

Original article

Structured intercomparison of nuclear medicine physicians' education and training programs in 12 EANM member-affiliated member countries

Analyse comparée des maquettes d'enseignement et de formation des spécialistes de médecine nucléaire dans 12 pays membres de l'European Association of Nuclear Medicine

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Abstract

Introduction. – The nuclear medicine physician is a member of a team responsible for the safe and correct implementation of radioactivity-based procedures. To ensure the consistent provision of high-quality services, sufficient education and training are necessary. The aim of this study was to provide a structured description of the present status of the education and training framework in 12 EANM member or affiliated member countries.

Materials and methods. – The acquisition of data describing national education and training systems was based on a questionnaire prepared by the authors. It comprised 19 questions related to education and training, the different professional levels, the presence or not of a national register and its characteristics, and finally of other miscellaneous professional issues.

Results. – In the majority of cases, being an accredited nuclear medicine physician is required to practice nuclear medicine. The specialty duration ranges from 4 to 6 years (or 5 to 7 years for dual accreditation). Successful completion of the specialty requires satisfaction of time-related as well as other threshold criteria. A national register is available in the majority of the countries. There can be a register renewal mechanism, based on a Continuing Professional Development system.

Discussion. – In conclusion, a common policy is generally followed in the countries evaluated, notwithstanding the presence of a few noted differences. Certain suggestions have been made, including the proposed threshold criteria for successful specialty completion, standardization of radiology-related training, the adoption of Continuing Professional Development systems and national registers' renewal mechanisms.

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Keywords: Nuclear medicine physicians; Education and training; Accreditation; Continuing Professional Development; Molecular imaging

Résumé

Introduction. – Le médecin nucléaire est un des piliers de l'équipe chargée de la mise en œuvre de procédures sécurisées et adéquates d'utilisation des radionucléides. Pour garantir le maintien d'une activité de haute qualité, un enseignement théorique et une formation pratique appropriés, sont indispensables. Cette étude vise à proposer une analyse comparative de la situation actuelle des systèmes d'enseignement et de formation en médecine nucléaire dans une douzaine de pays appartenant à l'European Association of Nuclear Medicine.

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Matériel et méthodes. – Le recueil systématisé de données décrivant les programmes nationaux d'enseignement et de formation a été effectué à l'aide d'un questionnaire préparé par les rédacteurs. Ce document comprenait 19 questions portant, outre l'enseignement et la formation, sur les éventuelles différences de qualification, l'existence et les procédures fonctionnelles d'une certification nationale, enfin sur diverses questions en rapport avec l'exercice professionnel.

Résultats. – Majoritairement, la reconnaissance de la spécialité requiert sa pratique effective. Être un médecin nucléaire spécialiste est nécessaire pour pratiquer la médecine nucléaire. La durée de la formation varie de 4 à 6 ans (ou 5 à 7 pour une double certification en médecine nucléaire et radiologie). L'acquisition du titre de spécialiste impose d'avoir satisfait à cette durée de formation ainsi qu'à d'autres critères de quotas minimums de réalisation de procédures. Un « registre » (« une inscription en spécialité ») existe dans la majorité des pays interrogés. Une procédure de « ré-inscription » dans le registre existe parfois, fondée sur les principes du « Développement Professionnel Continu ».

Discussion. – En conclusion, la procédure de formation est très voisine au sein des pays étudiés, au prix de quelques différences cependant. Certaines recommandations ont été proposées, comprenant notamment des critères quantitatifs de réalisation d'actes pour l'obtention de la spécialité, une harmonisation du contenu de l'enseignement d'imagerie radiologique, l'adoption de procédures de Développement Professionnel Continu et de procédures de re-inscription dans les registres nationaux.

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Mots clés : Médecins nucléaires ; Enseignement et formation ; Accréditation ; Développement Professionnel Continu ; Imagerie moléculaire

1. Introduction

Radiation-based diagnostic examinations and therapeutic procedures play a significant role in the management of cancer patients. An important component of these practices incorporates nuclear medicine (NM) diagnostic and therapeutic procedures. Their contribution to effective patient care has been widely appreciated, due to their efficiency in the assessment of organ and system function and metabolism. In addition, their proven cost-effectiveness has resulted in a substantial growth in both number and type of procedures [1,2]. In the United States, an increase in the number of NM procedures of approximately 20% has been noticed during the last decade [3]. In Australia, the increase in the number of the performed procedures during the period 2007–2012 was approximately 50%, due largely to an expansion of PET indications [4]. In both cases, part of the increase is attributed to the gradual adoption of hybrid imaging in a clinical setting, primarily for oncological patients [5–10]. With the advent of nuclear breast imaging (Molecular Breast Imaging [MBI], Breast Specific Gamma Imaging [BSGI] and Positron Emission Mammography [PEM]) and the gradual clinical adoption of dedicated nuclear breast imaging devices, this trend is expected to continue for the forthcoming years [11–13].

There are several factors affecting the quality of patient care provided via NM procedures. Such factors include the diagnostic performance of the medical imaging systems, the imaging and therapeutic protocols adopted and the adherence of the latter to the established international guidelines. Other factors are staff-related, such as staffing levels as well as level of professional competence.

The NM physician is the core link of a multidisciplinary chain, responsible for the effective and safe implementation of NM medical procedures. His/her main responsibilities include, among others, justification of all referrals, determination of the appropriate imaging or therapeutic protocol, regulation of the procedures and interpretation of their results, patients' follow-up, provision of education and training (E&T) and research [14]. Adequate NM physician's E&T, in addition to active

involvement in Continuing Professional Development (CPD) schemes, are therefore absolutely essential in order to ensure optimal outcomes.

