European Commission

# Analysis on workforce availability, education and training needs for the quality and safety of medical applications involving ionising radiation in the EU

Status and recommendations

Final Report

Service contract HADEA/2022/OP/0003

January 2025

EU-REST

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# Analysis on workforce availability, education and training needs for the quality and safety of medical applications involving ionising radiation in the EU

Status and recommendations

Final Report

Service contract HADEA/2022/OP/0003

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# List of Abbreviations

| | |
|---|---|
| **AB** | Advisory Board |
| **ACR** | American College of Radiology |
| **AFOMP** | Asia-Oceania Federation of Organizations for Medical Physics |
| **ASTRO** | American Society for Radiation Oncology |
| **CIRSE** | Cardiovascular and Interventional Radiological Society of Europe |
| **COCIR** | European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry |
| **COMP** | Canadian Organization of Medical Physicists |
| **CPD** | Continuing Professional Development |
| **CMPE** | Standing Committee of European Doctors |
| **EACCME** | European Accreditation Council for Continuing Medical Education |
| **EANM** | European Association of Nuclear Medicine |
| **EAPCI** | European Association of Percutaneous Cardiovascular Interventions |
| **EBR** | European Board of Radiology |
| **EC** | European Commission |
| **E.C.O.** | European Cancer Organisation |
| **ECPC** | European Cancer Patient Coalition |
| **ECTS** | European Credit Transfer System |
| **ED** | Emergency department |
| **EDIR** | European Diploma in Radiology |
| **EFOMP** | European Federation of Organizations in Medical Physics |
| **EFPIA** | European Federation of Pharmaceutical Industries and Associations |
| **EFRS** | European Federation of Radiographer Societies |

| | |
|---|---|
| **EQF** | European Qualifications Framework |
| **ESC** | European Society of Cardiology |
| **ESCO** | European Skills, Competences, Qualifications and Occupations |
| **ESMIT** | European School of Molecular Imaging and Therapeutics |
| **ESR** | European Society of Radiology |
| **ESTRO** | European Society for Radiotherapy and Oncology |
| **E&T** | Education and training |
| **ETAP** | European Training Assessment Programme |
| **ETC** | European Training Curriculum |
| **EU** | European Union |
| **FTE** | Full-time equivalent |
| **HERCA** | Heads of the European Radiological protection Competent Authorities |
| **HERO** | Health Economics in Radiation Oncology |
| **IAEA** | International Atomic Energy Agency |
| **IGP** | Internal Growth Product |
| **IR** | Interventional Radiology |
| **MDT** | Multidisciplinary Team |
| **MPE** | Medical Physics Expert |
| **MR** | Magnetic Resonance |
| **NM** | Nuclear Medicine |
| **OECD** | Organisation for Economic Co-operation and Development |
| **PAG** | Patient Advisory Group |
| **PET** | Positron Emission Tomography |
| **PRG** | Peer Review Group |
| **QA** | Quality assurance |

| | |
|---|---|
| **RANZCR** | Royal Australian and New Zealand College of Radiologists |
| **RP** | Radiation protection |
| **RPE** | Radiation Protection Expert |
| **RT** | Radiotherapy |
| **RTT** | Radiation Therapist |
| **SGPP** | European Commission DG SANTE Steering Group on Health Promotion, Disease Prevention and Management of Non-Communicable Diseases |
| **SGQS** | European Commission Steering Group on Quality and Safety |
| **TIPSS** | Transjugular intrahepatic portosystemic shunt |
| **TQC** | Total Quality Culture |
| **UEMS** | European Union of Medical Specialists |

# Abstract

The European Union Radiation, Education, Staffing & Training (EU-REST) study aimed to collect and analyse workforce availability, education, and training needs to ensure quality and safety aspects of medical applications involving ionising radiation and to develop staffing and education/training guidelines as well as conclusions and recommendations for key professional groups involved in ensuring radiation safety and quality of medical radiation applications in the European Union.

The study covered the following professional groups: Radiologists, Nuclear Medicine Physicians, Radiation Oncologists, Medical Physicists, Radiographers, and Radiation Therapists (RTT) for countries where this is a separate professional group independent from the category of Radiographers).

The survey carried out to collect data revealed considerable variability in staffing and education aspects across the EU, as well as a widespread lack of relevant data.

The draft guidelines and the resulting draft conclusions and recommendations were submitted to peer review and stakeholder consultation for general assessment and identification of potential barriers to implementation.

The study's recommendations include that Member States create and maintain national workforce registries for each professional group and that mandated continuing professional development (CPD) also includes techniques and knowledge relevant to each professional group, beyond radiation protection issues.

# Résumé

L'étude EU-REST (Radiation, Education, Staffing & Training) de l'Union européenne visait à collecter et à analyser la disponibilité de la main-d'œuvre et des besoins en matière d'éducation et de formation pour garantir la qualité et la sécurité des applications médicales impliquant des rayonnements ionisants et à élaborer des lignes directrices en matière d'éducation et de formation, ainsi que des conclusions et des recommandations pour les principaux groupes professionnels impliqués dans la garantie de la radioprotection et de la qualité des applications médicales utilisant des rayonnements au sein de l'Union européenne.

L'étude a porté sur les groupes professionnels suivants : Radiologues (« Radiologists »), médecins nucléaires (« Nuclear Medicine Physicians »), radiothérapeutes oncologistes/radio-oncologues (« Radiation Oncologists »), physiciens médicaux (« Medical Physicists »), manipulateurs d'électroradiologie médicale/technologues en imagerie médicale (« Radiographers ») et technologues en radiothérapie (« Radiation Therapists – RTT »)* pour les pays où il s'agit d'un groupe professionnel distinct, indépendant de la catégorie des métiers cités ci-dessus.

L'enquête menée pour collecter les données a révélé une grande variabilité des aspects liés à la présence de personnel et à l'éducation dans l'UE, ainsi qu'un manque généralisé de données pertinentes.

Le projet de lignes directrices et le projet de conclusions et de recommandations qui en résulte ont été soumis à un examen par les pairs et à une consultation des parties prenantes en vue d'une évaluation générale et de l'identification des obstacles potentiels à la mise en œuvre.

L'étude recommande notamment aux États membres de créer et de tenir à jour des registres nationaux des effectifs pour chaque groupe professionnel et de veiller à ce que le développement professionnel continu (DPC) obligatoire comprenne également les techniques et les connaissances pertinentes pour chaque groupe professionnel, au-delà des questions de radioprotection.

*Note : Les termes désignant certaines professions pouvant varier d'un pays ou d'une région francophone à l'autre, les termes anglais originaux ont été ajoutés entre parenthèses et s'appliquent à l'ensemble du texte.

# Acknowledgments

The EU-REST consortium wishes to acknowledge the major contributions from the national professional societies, radiation protection authorities and medical associations/chambers of the EU for having provided data on education and training, workforce availability and planning as well as quality and safety. The consortium also extends its gratitude to the stakeholders for their input on the draft guidelines on staffing and education/training as well as the draft project conclusions and recommendations, and to the Advisory Board and Peer Review Group members for their critical feedback on various draft deliverables during the entire study.

# Executive Summary

Ionising radiation is essential to the diagnosis of a wide range of conditions and treatment of major diseases. Ensuring a high level of quality and safety of medical applications involving ionising radiation requires appropriate levels of staffing and education and training.

The European Union Radiation, Education, Staffing & Training (EU-REST) study started on 1 September 2022 and continued until 31 August 2024. It was funded by the EU4Health Programme of the European Union and managed by the European Health and Digital Executive Agency (HaDEA), acting under the mandate from the European Commission's Directorate General for Health and Food Safety (DG SANTE), in collaboration with Directorate General for Energy (DG ENER). EU-REST was awarded to a consortium led by the European Society of Radiology (ESR) and consisting of the ESR, the European Federation of Organisations for Medical Physics (EFOMP), the European Federation of Radiographer Societies (EFRS), and the European Society for Radiotherapy and Oncology (ESTRO), with input from other stakeholders, including the European Association of Nuclear Medicine (EANM).

The EU-REST study is part of the EU4Health 2021 Work Programme[1] and contributes to the implementation of Europe's Beating Cancer Plan[2]. It is also part of the actions of the Strategic Agenda for Medical Ionising Radiation Applications (SAMIRA) Action Plan in the area of Quality and Safety of medical applications of ionising radiation.

The study aimed to provide an analysis of workforce availability, education, and training needs to ensure quality and safety aspects of medical applications involving ionising radiation in the EU and foresaw the development of staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications in the EU Member States.

## Objectives of the EU-REST study

The study aimed to meet the following specific objectives:

- Collect and analyse data on workforce availability, education, and training needs to ensure quality and safety aspects of medical applications involving ionising radiation, as well as related stakeholder mapping;

[1] 2021 EU4Health work programme - European Commission (europa.eu)

[2] Europe's Beating Cancer Plan - European Commission (europa.eu)

- Draft guidelines for staffing and education/training for medical and other professionals involved in medical radiation applications in EU Member States and related stakeholder consultation;
- Develop conclusions and recommendations on EU workforce availability, education, and training needs for the quality and safety of medical applications involving ionising radiation and related stakeholder consultation.

The study covered radiology, radiotherapy, nuclear medicine, and other medical practices utilising ionising radiation, and the main categories of staff under the Council Directive 2013/59/Euratom (BSSD) definitions of 'Practitioner', 'Medical Physics Expert', and staff carrying 'practical aspects of medical radiological procedures'. The following six professional groups are included: Radiologists, Nuclear Medicine Physicians, Radiation Oncologists (including clinical oncologists – depending on local nomenclature), Medical Physicists, Radiographers, and Radiation Therapists (RTTs) for countries where this group of workers is independent from the category of Radiographers.

## Overview of the EU-REST work programme and structure

The EU-REST study was carried out by a consortium consisting of ESR as group leader, EFOMP, EFRS, ESTRO as consortium members and EANM as an Advisory Board member, grouping a multi-disciplinary team of professionals from the following areas of expertise: quality and safety in radiology, radiation oncology (radiotherapy), medical physics, radiation protection, nuclear medicine and the education and training requirements underpinning quality and safe practice for all professions included in the field, as well as expertise in data management, data protection, statistics, scientific writing and project management. The ESR team consisted of three radiologists, a nuclear medicine physician appointed by the EANM, a radiographer as well as experienced project managers. The EFOMP team included four medical physics experts (MPEs), the EFRS provided two radiographers, and the ESTRO group consisted of two radiation oncologists, two radiotherapy MPEs and two RTTs.

The project team was supported by an Advisory Board and a Peer Review Group. The Advisory Board was established to provide views on the methodology and results of the work at each step of the project and consisted of relevant stakeholders, including professions using ionising radiation that were not otherwise represented in the project. It included representatives of the following organisations: ESR EuroSafe Imaging, EANM, ESC/EAPCI, ESNR, CIRSE, E.C.O., patient representation, IAEA, HERCA, UEMS, WHO as well as the RPE/RPO/MPE Study and the MARLIN study.

The Peer-Review Group represented the professional groupings involved in the project (radiology, radiography, radiotherapy, radiation oncology, nuclear medicine, medical physics) with proven expertise in professional and educational matters in the relevant professions, who were not otherwise directly involved in the project.

The study was divided into several components as summarised below.

### Data collection and analysis

As a first step, a survey (referred to as Pre-Survey in this report) was sent to relevant contacts, seeking to identify the appropriate authorities and professional bodies who would be able to provide relevant information on staffing and education/training for each EU country. Subsequently, a comprehensive survey (referred to as Main Survey in this report) was sent to the contacts indicated in the Pre-Survey, as well as to the relevant EU27 national professional societies, radiation protection authorities and medical associations/chambers, to collect information about the situation of workforce availability, education, and training needs of professionals involved with ionising radiation.

Data was ‘cleaned’ with the aim to indicate one response from each source (national authority, national society) to be used in the analysis. Replies were received from all EU Member States except Luxembourg.

General data about the Member States’ population as well as number of hospitals and hospital beds were added to facilitate data comparison.

### Stakeholder mapping

12 stakeholder categories were identified who would be consulted about the draft guidelines for staffing and education/training as well as on the draft conclusions and recommendations on the EU workforce availability, education, and training needs.

### Identification and analysis of existing guidelines

To inform the guidelines on staffing, a literature review of national, EU, and international staffing guidelines was carried out and considered in the context of current and future practice including the impact of new technologies and changing roles brought about by Artificial Intelligence (AI), for example.

