BJRS

BRAZILIAN JOURNAL
OF
RADIATION SCIENCES
11-01A (2023) | 01-14 | e2136

# Technical specialization in Nuclear Medicine: an analysis of courses in Brazil and a proposal for a basic curriculum

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## ABSTRACT

**Nuclear Medicine (NM) is a medical specialty that, through non-invasive methods, uses radioactive materials for diagnostic and therapeutic purposes. According to Standard NN 3.05 of the Brazilian National Nuclear Energy Commission (CNEN), a Nuclear Medicine System (NMS) must be composed of, at least, a Holder, a Nuclear Physician, a Radiation Protection Supervisor and higher and mid-level professionals, duly qualified for the performance of their duties, which may be exercised, in this case, by a radiology technician. Thus, in 2009, the National Council of Radiology Technicians (CONTER) granted a period of 5 (five) years for radiology technicians who work in the NM and Radiotherapy specialties to specialize in their areas of expertise, a period that was extended for another 5 (five) years. In this sense, this paper aims to carry out a survey of the Technical Specialization courses in NM offered in Brazil, considering that almost 10 years have passed since the CONTER Resolution No. 17, of 2014, verifying aspects such as structure and workload, based on the requirements of the Ministry of Education (MEC), in order to suggest a core curriculum for courses in NM. It was found that, with the legal requirement of this training, these courses began to be offered, but in a reduced number and only in some regions of Brazil, despite the existence of courses in the distance modality. It is understood, therefore, that an expansion of courses in the area is necessary, in view of the relevance of the service for NM.**

***Keywords:*** **specialization courses, nuclear medicine, Brazil, curriculum structure, radiology technicians and technologists.**

ISSN: 2319-0612
DOI: https://doi.org/10.15392/2319-0612.2023.2136
Submitted: 2022-10-31
Accepted: 2023-05-12

## 1. INTRODUCTION

Nuclear Medicine (NM) is a medical specialty that, using non-invasive methods, uses radioactive materials for diagnostic and therapeutic purposes. In this way, it uses radioactive substances (radiopharmaceuticals) as a tool to access the functioning of living organs and tissues, performing images, diagnoses and also treatments [1]. According to article 2 of Standard NN 3.05 of the Brazilian National Nuclear Energy Commission (CNEN), and the resolution CNEN 159/13, a Nuclear Medicine System (NMS) must consist of at least [1; 2]:

a) a Holder, legally responsible for the NMS;

b) a Nuclear Doctor, technically responsible for the NMS;

c) a Radiological Protection Supervisor (RPS), technically responsible for the Radiation Protection of the NMS; and

d) a necessary number of professionals with higher and secondary education, duly qualified for the exercise of their functions.

Also according to the Technical Regulation for the Installation and Operation of "in vivo" Nuclear Medicine Services, of the National Health Surveillance Agency (ANVISA), professionals with training and qualification to perform the following functions must be counted [3]:

a) Direct patient care;

b) Preparation and administration of radiopharmaceuticals;

c) Acquisition, processing and documentation of exams;

d) Interpretation of exams and issuance of reports;

e) Planning, carrying out and monitoring diagnostic or therapy procedures;

f) Execution of activities provided for in the Radiation Protection Plan;

g) Execution of the activities provided for in the Management Plan for medicines, pharmaceutical inputs, health products, hygiene products, sanitizing products, blood and blood components;

h) Cleaning and disinfection procedures;

i) Notification and investigation of adverse events; and

j) Waste management.

It is then observed that many of these functions can be performed by a technician in Radiology [4]. Thus, the National Council of Technicians in Radiology (CONTER), in its Resolution No. 13, of 2009, granted a period of 5 years, counting from its publication, for radiology technicians who worked in NM and Radiotherapy to specialize in their areas of expertise.

However, it was found, with CONTER, at the beginning of 2014 - the year in which the term would end -, that the vast majority of technicians had not yet completed the specialization course in Radiotherapy and NM, due to the lack of technical specialization courses.

In order to try to resolve this issue, on 2014, members of the Regional Council of Technicians in Radiology of Rio de Janeiro (CRTR-RJ) met with coordinators of technical courses in radiology to discuss the situation of what deals with the CONTER resolutions, in order to verify the opportunity to offer specialization courses in Radiotherapy and Specialization in NM and to extend the stipulated deadline.

