7 April, which approved the minimum instructional requirements for the profession. The objectives expressed in terms of capacities and the criteria for evaluation of the curriculum for the training program are established in the aforementioned Royal Decree.
2. The contents of the curriculum are established in Annex I of the present Royal Decree.
3 Annex II of the present Royal Decree establishes the physical requirements that must be met by educational centers that impart the training described herein.

Article 2:

The present Royal Decree is applicable in the territorial area under the authority of the Ministry of Education and Science.

Article 3:

The training modules of this program will be organized in two academic courses:

a) The professional training modules for the first course are:
   1. Organization and management of the assigned work area in the diagnostic imaging unit/office.
   2. Basic principles and techniques for carrying out studies with conventional radiology.
   3. Basic principles and techniques for carrying out studies with image digitization equipment.
   4. Radiological anatomy.
   5. Processing and treatment of the radiological image.

b) The training modules for the second course are:
   1. Basic principles and techniques for carrying out studies in nuclear medicine.
   2. Radiation protection.
   3. Occupational orientation and guidance.
   4. Practical training.

Sole additional provision

In accordance with the organizational and methodological requirements for adult education, both in the modality of classroom education and that of distance education, the Ministry of Education and Science may adapt the curriculum described in the present Royal Decree in accordance with the characteristics, conditions, and needs of the adult population.

First final provision

Application of the present Royal Decree will be optional in the Autonomous Communities that are fully exercising their educational authorities, in accordance with the provisions of Article 149.3 of the Constitution.

Second final provision

The weekly schedule for the various modules included in this training program will be established by the Ministry of Education and Science.

Third final provision

The Education and Science Minister will establish the pertinent standards for grading and the promotion students.

Fourth final provision

The Minister of Education and Science is authorized to issue whatever directives are necessary to ensure the application of the provisions contained in this Royal Decree.

Fifth final provision

The present Royal Decree will enter in effect on the day following the date of its publication in the Official Bulletin of the State.

Issued in Madrid on 7 April 1995. **JUAN CARLOS R.**

GUSTAVO SUAREZ PERTIERRA
Minister of Education and Science

Annex 1

Training Module 1:

Organization and Management of the Assigned Work Area in the Diagnostic Imaging Unit/Office

Content (duration 95 hours)

a) Health system organization:
- Structure of the public health system in Spain
- ***Levels of care*** and types of benefits
- Public health and community health
- Typical organic and functional structures of health institutions: public and private
- Health indicators
- Legislation applicable to the sector
- Safety and health standards applicable to health centers

b) Health documentation:
1. Clinical documentation: types of documents: hospital, extrahospital, and inter-center, uses and applications, criteria for compliance, methods of information circulation
2. Non-clinical documentation: types of documents: hospital, extrahospital and inter-center, uses and applications, criteria for compliance, methods of information circulation

c) Supply and inventory management:
- Storage systems: advantages and drawbacks
- Classification of health supplies: Criteria
- Inventory evaluation methods
- Record-keeping
- Inventories: classification and preparation
- Safety and health standards applicable to health center storerooms

d) Management of information/documentation:
- Documentation relative to purchasing and sales operations, purchase orders, receipts, invoices, payment/credit documents, legal requirements

e) Computer applications:
- Utilization of computer applications for the operation of diagnostic radiology equipment
- Computer applications for supply management and control

f) The process of care or service delivery:
- Objectives, phases, operations, and resources
- Applicable regulations

g) Quality of the delivery of services or products:
- Introduction to ***quality control*** techniques
- Internal and external ***quality control***

h) Fundamental concepts of health economics

Training Module 2:

Basic Principles and Techniques for Carrying Out Studies in Conventional Radiology