To inform the guidelines on education and training, a literature review on national, EU and international recommendations for education and training was performed.

## Stakeholder consultation

The draft guidelines as well as the draft project conclusions and recommendations were subject to stakeholder consultation.

## Development of guidelines

The staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality in medical radiation applications were developed by six author groups representing the relevant professions within the EU-REST study.

The primary objective of the guidelines that have been created was to delineate the minimum requirements for staffing and education/training across all 27 EU Member States.

The staffing guidelines were developed with the aim to offer methodologies for calculating staffing needs applicable for both current and future practice with potentially changed or expanded roles of professionals. This approach ensures the long-term applicability and relevance of the project outputs. The guidelines consider factors such as the level of available equipment, anticipated workload, and the complexities of the practices undertaken. Regardless of the size or complexity of the institution, an essential methodology for calculating the minimum number of staff required for each profession within each discipline has been established as a baseline. The guidelines are based on the findings of the survey conducted among professional organisations, national societies, government agencies, and regulators, coupled with a comprehensive literature review of national, EU, and international staffing guidelines.

The education and training guidelines are based on the current status of education and training according to the survey as well as the specific education and training requirements of the professions considered in this project. The guidelines aim to propose content to meet the fundamental requirement of a common core of knowledge in radiation safety for all professionals based on the Basic Safety Standards Directive (BSSD). In addition, the guidelines define knowledge and requirements specific to each professional group to ensure optimal and safe practice and take into account the impact of new technologies and techniques, increasing workload, the integration of new treatment approaches, and innovations on current and future practice. Training requirements encompass not only radiation protection but also the general training necessary for each profession.

## Benchmarking of workforce availability and training

The aim of this part of the study was to benchmark the data collected through the Main Survey against the EU-REST guidelines as well as data from the literature review. The limited amount of data obtained from the survey as well as of literature on staffing recommendations restricted the possibilities for benchmarking on the one hand but on the other hand was an important finding, as it led to the study's recommendation for each EU Member State to maintain a central registry of professionals involved in ionising radiation as well as on related equipment. This would facilitate benchmarking each country's situation against the EU-REST staffing guidelines and support their adoption where the proposed standards are not met yet.

## Project conclusions and recommendations

Based in particular on the guidelines for staffing and education/training including stakeholder consultation as well as the benchmarking, the study authors have come to the following main conclusions: 1. The project has revealed a lack of existing metrics about workforce availability for all relevant professional groups, and an absence of any widely applicable standards for appropriate staffing levels. 2. Approaches to calculating staffing needs differ between the professional groups for manifold reasons such as the diversity of the professions' roles and responsibilities. 3. The differentiation between Radiation Therapists (RTTs) and Radiographers in Radiation Therapy involves certain ambiguities. Resolving these is, however, beyond the remit of the present study.

# Summary of recommendations

## General

1. Each EU Member State should maintain a central registry for each professional group, and for equipment relevant to the performance of their work. These registries should operate on common standards across all EU Member States.
2. Continuing professional development (CPD) (already required in radiation protection) should be mandated for techniques and knowledge relevant to each professional group, beyond radiation protection issues.
3. Member States should adopt the recommendations of the EU-REST project in a uniform manner (allowing for limited adaptation of recommendations in justifiable specific situations).
4. Harmonisation of training (duration, curriculum, certification of successful completion) should be supported across all 27 EU Member States.

# Most urgent recommendation for each professional group

## Radiologists

- Adopt a uniform method across all EU Member States to calculate the number of radiologists needed to meet demand (as outlined in the project outcome guidelines), and commit to training and employing sufficient staff to meet the calculated needs.

## Nuclear Medicine Physicians

- Have the IAEA IRIS tool tested with real-world data from EU Member States by a consortium of clinical centres, in close collaboration with IAEA.

## Radiation Oncologists

- Apply activity-based staffing guidelines to optimise staffing capacity and develop consistent standard teaching and training programmes to ensure provision of high-quality radiotherapy across Europe.

## Medical Physics Experts

- Independent practice in medical physics requires MPE (EQF level 8) certification. Member states should establish training programmes and registration schemes for MPEs, aligned with the recommendations detailed in this document.

## Radiographers

- Recognise EQF Level 6 (Bachelors) programmes of 180 ECTs as the minimum standard for entry to the profession and implement a harmonised framework for the calculation of the Radiographer workforce across EU Member States.

## Radiation Therapists

- Commit to dedicated radiation therapy education designed to ensure quality and safe patient care and a sustained radiation therapist workforce which will address the career development issues that are hampering retention in the profession.

# Synthèse

Les rayonnements ionisants sont essentiels au diagnostic d'un large éventail de pathologies et au traitement de maladies essentielles. Garantir un niveau élevé de qualité et de sécurité des applications médicales impliquant les rayonnements ionisants nécessite des niveaux appropriés de personnel, d'éducation et de formation.

L'étude de l'Union européenne sur les rayonnements, l'éducation, le personnel et la formation (EU-REST) a débuté le 1er septembre 2022 et s'est poursuivie jusqu'au 31 août 2024. Elle a été financée par le programme EU4Health de l'Union européenne et gérée par l'Agence exécutive européenne pour la santé et le numérique (HaDEA), agissant sur mandat de la Direction générale de la santé et de la sécurité alimentaire (DG SANTE) de la Commission européenne, en collaboration avec la Direction générale de l'énergie (DG ENER). EU-REST a été attribué à un consortium dirigé par la Société européenne de radiologie (European Society of Radiology – ESR) et composé de l'ESR, de la Fédération européenne des organisations de physique médicale (European Federation of Organisations for Medical Physics – EFOMP), de la Fédération européenne des sociétés de manipulateurs en électroradiologie médicale (European Federation of Radiographer Societies – EFRS) et de la Société européenne de radiothérapie et d'oncologie (European Society for Radiotherapy and Oncology – ESTRO), avec la participation d'autres parties prenantes, notamment l'Association européenne de médecine nucléaire (European Association of Nuclear Medicine – EANM).

L'étude EU-REST fait partie du programme de travail EU4Health 20211 et contribue à la mise en œuvre du Plan européen de lutte contre le cancer (Europe’s Beating Cancer Plan). Elle fait également partie des actions du plan d'action SAMIRA (Strategic Agenda for Medical Ionising Radiation Applications) dans le domaine de la qualité et de la sécurité des applications médicales des rayonnements ionisants.

L'étude visait à fournir une analyse de la disponibilité de la main-d'œuvre, des besoins en matière d'éducation et de formation pour assurer la qualité et la sécurité des applications médicales impliquant des rayonnements ionisants dans l'UE et envisageait l'élaboration de lignes directrices en matière de personnel et d'éducation/formation pour les principaux groupes professionnels impliqués dans la garantie de la radioprotection et de la qualité des applications médicales des rayonnements dans les États membres de l'UE.

## Objectifs de l'étude EU-REST

L'étude visait à répondre aux objectifs spécifiques suivants :

- Recueillir et analyser des données sur la disponibilité de la main-d'œuvre, les besoins de l'éducation et de formation pour garantir les aspects de qualité et de sécurité des applications médicales impliquant des rayonnements ionisants, ainsi que la cartographie des parties prenantes ;
- Élaborer des lignes directrices pour la dotation en personnel et l'éducation/la formation des professionnels médicaux et autres impliqués dans les applications médicales impliquant des rayonnements dans les États membres de l'UE, ainsi qu'une consultation des parties prenantes ;
- Élaborer des conclusions et des recommandations sur la disponibilité de la main-d'œuvre, les besoins en éducation et de formation dans l'UE pour la qualité et la sécurité des applications médicales impliquant des rayonnements ionisants, ainsi que la consultation des parties prenantes.

L'étude a porté sur la radiologie, la radiothérapie, la médecine nucléaire et d'autres pratiques médicales utilisant des rayonnements ionisants, ainsi que sur les principales catégories de personnel au sens de la directive 2013/59/Euratom du Conseil (BSSD), à savoir « praticien », « expert en physique médicale » et personnel chargé des « aspects pratiques des procédures radiologiques médicales ». Les six groupes professionnels suivants sont inclus : Radiologues, médecins nucléaires, radio-oncologues (y compris les oncologues cliniques – selon la nomenclature locale), physiciens médicaux, manipulateurs d'électroradiologie médicale et radiothérapeutes (RTT)* pour les pays où ce groupe de personnel est indépendant de la catégorie des d'électroradiologie médicale.

* Pour toutes les professions, voir les termes anglais originaux ci-dessus.

## Aperçu du programme de travail et de la structure de l'étude EU-REST

L'étude EU-REST a été réalisée par un consortium composé de l'ESR en tant que leader , de l'EFOMP, de l'EFRS, de l'ESTRO en tant que membres du consortium et de l'EANM en tant que membre du conseil consultatif, regroupant une équipe multidisciplinaire de professionnels issus des domaines d'expertise suivants : qualité et sécurité en radiologie, radio-oncologie (radiothérapie), physique médicale, radioprotection, médecine nucléaire et exigences en matière d'éducation et de formation sous-tendants la qualité et la sécurité des pratiques pour toutes les professions incluses dans le domaine, ainsi qu'une expertise en matière de gestion et de protection des données, de statistiques, d'écriture scientifique et de gestion de projet. L'équipe de l'ESR était composée de trois radiologues, d'un médecin nucléaire nommé par l'EANM, d'un manipulateur d'électroradiologie médicale et de gestionnaires de projet expérimentés. L'équipe de l'EFOMP comprenait quatre experts en physique médicale (MPE), l'EFRS a fourni deux manipulateurs d'électroradiologie médicale, et le groupe de l'ESTRO était composé de deux radio-oncologues, de deux MPE en radiothérapie et de deux radiothérapeutes (RTT).

L'équipe de projet a été soutenue par un conseil consultatif et un groupe d'évaluation par les pairs. Le conseil consultatif a été créé pour donner son avis sur la méthodologie et les résultats des travaux à chaque étape du projet. Il était composé de parties prenantes concernées, y compris des professions utilisant des rayonnements ionisants qui n'étaient pas représentées dans le projet. Il comprenait des représentants des organisations suivantes : ESR EuroSafe Imaging, EANM, ESC/EAPCI, ESNR, CIRSE, E.C.O., représentation des patients, IAEA, HERCA, UEMS, OMS ainsi que l'étude RPE/RPO/MPE et l'étude MARLIN.

Le groupe d'évaluation par les pairs représentait les groupes professionnels impliqués dans le projet (radiologie, radiographie/ électroradiologie médicale, radiothérapie, radio-oncologie, médecine nucléaire, physique médicale) qui possédaient une expertise reconnue en matière de questions professionnelles et éducatives dans les professions concernées, sans pour autant être directement impliqué dans le projet.

L'étude a été divisée en plusieurs composantes résumées ci-dessous.

## Collecte et analyse des données

Dans un premier temps, une enquête (appelée « Pre-survey » - pré-enquête dans le présent rapport) a été envoyée aux contacts pertinents, afin d'identifier les autorités et les organismes professionnels appropriés qui seraient en mesure de fournir des informations pertinentes sur les effectifs et l'éducation/la formation pour chaque pays de l'UE. Par la suite, une enquête complète (appelée « Main survey » (enquête principale) dans le présent rapport) a été envoyée aux contacts indiqués dans la pré-enquête, ainsi qu'aux sociétés professionnelles nationales de l'UE27, aux autorités de radioprotection et aux associations/chambres médicales, afin de recueillir des informations sur la disponibilité de la main-d'œuvre, l'éducation et les besoins de formation des professionnels concernés par les rayonnements ionisants.

Les données ont été « nettoyées » dans le but d'indiquer une réponse de chaque source (autorité nationale, société nationale) à utiliser dans l'analyse. Tous les États membres de l'UE, à l'exception du Luxembourg, ont répondu.

Des données générales sur la population des États membres ainsi que sur le nombre d'hôpitaux et de lits d'hôpitaux ont été ajoutées pour faciliter la comparaison des données.

## Cartographie des parties prenantes

12 catégories de parties prenantes ont été identifiées pour être  pour se prononcer sur le projet de lignes directrices relatives aux effectifs et à l'éducation/la formation, ainsi que sur le projet de conclusions et de recommandations concernant la disponibilité de la main-d'œuvre de l'UE et les besoins en matière d'éducation et de formation.