Subsequently, the Resolution No. 13 [5], of 2009, was extended for another five years, according to CONTER Resolution No. 17 [6], of 2014, in view of the impossibility of time for training in NM.

## 2. **MATERIALS AND METHODS**

In this sense, this paper aims to make an analysis of the Technical Specialization courses in NM that can be performed by Radiology technicians in Brazil – considering that this specialization is necessary so that the technician can act as an integral part of the NMS, since it is a specialty in the NM area that uses radioactive substances, in the form of radiopharmaceuticals, for diagnosis and therapy – seeing that almost 10 years have passed since the CONTER Resolution No. 17, of 2014.

This analysis, based on the evaluation of the Quality (or compliance) of the courses, from the requirements of the Ministry of Education (MEC), verified aspects such as course structure, workload and curriculum, also aims suggest a core curriculum for courses in NM.

For this paper, a qualitative-quantitative research [7] was carried out as follows:

a) a qualitative research, to verify the norms of the courses on the digital platforms of MEC, in order to analyze the legal requirements and the structure of the courses in relation to the training and activities of radiology technicians in NM;

b) a quantitative research, to verify the number of existing training courses in Brazil on MEC's digital platforms. For this, a survey was carried out until the year 2023, along with the e-MEC Register, which is the official database of courses and Higher Education Institutions - IES [8]; and

c) Qualitative research to evaluate the structure of this courses, especially in relation to the curricular structure, in order to suggest a core curriculum for courses in NM.

### 2.1. Requirements for a Technical Specialization Course according to the MEC

According to MEC Ordinance No. 870 of 07/16/2008 [9], which approves the National Catalog of High School Technical Courses (CNCT), prepared by the Secretariat of Professional and Technological Education of the Ministry of Education, extract Environment, Health and Safety, the duration of the Technical Course in Radiology must be 1200 hours.

Also according to the MEC, secondary technical vocational education includes from the secondary technical professional qualifications (EPTNM), as intermediate outputs, to the corresponding professional qualification of the medium level technician [9].

It also includes high-level technical specialization, which professionally complements the training itinerary planned and offered by the institution [9].

Thus, high school technical professional education courses and programs are organized by technological axes, enabling flexible, diversified and up-to-date training itineraries, according to the interests of the subjects and possibilities of the educational institutions, observing the norms of the respective system and level of education for the EPTNM modality [10].

One of these courses is the Medium Level Technical Specialization, which are courses aimed at those who complete technical courses, with a minimum workload of 25% of the respective professional qualification that makes up the corresponding training itinerary of the Medium Level Technical Professional Qualification [10].

They then aim to provide the mastery of new skills to those who are already qualified and who wish to specialize in a particular professional segment [10].

In this sense, the minimum hours for a technical specialization course in Radiology must be 300 hours, since the Technician course in Radiology, according to the CNCT, has 1200 hours.

### 2.2. NM Clinics in Brazil

In order to show the need for training in the areas, according to the CNEN [11], there are about 473 authorized NMS in Brazil, with most of the concentration in the south and southeast regions, as can be seen in Table 1.

According to Table 1, it can be seen that in all states of Brazil there is at least one NM installations. Thus, there is a need for training centers across the country.

However, the distribution is not uniform. It is observed that the Midwest region has 10.15% of the total; the Northeast 15.43%; the North 4.86%; the Southeast 53.70%; and the South 15.86%.

### 2.3. Technical Courses in NM

An analysis was then carried out to verify the existence of technical specialization courses in NM, for radiology technicians, in order to comply with the resolution of CONTER Resolution Nº 13 [5] – which deals with the mandatory technical specialization for technicians working with NM, and which had its term extended for another 5 years by CONTER Resolution nº 17 [6] – in view of the low demand for technicians, according to CONTER.

Thus, a search was carried out on the e-MEC Registry [8], in April 2023, to verify the offer of these courses in Brazilian territory. The e-MEC Register, regulated by Normative Ordinance No. 21, of 2017 of MEC, is the official database of Higher Education courses and Institutions - HEIs, regardless of the Education System.

The e-MEC Registration data must comply with the authorizing acts of the courses and HEIs, edited by the public power or competent body of the institutions within the limits of the exercise of their autonomy.

The regularity of the courses and institutions depends on the validity of the respective authorizing acts and the timeliness of the protocol of the regulatory processes for maintaining the authorization for the institution to operate and offer the courses. The information inserted by the HEIs of the state systems, regulated and supervised by the respective State Council of Education, or

by the HEIs of the Federal System, within the scope of university autonomy, are declaratory and the veracity is the responsibility of the respective institution, under the terms of the legislation.