Content (duration 435 hours)

a) Principles of conventional radiology:
   - Properties of ***x-rays***
   - Physical characteristics of matter

b) Conventional radiology units:
   - Organization, functions, activities, and tasks
   - Installations and availability of equipment

c) Equipment for conventional radiology:
   1 Production of ***x-rays***: the ***x-ray*** tube. Procedures for heating and cooling the tube, characteristics of radiation produced by the tube, the ***x-ray generator***, penetration of ***x-rays***: scattering and contrast of ***x-rays***, collimation, grid assemblies, image intensifiers, artifacts
   2. Special techniques—tomography, xeroradiography, fluoroscopy with contrast media

d) Contrast media used in radiology:
   - Positive contrast media: composition and applications
   - Negative contrast media: composition and applications
   - Liposoluble contrast media: composition and applications
   - Double-contrast techniques
   - Complications and adverse reactions produced by contrast media

e) Radiological techniques:
   - Radiological studies of the scapula, acromioclavicular articulation, and shoulder: simple radiographic technique
   - Radiological studies of the upper limb: simple radiographic technique
   - Radiological studies of the pelvis and hip joint: simple radiographic technique
   - Radiological studies of the lower limb: simple radiographic technique
   - Radiological studies of the osseous portion of the chest: simple radiographic technique
   - Radiological studies of the skull, face, and neck: simple radiographic technique; special radiographic techniques
   - Radiological studies of the chest: simple radiographic technique; special radiographic techniques; fluoroscopy
   - Radiological studies of the abdomen: simple radiographic technique; special radiographic techniques
   - Radiological studies of the digestive system. simple radiographic technique; special radiographic techniques
   - Radiological studies of the urinary tract: simple radiographic technique; special radiographic techniques
   - Radiological studies of the bile duct: special radiographic techniques
   - Hysterosalpingography
   - Mammography

f) Interventional radiological techniques:
- Radiological studies of the chest
- Radiological studies of the heart
- Radiological studies of the abdomen
- Radiological studies of the pancreas and spleen
- Radiological studies of the liver
- Radiological studies of the urinary tract
- Radiological studies of hollow viscera
- Radiological studies of the reproductive system
- Radiological studies of the face and neck
- Radiological studies of the skull
- Angiography
- Phlebography

Training Module 3:

Basic Principles and Techniques for Carrying Out Studies with Digital Imaging Equipment

Content (duration 225 hours)

a) Principles of computed axial tomography (CT):
- Properties of ***x rays***
- Physical characteristics of matter
- Technical aspects of CT

b) Principles of magnetic resonance (MR):
- Properties of magnetic fields
- Characteristics of the magnetic moments of ***protons***
- Technical aspects of MR

c) Radiology units with computerized image processing equipment:
- Organization, functions, activities, and tasks
- Installations and availability of equipment

d) Equipment for computed axial tomography:
1. Production of ***x-rays***, the ***x-ray*** tube, automatic procedures for heating and cooling the tube, characteristics of the radiation produced by the tube, detector ring
2. Production of high-intensity magnetic fields: the external-magnetic-field-producing magnet
3. Data collection system
4. Equipment data intake
5. Mathematical data processing
6. Reconstruction of the object
7. Special techniques: use of contrast media

e) Contrast media utilized in CT and MR:
- Positive contrast media: composition and applications
- Negative contrast media: composition and applications
- Liposoluble contrast media: composition and applications
- Double-contrast techniques
- Complications and adverse reactions produced by contrast media

f) Radiological techniques with CT:
   - Studies with and without contrast media
   - High-definition studies
   - Sequential dynamic and single-plane studies
   - Volumetric acquisition
   - Angio-CT
   - Multiplane and 3D reconstruction
   - Bone densitometry

g) Radiological techniques with MR:
   - Studies with and without contrast media
   - Contraindications
   - Spin-echo techniques
   - Echo-gradient techniques
   - Ultra-rapid techniques
   - Angio MR
   - Spectroscopy

h) Radiological studies with CT and MR:
   - Radiological studies of the chest
   - Radiological studies of the heart
   - Radiological studies of the abdomen
   - Radiological studies of the pancreas and spleen
   - Radiological studies of the liver
   - Radiological studies of the urinary tract
   - Radiological studies of hollow viscera
   - Radiological studies of the male reproductive system
   - Radiological studies of the female reproductive system
   - Radiological studies of the neck
   - Radiological studies of the face
   - Radiological studies of the skull
   - Radiological studies of the temporal bone region