## Identification et analyse des lignes directrices existantes

Pour éclairer les lignes directrices sur la dotation en personnel, une analyse documentaire des lignes directrices nationales, européennes (UE) et internationales en matière de dotation en personnel a été réalisée et examinée dans le contexte des pratiques actuelles et futures, y compris l'impact des nouvelles technologies et l'évolution des rôles induite par l'intelligence artificielle (IA), par exemple.

Afin d'éclairer les lignes directrices sur l'éducation et la formation, une analyse documentaire des recommandations nationales, européennes et internationales en matière d'éducation et de formation a été réalisée.

## Consultation des parties prenantes

Le projet de lignes directrices ainsi que le projet de conclusions et de recommandations ont fait l'objet d'une consultation des parties prenantes.

## Élaboration des lignes directrices

Les lignes directrices relatives au personnel et à l'éducation/la formation pour les groupes professionnels clés impliqués dans la garantie de la radioprotection et de la qualité des applications médicales des rayonnements ont été élaborées par six groupes d'auteurs représentant les professions concernées dans le cadre de l'étude EU-REST.

L'objectif premier de ces lignes directrices était de définir les exigences minimales en matière de personnel et d'éducation/de formation dans les 27 États membres de l'UE.

Les lignes directrices sur les personnels effectifs ont été élaborées dans le but de proposer des méthodes de calcul des besoins en personnel applicables à la fois à la pratique actuelle et à la pratique future, avec des rôles professionnels potentiellement modifiés ou élargis. Cette approche garantit l'applicabilité et la pertinence à long terme des résultats du projet. Les lignes directrices tiennent compte de facteurs tels que le niveau d'équipement disponible, la charge de travail prévue et la complexité des pratiques entreprises. Indépendamment de la taille ou de la complexité de l'institution, une méthodologie essentielle pour calculer le nombre minimum de personnel requis pour chaque profession dans chaque discipline a été établie comme base de référence. Les lignes directrices sont basées sur les résultats de l'enquête menée auprès des organisations professionnelles, des sociétés nationales, des agences gouvernementales et régulatrices, ainsi que sur une analyse documentaire complète des lignes directrices nationales, européennes (UE) et internationales en matière de dotation en personnel.

Les lignes directrices en matière d'éducation et de formation sont basées sur l'état actuel de l'éducation et de la formation selon l'enquête ainsi que sur les exigences spécifiques en matière d'éducation et de formation des professions considérées dans ce projet. Les lignes directrices visent à proposer un contenu qui réponde à l'exigence fondamentale d'un tronc commun de connaissances en radioprotection pour tous les professionnels, sur la base de la directive sur les normes de base (BSSD). En outre, les lignes directrices définissent les connaissances et les exigences spécifiques à chaque groupe professionnel afin de garantir une pratique optimale et sûre et prennent en compte l'impact des nouvelles technologies et techniques, de l'augmentation de la charge de travail, de l'intégration de nouvelles approches thérapeutiques et des innovations sur la pratique actuelle et future. Les exigences en matière de formation englobent non seulement la radioprotection, mais aussi la formation générale nécessaire à chaque profession.

### Analyse comparative de la disponibilité de la main-d'œuvre et de la formation

L'objectif de cette partie de l'étude était de comparer les données recueillies dans le cadre de l'enquête principale aux lignes directrices EU-REST ainsi qu'aux données issues de l'analyse documentaire. La quantité limitée de données obtenues à partir de l'enquête et de la littérature sur les recommandations en matière de personnel a limité les possibilités d'évaluation comparative, mais a constitué une conclusion importante, car elle a conduit à la recommandation de l'étude pour que chaque État membre de l'UE tienne un registre centralisé des professionnels concernés par les rayonnements ionisants et par l'équipement connexe. Cela faciliterait l'analyse comparative de la situation de chaque pays par rapport aux lignes directrices de l'EU-REST en matière de personnel et favoriserait leur adoption où les normes proposées ne sont pas encore adoptées.

### Conclusions et recommandations du projet

En se basant notamment sur les lignes directrices relatives à la dotation en personnel et à l'éducation/la formation, y compris la consultation des parties prenantes, ainsi que sur l'analyse comparative, les auteurs de l'étude sont parvenus aux principales conclusions suivantes : 1. Le projet a révélé un manque de données sur la disponibilité de la main-d'œuvre pour tous les groupes professionnels concernés, et l'absence de normes largement applicables pour les niveaux de dotation appropriés. 2. Les méthodes de calcul des besoins en personnel diffèrent d'un groupe professionnel à l'autre pour de multiples raisons telles que la diversité des rôles et des responsabilités des professions. 3. La différenciation entre les radiothérapeutes (RTT) et les manipulateurs d'électroradiologie médicale/ technologues en imagerie médicale en radiothérapie comporte certaines ambiguïtés. La résolution de ces ambiguïtés dépasse toutefois le cadre de la présente étude.

## Résumé des recommandations

### Généralités

1. Chaque État membre de l'UE devrait tenir un registre central pour chaque groupe professionnel et pour les équipements nécessaires à l'exécution de leur travail. Ces registres devraient fonctionner selon des normes communes à tous les États membres de l'UE.
2. Le développement professionnel continu (DPC) (déjà requis en radioprotection) devrait être obligatoire pour les techniques et les connaissances pertinentes pour chaque groupe professionnel, au-delà des questions de radioprotection.
3. Les États membres devraient adopter les recommandations du projet EU-REST de manière uniforme (en autorisant une adaptation limitée des recommandations dans des situations spécifiques justifiables).
4. L'harmonisation de la formation (durée, programme, certification de la réussite) devrait être soutenue dans les 27 États membres de l'UE.

## Recommandation la plus urgente pour chaque groupe professionnel

### Radiologues (« Radiologists »)

- Adopter une méthode uniforme dans tous les États membres de l'UE pour calculer le nombre de radiologues nécessaires pour répondre à la demande (comme indiqué dans les lignes directrices développées par le projet), et s'engager à former et à employer suffisamment de personnel pour répondre aux besoins calculés.

### Médecins nucléaires (« Nuclear Medicine Physicians »)

- Faire tester l'outil IRIS de l'AIEA avec des données réelles provenant des États membres de l'UE par un consortium de centres cliniques, en étroite collaboration avec l'AIEA.

### Radio-oncologues/radiothérapeutes en oncologie (« Radiation Oncologists »)

- Appliquer des lignes directrices relatives à la dotation en personnel basée sur l'activité afin d'optimiser la capacité en personnel et développer des programmes d'enseignement et de formation standardisés et cohérents afin de garantir la fourniture d'une radiothérapie de haute qualité dans toute l'Europe.

### Experts en physique médicale (« Medical Physics Experts »)

- L'exercice indépendant de la physique médicale nécessite une certification MPE (niveau 8 du CEC). Les États membres devraient mettre en place des programmes de formation et des systèmes d'enregistrement pour les experts en physique médicale, conformément aux recommandations détaillées dans le présent document.

### Manipulateurs d’électroradiologie médicale (« Radiographers »)

- Reconnaître les programmes de niveau 6 du CEC (licence) de 180 ECT comme la norme minimale pour l'accès à la profession et mettre en œuvre un cadre harmonisé pour le calcul de la main-d'œuvre des manipulateurs d’électroradiologie médicale dans l'ensemble des États membres de l'UE.

### Radiothérapeutes (« Radiation Therapists »)

- S'engager à dispenser une formation spécialisée en radiothérapie afin d'assurer des soins de qualité et sûrs aux patients, ainsi qu'une main-d'œuvre durable de radiothérapeutes, en s'attaquant aux problèmes d'évolution de carrière qui entravent la rétention dans la profession.

# 1. Introduction

The European Union Radiation, Education, Staffing & Training (EU-REST) study started on 1 September 2022 and continued until 31 August 2024. It was funded by the EU4Health Programme of the European Union and managed by the European Health and Digital Executive Agency (HaDEA), acting under the mandate from the European Commission's Directorate General for Health and Food Safety (DG SANTE), in collaboration with Directorate General for Energy (DG ENER). EU-REST was awarded to a consortium led by the European Society of Radiology (ESR) and consisting of the ESR, European Federation of Organisations for Medical Physics (EFOMP), European Federation of Radiographer Societies (EFRS), and European Society for Radiotherapy and Oncology (ESTRO) (with input from other stakeholders, including the European Association of Nuclear Medicine, EANM).

The EU-REST study is part of the EU4Health 2021 Work Programme[1] and contributes to the implementation of Europe's Beating Cancer Plan[2]. It is also part of the actions of the Strategic Agenda for Medical Ionising Radiation Applications (SAMIRA) Action Plan in the area of Quality and Safety of medical applications of ionising radiation.

The study aimed to provide an analysis of workforce availability, education, and training needs to ensure quality and safety aspects of medical applications involving ionising radiation in the European Union (EU) and foresaw the development of staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications in the EU Member States.

## 1.1 Terminology and professions considered

The professional groups below were initially included:

a. Medical doctors
   i. Radiologists
   ii. Radiation Oncologists (including clinical oncologists – depending on local nomenclature) and, in some countries, Radiotherapists, distinct from b.iii below)
   iii. Nuclear Medicine physicians

b. Radiographers (known by a variety of terms, including radiology technologists etc.) and Radiation Therapists (known as RTT, radiotherapy technologist or therapeutic radiographer in some countries, distinct from a.ii above)
   i. Diagnostic & Interventional Radiology
   ii. Nuclear Medicine
   iii. Radiotherapy / Radiation Oncology

c. Medical Physicists (including Radiation Protection Advisors & Medical Physics Experts, depending on categorisation in each country)
   i. Diagnostic & Interventional Radiology
   ii. Radiation Therapy
   iii. Nuclear Medicine

d. Other professions using ionising radiation (focusing on high-dose procedures): Some other medical specialists and professions utilise ionising radiation in the performance of their work. Some of these confer relatively low radiation doses on patients (e.g. dentists). Examples of usage with the potential for high radiation dose include interventional cardiology, gastroenterology, endovascular intervention, and some surgical specialties (e.g. urology, orthopaedic and trauma surgery, neurosurgery).

The first step prior to collecting up-to-date data on staffing, education, and training of the above listed key professional groups in the EU Member States was a Pre-Survey directed at professional societies and associations within each country, asking for information and contacts of those bodies which could provide the information required.

It was subsequently agreed to address Radiographers and Radiation Therapists separately in the Main Survey, where country-specific information suggested this is appropriate. The Main Survey collected data related to A) education and training, B) workforce numbers, demographics and availability, C) workforce planning and D) quality and safety.

The following professional groups are, therefore, covered by the EU-REST study:

- Radiologists
- Nuclear Medicine Physicians
- Radiation Oncologists (including clinical oncologists – depending on local nomenclature)
- Medical Physicists/Medical Physics Experts
- Radiographers
- Radiation Therapists (RTT – for countries where this group of workers are independent from the category of Radiographers)

The study consortium recognises the different viewpoints related to “Radiation Therapist (RTT)” as a profession separate from Radiographer, expressed as follows:

<u>ESTRO:</u>

ESTRO highlights the recognition of the radiation therapist profession by the ESCO framework. ESCO describes radiation therapists (code 3211.2, category "Technicians and associate professionals") as follows: "Radiation therapists are responsible for the accurate delivery of radiotherapy to cancer patients and, as part of the multidisciplinary team, for elements of treatment preparation and patient care. This encompasses the safe and accurate delivery of the radiation dose prescribed and the clinical care and support of the patient throughout the treatment preparation, treatment delivery and immediate post treatment phases." ESTRO points out that Radiation Therapists (distinct from Radiation Oncologists) are known across Europe by over 20 titles, including RTT, radiotherapy technologist, therapeutic radiographer, nurse working in radiotherapy etc., the key criteria being that they are directly involved in radiotherapy preparation and delivery. The full list of titles used across the EU for radiation therapist is available at:

https://esco.ec.europa.eu/en/classification/occupation?uri=http://data.europa.eu/esco/occupation/e139b0a3-3bc5-4c33-bfbf-51ac20ac12fa

EFRS:

Radiographers in radiation therapy are included, along with medical imaging and nuclear medicine radiographers, in the professional group 'Radiographers' as defined by the EFRS.

According to ESCO (code: 2269.8, category "Professionals"), "Radiographers use a range of technologies to examine, treat and care for patients. They work in the fields of Medical Imaging, Radiotherapy and Nuclear Medicine and apply ionising radiation, ultrasound, magnetic resonance imaging and radioactive sources."