The basic E&T framework is common worldwide, however the structure differs from country to country [14–20]. Professional mobility, as an international strategy, should also be emphasized. It should not be considered as a self-serving objective, but it should rather be adopted in order to achieve dissemination of knowledge, as well as substantial improvement and standardization of professional skills. Therefore, professional mobility constitutes a fundamental goal of current policies. Such policies are expressed in the European Union (EU) countries by means of the Bologna Declaration, which defines the context of current developments in the European Higher Education Area, in addition to Directive 2005/36/EC for the establishment of professional qualification frameworks and the European Qualifications Framework for Lifelong Learning [21–23].

In a recently updated syllabus, the Union Européenne des Médecins Spécialistes/European Board of Nuclear Medicine (UEMS/EBNM) recommended the adoption of a similar E&T framework concerning the NM specialty in the EU. Such a strategy would substantially facilitate professional mobility, which was additionally encouraged during the training period. It was recommended that the NM resident should rotate in more than one department, preferably accredited by the UEMS/EBNM [20].

The aim of this study was the structured collection of information regarding the present status of NM physicians' E&T frameworks in a sample of 12 European Association of Nuclear Medicine (EANM) member and affiliated member countries. Further analysis of these data can set the stage for free movement of NM physicians among the corresponding countries.

2. Material and methods

The structured collection of data describing national E&T systems was based on a questionnaire prepared by the authors,

in agreement to the principle adopted in previous studies describing the corresponding frameworks of other health care professionals involved in radiation-based medical procedures [24–26]. A list of the participant countries, along with the set of questions utilised, are provided in [Tables 1 and 2](#) respectively.

The questionnaire comprised a set of 19 questions, subdivided in 4 core parts. The questions in Part A addressed the specialty required for a physician to practice as a NM specialist, the duration of training, as well as the body responsible for the accreditation of the program. Part B examined the presence of different professional levels of NM physicians, along with the requirements for their professional promotion. Part C dealt with matters concerning the existence of a national register and the pathways to registration, as well as renewal requirements based upon a CPD system. Part D dealt with miscellaneous professional issues, such as the authorization of NM physicians to report hybrid imaging studies independently, their right to prescribe non-NM studies as well as medications through a patient's Insurance Body and the independence of the NM specialty in general.

The questionnaire was filled in by 12 EANM member and affiliated member countries, including 9 European, 1 Eurasian and 2 Australasian countries. The professionals that filled in the questionnaire were either EANM national delegates or NM physicians practicing at a national level. Some of the latter are

Table 1
List of participant countries.
Liste des pays participants.

Geographical region	Countries
Europe	Bulgaria, Czech Republic, France, Germany, Greece, Portugal, Serbia, Sweden, United Kingdom
Eurasia	Turkey
Australasian	Australia, New Zealand

currently actively engaged in the national training programs and exams for NM specialty accreditation. In all cases, the NM physicians were considered as fully capable to respond to the content of the questionnaire accurately and reliably.

3. Results

The results of this study are presented in [Tables 3–21](#). Part A of the questionnaire is analysed in [Tables 3–8](#), Part B in [Tables 9–11](#), Part C in [Tables 12–14](#) and Part D in [Tables 15–21](#).

3.1. Part A: education and training

As far as the essential E&T is concerned (Part A), successful completion of the NM specialty is required in

Table 2
Set of questions utilized in the framework of this study.
Organisation thématique des questions de l'étude.

Part A. E&T

- Question 1: Which specialty is required in order to practice NM and what is the corresponding duration time?
Question 2: Is taking an exam compulsory for the initiation of the NM specialty? If so, does this exam take place in a national level? Which are the fields examined?
Question 3: Is there a nationally-approved E&T program? Which official body is responsible for the accreditation?
Question 4: Which are the fields of training during NM specialty? How is the specialty time distributed?
Question 5: Which are the requirements for successful completion of the NM specialty, apart from time-related thresholds?
Question 6: Are there any official NM sub-specialties? If so, are they awarded based on medical procedures-related thresholds and/or after successfully sitting a relevant exam?

Part B. Different professional levels of NM physicians

- Question 1: Are there different professional levels of NM physicians? If so, to which professional level is the specialty equivalent?
Question 2: Are the NM physicians' professional rights differentiated, based on their corresponding professional level?
Question 3: Which are the criteria and procedures for the professional promotion of a NM physician to the higher professional level?

Part C. Existence of a national register – possible correlation with CPD procedures

- Question 1: Is there a national NM physicians' register? If so, how is someone registered? Is the entrance in the register voluntary or compulsory?
Question 2: Is there a renewal mechanism in the register? If so, does this mechanism incorporate Continuing Professional Development (CPD) procedures?
Question 3: Is there an age limit for a NM physician to be a member of the national NM physicians' register?

Part D. Miscellaneous professional issues

- Question 1: Is the NM physician officially and directly involved in the radiopharmaceuticals' preparation in the hot lab?
Question 2: Is it legal for physicians of specialties other than NM to administer diagnostic or therapeutic radiopharmaceuticals?
Question 3: Is it legal for NM physicians to sign a SPECT/CT or PET/CT report independently, i.e. without being necessary to have the report additionally signed by a radiologist?
Question 4: Is the NM specialty totally independent of the Radiology specialty in your country?
Question 5: Is there any time off and/or reduced working hours for NM physicians, as compared to the staff working in non-ionizing radiation environment?
Question 6: Is a NM physician authorized to prescribe non-NM examinations as well as drugs through a patient's insurance body?
Question 7: Is it required for a NM physician to receive an extra-certification to individually carry out non-NM examinations, such as physical stress testing and pharmacological vasodilation prior to administration of myocardial perfusion agents?

E&T: education and training; NM: nuclear medicine.

Table 3

Part A. Question 1: Which specialty is required in order to practice nuclear medicine (NM) and what is the corresponding duration time?

Quelle spécialité médicale est requise pour la pratique de la médecine nucléaire et quelle durée de formation est nécessaire ?