Training Module 4:

Basic Principles and Techniques for Carrying Out Studies in Nuclear Medicine

Content (duration 165 hours)

a) Principles of nuclear medicine
   1. ***Radionuclides***: concept, ***radionuclide*** production, ***generators***
   2. Radiotracers. concept, techniques, duration, ***quality control***, presentation, dosage, and administration
   3. Mechanisms of distribution and localization of radiopharmaceuticals
   4. Imaging techniques
   5. Information processing techniques

b) Nuclear medicine units
   - Organization, functions, activities, and tasks
   - Installations and availability of equipment

c) ***Gamma radiation*** imaging equipment
   1. Radiopharmaceuticals: Basis for detection, clinical applications
   2. Types of studies. Assessment methods
   3. Imaging equipment
   4. Imaging protocols

Training Module 5:

Radiation Protection

Content (duration 95 hours)

a) Radiation physics:
   - Atomic structure of matter
   - Concept and types of ***ionizing radiation***
   - Interaction of ***ionizing radiation*** with matter
   - ***Sources*** and ***generators*** of ***ionizing radiation*** for medical use
   - Radiological quantities and units

b) Physical characteristics of ***x-ray*** equipment and beams
   - Elements and devices associated with an ***x-ray*** tube
   - Characteristics of radiation produced by ***x-ray*** tubes
   - Encapsulated and non-encapsulated ***sources***
   - Generating equipment utilized in radiation therapy (***accelerators*** and therapeutic ***x-ray***)
   - Characteristics of different imaging systems

c) Detection and measurement of radiation:
   1. Basic principles of radiation detection
   2. Detectors used in radiological installations: radiation dosimetry: monitoring and control of external radiation, monitoring and control of ***contamination***, control of personnel dosimetry
   3. ***Quality control*** of radiological installations

d) Radiation biology:
   - Action of radiation on biological material
   - Radiosensitivity: total cellular, systemic, and organic response
   - Late effects of radiation: somatic and genetic

e) Radiation protection:
   - Concept and objectives
   - Operational radiation protection in different units
   - Classification of areas: warning sign placement and general standards
   - Protective barriers, devices, and clothing
   - Personal protection
   - Inverse square law

f) Management of radioactive material:
   - Techniques for ordering, receiving, storing, handling, and monitoring radioactive materials and waste
   - ***Source*** encapsulation and control
   - Effluents and ***waste***

g) Emergencies:
   - ***Emergency plan***

- Response protocols

h) National and international regulation:
   - National regulation
   - International harmonization and standardization regulation
   - Registries: types and maintenance

i) ***Quality control*** of the process:
   - Factors that affect the quality of the process
   - ***Quality control*** instruments
   - ***Quality assurance*** and maintenance
   - ***Quality control*** documentation

Training Module 6:

Radiological Anatomy

Content (duration 105 hours)

a) Radiological anatomy of the upper limb
   - Anatomy of the shoulder girdle
   - Anatomy of the arm
   - Anatomy of the elbow
   - Anatomy of the forearm
   - Anatomy of the wrist
   - Anatomy of the hand

b) Radiological anatomy of the lower limb
   - Bone anatomy of the pelvic girdle
   - Anatomy of the femur
   - Anatomy of the knee
   - Anatomy of the leg
   - Anatomy of the ankle
   - Anatomy of the foot

c) Radiological anatomy of the thoracic cage:
   - Ribs
   - Sternum
   - Clavicle

d) Radiological anatomy of the spinal column:
   - Cervical
   - Dorsal
   - Lumbar
   - Sacroiliac

e) Radiological anatomy of the craniospinal region:
   - Skull
   - Base of the skull
   - Hypophysis
   - Orbitae
   - Face

f) Radiological anatomy of the thoracic viscera:
   - Lungs and pleura
   - Heart and pericardium