The list of titles used across the EU for radiographer is available at:

https://esco.ec.europa.eu/en/classification/occupation?uri=http://data.europa.eu/esco/occupation/7639a601-6db0-41ed-9fb0-813d9b8beb05

WHO:

The World Health Organization's Radiation and Health Unit, which is represented on the EU-REST Advisory Board, pointed out the ambiguity of the term "Radiation Therapist (RTT)", mentioning that in many languages "therapist" is used for medical doctors performing the therapy rather than for radiation technologists or radiographers, and raised concerns about possible confusion resulting from treating RTTs as a separate profession in the EU-REST Conclusions and Recommendations.

Stakeholder consultation:

3 out of the 73 stakeholders who provided feedback pointed out the overlap between the radiographer and the RTT sections and the unclarity resulting from it.

The EU-REST study leaders acknowledge these different standpoints and the resulting ambiguities. Resolving this issue is, however, beyond the scope of the EU-REST study.

# 2. Study overview

## 2.1 Data collection and analysis

Authors: Jonathan McNulty, Graciano Paulo

At the inception phase of the project, a Pre-Survey was directed at professional societies and associations within each country, asking for information and contact details for those bodies which would be expected to be able to provide information on workforce numbers, education and training requirements etc.

The elements of the methodology, as well as the approach for each element, included:

1. Definition of the main specialties/professional groups with responsibilities in use of ionising radiation in medicine (see Section 1.1 above);
2. Availability/numbers of staff in the staff categories covered by the surveys and identified in point 1;
3. Professional qualifications of the staff categories covered by the surveys and identified in point 1;
4. Training relevant for the staff categories covered by the surveys and identified in point 1;
5. Documents available providing guidance on staffing to ensure safe and high-quality radiation methods;
6. Selection of data sources, methods (literature reviews, questionnaires, expert interviews, etc.), tools (user-friendly and timesaving) and other practical elements of the data collection methodology;
7. Definition of data analysis methodology and tools allowing for EU-wide and country-specific analyses.

A summary of the project ‘Report on data collection and analysis’ is provided in Section 3 below.

### 2.1.1 Data Collection

#### Target groups, countries, and recipients

The target professional groups were as stated in Section 1.1 above. Databases held by the professional societies at the European level involved with the project (ESR, ESTRO, EFOMP, EFRS, and EANM as an Advisory Board member) covering the professional categories described in Section 1.1 were used. Based on these databases, a Pre-Survey was distributed to gather up-to-date information on the relevant authorities/professional bodies in the EU 27 countries responsible for staffing, education and training issues. At the same time this Pre-Survey was circulated to the SAMIRA Steering Group on Quality and Safety (SGQS) by the EC.

A total of 109 responses were received, including at least one from all EU27 countries.

### 2.1.2 Main Survey implementation

The Main Survey was implemented in English on SurveyMonkey (www.surveymonkey.com). It was divided into four sections related to:

- education and training (including CPD/Continuing Education)
- workforce availability
- workforce planning
- quality and safety

An abbreviated version of the survey was made available for national radiation protection authorities in the EU27, focusing on the quality and safety elements only.

The survey was distributed to:

- the different national organisations and competent authorities from the database established through the Pre-Survey mentioned above
- the EU27 national professional societies for Radiology/Nuclear Medicine/ Radiotherapy/ Radiography/Medical Physics through ESR, EANM, ESTRO, EFRS and EFOMP
- the EU27 national radiation protection authorities through HERCA
- the EU27 national medical associations/chambers through UEMS

### 2.1.3 Data Cleaning

The purpose of the data cleaning was agreed as being:

- not to verify the correctness of the responses.
- to indicate one response from each source (national authority, national society) to be used in the analysis.
- in the case of multiple, differing answers provided by professional societies or national authorities, the relevant person within each national society or authority was asked to clarify these differences. At the end of this process one of the responses was kept for each of the national societies and for each of the 6 professional categories per country that had provided responses.
- in the very few cases where responses were also available from the national authorities, a single such response was kept per country and professional category for the analysis, despite the very small sample size, to highlight differences between the national authorities and national society responses.

Following a first check of the cleaned data by the relevant task lead, efforts through personal contacts continued to obtain missing data from some countries, in order to allow at least a basic analysis across all EU27 countries.

### 2.1.4 Data Analysis

The results obtained from the Main Survey and cleaned according to the methodology described in the previous section were presented by profession, with the aim to provide data on

a) staffing, education and training of the key professional groups involved in ensuring radiation safety and quality of medical radiation practices in Member States.

b) the areas of radiology, radiotherapy, nuclear medicine and other medical practices utilising ionising radiation, with an emphasis on procedures delivering high(er) radiation doses to patients and/or staff.

c) the main categories of staff falling under BSSD’s definitions of ‘practitioner’, ‘medical physics expert’ and staff carrying ‘practical aspects of medical radiological procedures’, including staff dealing with reporting and learning from adverse radiological events.

General data about Member States population and number of hospitals and hospital beds were added to facilitate data comparison. Data from Luxembourg is missing, since no replies were received except from one highly incomplete response, which was removed during data cleaning.

### 2.1.5 External Peer Review

External peer review was undertaken by:

- the Peer Review Group (PRG), a group of external peer reviewers representing the professional groupings involved in the project (radiology, radiography, radiotherapy, nuclear medicine, medical physics) with proven expertise in professional and educational matters in the relevant professions, but who were not otherwise directly involved in the project, and by
- the Advisory Board (AB), which was established to provide views on the methodology and results of the work at each step of the project and included representatives from relevant stakeholders, including key professions using ionising radiation not represented in the consortium.

## 2.2 Stakeholder mapping

Author: Boris Brkljačić

The objective of this task was to identify and map the stakeholders, including academics, the wider scientific community, clinicians, regulatory bodies, representatives of industry and patients, who would be consulted (1) about drafting guidelines for staffing and education/training after existing guidelines were collected and (2) regarding the conclusions and recommendations on the EU workforce availability, education and training needs for the quality and safety of medical applications involving ionising radiation.

The stakeholder categories initially identified included:

1. European professional societies (EANM, EFOMP, EFRS, ESR, ESTRO, ESC, CIRSE, etc.)
2. European/ international organisations/networks (HERCA, IAEA, UEMS, CPME, E.C.O., SAMIRA SGQS, EC DG SANTE SGPP)
3. Patient groups (patient advisory committees of European professional societies, e.g. the ESR Patient Advisory Group - PAG, or organisations such as E.C.O, European Cancer Patient Coalition - ECPC)
4. Industry (COCIR, EFPIA, Nuclear Medicine Europe)
5. National professional societies in the EU27, and
6. National medical associations in the EU27.

The organisations represented in the project consortium are European professional organisations, representing relevant professions using medical ionising radiation within and beyond Europe, and, as such, have contact information in their databases for other relevant affiliated and associated international and national professional organisations in their disciplines, with industry representatives, national competent authorities, patient organisations and academic and research clinical institutions. Consortium members have also developed relationships and experience from recently undertaken European projects (e.g., QuADRANT[3], EU-CT-JUST[4], EURAMED rocc-n-roll[5]). All of these were used to identify appropriate stakeholders for consultation.

In addition, participants in the Pre-Survey (see Section 2.1) were asked to identify any other stakeholders who may potentially be able to provide useful input (e.g. industry companies providing specific training in relevant areas, NGOs given responsibility for aspects of education, training or workforce determination, etc.). 95 names/e-mails of potential stakeholders to be included in future consultations were provided, from the following countries: AT: 1, BE: 11, BG: 1, HR: 15, CY: 3, CZ: 6, DK: 2, EE: 2, FI: 6, FR: 4, DE: 4, GR: 3, HU: 1, IE: 0, IT: 2, LV: 6, LT: 3, LU: 8, MT: 1, NL: 1, PL: 1, PT: 2, RO: 1, SK: 2, SI: 2, ES: 6, SE: 1. These contacts were sorted into the categories above and included in the stakeholder list.

The stakeholders were then approached through the Main Survey and were included in the consultation processes in further activities of the project.

The stakeholder mapping methodology included several steps. A set of generic stakeholder categories was developed based on the above-mentioned initial list of stakeholder categories. EU-REST partners were asked to identify stakeholders, and relevant stakeholders from contact databases established for previous projects on quality & safety were identified and included. The Advisory Board and Peer Review Group were invited to review the methodology and provide additional contacts they considered relevant for inclusion in the stakeholder list.

The list of stakeholder categories and an overview of organisations per stakeholder category are provided in Annex 2.

## 2.3 Identification and analysis of existing guidelines

Author: Cristina Garibaldi

[3] https://www.eurosafeimaging.org/clinical-audit/quadrant (accessed on 5 August 2024)

[4] https://www.eurosafeimaging.org/eu-just-ct (accessed on 5 August 2024)

[5] https://roccnroll.euramed.eu/ (accessed on 5 August 2024)

### 2.3.1 Identification of existing guidelines

To inform the guidelines on education and training, a literature review was carried out on national, EU and international recommendations for education and training for all professional groups. This literature review initially considered the general curriculum content and its appropriateness to ensure that the necessary knowledge, skills and competencies underpinning best practice are covered. Then it focussed more specifically on the components of a curriculum that relate to the quality and safety aspects of medical applications involving ionising radiation and radiation protection.

To inform the guidelines on staffing, a literature review of national, EU, and international staffing guidelines was carried out and considered in the context of current and future practice and the impact of the introduction of new technologies and changing roles (as a result of the greater application of Artificial Intelligence, for example).

The search period was restricted to the years 2010-2022, and Embase, Medline and Pubmed-not-Medline were used as sources. The search was limited to papers with abstracts and written in English. Only the following publication types were considered: articles in press, articles, reviews and editorials.

The search was focused on national/international guidelines on education and training and on staffing/workload at EU level, but guidelines from non-European countries with healthcare systems considered to be of a similar level (e.g. the US, Canada, Australia, Japan) were also considered. Additional relevant documents not found in the literature but issued by relevant societies/organisations, such as IAEA, EC, etc. were also considered.

A total of 387 papers were selected for education and training, while a total of 191 papers were selected for staffing/workload.

### 2.3.2 Analysis of existing guidelines on education and training

The most important elements retrieved from the core curricula issued by the European scientific societies or guidelines on education and training by international organisations (e.g. IAEA), papers reporting the situation of education and training at the European level and outside Europe are reported in the tables in Annex 3. These tables show aspects such as pre-education requirements, structure and content of the education and training, and certification.

A summary of the key findings of the literature analysis for each profession is reported below.

## Radiologists

- The European Training Curriculum (ETC) for Radiology as issued by the European Society of Radiology in its latest edition in March 2020 provides a detailed and elaborated roadmap for Radiology Residency, including detailed content description for almost all topics and fields in modern and state of the art medical imaging.
- AI, however, is currently not sufficiently provided for.
- Radiation protection training and education is part of the content at all levels and in all fields, underlining its importance for both patients and medical staff. However, the number of ECTS for radiation protection is not defined.
- Despite the fact that numerous national societies in Europe and even abroad support this ETC, the final responsibility for defining the training remains at national, and even local levels.
- There is a clear call for competency-based training, rather than training based exclusively on specified numbers of cases to be read/performed. Furthermore, no such specified numbers are provided in the available literature.
- The EC Guidelines on Radiation Protection Education and Training of Medical Professionals in the EU in 2014 (EC Radiation Protection No. 175) includes a specific section for Radiologists.

## Radiation Oncologists

- The 4th edition of the ESTRO Core Curriculum (CC) for Radiation Oncologists/Radiotherapists released in April 2019 is the most comprehensive document covering the education and training of radiation oncologists/radiotherapists in Europe.
- In 2021 ESTRO developed a Clinical Oncology module that could be combined with the ESTRO CC to enable clinical oncology trainees to follow a single curriculum.
- AI is not mentioned in the ESTRO CC.
- Although the ESTRO CC recommends training for safety procedures and quality assurance, this part is not detailed and not structured.
- The EC Guidelines on Radiation Protection Education and Training of Medical Professionals in the EU in 2014 (EC Radiation Protection No. 175) include a specific section for Radiation Oncologists and define a set of learning outcomes based on the competences mentioned in the ESTRO CC.

- The IAEA developed a Syllabus for the Training of Radiation Oncologists in 2009 which defines the minimum requirements for radiation oncology training across the world.