Country	Which specialty/training	Duration of E&T (years)
Australia ^a	NM training	6–7
Bulgaria	NM specialty	4
Czech Republic ^b	NM specialty	5
France	NM specialty	4
Germany ^c	NM specialty	5
Greece	NM specialty	5
New Zealand ^d	NM training	5–6
Portugal	NM specialty	4
Serbia	NM specialty	4
Sweden ^e	NM training	6
Turkey	NM specialty	4
United Kingdom ^f	NM training	6

^a Radiologists: 2 years, physicians: 2–3 years.

^b Initial training either in Radiology or Internal Medicine (2 years).

^c Radiologists: 2 years.

^d Radiologists: 2 years, physicians: 3 years.

^e Radiologists: 1 year. Total training time is under evaluation.

^f Following radiology training: 1 year, following core medical training: 4 years (currently under review). Opportunity for dual accreditation—completion of an MSc course is further required.

8 countries investigated in order someone to practice NM. In this case, the specialty duration ranges from 4 to 5 years. In the rest of the countries it is possible to practice after successful completion of the Radiology specialty. In that case, it is possible to gain dual accreditation after a total duration of 5 to 7 years (Table 3). In most cases, dual accreditation occurs

automatically after completion of the NM training, without any further requirement. In UK, completing an MSc course is an additional requirement for dual accreditation. Passing an exam in order to start the NM specialty is essential in 9 countries. In all these cases the exam takes place in a national level, whereas the fields examined can be slightly different depending on the E&T pathway that is followed (Table 4). The E&T programs are nationally approved, either by the corresponding scientific societies/specialist medical colleges or by the Ministry of Health (Table 5). The core fields of training during specialty are similar, whereas the time distribution among them varies from country to country (Table 6). Successful completion of the NM specialty requires satisfaction of time-related as well as other threshold criteria. Such threshold criteria can be expressed in terms of the minimum number of NM procedures carried out (in 7 countries), the number of trainees' reports that are periodically audited (in 5 countries) or a final exam (in 3 countries). In France, carrying out research related to NM and submitting a research paper to a journal is also required as part of the training (Table 7). In all countries investigated, NM sub-specialties are not officially provided (Table 8).

3.2. Part B: professional Levels

The results of the study were less homogeneous as far as the questions of Part B are concerned. In 3 countries of the survey, there are different professional levels of NM physicians, where successful completion of the specialty corresponds to the lowest one (Table 9). The only country where the professional rights are different, depending on the professional

Table 4

Part A. Question 2: Is taking an exam compulsory for the initiation of the nuclear medicine (NM) specialty? If so, does this exam take place in a national level? Which are the fields examined?

Une épreuve de sélection est-elle nécessaire pour être autorisé à commencer une formation en médecine nucléaire ? Si oui, cette épreuve est-elle organisée à un niveau national ? Quels sont les champs de connaissances concernés ?

Country	Is there an exam?	Is the exam in a national level?	Fields examined
Australia ^a	Yes	Yes	1. Basic Training Physician Clinical Examination of RACP for physicians 2. Fellowship Part I and Part II Radiology Examinations of RANZCR for radiologists
Bulgaria	Yes	Yes	Physics, radiochemistry, radiology, radiotherapy, NM, radiation protection
Czech Republic	Yes	Yes	Internal medicine, radiology
France	Yes	Yes	Corpus of medicine, surgery and biology
Germany	No	No	
Greece ^b	No	No	
New Zealand	Yes	No	PREP examination of the RACP (college-based)
Portugal	Yes	Yes	Cardiology, lung, hematology, kidney, gastroenterology
Serbia ^c	Yes	No	General medicine
Sweden	No	No	
Turkey	Yes	Yes	Multiple choice exam: basic and clinical medicine
United Kingdom	Yes	No	1. MRCP exam (physicians' pathway) 2. FRCR exam (radiologists' pathway)

RACP: Royal Australasian College of Physicians; RANZCR: Royal Australian and New Zealand College of Radiologists; PREP: Physician Readiness for Expert Practice; MRCP: Membership of the Royal Colleges of Physicians; FRCR: Fellowship of the Royal College of Radiologists.

^a Two pathways in the national level exam.

^b Exception for military doctors (examination in the fields of NM and Medical Physics, under the auspice of the Ministry of Defense).

^c State exam.

Table 5

Part A, Question 3: Is there a nationally-approved education and training (E&T) program? Which official body is responsible for the accreditation?
Existe-t-il un programme de formation validé par les autorités au niveau national ? Quel organisme officiel délivre la reconnaissance de spécialité ?

Country	Nationally-approved E&T program	Responsible for accreditation
Australia	Yes	Australian Medical Council. The coordination of NM Advanced training is undertaken by the RACP on behalf of the two medical colleges (RACP-RANZCR). The Joint Specialist Advisory Committee of the RACP and the RANZCR accredits NM Advanced Training
Bulgaria	Yes	Regional Schools of Medicine and the Ministry of Health
Czech Republic	Yes	The Ministry of Health
France	Yes	University – Medicine faculties (National Committee of NM training), final accreditation by the National Council of Medicine Board (Conseil National de l'Ordre des Médecins)
Germany	Yes	The Medical Board (Ärzttekammer) of each federal state
Greece	Yes	The Ministry of Health
New Zealand	No	RACP
Portugal	Yes	A special board of “Ordem dos Médicos” and Government
Serbia	Yes	The Ministry of Health
Sweden	Yes	The Swedish National Board of Health and Welfare
Turkey	Yes	The Ministry of Health
United Kingdom	Yes	The RCP issues the Certificate of Completion of training (overall regulation by the General Medical Council)

RCP: Royal Colleges of Physicians.

level of the NM physician, is Greece. In that case, a NM physician is entitled to practice in the larger cities of Greece as department director only if he/she has at least 2 years of experience (Table 10). The criteria for professional promotion mainly include years of experience, postgraduate titles and publications (Table 11).

3.3. Part C: National register and Continuing Professional Development

A national NM physicians' register is available in the majority of the countries of this study and registration is mainly compulsory in order to practice the specialty (Table 12).