**Table 1:** NM Installations in Brazil.

| Region | NM Installations |
|---|---|
| **Midwest Region** | |
| Distrito Federal | 23 |
| Goiás | 14 |
| Mato Grosso | 5 |
| Mato Grosso do Sul | 6 |
| **Total** | **48** |
| **Northeast Region** | |
| Alagoas | 6 |
| Bahia | 22 |
| Ceará | 9 |
| Maranhão | 5 |
| Paraíba | 5 |
| Pernambuco | 13 |
| Piauí | 5 |
| Rio grande do Norte | 4 |
| Sergipe | 4 |
| **Total** | **73** |
| **North Region** | |
| Amapá | 2 |
| Amazonas | 6 |
| Acre | 1 |
| Pará | 8 |
| Rondônia | 3 |
| Roraima | 1 |
| Tocantins | 2 |
| **Total** | **23** |
| **Southeast Region** | |
| Espírito Santo | 12 |
| Minas Gerais | 55 |
| Rio de Janeiro | 55 |
| São Paulo | 132 |
| **Total** | **254** |
| **South region** | |
| Paraná | 24 |
| Rio Grande do Sul | 32 |
| Santa Catarina | 19 |
| **Total** | **75** |

Source: [11]

Data from specialization courses are declaratory in nature, and the institutions are responsible for the veracity of the information entered in the Register, under the terms of the legislation. In total, in the search in the field referring to e-MEC Specialization courses, the keyword "Nuclear Medicine" was used, and and thirty-three (33) courses were found, as shown in Table 2.