## Nuclear Medicine Physicians

- The most comprehensive European CC is proposed by the Union Européenne des Médecins Spécialistes (UEMS) and the European Board of Nuclear Medicine (EBNM), and proposes individual qualification as well as department accreditation, but does not propose compulsory training, according to a European Directive. Individual accreditation can be granted through the Fellowship of EBNM (FEBNM). All EU27 Member States are members of the UEMS.
- UEMS does not impose this kind of accreditation anywhere in Europe, even if a large number of Member State representatives adhere to the principle.
- UEMS published a revised version of its 2015 CC in October 2023.
- The EANM and the European School of Molecular Imaging & Therapy (ESMIT) are currently separated from UEMS/EBNM. UEMS/EBNM offers a CC, ESMIT at this stage proposes content at three levels: Basic level (online), in-depth level (on site) and advanced knowledge (at ESMIT in Vienna/AT) for upper level.
- In addition, the EANM proposes ad hoc accreditation, as currently done for cardiac imaging or radiopharmacy.
- The IAEA published in 2019 the Training Curriculum for Nuclear Medicine Physicians, which defines the minimum requirements for training in nuclear medicine worldwide.
- The nuclear physicians' education and training in 12 EANM affiliated member countries (including Australia and New Zealand) show major differences between countries.
- As of today, there is no standard curriculum requested in the EU27.
- Education in radiation protection adheres to the European Directive 2013/59 (BSSD), but without a uniform guidance, as far as the content, duration, re-accreditation are concerned. HERCA has issued some guidance, that has not been enforced yet even if all EU27 Member States are members of HERCA.
- The EC published Guidelines on Radiation Protection Education and Training of Medical Professionals in the EU in 2014 (EC Radiation

Protection No. 175[6]), which include a specific section for Nuclear Medicine Physicians.

## Medical Physicists

- The reference guidelines for education and training for Medical Physics Experts (MPEs) are the Core Curricula (CC) issued by EFOMP, in collaboration with the European Societies of Radiology (ESR), Nuclear Medicine (EANM), and Radiotherapy and Oncology (ESTRO). These curricula are aligned with the European Commission guidelines on MPE RP 174[11], yet they go beyond these guidelines to provide comprehensive education and training for MPEs. These CC have been endorsed by the majority of EU countries' national professional organisations for medical physics. The joint EFOMP/ESTRO CC for MPEs in radiotherapy has recently been updated and published in 2021[12]. The previously published CC for Nuclear Medicine has been updated and is about to be published, and the CC for Diagnostic Radiology MPEs is currently in the process of being updated. Both will follow the format of the recently updated radiotherapy CC. The objective at the end of this CC revision process is to provide a single CC for MPEs throughout the EU.RP174 already sets an EQF level 8 for MPE and proposed a BSc in Physics and a MSc in Medical Physics or equivalent as entry requirements for MPE training.
- Recommendation documents have been issued by EFOMP, IAEA and the EC defining the national training scheme, role and responsibilities for the MPE.
- The situation of education and training of MPE in the different disciplines in the European countries shows significant differences, as reported by two recent surveys carried out by ESTRO and EFOMP.
- The EC-published Guidelines on Radiation Protection Education and Training of Medical Professionals in the EU in 2014 (EC Radiation Protection No. 175) include a specific section for Medical Physicists. RP No. 175 defines a set of learning outcomes based on the competences mentioned in the ESTRO/EFOMP CC.
- There are ongoing debates regarding the potential merging of Nuclear Medicine and Radiology Medical Physics residency programmes, reflecting differing views on the optimal structure for these training areas. It is recommended that training curricula include soft skills such as communication, leadership, and mentoring, particularly for medical physicists in patient-facing roles. Expanding the medical physicist

[6] European Commission (2014) Radiation Protection no 175, Guidelines On Radiation Protection Education And Training Of Medical Professionals In The European Union.

curricular and professional programme to include AI and other new topics.

- AI theory and applications for radiation protection and Q&S are rarely included in the CC at European and international level.
- There is a recognised need to harmonise certification processes across countries to ensure consistency in the qualification of MPEs.
- Structured, formal training model for clinical residencies need to be established to standardise the education and professional development of MPEs.

## Radiation Therapists (RTT)

- CC for Radiation Therapists have been produced by ESTRO and IAEA.
- Two benchmarking documents released by ESTRO for Radiation Therapist practice: EQF Level 6 relates to competences desired of a graduate from an initial programme and EQF Levels 7 and 8 for advanced practice.
- Education and training for Radiation Therapists across Europe is very varied with minimal content related to radiotherapy in many countries. However, there are pockets of excellence in radiation therapy education within the EU with Ireland being notable.
- Core curricula recommendations have been developed in Canada, Australia and the USA.
- The EC Guidelines on Radiation Protection Education and Training of Medical Professionals in the EU in 2014 (EC Radiation Protection No. 175) include a specific section for Radiation Therapists.

## Radiographers

- The CC for undergraduate education and training of Radiographers (considered as the basic entry training level to the Radiographer profession) is reflected in the EFRS European Qualifications Framework (EQF) Level 6 benchmarking document (2018) which is currently being revised. EQF Level 6 benchmarking documents for RTTs and nuclear medicine radiographers / technologists have also been published by ESTRO and the EANM. Further documents resulted from two surveys conducted by the EFRS and presented as the EFRS Statement on Radiography Education in Europe (2012) and the EFRS Statement on Clinical Radiography Education across Europe (2017) and updated through the EFRS Statement on Radiography Education (2019).

- CC for postgraduate education and training of Radiographers is reflected in the EFRS European Qualifications Framework (EQF) Level 7 benchmarking document (2017).
- CC for education and training specific to Radiotherapy is reflected in the EFRS Statement on Radiographers in Radiotherapy (2019).
- The EFRS white paper: Radiographer Education, Research and Practice (RERP) (2021) outlines the Radiographer profession requirements for the coming 30 years in the disciplinary areas of medical imaging/radiology, nuclear medicine, and radiotherapy.
- EFRS Statement on Continuous Professional Development (CPD) (2013) and a literature review, continuing professional development (CPD) in radiography (2017) highlight CPD requirement for Radiographers.
- The EC-published Guidelines on Radiation Protection Education and Training of Medical Professionals in the EU in 2014 (EC Radiation Protection No. 175) include a specific section for Radiographers.
- Radiation Protection Officer (RPO) Role Descriptor for Radiographers published by the EFRS in 2020 is specific to radiation protection.

### 2.3.3 Analysis of existing guidelines on staffing

The main focus of the study's literature analysis was workforce. Whenever available, the algorithms used to determine workforce were reported. The current situation of workforce at European level, as well as in those countries with a health system similar to that in Europe were analysed, if available. The workforce availability and planning including the presence of a central national registry, the use of skill mix to address staff shortages, and the gender/age profile, diversity/equality were evaluated, if available. Another interesting point found in the analysis were the challenges related to workforce, such as the risk of burnout, and the opportunities and risks linked to the introduction of artificial intelligence in different fields of Radiology, Radiation Oncology, Nuclear Medicine and Medical Physics. Other topics such as the link between workload and quality, equity and diversity and job/workplace satisfaction were found in our analysis. Moreover, topics such as radiation exposure and workforce safety were also reported.

A summary of the key findings of the literature analysis for each profession is reported below.

## Radiologists

- Potential physician work efficiencies and appropriate multiple payment reduction for different pre-service, intra-service and post-service imaging work activities.
- Advantages for patient care of extended working hours of Radiologists in the emergency service; by increasing working after hours for Radiologists, time for ED physicians can be saved.
- The presence of a dedicated ED Radiologist reduces final report turnaround time and positively impacts patient care.
- Time for Radiologists can be saved by involving specialist CT and MR technicians for protocol assignment.
- Application of AI is not reducing but increasing workload for Radiologists.
- Radiology workload changes differ between subspecialties.
- Need for sufficient workforce to avoid loss of quality due to tired doctors.
- Proof of reduced performance after overnight shifts.
- Persistent underrepresentation of women among entire workforce.
- Need for acute intervention to reduce gender and diversity discrepancy.
- A survey among ESR members indicated that only 13.3% of respondents had intentions to acquire AI tools.
- Use of medical simulation to teach and educate IR.
- A newly developed workflow allows for exposition-free (for the staff involved) CT-guided interventions without prolonging the procedure significantly.

## Radiation Oncologists

- The HERO project of ESTRO reported the number of Radiation Oncologists (RO) per million population and also patients treated per RO. There are huge variations in both parameters among the European countries.
- An EORTC paper presented the evolution of the workload criteria and actual staffing levels among the EORTC member institutes. It is evident that the criteria both for the RO workload and the (number of patients per RO) actual workload have decreased gradually in the last 3 decades due to increasing complexity of the treatment.
- The IAEA published a series of documents for staffing of RO where the activity-based calculation method was introduced.

- The Royal College of Radiologists (RCR) in the UK reported the number of clinical oncologists per 100,000 population ages older than 50. There are striking differences among the UK regions.
- The White book in France (Livre blanc) for RO presents the actual workload of RO per patient, however, does not specify criteria for assessing the workload.
- The White Book in Spain (Libro blanco) presents the workload of ROs and makes projections for the future. The report points out the dropout rate of residents and difficulties in obtaining a working permit for foreign ROs among the challenges to increasing the number of ROs in the country.
- A paper from Italy reported the ROs workforce and infrastructure in the region of Lombardy and evaluated the changes in a decade.
- Hungary published a comprehensive document for the infrastructure and workforce of RO in the country. Despite some improvements, significant gaps remain.
- The American College of Radiology (ACR) published the ACR Radiation Oncology Practice Accreditation Program where the patients per RO were stratified according to the type of institution.
- ASTRO published the framework for quality radiation oncology care. Although there are sophisticated calculations for the numbers of MP and RTT covering patients in a department there are no guidelines for RO. The only recommendation is that a minimum 1 RO is required to run a RO department.
- A series of documents in Australia and New Zealand sponsored by the RANZCR reported the situation of infrastructure and workforce which resulted in the “Tripartite National Strategic Plan for Radiation Oncology 2012-2022”.

Only the guidelines from IAEA present the details of the algorithm used to calculate the required number of RO. Very few reports presented the data based on FTE calculations. Many countries simply adapted the IAEA and ESTRO staffing guidelines as reference in country reports without developing their own guidelines. The table below shows the number of patients per RO suggested by the guidelines, the actual number and the corresponding contributing factors reported by the analysed papers.

**Table 1 – Number of patients per RO suggested by guidelines**

| | | Guideline (Pts per RO) | Actual(Pts per RO) | Contributing factors |
|---|---|---|---|---|
| | | Europe | | |
| 1 | ESTRO-HERO | National guidelines: 130-300 | Pts/RO: 209 (100-349) | • Complexity of treatment<br>• Chemotherapy delivery<br>• GNI per capita |
| 2 | EORTC | 1993: 300<br>2008: 250-300<br>2014: 180-250 (max 300) | 1992: 316<br>2008: 258<br>2013: 242<br>2019: 225 | • Complexity of treatment |
| 3 | IAEA | 200-250 | | • Activity based calculation |
| | | Europe National | | |
| 4 | RCR | | | • Retirement<br>• Less than full time working<br>• Burnouts |
| 5 | Italy – Lombardy | NA | 152 (72-246) | |
| 6 | Hungary | 300 | 274 | • Urban-rural difference |
| 7 | France | NA | 305 (+/- 93) | • Geographical distribution<br>• Public/private employment |
| 8 | Spain | 150-200 | 241 | • Dropouts of residents<br>• Work permits for foreign RO |
| | | Outside of Europe | | |
| 9 | ACR | NA | 212 (187-273) | • Institution type<br>• Number of patients |
| 10 | RANZCR | NA | NA | • Early retirement<br>• Declining interest<br>• Regional differences |

## Nuclear Medicine Physicians

A significant shortage of Nuclear Medicine Physicians already exists or may appear in the future.

- The IAEA proposed in 2022 a model for assessing the needs for all professions in NM. Actions are accounted for as time units (15 min), with the more complex procedures necessitating more time units. A website proposes a calculator that allows to predict the required workforce for a particular university- or non-university-based hospital or private practice.

The calculation takes into account the available equipment, the number and complexity of diagnostic and therapeutic procedures, and the availability of a radiopharmacy with three levels of complexity. The calculator was tested with real data: it comes with ideal staffing requirements that would not be economically viable in a state-based health care system in the EU27. The EU-REST study authors suggest that this tool should be explored in terms of utility.