- Mediastinum, large vessels

g) Radiological anatomy of the abdominal viscera.
   - Liver
   - Spleen
   - Stomach
   - Duodenum and pancreatic area
   - Small and large intestine
   - Mesentery and peritoneum
   - Kidneys and suprarenal glands
   - Retroperitoneum

h) Pelvic cavity:
   - Female
   - Male

i) Brain and brain stem:
   - Cerebral hemispheres
   - Midbrain and brain stem
   - Cerebellum
   - Cerebral ventricles
   - Subarachnoid space—cisterns
   - Spinal cord

j) Radiological anatomy of the breast

Training Module 7:

Processing and Treatment of the Radiological Image

Content (duration 105 hours)

a) Radiological image:
   - Concepts of analog image and digital image
   - Image receptors
   - Image processing

b) Fluoroscopic image:
   - Characteristics of the image
   - Intensifier
   - Image receptors
   - Cinefluorography
   - Digital fluorography

c) Computed tomography:
   - Image reconstruction process
   - Image quality
   - Artifacts
   - Image manipulation

d) Magnetic resonance:
   - Instrumentation
   - Imaging
   - Image contrast
   - Coding of the signal

e) Radiographic film:
   - Types and classes
   - Applications and indications
   - Development procedures
   - Filing procedures
   - Automatic developing and processing procedures

f) Computer image processing applied to radiology:
   - Coding system
   - Operating systems
   - Programs for processing radiological images
   - Digital image: digital-analogue and analogue-digital converters, processing

Training Module 8:

Occupational Orientation and Guidance

Content (duration 65 hours)

a) Occupational health
   - Safety and working conditions. Occupational health and quality of life. The environment and environmental protection
   - ***Risk*** factors: physical, chemical, biological, organizational. Prevention and protection measures
   - Applied techniques for safe organization of the workplace
   - General preventive/protective techniques. Analysis, assessment. and proposal of measures
   - Case studies
   - Priorities and sequences of action in case of ***accidents***
   - First aid techniques: consciousness/unconsciousness, cardiopulmonary resuscitation, injuries, rescue and transport of injured persons

b) Labor legislation and labor relations:
   - Labor law: Basic standards
   - Labor relations: Contracting modalities, wages and benefits, layoff and termination
   - Social security and other benefits
   - Labor organizations
   - Collective bargaining and agreement

c) Socio-occupational orientation and guidance
   - The labor market, structure, job prospects
   - The job search process: sources of information, supply-demand mechanisms, procedures and techniques
   - Self-employment initiatives. Procedures and resources for establishing small businesses
   - Resources for occupational self-assessment: Analysis—evaluating one's own potential and interests. Overcoming discriminatory social practices. Pursuing professional training and continuing education opportunities. Decision-making

d) Principles of economics:
   - Macroeconomic variables, socioeconomic indicators, their interrelationships
   - Market economy: Supply and demand, competitive markets
   - International socioeconomic relations: European Union (EU)

e) Business economics and organization:
   - Economic activity of the business· Criteria for classification
   - Businesses: Types of organizational models, functional areas, organizational structure

Practical Training Module

Content (duration 710 hours)

a) Introduction to the workplace:
   - Organization of the workplace: organizational structure
   - Chain of command. Reporting of all incidents Needs and contingencies in the course of activities
   - Technical information on the process. Procedures manual. Quality standards
   - Correct behavior within the organizational structure of the company and the working team

b) Preparation and adjustment of diagnostic radiology equipment:
   - Organization of work, interpretation of documentation on techniques and equipment
   - Selection of procedures to be carried out
   - Verification of compliance with safety standards for the start-up and operation of diagnostic radiology equipment
   - Start-up, programming, automatic monitoring and control of diagnostic radiology equipment
   - Detection of anomalies in equipment, reporting of incidents and/or breakdowns detected
   - Maintenance of the corresponding logbooks