**Table 2**: Courses in Nuclear Medicine.

| Institution | Category | Name of the Course | Type | Hours | Federative Unit | Start Year | Situation |
|---|---|---|---|---|---|---|---|
| UNIBF | Private for profit | Studies in Radiotherapy and Nuclear Medicine | Distance Education | 1080 | Paraná (PR) | 2019 | Active |
| Unyleya Faculty | Private for profit | Studies in Radiotherapy and Nuclear Medicine | Distance Education | 360 | Rio de Janeiro (RJ) | 2021 | Active |
| Unyleya Faculty | Private for profit | Physics of Radiodiagnosis and Nuclear Medicine – Radiation Protection and Quality Control | Distance Education | 360 | Rio de Janeiro (RJ) | 2020 | Active |
| Faculty of Philosophy, Sciences and Letters Souza Marques - (FFCLSM) | Private non-profit | Physics of Radiodiagnosis - Emphasis on CT and Nuclear Medicine | Face-to-Face Education | 438 | Rio de Janeiro (RJ) | 2011 | Active |
| Rio Sono (RISO) | Private non-profit | Medical Physics and Nuclear Medicine | Face-to-Face Education | 3250 | Distrito Federal (DF), Minas Gerais (MG), São Paulo (SP) | 2022 | Active |
| Ingá University Center (UNINGÁ) | Private for profit | Imaging with Emphasis in Nuclear Medicine | Face-to-Face Education | 360 | Paraná (PR) | 2017 | Active |
| University Center of Patos (UNIFIP) | Private for profit | Imaging with Emphasis in Nuclear Medicine | Face-to-Face Education | 400 | Pará (PA) | 2013 | Active |
| Redentor University Center (Facredentor) | Private for profit | Imaging with an emphasis on Tomography and Nuclear Medicine | Face-to-Face Education | 360 | Rio de Janeiro (RJ), São Paulo (SP) | 2011 | Disabled |
| Redentor University Center (Facredentor) | Private for profit | Nuclear Medicine | Face-to-Face Education | 360 | Pernambuco (PE), Rio de Janeiro (RJ) | 2014 | Disabled |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| FG Global Faculty (FG) | Private for profit | Nuclear Medicine | Distance Education | 432 | Rio Grande do Sul (RS) | 2020 | Active |
| Curitiba University Technology Center (UNIFATEC) | Private for profit | Nuclear Medicine | Distance Education | 450 | São Paulo (SP) | 2020 | Active |
| Curitiba University Technology Center (UNIFATEC) | Private for profit | Nuclear Medicine | Face-to-Face Education | 450 | São Paulo (SP) | 2020 | Active |
| Tuiuti University of Paraná (UTP) | Private for profit | Nuclear Medicine | Face-to-Face Education | 370 | Paraná (PR) | 2016 | Active |
| Avantis University Center (UNIAVAN) | Private for profit | Nuclear Medicine | Face-to-Face Education | 440 | Paraná (PR), Santa Catarina (SC) | 2016 | Disabled |
| Educamais Faculty (EDUCA+) | Private for profit | Nuclear Medicine | Distance Education | 450 | São Paulo (SP) | 2020 | Active |
| UNIBF Faculty | Private for profit | Nuclear Medicine | Distance Education | 450 | Paraná (PR) | 2021 | Active |
| Faculty of Governance, Engineering and Education of São Paulo (FGE-SP) | Private for profit | Nuclear Medicine | Distance Education | 450 | São Paulo (SP) | 2022 | Active |
| Centro Universitário Senac (SENACSP) | Private non-profit | Nuclear Medicine and PET/CT | Face-to-Face Education | 366 | São Paulo (SP) | 2012 | Disabled |
| Faculdade Novoeste (NOVOESTE) | Private for profit | Nuclear Medicine and PET/CT | Distance Education | 368 | Mato Grosso do Sul (MS) | 2022 | Active |
| Faculdade do Centro Oeste Paulista (FACOP) | Private for profit | Nuclear Medicine and PET/CT | Face-to-Face Education | 368 | São Paulo (SP) | 2021 | Active |
| Camões Integrated Faculty (FICA) | Private for profit | Nuclear medicine and Radiotherapy | Face-to-Face Education | 420 | Paraná (PR) | 2020 | Active |
| Vanguarda Faculty | Private for profit | Nuclear Medicine | Face-to-Face Education | 540 | São Paulo (SP) | 2021 | Active |
| Pontifical Catholic University of Rio Grande do Sul (PUCRS) | Private non-profit | Medical Physics of Nuclear Medicine | Face-to-Face Education | 5775 | Rio Grande do Sul (RS) | 2016 | Disabled |
| SOCIESC faculty of Jaraguá do Sul (SOCIESC) | Private for profit | Radiopharmaceuticals – Diagnosis and Therapy in Nuclear Medicine | Face-to-Face Education | 360 | Goiás (GO) | 2014 | Active |
| University of | Private for | Radiotherapy and | Face-to- | 490 | São Paulo | 2020 | Disabled |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Franca (UNIFRAN) | profit | Nuclear Medicine | Face Education | | (SP) | | |
| Faculty of Centro-Oeste Paulista (FACOP) | Private for profit | Radioterapia e Medicina Nuclear | Face-to-Face Education | 384 | São Paulo (SP) | 2020 | Active |
| Novoeste Faculty (NOVOESTE) | Private for profit lucrativos | Radiotherapy and Nuclear Medicine | Distance Education | 382 | Mato Grosso do Sul (MS) | 2022 | Active |
| Faculty of Centro-Oeste Paulista (FACOP) | Private for profit | Radiotherapy and Nuclear Medicine | Face-to-Face Education | 384 | São Paulo (SP) | 2019 | Active |
| National Institute of Education and Research (INESP) | Private for profit | Computed Tomography and Nuclear Medicine | Face-to-Face Education | 460 | São Paulo (SP) | 2013 | Active |
| TECH Law School of São Paulo (FADITECH) | Private for profit | Computed Tomography, Magnetic Resonance and Nuclear Medicine | Face-to-Face Education | 460 | São Paulo (SP) | 2019 | Disabled |
| Redentor University Center (Facredentor) | Private for profit | Tomography and Nuclear Medicine | Face-to-Face Education | 360 | Rio de Janeiro (RJ) | 2010 | Disabled |
| National Institute of Education and Research (INESP) | Private for profit | Tomography, Magnetic Resonance and Nuclear Medicine | Face-to-Face Education | 460 | São Paulo (SP) | 2020 | Active |
| National Institute of Education and Research (INESP) | Private for profit | Tomography, Magnetic Resonance and Nuclear Medicine II | Face-to-Face Education | 460 | São Paulo (SP) | 2020 | Active |

Source: [8]