- The IAEA provided guidance on quality through the publication of the QUANUM document (Quality Management in Nuclear Medicine; version 3.0, 2021).
- Based on Eurostat data, there is a clear increase in the availability of PET/CT across Europe, while the numbers of SPECT/CT systems are either stable or slightly declining (mainly in high income countries) but the link between the workload, quality and workforce has not been established.
- Based on Eurostat data, there is a tremendous variation across the EU27, extended to EU Council Member States.
- No publication reports the adequacy between the actual workforce and utilisation of NM techniques, except for the prospective Turkish document, which gives a forecast of needs in 2023.
- The EANM has recently founded the Women's Empowerment initiative, to improve the participation of women in NM. This initiative is very recent, and it remains unclear to what extent it may influence the gender balance of NM physicians.
- In a commentary in the Journal of Nuclear Medicine in 2011, it was reported that 18% of board-certified NM Physicians declared that they had been unable to find a NM job. These concerns need to be addressed in the near future in Europe, to avoid a decline in the number of specialists to hire, at the time as considerable progress is ongoing in the specialty, namely the expansion of PET/CT or PET/MR, and the blockbuster of radioligand therapies.

## Medical Physicists

- In 2014 the workforce availability for radiotherapy (RT) services in Europe was studied by HERO. They found a large variability of the number of MPE per million inhabitants in the different European countries, ranging from 0 to 19.7 with a mean of 7.6 MPE/million. IAEA and EFOMP also ran a survey in 2016 focusing on MPE in the four areas RT, Diagnostic and Interventional radiology (RD), Nuclear Medicine (NM) and Radiation Protection (RP). They found similar numbers in RT as the ones provided by HERO, a mean of 9.6 and a range of 3.8 to 22 MPE per million. For NM the mean was 2.6 (0.3-6.9), RD 5 (0.1-25) and RP 1.8 (0-5). They recommend a minimum of 9 MPE for RT, 2 for NM, 5 for RD and 2 for RP per million population.

- The EFOMP Policy Statement 7.1 issued in 2016 presents guidelines for the roles, responsibilities and status of the medical physicist together with recommended minimum staffing levels. These recommendations address the growing demands for competence, patient safety, specialisation and cost effectiveness of modern healthcare services. They also align with the requirements of the European Union Council Directive 2013/59/Euratom laying down the basic safety standards for protection against the dangers arising from exposure to ionising radiation as well as the European Commission's Radiation Protection Report No. 174: ''Guidelines on medical physics expert", and relevant IAEA publications. The guidelines offer general recommendations for the assessment of the full time equivalent (FTE) number of experienced medical physicists/MPEs required to provide services to radiotherapy, nuclear medicine and diagnostic & interventional radiology. This assessment takes into account factors such as equipment load, number of patients treated, treatment complexity and involvement of medical physicists/MPEs in training, department management, clinical studies, consultation and results interpretation. Both the factors and their corresponding weights are based on EU report No 174. The EFOMP guidelines clearly state that the staffing recommendations refer to experienced Medical Physics Experts in the specialities of radiotherapy, diagnostic and interventional radiology, nuclear medicine, and occupational/ public radiation protection to at least EQF level 8.
- The IAEA Human Health Reports No. 15 provides a set of robust algorithms to estimate the numbers of the required medical physics experts and medical physics staff based on their roles and responsibilities as they arise from the requirements of good practice, as highlighted in international guidelines. The algorithm takes into account six categories related to equipment, patients, radiation protection, service, training and academic teaching and research. Input variables include factors such as the number of equipment units, number of patient procedures performed per year, etc. Each variable is assigned a weight factor for the computation of the required number of medical physicists as follows:

$$Number\ of\ medical\ physicists = \left( \sum_{x=1}^{6} \sum_{i} w_i n_i \right) \varepsilon$$

With x=1…6 representing the six categories, wi and ni are the weights and values for the different variables and ε is an efficiency factor described in the document. The report includes detailed tables of the different variables for each of the six categories for the medical physicists in radiotherapy, in diagnostic and interventional radiology and nuclear medicine. However, it does not provide any recommendation regarding the gender-profile mix or age-profile mix of the staff.

- Spain, through its national scientific societies (SEFM and SEPR) and Nuclear Safety Authority (CIEMAT) in 2016 monitored the numbers of MPE working in the different areas (RT, NM, RAD and RP) and have proposed a methodology to calculate the workforce needed taking into consideration the number of hours to perform the tasks allocated to MPE in each of the areas taking into consideration training, research, procurement of equipment, management tasks and leaves. As there is no public national registry of MPE, the workforce was collected by a national survey in 2016.
- The French society of Medical Physicists developed an algorithm to evaluate the medical physics staffing requirements, considering several elements such as:
    - scope of activity of the department, including its organisation and management
    - number and complexity of the equipment and procedures used
    - number of patients cared for and the complexity of their treatments
    - involvement in training and teaching
    - level of participation in research and development
    - level of training, experience and skills of the personnel
- In 2002, IPEM issued a Policy Statement with recommendations for the provision of a Physics Service in Radiotherapy, which was reviewed in 2017. They propose a grid model that accounts for the number and complexity of used equipment, the number of patients treated and the complexity of the treatments and departmental working arrangements (including radiation protection, accredited quality systems and clinical trial support). The Policy Statement also provides tables to calculate the total FTE staff needed.
- AAPM developed a demand and supply dynamic model to estimate the needs of MPE workforce in RT where the projection of cancer incidence together with the projection of retirements in the years to come was considered. For the calculations they used 400 patients/MPE as suggested by the IAEA, acknowledging that this might not apply for modern situations. Another important point is that in different countries the support by RTTs and other personnel may be different, and this fact will impact on the number of MPE needed.

The Diagnostic Demand and Supply projection working group published a report7 in 2022, which estimated the size of the clinical medical imaging physics workforce in the USA, which in 2019 consisted of approximately 1794 physicists supporting diagnostic X-ray (1073 board-certified) and 934 physicists supporting nuclear medicine (460 board-certified), with a number of individuals practicing in both subfields. There were an estimated 235 physicists supporting nuclear medicine exclusively (150 board-certified). The estimated total workforce, accounting for overlap, was 2029 MPs. These estimates are broadly consistent with findings from other published studies on segments of the workforce.

- The American College of Radiology (ACR) developed a workload-driven staffing grid methodology to estimate the FTE requirements to meet the full spectrum of medical physics activities including administrative, regulatory, educational, developmental, and technical demands. Their detailed grid example is for a large academic facility, but the methodology can be extended to a non-academic setting and to a smaller scale. The grid is easily adaptable when changes to the clinical environment occur, such as an increase in IMRT or IGRT applications.
- The American Society for Radiation Oncology (ASTRO) Comprehensive Workforce Study including age and gender distribution, educational background, workload, and primary work setting was issued in 2012.
- The Canadian Organization of Medical Physicists (COMP) updated the staffing algorithm based on a grid of FTE coefficients for each type of staff functioning as a team providing medical physics services in a radiation treatment programme. They report a table of FTE weighting coefficients for clinical procedures and clinical equipment components of the Ontario-2021 staffing algorithm.
- The Asia-Oceania Federation of Organizations for Medical Physics (AFOMP) proposed in 2010 a calculation scheme to aid in estimating medical physics staffing requirements in RO that is primarily based on equipment levels and patient numbers but also with allowances for staff training, professional development, management/administration tasks, research/clinical projects and leave requirements.
- The literature search revealed that several references reported a shortage of MPEs in radiology and nuclear medicine in the USA and highlighted the need for updated workforce projections.

[7] Rose et al. journal of applied clinical medical physics volume 23:7 2022

## Radiation Therapists (RTTs)

- In terms of the benchmarking method used to match workforce numbers to workload (activity and equipment availability), the ESTRO-HERO study found that 20 of 27 countries indicated the number of RTTs per linear accelerator ranging from 2–6, 4 countries defined the numbers on annual patients or treatment delivered per RTT. 14 of 25 countries based equipment levels on population and 13 of 25 national guidelines were based on the number of patients/treatment courses. In 14 countries the number of linear accelerator guidelines depend on the number of patients, treatment or fractions with 7 being explicit.
- The EORTC recommends more than 2 RTTs per treatment unit.
- The IAEA recommendations are quite specific and based on equipment levels – RTT supervisor: 1 per centre, RTT: 2 per megavoltage unity up to 25 patients treated daily, 4 per megavoltage unit up to 50 patients treated daily, 2 for 500 patients simulated annually, brachytherapy as necessary. The IAEA recommends 100-150 patients per year per RTT.
- Need for increasing advanced practice roles for RTTs in the context of new developments relating to Artificial Intelligence and changing practice.
- A paper from Turkey discussing current status and future perspectives in radiation oncology facilities stated that they currently graduate 110 RTTs per year, but given the increasing numbers of linear accelerators the requirement is 1400.
- Two Canadian papers stated a staffing level of 1.1 FTEs per linear accelerator hours and 66 courses per RTT FTE per year with their staffing models including time for other non-clinical duties such as administration, quality and safety and education. It is recommended to review staffing models on a regular basis to reflect changes in technology and practice. A paper from Australia based staffing numbers of an 8-hour day with a range of RTTs per linear accelerator operating between 1.3 and 1.39 with smaller centres requiring higher numbers of RTTs. They also included additional roles and responsibilities.
- One paper from Canada defined the workload as the number of courses of radiation therapy delivered per year at each centre, divided by the number of FTE RTTs at that centre or courses per FTE. All FTEs were normalised to 1950 hours per year, the most common number of hours worked by RTTs per year in the survey. Within the survey a range of staffing models was used to determining staffing levels including number of patient visits, number of linear accelerators, previous year's staffing and availability of operating funds. Numbers were higher where more non-clinical (pre-treatment and treatment related) tasks were included,

this included RTTs working in education research, advanced practice, and support.

- The recommendation of the model adopted in Ontario was 11 RTTs per linear accelerator for a 10-hour working day. Details of the roles and responsibilities of staff in the five domains of practice are provided in this paper and will be useful in drawing up the guidelines.
- Three RT staffing models described allocating staff depending on the number of linear accelerators in the department. One Australian study used the Total Quality Culture (TQC) model which allowed for more autonomy for RTTs giving improved patient safety and increased RTT work satisfaction. An Indonesian study used the Markov model to estimate staffing across the hospital setting which addresses the problem of trying to provide for a growing population something that is relevant for radiotherapy in the future. Another paper discussed the use of skill mix to address staff shortages.
- One paper stated that the male/female ratio for RTTs was 10%-90% and a paper on the introduction of 12-hour shifts for RTTs showed no difference between genders and no difference for women with children, either, which might have been expected. No paper discussed an age-profile recommendation.

## Radiographers

- The identified ‘European Society guidelines considered the future needs of the profession across medical imaging, nuclear medicine, and radiotherapy; the need for advanced practice to enhance services, provide career progression opportunities, and increase job satisfaction. In addition, one of these documents focuses on the need for adequate skills mix, consideration for service design, and for the roles and responsibilities of radiotherapy radiographers / radiation therapists.
- For the sources identified at a national level in Europe, all but one related to the UK. Across these sources, a range of topics are discussed including skills mix across care pathways, staffing levels, the workplace environment, equipment availability, changing roles, workforce planning, service delivery models, clinical governance, the impact of education and training, quality management, and clinical audit on developing the workforce.
- Opportunities for skills mix and advanced practice feature strongly across sources and are clearly viewed at the European and UK levels as vital to the future of medical imaging, nuclear medicine, and radiotherapy service provision.

- At UK level, issues of retention of radiographers and opportunities, or lack thereof, for career progression, are considered. Challenging working patterns, lack of flexibility in working terms and conditions, lack of timely career progression, financial, logistical, and political barriers to workforce and service evaluation, the slow development of enhanced skills mix, and the need for cultural change, with the attitudes and opinions of radiologists about radiographers cited.
- The Northern Ireland Department of Health AHP Workforce Review Report for Diagnostic Radiographers specified the need for two radiographers to be working per CT or MRI scanner with just one at a time required per general X-ray room or ultrasound room; numbers for other areas are not specified.
- In the Netherlands the situation appears to be more positive: the increase in patient numbers presenting for radiotherapy is met by a proportional growth in equipment and workforce availability. Importantly, the need for expansion of existing departments is highlighted, facilitating more rapid introduction of new technologies and sufficient subspecialisation of staff.
- Need for national registers for the radiographer workforce.
- Consideration on the number of current FTE versus service needs, including per capita considerations.
- Need for the gender and age mix of the workforce.
- Future workforce needs including new skills and associated education and training demand.
- The essential nature of clinical audit and quality management in terms of staffing and workforce.