Table 6

Part A, Question 4: Which are the fields of training during nuclear medicine (NM) specialty? How is the specialty time distributed?
Quels sont les domaines de formation pour la spécialité de la médecine nucléaire ?

Country	Current status
Australia	General NM, Basic Sciences, PET, BMD, NM therapy, Paediatric NM There is no mandated specialty time, but a minimum number of studies per year over minimum of 2 years (2000 general NM studies per year and 500 other NM procedures including PET, therapy, paediatric NM)
Bulgaria	2 years: NM Diagnosis, 1 year: NM Therapy, 3 months: NM Physics, 3 months: Radiochemistry, 6 months: Radiology
Czech Republic	Internal Medicine or Radiology 2: years, therapy with unsealed sources: 1 month, PET/CT: 2 months, Radiology: 3 months (in case of Internal Medicine pathway), Internal Medicine: 4 months (in case of Radiology pathway). NM for the remaining training period
France	1. Fundamental training, an average 650-hour training program including 8 “Value Units” (UV) 2. Clinical training, in NM training accredited departments. 4 semesters in NM departments and 4 semesters in “associate” clinical specialties (internal medicine, oncology, cardiology, endocrinology) 3. Trainee booklet with the procedures performed An end-training memoir submitted as an article, presenting an original work. This work also has to be presented in front of a committee
Germany	6 months of therapy. Diagnostic NM for the remaining training period. Training at a department of radiology is not obligatory, however up to 24 months is allowed. 3 radiation protection courses
Greece	1 year: internal medicine, 3 years: NM (including 2.5 months of Medical Physics), 6 months: Radiology, 6 months: clinical training (Cardiology, Paediatrics, Endocrinology or Oncology)
New Zealand	1. PREP Basic training (two years) 2. PREP Advanced Training in NM as above Three years for RACP trainees (24 months in a core training and 12 months in a non-core training position e.g. clinical training) Two years for RANZCR trainees in core training position
Portugal	Basic science – during the first year together with bone scintigraphy, renography Oncology and Internal Medicine are not official parts of the training. Radiology: 2 months. Cardiology: 2 months
Serbia	Emergency medicine: 2 months; Radiology: 3 months; Cardiovascular system: 1 month; Paediatrics: 1 month; Neurology: 1 month; Endocrinology: 2 months; Oncology: 2 months; NM for the remaining of the training period
Sweden	Clinical Radiology, Clinical Physiology and NM
Turkey	Medical oncology (2 months), endocrinology (2 months), cardiology (2 months), Radiology (4 months), radiation oncology (1 month), NM (37 months)
United Kingdom	Clinical training is not obligatory, however one can spend periods of attachment to other specialised departments e.g. Paediatrics, Radiology. The resident also participates in Multidisciplinary Team Meetings, reporting of all types of studies, including hybrid studies and delivering therapies if applicable

Table 7

Part A. Question 5: Which are the requirements for successful completion of the nuclear medicine (NM) specialty, apart from time-related thresholds?
Quelles exigences sont requises pour la reconnaissance de la spécialité de médecine nucléaire et dans quelles contraintes de temps sont-elles requises ?

Country	Current status
Australia	1. Minimum 2 core years of training in NM (for physicians who are dual-trained in another physician specialty and for radiologists)—must see required minimum number of studies per year (see Table 4, Part A. Question 4) 2. 3 years' training (2 core years and 1 elective year) for physician trainees without another physician specialty 3. Successful completion of Basic Sciences Course and examination 4. Must complete all assessments during core training 5. Satisfactory supervisors' reports
Bulgaria	Minimum requirement of 3000 examinations
Czech Republic	A minimum number of performed procedures (e.g. central nervous system: 80, skeletal system: 600, cardiovascular: 350, lung: 200, kidneys: 400, endocrine: 150, tumors and inflammation including PET: 500)
France	2 written exams at national level using either short questions for UV 1–3 or 100 MCQs for UV 4–7 Minimum 3000 scintigraphies (different fields) and 100 therapies (as recommended by the Syllabus of the UEMS-EBNM) An end-training memoir written as an article, to be submitted to a French or English-speaking Journal (first author). His work has to be original and is presented in front of a committee
Germany	A detailed list of procedures (ultrasound, diagnostic procedures including SPECT and PET, therapeutic procedures), however a specific number of procedures is not required
Greece	Sitting an exam, organized by the Ministry of Health
New Zealand	1. PREP Basic training (two years), with regular progress reports and final basic training examination 2. PREP Advanced Training in NM as above 3 years for RACP trainees (24 months in a core training and 12 months in a non-core training position e.g. clinical training) 2 years for RANZCR trainees in core training position During advanced training in nuclear medicine trainees are required to complete assessments (progress and supervisor's report, one per year)
Portugal	Minimum number of examinations and therapies Examinations: Central nervous system: 50 (80% SPECT or PET); Bone: 1000; Cardiovascular: 500 (50% SPECT or PET); Pulmonary system: 200 (50% V/Q); Gastrointestinal: 80; Urinary system: 400; Endocrine system: 400; Haematology & Lymphatic system: 50; Inflammation & Tumours: 100 (80% SPECT or PET); Bone densitometry: 50 Therapies: Thyroid: 40 (benign disease), 20 (malignant disease); Other therapies: 10
Serbia	Minimum of 3000 diagnostic and therapeutic procedures. Must complete all assessments (oral/MCQ, etc.) during training. Final exam
Sweden	There are specific levels of knowledge that one should have, which are checked continually during training
Turkey	Radiopharmacy lab procedures: 25; Gamma camera diagnostic procedure: 3150; Therapy applications: 50 benign and 25 malignant A thesis at the end of residency, in addition to a successful oral exam
United Kingdom	Certificate of Completion of Training. The appointed educational supervisor provides regular appraisals. The trainee must pass a Postgraduate Diploma in Nuclear Medicine (MSc)

MCQ: Multiple Choice Questions.