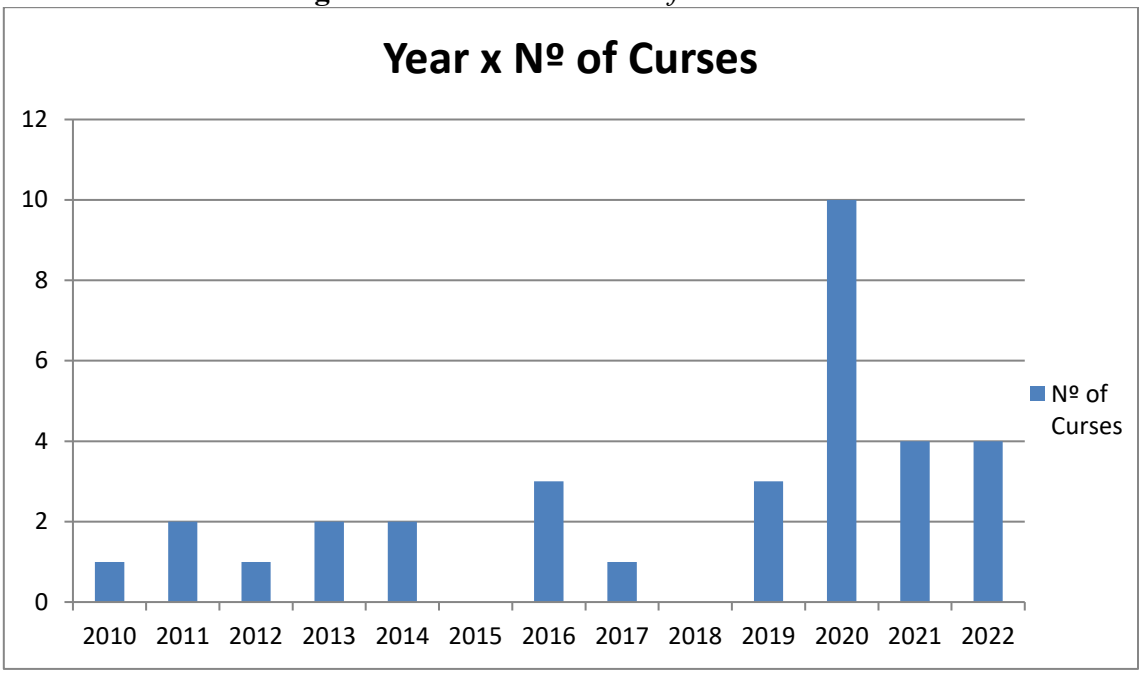
According to Table 2, all regions of the country (however, not in all states) are covered by at least 1 Face-to-Face Course. In this case, the Midwest Region with 2 (Distriro Federal - 1; Goiás - 1); Northeast with 1 (Pernambuco - 1); North with 1 (Pará - 1); Southeast with 18 (Minas Gerais – 1; Rio de Janeiro – 4; São Paulo - 13); and South with 6 (Paraná – 4; Rio Grande do Sul – 1; Santa Catarina – 1).

In addition, 10 courses offered at a distance were found, which can be carried out in any region of the country.

However, of the total of 33 courses, 8 are disabled. Being disabled could mean that they haven't been offered yet or they already were and are now discontinued.

Finally, it appears that the first course was only offered in 2010, that is, practically at the end of the first period stipulated by CONTER [7], while the vast majority only from 2019 onwards. The temporal distribution of course offerings can be seen in Figure 1.

**Figure 1:** *Time Distribution of NM Courses.*




Source: [8]

### 3.4. Proposal of a Basic Curriculum for Technical Specialization in NM

According to the national catalog of MEC courses [9; 10], a technical course in radiology must have 1200 hours. A technical specialization course in nuclear medicine needs at least 360 hours (according to the MEC, the workload for a Specialization varies between 360h and 470h) and has professionals who have knowledge in the areas that make up a nuclear medicine service. Ideally, its faculty should be composed of at least: nuclear physician, nuclear medical physicist, radiopharmaceutical and nuclear technician or technologist.

Based on the curriculum matrix of courses analyzed on the e-MEC Register (however, not all courses provide the curriculum) [8], a NM curse with a core curriculum is proposed (where some subjects may be offered by e-learning and with a total of 360 hours) with the following disciplines, as shown in the Table 3.