## 2.4. Development of staffing and education/training guidelines

Author: Francis Zarb

The Staffing and Education/Training Guidelines for key professional groups involved in ensuring radiation safety and quality in medical radiation applications were developed by six author groups representing the relevant professions within the EU-REST study. The draft guidelines were submitted for review to the Peer Review Group (PRG) and the Advisory Board (AB) as well as to the stakeholders identified for the study.

The primary objective of the guidelines is to delineate the minimum requirements for staffing and education/training across all 27 EU Member

States. They are intended to serve as a foundational reference for countries and institutions to enhance their specific practices as necessary.

The guidelines for the various professional groups adhere (as far as possible) to a standardised approach, while considering the specificities of the medical procedures and staff responsibilities involved.

The guidelines are founded on the following three pillars:

i. Existing Practice across the 27 EU Member States

- Each professional group endeavoured to identify consistencies and uniformity in current reasonably good practices based on available data, including survey results and literature review.
- Acknowledging the paucity of literature in this domain, the establishment of these guidelines was grounded in evidence-based research and evidence-based practices whenever possible.

ii. Recommendations

- Recommendations were formulated to promote safe and correct practices while reflecting minimum requirements.
- These recommendations are substantiated by authoritative literature, established guidelines, evidence-based research, or consensus papers, where available.

iii. Improvements

- Any necessary changes or improvements, identified as evident and required, are supported by data derived from the aforementioned sources and agreed upon by all consortium partners.

### 2.4.1 Staffing guidelines

The staffing guidelines were meticulously prepared by writing group members representing each discipline and profession, acknowledging the significant variation in practices both between and within disciplines concerning the roles and responsibilities of individual professionals. The foundation of these guidelines lies in the findings of the survey conducted among professional organisations, national societies, government agencies, and regulators (see Section 2.1), coupled with a comprehensive literature review of national, EU, and international staffing guidelines. These sources provided a basis for determining optimum staffing levels relative to the activities performed.

The guidelines consider factors such as the level of available equipment, anticipated workload, and the complexities of the practices undertaken.

Regardless of the size or complexity of the institution, an essential methodology for calculating the minimum number of staff required for each profession within each discipline has been established as a baseline. Additional staffing requirements can be determined using the outlined methods, taking into account factors such as increasing complexity of work, workload, equipment levels, and the introduction of new roles and responsibilities, as identified in the survey results and recommended by the literature.

The primary objective was to offer guidelines on methodologies for calculating staffing needs, applicable to both current practices and future expansions of services or new roles. This approach ensures the long-term applicability and relevance of the project outputs.

### 2.4.2 Education and training guidelines

It is recognised that a common core of knowledge regarding radiation safety is essential for all professionals, and this core should be grounded in the requirements of the Basic Safety Standards Directive (BSSD).

Article 18 of the BSSD states: “Member States shall ensure that practitioners and the individuals involved in the practical aspects of medical radiological procedures have adequate education, information, and theoretical and practical training for the purpose of medical radiological practices, as well as relevant competence in radiation protection.” This article also emphasises the necessity for recognition of qualifications and the need for continuing education. In addition, Article 59 of the BSSD requires that Member States ensure that training and recognition requirements are met for practitioners, medical physics experts and delegated individuals, while Article 79 requires Member States to ensure that arrangements are in place for recognition of, *inter alia*, medical physics experts and radiation protection experts, and the continuity of expertise of their services.

Article 14 of the BSSD further mandates: “Member States shall establish an adequate legislative and administrative framework ensuring the provision of appropriate radiation protection education, training, and information to all individuals whose tasks require specific competences in radiation protection.”

Based on the data collected, the current status of education and training in radiology, radiotherapy, nuclear medicine, and medical physics, as well as the professionals involved in each discipline, was assessed. Recognising the importance of a common core of knowledge in radiation safety for all professionals, the guidelines propose content to meet this fundamental requirement.

Subsequently, the specific education and training requirements for radiology, radiotherapy, nuclear medicine, and medical physics, along with the professional groups involved in their delivery, were considered. Each discipline had an additional core of knowledge defined, followed by the specific requirements for each professional group to ensure optimal and safe practice.

Moreover, the guidelines account for the impact of new technologies and techniques, increasing workload, the integration of new treatment approaches, and innovations on current and future practices. These factors are reflected in the guidelines produced.

Training requirements encompass not only radiation protection but also the general training necessary for each profession.

A summary of the staffing and education/training guidelines is provided in Section 4 below. The entire guidelines are provided in Annex 5.

## 2.5. Benchmarking of staffing and education/training guidelines

Author: Francis Zarb

The aim of this part of the EU-REST study was to benchmark the data collected through the Main Survey, to inform the project recommendations, against the EU-REST guidelines as well as data from the literature review. The benchmarking was performed by the relevant professional groups, who referred to guidelines derived from the outcome of the systematic review during the development of the relevant guidelines and stakeholder consultations. As the data obtained through the survey as well as the literature on appropriate staffing was very limited, benchmarking was only possible to a limited extent. This relative absence of existing standards or guidelines, however, constituted an important finding and corroborates the study’s recommendation for each EU Member State to maintain a central registry of health professionals involved in the use of ionising radiation.

## 2.6 Stakeholder consultation

### 2.6.1 Stakeholder consultation on draft guidelines

Author: François Jamar

The project initially foresaw three stakeholder consultations, the first one aiming to identify the professions for which the staffing and education/training guidelines should be established as well as regarding the elements to be covered by such guidelines. As it turned out that sufficient information had already been gained in this regard, and considering the general survey fatigue among stakeholders, the plan to send out such survey was abandoned.

The first implemented stakeholder consultation ran from 3 November until 7 December 2023. It aimed to seek the EU Member States' views on the usefulness of the EU-REST draft staffing and education/training guidelines in their respective national context, as well as to gain feedback on the needs for further European staffing and education/training guidelines and support for education/training of medical professionals in quality and safety of medical radiation applications. This feedback was used to inform the EU-REST study's conclusions and recommendations.

The questionnaire was implemented in the Survey Monkey tool and included:

- questions on the usefulness and applicability of the proposed staffing and education/training guidelines in the stakeholders' national context for their relevant profession,
- questions on the need for formally adopted European staffing and education/training guidelines (potentially based on those proposed through the EU-REST study) and if so, in which areas, and
- questions on the need for, and type of, additional support for education/training of medical professionals in quality and safety of medical radiation applications, including CPD.
- Further questions related to details of the staffing as well as the education/training guidelines.
- Free text comments were allowed for additional remarks on the guidelines and the topic in general.

Incomplete answers addressing less than the first part – staffing guidelines – were removed from the analysis. Considering 73 responses included in the analysis plus an extensive comment sent by a stakeholder via email, the response rate was 39%.

## Results

The main outcomes of the stakeholder consultation on the draft staffing guidelines are summarised below:

- 59% of the respondents considered the draft staffing guidelines as very useful. None of the respondents considered the staffing guidelines as not useful. Other answer options were: "moderately useful", "marginally useful", and "other, please specify".

- 56% considered the proposed staffing guidelines realistic and applicable in their country, 30% did not consider them applicable and 14% replied they did not know.
- Political framework/government related barriers and financial issues were the major perceived or expected barriers to implementation of the staffing guidelines. Concrete suggestions on how to overcome barriers to implement the proposed staffing guidelines as well as on how to introduce the proposed staffing guidelines in the respondents' countries were collected through free-text comment fields.
- 72% of the respondents saw a need for formally adopted European staffing guidelines (potentially based on those proposed through the EU-REST study), 3% did not and 25% did not know.
- 70% saw a need for regular revision of such guidelines (most of the respondents were in favour of every >5-10 years), while 11% did not consider this necessary.

The main outcomes of the stakeholder consultation on the draft education and training guidelines are summarised below:

- 61% of the respondents considered the proposed education and training guidelines useful for their national context and profession. None of the respondents considered them not useful. Other answer options were: "moderately useful", "marginally useful", and "other, please specify".
- 83% of respondents considered the content as appropriate, 7% as too wide, 0% as too narrow, and 10% did not know.
- 81% considered the proposed length of training for their relevant profession as appropriate.
- 69% considered the guidelines as realistic and applicable in their country, 10% did not, and 21% did not know.
- Political framework/government-related as well as financial issues and staff motivation were the most-cited perceived or possible barriers to implementation of the education/training guidelines.
- Concrete suggestions on how to overcome barriers to implement the proposed education/training guidelines as well as on how to introduce the proposed staffing guidelines in the respondents' country were collected through free-text comments.
- 75% saw a need for formally adopted European education and training guidelines (potentially based on those proposed through the EU-REST study). 6% did not see such a need, and 20% did not know.

- 83% saw the need for regular revision of such guidelines (most of them every >5-10 years), while 1% did not consider this necessary.
- 77% of respondents saw a need for additional support for education/training of medical professionals in quality and safety of medical radiation applications, including continuing professional development. Most of them saw a need for financial support and support in terms of accessibility.

The comments provided by stakeholders were addressed, as appropriate, by the relevant guideline author groups of the EU-REST consortium.

### 2.6.2 Stakeholder consultation on project conclusions and recommendations

Author: Csilla Pesznyak

The objective of the stakeholder consultation Step 3 was to seek comments on the content of the draft project conclusions and recommendations (see Section 2.7), by consulting the stakeholders as identified and explained in Section 2.2 above.

For this purpose, the draft project conclusions and recommendations were sent together with a SurveyMonkey questionnaire consisting of 26 questions in total, including multiple choice questions (one answer possible), checkboxes (multiple responses possible) and comment fields. Free-text comments were passed on to the relevant authors (professional groups) to be considered for the preparation of the final Report on project conclusions and recommendations.

The survey period was from 14 May until 6 June 2024. Based on 175 stakeholders whom the questionnaire was sent to, and 70 responses considered for analysis, the response rate was 40%.

#### Results

The draft project conclusions and recommendations received overall positive evaluations. In addition to a high degree of agreement regarding the proposed recommendations, several critical comments helped improve the document. The percentages indicated in the following paragraphs for the most striking answers are rounded to whole numbers.

## Central registries:

85% of the respondents strongly agreed that each EU Member State should maintain a central registry for each professional group, including the number of professionals and, if possible, number of full-time equivalents. None of the respondents strongly disagreed. Other reply options were “somewhat agree”, “somewhat disagree” and “don’t know”.

Further questions related to the elements of the central registries such as age (71% strongly agreed), gender (35% strongly agreed), qualifications (83% strongly agreed) and equipment (55% strongly agreed that this should be included in the central registries).

45% of the respondents expected barriers to implementing a national registry in their country, no matter whether they would support this idea or not. 38% did not expect any barriers and 17% did not know.

In terms of elements of the central register that could meet barriers, information on equipment was stated by 77% of those respondents who generally expected barriers to implementing a national registry in their country, appropriate qualifications needed for inclusion in the registry and for licensing for independent practice (47%), gender of professionals (40%) and age profile of professionals (26%).

81% of those respondents who expected barriers to implementing a national registry in their country indicated financial/human resources related barriers. 60% expected political framework/government related barriers, 42% staff motivation, and 30% expected accessibility related barriers.

## Continuing Professional Development (CPD)

74% of the respondents strongly agreed that mandated CPD should include, in addition to radiation protection and safety issues already covered by the BSSD, techniques and knowledge relevant to each professional group, beyond radiation protection issues. 1.45% strongly disagreed. Other answer options were “somewhat agree”, “somewhat disagree” and “don’t know”.

54% of the respondents expected barriers to implementing the requirement for CPD beyond radiation protection issues for their profession in their country, no matter whether they would support this idea or not. 23% did not expect any barriers and another 23% did not know.

67% of those who expected related barriers or did not know saw financial/human resource related issues as barriers to implementing the requirement for CPD. 57% expected political framework/government related barriers and 46% mentioned staff motivation.

### Adoption vs adaptation

64% of the respondents strongly agreed that adoption of recommendations by all Member States in a uniform manner would likely be more beneficial than adaptation of the recommendations and that adoption should be the goal of the study and the European Commission. 1.45% strongly disagreed. Other answer options were “somewhat agree”, “somewhat disagree” and “don’t know”.