In 5 countries there is a renewal mechanism in the register, based on a CPD system (Table 13). For all countries investigated, there is no age limit for a NM physician to be a member of the national NM physicians' register (Table 14).

3.4. Part D: miscellaneous professional issues

With respect to the questions of Part D, a variability among the countries investigated is noticed. The NM physician is not directly involved in the radiopharmaceuticals preparation in the hot lab in 11 countries investigated. Nevertheless, in 4 countries he/she is officially held responsible for the corresponding preparation and quality control procedures (Table 15). It is legal for non-NM physicians to administer radiopharmaceuticals intended to be used for either diagnostic or therapeutic purposes in 5 countries of the study, provided that they have attained relative competence through appropriate training (Table 16). In all countries examined, the NM physicians are fully entitled to sign hybrid imaging reports independently, without the necessity of the report being additionally signed by a radiologist (Table 17). The NM specialty is totally independent of the Radiology specialty in 10 countries, the situation currently being different in Sweden and UK (Table 18). The NM physicians have specific benefits as compared to the staff

working in non-ionizing radiation environment in 4 countries. These benefits may include decreased working hours per week or additional vacation time, the duration of which can be either fixed or related to the effective dose received by the NM physician (Table 19). The NM physician is authorized to prescribe non-NM examinations as well as drugs through a patient's Insurance Body in 8 countries, in certain cases and under specific circumstances related to the patient's insurance or possible qualification of the NM physician in a second specialty (Table 20). The question of whether or not it is possible for a NM physician to receive a certification to individually carry out non-NM examinations, such as physical stress testing and pharmacological vasodilation prior to administration of myocardial perfusion agents, revealed significant variations among the countries investigated. The response concerning carrying out such examinations was positive in the case of 7 countries, for which it was stated that no additional certification is required (Table 21).

4. Discussion

Apart from disease-related factors, other parameters affecting the survival and further growth of a specialty are correlated to its revenue-generating capabilities. A substantial

Table 8
Part A. Question 6: Are there any official nuclear medicine (NM) sub-specialties? If so, are they awarded based on medical procedures-related thresholds and/or after successfully sitting a relevant exam?

Au plan officiel, existe-t-il des sous-spécialités en médecine nucléaire ? Si oui, sont-elles reconnues sur la base d'un nombre minimum d'examens de médecine nucléaire effectués et/ou sur la base de la réussite à un examen spécifique ?

Country	NM sub-specialties	Requirements for NM sub-specialties
Australia	No	NM specialists may be credentialed for PET if they have completed PET training
Bulgaria	No	
Czech Republic	No	
France	No	
Germany	No	Additional qualifications may be achieved (e.g.: MRI, Radiation Protection, RIA, Skeletal Diagnostics [RSO])
Greece	No	
New Zealand	No	
Portugal	No	
Serbia	No	
Sweden	Yes	One needs to meet a stated knowledge-level, which is un-officially based on the UEMS training curriculum. There is no exam
Turkey	No	
United Kingdom	No	NM specialists from a Radiology background with only one extra year of NM only have diagnostic qualifications. Ability to deliver therapy is acquired in case of 2 extra years of NM

number of referrals for NM diagnostic and therapeutic procedures is therefore required in order to sustain a positive prospect for the specialty. The *quantity* of referrals is a clear indicator of the referring physicians' level of trust to the *quality* of the result of the corresponding procedures. Therefore, action should be taken in order to optimise the quality of the services provided through NM procedures. As a consequence, the quantity of referrals is expected to be gradually increasing.

As far as the contribution of the NM physician to quality optimization is concerned, this study has shed light to a series of key points that could be taken into consideration by the corresponding scientific societies and organizations during the formation of their policies. These points are temporally related either to the initial E&T stage or to the subsequent practice of

the NM specialty. The first category includes proposed threshold criteria for successful completion of the specialty, standardization of radiology-related training and carrying out research as an essential ingredient of the specialty. The second category includes the adoption of CPD systems and national registers' renewal mechanisms.

Successful completion of the NM specialty should incorporate mechanisms for the objective quantification of the trainee's skills, with respect to his/her active involvement in the whole spectrum of NM procedures currently available. Setting threshold criteria in terms of the minimum numbers of various NM procedures required could facilitate such quantification, in accordance with the recently published EU recommendations [20]. This policy is already followed in many countries of this study. In the event that the trainee's main department cannot provide sufficient training as far as certain

Table 9
Part B. Question 1: Are there different professional levels of nuclear medicine (NM) physicians? If so, to which professional level is the specialty equivalent?
Différents niveaux de compétence professionnelle en médecine nucléaire sont-ils officiellement reconnus ? Si oui, quel niveau est exigé pour obtenir l'équivalent de la spécialité ?

Country	Current status
Australia	Only one professional level (FRACP or FRANZCR)
Bulgaria	No
Czech Republic	No
France	No
Germany	No
Greece	Not in private sector. In public sector, the lowest professional level of a NM physician is called "grade B"
New Zealand	No
Portugal	Medical careers for all physicians are 1. Assistentes (as soon as one is a specialist). 2. Assistente Graduado (after five years of practice as an Assistente) 3. Chefe de Serviço (after five years of practice as an Assistente Graduado)
Serbia	No
Sweden	No
Turkey	Only regarding academic degree (NM Specialist; Assis. Prof.; Assoc. Prof.; 4. Full Prof.)
United Kingdom	No

Table 10
Part B. Question 2: Are the nuclear medicine (NM) physicians' professional rights differentiated, based on their corresponding professional level?
Les pratiques professionnelles autorisées sont-elles différentes en fonction du niveau de formation professionnelle ?