c) Documentation used in the diagnostic radiology unit/office:
   - Recording of receipt and dispatch of documentation and requests for studies
   - Interpretation of requests for studies
   - Application of priority, safety, confidentiality, punctuality, and efficiency criteria
   - Preparation of job lists by conventional and/or computerized means
   - Identification of applicable legal regulations
   - Utilization of appropriate technical terminology to describe the procedures and processes to be carried out
   - Maintenance of supply records applying established criteria of inventory valuation

d) Patient care and information:
   - Adherence to accepted standards of professional behavior, communication and transmission of information to patient/clients
   - Identification, in requests for studies, of patient/client preparation protocols
   - Provision of contextualized information for each patient/client
e) Application of safety and health standards:
   - Identification of the ***risks*** associated with different procedures
   - Monitoring of protective measures, preventive behavior
   - ***Risk*** assessment, corrective action
   - Verification of compliance with safety and health standards
   - Verification of correct ***waste*** management
   - Environmental protection
f) Diagnostic radiology study techniques:
   - Dosimetric planning and ***dose*** calculation for various radiological studies
   - Verification of the functioning of alarm and interlocking systems and emergency shut-off switches
   - Personnel and area dosimetry controls, monitoring, control of radiation levels
   - Patient positioning, anatomical localization
   - Audiovisual monitoring of the patient during studies
   - Application of simple radiological study techniques on different parts and organs of the human body
   - Use of study techniques with portable equipment
   - Programming of processing equipment for digital image manipulation
   - Application of radiographic film processing techniques, identification of appropriate equipment and processes
   - Verification of compliance with quality standards for procedures carried out
   - Discussion of technical interpretation of the results obtained

Annex II

Physical requirements for centers that impart training for diagnostic imaging technologists

In accordance with the second final provision of Royal Decree 545/1995, issued 7 April, which established the degree and curriculum for the training of diagnostic imaging technologists, the physical requirements for centers imparting such training are:

Training Area	Size - Area in m^2	Use Rate -Percentage
Radiology laboratory	120	45
CT/MR laboratory	60	30
Multipurpose classroom	60	25

The "use rate" expresses as a percentage the amount of time a group of students is expected to spend in each area during the training program.

When the training areas are not being used for the training program, they may be used by other groups of students who are enrolled in the same or other training programs, or who are at other stages of their education.

In any case, the learning activities that take place in the training areas (with the amount of time devoted to each expressed by the use rate) can be carried out in areas that are also utilized for other related instructional activities.

The various training areas need not necessarily be physically separated from one another by partitions.

Appendix III-E

Draft Curriculum for the

Profession of Radiological Technologist:

*Diagnostic Radiology - Radiation Therapy - Nuclear Medicine**

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* Taken from: Asociación Española de Técnicos en Radiología. Borrador de Programa Educativo para la Profesión de Técnico en Radiología. Madrid: Asociación Española de Técnicos en Radiología. (Free translation).

Draft Curriculum for the Profession of Radiological Technologist: Diagnostic Radiology - Radiation Therapy - Nuclear Medicine

Introduction

This proposed curriculum for the education of **Medical Radiological Technologists** has the following features:

a It is only a proposal and is therefore subject to such modifications as the "University" deems appropriate.

b. The curriculum comprises subject matter common to the following three specialties:

Diagnostic Radiology, Radiation Therapy, and Nuclear Medicine

c. The expected duration of the training program is three years.

d. It provides for a mandatory practical examination.

e It permits European Community accreditation inasmuch as it complies with Article I-A of Directive 89-48-EEC of 21 December 1988, previously Common Position of June 1988.

f. It facilitates transfer between specialties for **Technical** professionals who are interested, and in order to fill social needs

g It provides a standardization module for current **Radiological Technologists**, enabling them to obtain European Community accreditation.

h The proposed course load distribution is only an example. It is understood that it is the prerogative of the "University" to establish the course load according to its own criteria or considerations.