**Table 3:** Proposal of a NM curse with a core curriculum.

| DISCIPLINE | HOUR |
|---|---|
| Instrumentation | 20h |
| Image Reconstruction | 25h |
| Biosafety (e-learning) | 20h |
| Radiological Anatomy (e-learning) | 25h |
| Applied Physics in Nuclear Medicine | 25h |
| Pathology Applied to Nuclear Medicine (e-learning) | 25h |
| Radiation Protection Standards / CNEN and ANVISA Legislation | 20h |
| Radiopharmacy (e-learning) | 25h |
| Protocols for Examinations and Therapies (e-learning) | 25h |
| Therapeutics in Nuclear Medicine | 25h |
| Radiobiology | 20h |
| Professional Ethics/ (e-learning) | 10h |
| Final Work | 15h |
| Supervised Internship | 80h |
| **TOTAL** | **360** |

The basic content of each discipline will now be presented:

1) Instrumentation – this module shows all the instrumental components of the NM service, such as: Anger Scintillation Chambers (known as gamma-camera); Radiation detectors, such as dose calibrator-type Ionization cameras, Geiger-Müller counters, Gamma-probe, etc.; Collimators such as Parallel Hole Collimator for low energy like 99m Tc => 140 KeV, medium energy like 67Ga => multiple energies: 93, 185, 300 and 395 KeV and high energy like Iodine 131 => 364, with photons above of 600 KeV; Single hole (pinhole) collimators that increase the field of view of the region under study, etc. ; CT scanners, such as Single Photon Emission Tomography (SPECT); Positron Emission Tomography (PET).

2) Image Reconstruction – each scintigraphy exam generates images that need to be reconstructed according to the service protocols, such as: layout, colors, disposition sequences, etc. Being of fundamental importance, because these are the images that the nuclear doctors will work in the elaboration of the reports.

3) Biosafety - this module talks about the actions aimed at the prevention and protection of the worker and/or patient, minimizing the risks inherent to the activities in a NM service, emphasizing

its peculiarity in relation to other radiodiagnostic services due to the fact that it is use unsealed sources of ionizing radiation.

4) Radiological Anatomy - shows the study of organs and tissues by this diagnostic method, aiming at the easy identification of normal and abnormal structures and recognizing the alterations caused by diseases and injuries.

5) Applied Physics in NM - will address all the physics used in image acquisition methods such as: atomic and nuclear structure, radiation, radioactivity, radioactive decay and the metrology used in this method.

6) Pathology Applied to NM - this module will show the types of pathology that can be visualized in nuclear medicine as a deficiency in some organ or system.

7) CNEN Radioprotection Norms/Legislation - a detailed study of the guidelines on radioprotection in nuclear medicine services and the legislation that governs radioactive nuclear medicine facilities.

8) Radiopharmacy - will study the pharmacological, biological, chemical and physical aspects in the use of radionuclides and associated drugs as tracers, used in scintigraphy exams.

9) Examination and Therapy Protocols - the different types of protocols for each type of examination will be shown, such as: time, counting, peak energy adjustment, etc.

10) Therapeutics in NM - this module will show the entire conduct in the treatment with radionuclides, as well as all part of radiological protection involving this method.

11) Radiobiology - the cells of the human body can suffer damage due to the action of the interaction of radiation with the atoms that form these cells, this module talks about the deterministic and stochastic effects of radiation.

12) Professional Ethics - will study the professional code of ethics of CONTER/CRTRs Radiology Technicians.

## 3. **CONCLUSION**

It is concluded that, despite the requirement by law of Specialization in NM, the existing courses are still incipient, with a curriculum and quality structure still in formation. It is understood, therefore, that a more in-depth study is necessary, in view of the relevance of the service to the NM.

The courses offered do not specify their target audience. They only inform that they are aimed at professionals who work with NM.

Despite the legal requirements, a lack of market action was observed in relation to the offer of these courses. In addition, there was a high number of Facilities that offer NM and that need the qualified service of the technician in the area.

It is therefore understood that a joint Action Strategy must be developed by CONTER, the Educational Institutions, the Medical Facilities so that this training is properly offered.

Furthermore, the question of the quality of the training provided must be kept in mind, since it also contributes to the technical qualification, not only for the professional, but also for their services.

Therefore, it is necessary to promote awareness-raising actions for both courses and professionals, in order to achieve greater adherence to the project, which in addition to improving the company's competitive position, also contributes to better technical qualification.

Finally, given the need for technical professionals in radiology to meet the CONTER resolutions and for their own qualification, a model of a technical specialization course in NM was presented.

Although the curricular structure model presented, both the workload and the sequence of classes can be readapted for a better use of the class program.

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