Country	Current status
Australia	Not applicable
Bulgaria	Not applicable
Czech Republic	Not applicable
France	Not applicable
Germany	Not applicable
Greece	To practice as the Head of NM departments located in the two largest cities of Greece (Athens, Thessaloniki) it is compulsory to have at least 2 years of experience
New Zealand	No
Portugal	No
Serbia	No
Sweden	Not applicable
Turkey	No
United Kingdom	Not applicable

Table 11

Part B. Question 3: Which are the criteria and procedures for the professional promotion of a nuclear medicine (NM) physician to the higher professional level?

Quels sont les critères et les voies de promotion professionnelle pour qu'un médecin nucléaire accède à un niveau supérieur ?

Country	Current status
Australia	Depends on individual employer
Bulgaria	Not applicable
Czech Republic	Not applicable
France	There are promotion criteria only for University NM physicians
Germany	Not applicable
Greece	In private sector, promotion is mainly based on experience. In public sector, number of publications is taken into consideration, in addition to any relative postgraduate studies
New Zealand	1. Experience 2. Level in the Multi-Employer Collective Agreement
Portugal	Mainly time of practice
Serbia	Not applicable
Sweden	Not applicable
Turkey	Qualifying in the national multiple choice English exam, working as a NM specialist for two years, 1 to 3 publications (original articles), student lesson on a special subject which may differ among universities
United Kingdom	Not applicable

NM procedures are concerned, the trainee should be allowed and encouraged to spend a period in another recognized host centre offering such experience. The country of such host centres could be different from the country of the main department, provided that the national scientific societies reach a consensus.

Except for the countries in which practicing NM is possible after successful completion of the radiology specialty pathway,

in the rest of the countries investigated the duration of radiology training varies from no required time to up to 10% of the total duration of the specialty. During this part of their training, the NM physicians should be adequately trained in cutting-edge technologies utilised in their specialty, such as hybrid imaging systems (SPECT/CT, PET/CT or PET/MRI). Such systems enable the display of the parametric, physiologic, metabolic, molecular information provided by radiopharmaceutical imaging on the anatomical information provided by the cross-sectional images. Since anatomical information is only used as a tool increasing specificity and localization precision, hybrid imaging systems do not require multi-detector row CT dedicated to primary imaging diagnostics. The usage of such very high resolution systems would not be cost-effective [27,28]. The knowledge and skills required to successfully interpret 3-dimensional anatomical information provided by hybrid imaging systems are currently gained in nuclear medicine departments, where hybrid imaging systems have been installed since the beginning of the multimodality approach. Additional theoretical training in ultrasound imaging with microbubbles and MR spectroscopy should also be encouraged, since these technologies are expected to play an important role in molecular imaging [29]. Adopting policies towards the standardization of Radiology-related training should be considered at both national and international level.

Successful practice of the specialty by NM physicians does not solely require efficient application of acquired skills to deal with a heavy clinical workload. This approach may lead to short-term benefits, such as successful patient management as well as increased wages for NM physicians; however, it is not by itself beneficial for the growth of the specialty in the long term. Promotion of the specialty through active involvement of NM physicians in organised research projects is also required. In this way, advanced technological instrumentation, as well as

Table 12

Part C. Question 1: Is there a national nuclear medicine (NM) physicians' register? If so, how is someone registered? Is the entrance in the register voluntary or compulsory?

Existe-t-il une liste nationale officielle de médecins nucléaires ? Si oui, comment y accède-t-on ? Cette inscription est-elle volontaire ou obligatoire ?

Country	Current status
Australia	1. Register of Credentialed NM and PET specialists held by Medicare Australia (in order for services be paid by Medicare) 2. Australian Health Practitioner Regulation Agency (AHPRA) of the Australian Government
Bulgaria	Yes
Czech Republic	A register is kept by the Ministry of Health and the Czech Medical Association. The entrance is compulsory
France	Yes, it is compulsory. 1: National Health Organization, 2: Nuclear Security Authority
Germany	Yes. One has to request his immatriculation in the physicians register and pay a fee. It is voluntary, but if someone wants to have a private practice, he is obliged to register
Greece	There is a national NM physicians' register, kept by the Ministry of Health. In addition, a NM specialist may apply for membership to the Hellenic Society of Nuclear Medicine and Biology. However, being a member of this Society is not compulsory in order to practice the specialty
New Zealand	NM specialists are recorded in the field of Internal Medicine
Portugal	Yes. The entrance is voluntary but everybody registers, in order to be able to receive official certification of being a NM specialist if requested
Serbia	Yes, there is a register
Sweden	An application to The Swedish National Board of Health and Welfare is essential to get a license as a specialist in nuclear medicine
Turkey	A compulsory registration is kept by the Ministry of Health. In addition, a NM specialist may voluntarily apply for membership to the Turkish Society of nuclear medicine
United Kingdom	All physicians belong either in the RCP or in the RCR. Registration through the General Medical Council of specialty is compulsory. Other organizations exist which physicians voluntarily subscribe to

Table 13

Part C. Question 2: Is there a renewal mechanism in the register? If so, does this mechanism incorporate Continuing Professional Development (CPD) procedures?

Existe-t-il une procédure de renouvellement de cette inscription sur ce registre national ? Si oui, cette procédure repose-t-elle sur le Développement Professionnel Continu (DPC) ?

Country	Current status
Australia	NM physicians/specialists are required to participate in CPD in order to maintain their annual medical registration
Bulgaria	Yes. Points are collected by participating in CPD programs
Czech Republic	Everybody must achieve appropriate number of CME points during a period of time
France	1. Nuclear Security Authority requires a renewal of knowledge and practice for “Patient radioprotection” every 5 years One of the National Professional College mission is CPD and renewal mechanism
Germany	No
Greece	No
New Zealand	NM physicians are required to participate in CPD in order to maintain their annual medical registration
Portugal	No
Serbia	Yes
Sweden	No
Turkey	No
United Kingdom	Yes, all licensed doctors will have to revalidate, usually every five years, by having regular appraisals that are based on core guidance for doctors, GMC

GMC: General Medical Council.

novel radiopharmaceuticals and protocols, may be evaluated by experts in order to be subsequently gradually added in the everyday clinical practice. In USA, the invaluable contribution to specialty promotion of physicians devoting substantial professional efforts in research (defined as “physician-scientists”) has been practically recognised, through their recruitment in well-respected departments [30,31]. In France, carrying out research during the NM specialty is an essential requirement for NM trainees to successfully complete the

Table 14

Part C. Question 3: Is there an age limit for a nuclear medicine (NM) physician to be a member of the national NM physicians’ register?