Degree: MEDICAL RADIOLOGICAL TECHNOLOGIST*

Specialist in: *Diagnostic Radiology*
Radiation Therapy
Nuclear Medicine

* International nomenclature adopted by the ISRRT (International Society of Radiographers and Radiological Technicians)

	Areas of knowledge
1.	Radiation physics
2.	Medical and biological knowledge
3	Pharmacology
4.	Radiation biology and radiation protection
5.	Biostatistics and information science
6.	Public health, hygiene, and hospital organization
7.	Patient care
8.	Diagnostic radiology Radiation therapy Nuclear medicine
9.	Legislation and professional ethics
10.	Language

Note: This is only an example of how the course load might be distributed.

Medical Radiological Technologist
Graduate in Diagnostic Radiology

Course	hours*
Anatomy and Physiology	150
General Pathology and Semiology	120
Radiation Physics	150
Biology and Genetics	90
Radiation Biology	40
Radiation Protection	100
Biostatistics	80
Information Science	60
Hospital Administration and Organization	30
Public Health and Hygiene	50
Patient Care	50
Legislation and Occupational Ethics	40
Language	180
* Hours common to the three specialties	1,140

Diagnostic Radiology

Radiological Pathology	180
Radiological Technology	180
Applied Pharmacology	30
Diagnostic Imaging Technique	150
Positions in Radiology	90
Practicum Diagnostic Radiology	1,330
Specific hours	1,960

Total course hours: 3,100
- Practical 43%
- Theory 57%

Note: This is only an example of how the course load might be distributed.

Medical Radiological Technician
Graduate in Diagnostic Radiology

First course	**hours**
Anatomy and Physiology	150
Radiation Physics	150
Biology and Genetics	90
Biostatistics	80
Language	60
Positions in Radiology	90
Theory	620
Practicum I	
Second course	
General Pathology and Symptomatology	120
Radiation Biology and Radiation Protection	40
Information Science	60
Language	60
Diagnostic Imaging Technology I	75
Radiological Pathology I	90
Radiological Technology I	90
Radiation Protection I	50
Patient Care	50
Theory	635
Practicum II	
Third course	
Radiological Pathology II	90
Radiological Technology II	90
Applied Pharmacology	30
Diagnostic Imaging Technology II	75
Radiation Protection II	50
Public Health and Hygiene	50
Legislation and Occupational Ethics	40
Hospital Organization and Administration	30
Technical Language	60
Theory	515

Practicum III

Total for Diagnostic Radiology: 3,100 hours

- Theory 57%
- Practical 43%

Medical Radiological Technician
Graduate in Radiation Therapy

Course	hours*
Anatomy and Physiology	150
General Pathology and Symptomatology	120
Radiation Physics	150
Biology and Genetics	90
Radiation Biology	40
Radiation Protection	100
Biostatistics	80
Information Science	60
Hospital Administration and Organization	30
Public Health and Hygiene	50
Patient Care	50
Legislation and Occupational Ethics	40
Language	180
* Hours common to the three specialties	1,140

Radiation Therapy

Radiation Therapy Technology	
Clinical Radiation Therapy	
Instrumentation and Dosimetry	
Psychology of the Oncological Patient	
Course Load	630
Practicum in Radiation Therapy	1,330

Total Course Load: 3,100 hours
- Theory 57%
- Practical 43%

Medical Radiological Technician
Graduate in Nuclear Medicine

Course	hours*
Anatomy and Physiology	150
General Pathology and Symptomatology	120
Radiation Physics	150
Biology and Genetics	90
Radiation Biology	40
Radiation Protection	100
Biostatistics	80
Information Science	60
Hospital Administration and Organization	30
Public Health and Hygiene	50
Patient Care	50
Legislation and Occupational Ethics	40
Language	180
* Hours common to the three specialties	1,140

Nuclear Medicine

Nuclear Medicine Technology
Instrumentation in Nuclear Medicine
Radiation Chemistry and Radiopharmacology
Clinical Nuclear Medicine

Course Load	630
Practicum in Nuclear Medicine	1,330

Total Course Load: 3,100 hours
- Theory 57%
- Practical 43%