Existe-t-il une limite d’âge pour le maintien sur ce registre national de reconnaissance de spécialité ?

Country	Current status
Australia	No
Bulgaria	No
Czech Republic	No
France	No
Germany	No
Greece	No
New Zealand	Not applicable
Portugal	No
Serbia	No
Sweden	No
Turkey	No
United Kingdom	No

Table 15

Part D. Question 1: Is the nuclear medicine (NM) physician officially and directly involved in the radiopharmaceuticals’ preparation in the hot lab?

Le médecin nucléaire est-il officiellement et directement impliqué dans la préparation des radiopharmaceutiques dans le labo chaud ?

Country	Current status
Australia	NM physician has responsibility for the quality control of all radiopharmaceuticals, even if not involved directly in their preparation
Bulgaria	No
Czech Republic	No
France	The NM physician is not directly involved in the reconstitution of radiopharmaceuticals, except blood cells labeling process. In hospitals, the responsibility is held by the pharmacist whereas in case of private practice by the NM physician
Germany	The NM physician is responsible for the preparation and quality control of radiopharmaceuticals. In daily practice, however, the preparation is performed by technologists
Greece	No
New Zealand	The laboratory radiation licensee has the responsibility for procedures, however it is unlikely to actually perform the preparations
Portugal	Depends on the size of the department and complexity of the preparations. Some departments have a radiopharmacist. Otherwise, the professional who is responsible for the radiopharmaceuticals’ preparation is either the pharmacist of the hospital (in collaboration with the NM specialist) or the NM specialist
Serbia	No
Sweden	There must be a specialist in NM responsible for all procedures of a NM department, especially those related to radiation safety issues and corresponding education and training of staff
Turkey	No
United Kingdom	No

specialty. In other countries of the study the trainees may participate in research projects, however this is not compulsory for specialty completion. Modification of the NM specialty programs with obligatory participation of the trainees in research projects related to the specialty is expected to fortify the specialty in the long term.

The NM specialty is highly based on technological advances and is therefore considered to be a rapidly evolving specialty. As a result, a substantial percentage of current knowledge and skills of specialised NM physicians is expected to be obsolete by the next decade. In order for the NM physicians to be up to date during their whole professional life, their participation in CPD schemes is crucial. Such schemes should incorporate renewal mechanisms that will reward active involvement in various activities, including organised research efforts with quantified results. This approach is currently adopted by only 4 of the countries investigated.

Additional general issues concerning quality assurance of NM diagnostic and therapeutic procedures should also be mentioned. With respect to NM diagnostic procedures, interpretation of advanced NM studies should be carried out by experts highly trained in the specific field. Therefore, the probability of accurate image interpretation and subsequent report to the referring physician with significant relevant

Table 16

Part D. Question 2: Is it legal for physicians of specialties other than nuclear medicine (NM) to administer diagnostic or therapeutic radiopharmaceuticals? *D'autres spécialistes que ceux de médecine nucléaire sont-ils autorisés à administrer des radiopharmaceutiques à visée diagnostique ou thérapeutique ?*

Country	Current status
Australia	Generally no, but in very limited circumstances other specialist with a current radiation safety licence may administer radiopharmaceuticals
Bulgaria	Not for diagnostic procedures, however oncologists are allowed to administer radiopharmaceuticals for therapeutic purposes
Czech Republic	No
France	No
Germany	No
Greece	No
New Zealand	Yes (Radiologists, Radiation Oncologists, Endocrinologists, Haematologists)
Portugal	Yes, under the supervision of a NM specialist
Serbia	No
Sweden	Yes, it is the responsibility of the Head of Department that all staff and physicians have the right knowledge and training for the work that they are doing. The important issue is not the formal competence but the real competence
Turkey	No
United Kingdom	Yes, if appropriate training and licensing are obtained (e.g.: oncologists or endocrinologists)

Table 17

Part D. Question 3: Is it legal for nuclear medicine (NM) physicians to sign a SPECT/CT or PET/CT report independently, i.e. without being necessary to have the report additionally signed by a radiologist? *Le médecin nucléaire est-il, réglementairement, autorisé à signer des comptes rendus de TEMP/TDM ou de TEP/TDM, c'est-à-dire sans avoir obligatoirement recouru à un radiologue ?*

Country	Current status
Australia	Yes
Bulgaria	Yes
Czech Republic	Yes, if the physician has appropriate training. However, both physicians must be employed in the department to receive payment from insurance companies
France	Yes
Germany	Yes, if the performed CT scan is low-dose. Additionally, in previous years and according to former standards in nuclear medicine specialization, a NM physician could acquire CT accreditation and be allowed to perform and report on a full-dose CT scan as well
Greece	Yes
New Zealand	Yes
Portugal	Yes
Serbia	Yes
Sweden	Yes, the Head of department decides who can do that
Turkey	Yes
United Kingdom	Yes. Training of all nuclear medicine physicians incorporates hybrid imaging

clinical value is expected to be optimised, to the benefit of the patient and the specialty. With respect to NM therapeutic procedures, the patient treatment should be individualised, in accordance to the procedures described in proposed EU

Table 18

Part D. Question 4: Is the nuclear medicine (NM) specialty totally independent of the Radiology specialty in your country? *La médecine nucléaire est-elle une spécialité indépendante de la radiologie dans votre pays ?*

Country	Current status
Australia	Yes
Bulgaria	Yes
Czech Republic	Yes
France	Yes
Germany	Yes
Greece	Yes
New Zealand	Yes
Portugal	Yes
Serbia	Yes
Sweden	No. It is not totally independent at the moment. From 2014 it will be possible to become a specialist in NM if one is a specialist in Radiology, Clinical Physiology or Oncology
Turkey	Yes
United Kingdom	Not in most departments in the country

Table 19

Part D. Question 5: Is there any time off and/or reduced working hours for nuclear medicine (NM) physicians, as compared to the staff working in non-ionizing radiation environment? *Des restrictions et/ou des interdictions temporaires d'activité sont-elles imposées aux médecins nucléaires en comparaison au personnel ne travaillant pas en milieu professionnel non exposé aux rayonnements ionisants ?*

Country	Time off and/or reduced working hours for NM physicians – Current status	Detailed description
Australia	No	
Bulgaria	Yes	35-hours working time per week
Czech Republic	No	
France	No	
Germany	No	
Greece	Yes	Additional time off due to radiation burden, the exact amount of which is related to the effective dose received
New Zealand	No	
Portugal	No	
Serbia	Yes	6 working hours per day
Sweden	No	
Turkey	Yes	35-hours working time per week. Medical people working in ionising radiation field can have 1 month extra-vacation per year in addition to their legal annual holiday, only if they are paid by government. Medical staffs working in private hospital or university are not allowed to have this extra-vacation
United Kingdom	No	

guidelines and already applied in the case of external beam radiotherapy [32]. Such an approach should incorporate individualised patient treatment planning and dosimetric evaluation of cancer tissues and critical organs during the

Table 20

Part D. Question 6: Is a nuclear medicine (NM) physician authorized to prescribe non-NM examinations as well as drugs through a patient's insurance body?
Un médecin nucléaire est-il autorisé à prescrire des examens autres que ceux de médecine nucléaire ou des médicaments, sous couvert d'une assurance professionnelle personnelle ?

Country	Current status
Australia	If the NM specialist is qualified in a second specialty (e.g. radiology, gastroenterology, cardiology etc.) she/he is qualified to provide services specific to the second specialty, in addition to the provision of NM services
Bulgaria	Yes
Czech Republic	Yes
France	Yes. NM specialists can prescribe non-NM examinations as well as drugs through a patient's Insurance Body. However, this setting should happen very rarely
Germany	It depends on the patient's insurance. For private patients yes, for normal patients no. Exceptions to this rule are thyroid/parathyroid drugs and after-care of patients with thyroid cancer
Greece	No
New Zealand	Yes
Portugal	Yes. However, it is generally considered more appropriate to suggest the referring physician the need of carrying out further investigation
Serbia	No
Sweden	Yes
Turkey	Not completely. NM physicians are only authorized to prescribe non-NM examinations as well as drugs for patients treated by NM physicians
United Kingdom	Yes, if qualified to do so (e.g.: radiology examinations)

Table 21

Part D. Question 7: Is it required for a nuclear medicine (NM) physician to receive an extra-certification to individually carry out non-NM examinations, such as physical stress testing and pharmacological vasodilation prior to administration of myocardial perfusion agents?

Le médecin nucléaire doit-il obtenir une autorisation spéciale personnelle pour effectuer des examens autres que ceux de médecine nucléaire, tels qu'une épreuve d'effort ou un test pharmacologique, avant l'administration de radiopharmaceutiques à visée d'étude la perfusion myocardique ?

Country	Current status
Australia	The NM specialist is responsible for the entire NM procedure. Physical stress testing and pharmacological vasodilation are considered part of the suite of NM examinations in Australia
Bulgaria	Yes
Czech Republic	No
France	It is legally possible. However, the two French Societies of Cardiology and NM agreed to recommend the two stimulating tests should be, at the most secure, performed by a cardiologist
Germany	No extra-certification is required. Such duties are part of the specialty
Greece	No
New Zealand	There is no any applicable certification, nor is any necessary to perform these or any other ancillary procedures
Portugal	The NM physicians are allowed to carry out pharmacological stress tests (adenosine). Treadmill and dobutamine administration is only allowed in the presence of a cardiologist
Serbia	No
Sweden	No
Turkey	No need for any additional certification (because of cardiology rotation during the residency)
United Kingdom	NM physicians are trained and are allowed to carry out the above mentioned procedures by themselves. Any one receiving official training on anything even beyond his specialty is allowed to perform it

various therapy stages. Monitoring of the patient's response to the NM therapeutic procedure based on dosimetric quality metrics should be encouraged during specialty, since it is expected to improve the therapeutic outcome.

Quality optimisation of the services provided by the NM physicians (sufficient level of professional competence) is unavoidably related to their *quantity* (staffing levels). The significance of the latter should not be underestimated and staffing guidelines should be officially proposed by international organizations, in accordance to the policies followed by other health care professionals [33–35]. These guidelines should take into account specific department conditions, such as medical equipment utilized, patient workload, administrative requirements, training and research activities, allowance for leave requirements and miscellaneous factors. In this way, the

NM physicians will be facilitated to meet the specialty's high expectations and responsibilities, to the benefit of the patient [20].

5. Conclusion

In conclusion, a questionnaire that consisted of 19 questions subdivided in 4 core parts was prepared, in order to organize the structured collection of data concerning national NM physicians' E&T systems of 12 EANM member and affiliated member countries. Analysis of the collected data demonstrated that a common policy is generally followed in the countries investigated on topics included in the specific questionnaire, notwithstanding the presence of a few noted differences. Certain suggestions have been made, concerning the proposed

threshold criteria for successful completion of the NM specialty, standardization of radiology-related training, carrying out research as an essential ingredient of the specialty, the adoption of CPD systems and national registers' renewal mechanisms. The expansion of this survey to a greater number of countries is expected to confirm the similarities and differences noted with increased confidence, which may form the ground for the development of guidelines from official bodies at national and international level.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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