### Assessment of staffing guidelines

Approx. 72% of the respondents considered the proposed recommendations on staffing for the profession they were answering for as appropriate. Approx. 4% found them too detailed, 7% considered them incomplete and 16% did not know.

### Assessment of education and training guidelines

Approx. 91% considered the recommendations on education and training for their profession as appropriate. 1.45% considered them incomplete and 7% did not know. None of the respondents considered the education/training recommendations as too detailed.

### Major adaptations based on the consultation

Following the comments from some stakeholders regarding apparent ambiguities and uncertainties arising from RTT- separate from radiography sections, a paragraph has been included in the Project conclusions and recommendations listing the professional groups considered in the EU-REST study, acknowledging the different viewpoints and resulting ambiguities, and stating that resolving the matter is beyond the scope of the study.

### Challenges and limitations of proposed recommendations

The challenges of setting up central registries, e.g., in terms of resources, were pointed out. While the study members acknowledge these, they still believe such registries would be appropriate and, therefore, recommend them.

It was also suggested by a respondent to harmonise the level of detail of the recommendations for the professions. However, priority was given to addressing the key issues of each profession. Due to the diversity of professional groups involved in the project, a "one size fits all" approach to the recommendations and guidelines was not suitable or achievable.

## 2.7 Project conclusions and recommendations

Author: Adrian Brady

The objective of this particular element of the EU-REST study was to formulate project recommendations with respect to:

1. further European staffing and education/training guidelines, and
2. the needs for national and European support for education/training of medical professionals in quality and safety of medical radiation applications.

Draft conclusions and recommendations were subjected to stakeholder consultation, and modified/updated in response to issues raised, to arrive at the final conclusions and recommendations summarised in Sections 4 and 5 (and reported in detail in the ‘Report on project conclusions and recommendations’, which is attached as Annex 6 to this Final report).

# 3. Data collection and analysis

Authors: Dimitris Visvikis, Graciano Paulo

This section provides a summary of the data collection and analysis process. Details can be found in the Final report on data collection and analysis (Annex 4).

The Main Survey was implemented in English in the SurveyMonkey tool. It was divided into four sections related to

- education and training (including CPD/Continuing Education)
- workforce availability
- workforce planning
- quality and safety

and consisted of 457 questions in total. The survey was distributed to the

- different national organisations and competent authorities from the database established through the Pre-Survey as mentioned in Section 2.1
- EU27 national professional societies for Radiology/Nuclear Medicine/Radiotherapy/ Radiography/Medical Physics through ESR, EANM, ESTRO, EFRS and EFOMP
- EU27 national radiation protection authorities through HERCA
- EU27 national medical associations/chambers through UEMS.

At the end of this process a total of 186 responses of various levels of completeness were received. Out of the final number of responses for all medical specialties (84), 45.1% (38) were received from radiologists, 37% (31) from radiation oncologists and 17.9% (15) from nuclear medicine physicians. In terms of the other professional categories, the responses received corresponded to 15% for radiographers, 7% for RTTs and 35% for medical physicists/MPEs. In terms of data collection, the large majority of responses came from national professional / scientific societies rather than national authorities, most probably reflecting the fact that national professional societies have more up-to-date registers of the workforce in the different categories evaluated in this study. In terms of responses from medical doctor specialties, the lowest number of responses (14/27 EU countries) was received from nuclear medicine physicians, which is most probably a result of the different practices currently in place in the different Member States concerning the field of nuclear medicine. The largest proportion of responses among clinical specialities was provided by radiologists (23/27 EU countries). In terms of professionals other than those in medical specialties, medical physicists'/Medical Physics Experts' (MPE) responses were received from all EU27 countries apart from Luxembourg, which was up until recently not a member of EFOMP. In terms of radiographers, responses were received from 21 out of 27 EU countries. Finally, responses from RTTs were received only from 7 countries given that this subspecialty is not independent from radiographers in most EU27 countries. Therefore, although in certain professional categories a limited number of responses have been received, these reduced numbers mostly reflect the large diversity of practices within the different EU Member States in certain professional categories targeted by this survey. Details can be found in Tables 5 (before cleaning process) and 6 (after the cleaning process) of the Final Report on Data Collection and Analysis (see Annex 4).

According to the results of the survey, there are approximately 255,000 health professionals directly involved in the use of ionising radiation in Europe, with DE, IT and FR having the highest numbers of them, in line with the fact that they also have larger populations. However, although IT has a lower population compared to FR, it has a higher number of health professionals (45,691 vs 41,436). Radiographers are by far the largest group (67%), followed by Radiologists (24%), Medical Physicists/MPEs (4%), Radiation Oncologists (3%) and Nuclear Medicine Physicians (2%) (see Fig. 15, Annex 4). Results clearly demonstrate that for both workforce availability and corresponding education and training, there is huge heterogeneity between Member States and professions, which will obviously have an impact on healthcare delivery and the level of knowledge, skills and competences in radiation protection.

Concerning the medical specialties:

- For radiologists, the number of professionals per million inhabitants varies from 51 (Bulgaria) to 270 (Sweden), with the EU average being 127. This variation may be due to country specific practices in terms of private or public practice, teleradiology services, and/or hybrid (Nuclear Medicine) imaging.
- For Radiation Oncologists/Clinical Oncologists, the number of professionals per million inhabitants varies between 3 (Greece) and 41 (Finland), with the EU average being 19. This heterogeneity might be related to the fact that clinical oncologists also deliver systemic anti-cancer therapies while in some countries there are other medical oncologists that provide the systemic therapies.
- For Nuclear Medicine physicians, the number of professionals per million inhabitants ranges from 2 (Ireland) to 36 (Belgium) with the EU average being 13. This heterogeneity might be related to the fact that in some countries, the role of Nuclear Medicine Physicians is fulfilled by other health professionals (e.g. Radiologists).

- Although medical speciality training in Europe is (to some extent) harmonised, education and training (E&T) in radiation protection (RP) shows large variations (from less than 2 weeks to 24 weeks). (*While the answers provided to this question relate to the specific amount of time dedicated to radiation protection training, it is accepted that training in radiation protection is embedded throughout training, beyond specific modules. Nonetheless, this concerning variation in the dedicated training time allocated to radiation protection has led to a project outcome recommendation of the establishment of a minimum amount of practical radiation protection training for all relevant professional groups*.)

For the other professional categories:

- For Radiographers and RTT's, the number of professionals per million inhabitants varies from 86 (Belgium) to 613 (Finland) with the EU average being 385. This huge heterogeneity was already known, as several studies have related that fact, since in some countries the E&T was only established recently and therefore other professionals took over the Radiographer/RTT role. The duration of the E&T programme is very diverse (from 2 to 4 years) and in some countries (ES, DE) the programmes are not included in the higher education system. The Radiographer/RTT's E&T in RP varies from less than 2 to 52 weeks. In most of the countries specific certification in RP is required, CPD in RP is mandatory.
- For Medical Physicists, the number of professionals per million of inhabitants varies from 4 (Lithuania) to 43 (Sweden) with the EU average being 21. This huge heterogeneity was already known from other EU projects, due to the fact that there is a lack of Medical Physicists particularly in Diagnostic imaging. The Medical Physicist speciality training in Europe is very heterogeneous (from 1 to 5 years) and the same applies to E&T in RP (from less than 2 to more than 52 weeks). One of the reasons for this heterogeneity is the existence of different levels in some countries: a basic level, known as Medical Physicist, and a more advanced level, called Medical Physics Expert. In most of the countries specific certification in RP is required, but the answers to the question "if CPD in RP is mandatory" were scarce and therefore not possible to analyse.

# 4. Staffing and education/training guidelines for key professional groups

Author: Mary Coffey

The guidelines presented have been developed by each professional group based on the findings of a literature review, the survey results, existing guidelines, and recommendations of professional organisations, reflecting additional professional knowledge and expertise. In addition, the guidelines take into account the level of equipment currently available, technological developments, current and expected workload and the increasing complexities of practices as they impact on roles and responsibilities and therefore on staffing and education/training requirements to ensure workforce sustainability for the future.

The importance of establishing national registers of professionals was identified as a key factor in maintaining a sustainable workforce providing a baseline for staffing calculations. The register also would take account of the ageing workforce consistent across all healthcare workers, supporting the future requirements of education/training. Maintaining professional competence through continuing professional development (CPD), a requirement of the BSSD, is an essential component in providing quality and safe care for patients.

Staffing and Education/Training guidelines have been developed for each profession and are summarised below. Full details of the findings and analysis can be found in the Guideline document in Annex 5.

## 4.1 Radiologists

### 4.1.1 Radiologists' staffing

Measuring how much work is done by a radiologist, and calculating a radiologist's appropriate workload, are far-from-simple tasks. Many efforts have been made in the past to define reproducible, accurate and scalable methods, including definition of workforce needs related to the number of inhabitants, number of machines, number of beds and more. Additional attempts included different concepts of introducing and defining radiology value units to compare the workforce needs related to different radiological examinations. Calculating workload for radiologists is complex and varied reflecting the size and type of practice where they are based. Historically, staffing requirements were often based on the number of imaging reports issued per annum, with crude study numbers of between 10,000 – 20,000, used as a benchmark. This type of approach has not been applicable for many years, given increasing complexity of diagnostic imaging procedures, and the wide variation in time required to report studies varying in complexity from single-view plain radiographs to multiphase CT or multi-parametric MRI. Additionally, no existing methodology reflected the current level of involvement of radiologists in the multi-disciplinary care of patients, which has emphasised radiologists' clinical input and role in promoting health and wellbeing, and optimising outcomes for patients and the value provided both to individual patients and society in general: the value-based radiology concept.

The survey described above in 2.1, and the literature review described above in 2.3 failed to identify any existing usable guidelines. The lack of stable data / standards about the number of examinations needed per population, the number of pieces of equipment needed per population, and/or the appropriate per-radiologist reporting output as well as the huge variation regarding the number of radiologists among European countries supported the need to define a new, rather simplified approach for staffing needs in Europe (explained in detail in the EU-REST Staffing and Education/Training guidelines attached to this final report as Annex 5), based on calculable denominators which can be generalised across many countries and practice styles.

In preparing the final guidelines a number of possible methods for calculating appropriate workforce numbers were considered, together with an analysis of their pros and cons. These included:

- Population-based which, whilst applicable to all countries and types of practice, was considered a crude method which did not consider age-profile, variation in complexity and evolution of practice over time, time frame of population consensus data and the education/training requirements.
- Workload-based which, if standardisation of measurement of workload could be achieved at EU level, would be a valid method, but currently does not exist. This approach also does not reflect local working conditions, variations in practice including radiologist expertise and infrastructure availability.
- Equipment- or bed-availability was not considered to be a reliable measure. Whilst it does allow for consideration of the variation in level of service offered, and can reflect changing staffing requirements with equipment availability, the number and type of equipment available does not reflect variation in practice and utilisation, Radiology provides both an in- and out-patient service with wide variation in the performance status of patients using the service, thus negating the use of bed numbers in defining staffing requirements.

The guidelines also needed to reflect the increasing demand for imaging, the ageing patient population across the EU, and variations in working conditions and scope of practice, including the impact of Artificial Intelligence.

Taking all of the above into consideration, it was proposed to develop a new, rather simplified guideline for staffing needs in Europe, using an **hour of machine/system/activity** as the basic unit. This basic unit would be multiplied by the running hours for the specific imaging system or activity to calculate staffing requirements for current practice. The proposed concept can be easily adapted in case of changed working times, changed case mix, and new methods/procedures, and can also reflect specific requirements in the teaching and research setting. This basic unit can also be used in settings such as interventional radiology, taking into account the type of intervention, the clinical setting and room time and change-over period, and the attendance at multidisciplinary team meetings.

A basic unit defined by hour of machine/system/activity which is multiplied by a specific conversion factor was defined for each Radiological modality (i.e. MR, CT, Interventional Radiology, etc.). The derived number can be multiplied by the working hours of the respective machine, to indicate the number of radiologists required to deliver the necessary service. For better understanding, the approach to Interventional Radiological procedures is presented here as example (further worked examples can be found in Annex 5):

*The basic unit as described above in Interventional Radiology refers to the room-time of the patients. One hour IR ($HR_{IR}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour room-time for a patient. The conversion factor applied for Interventional Radiology was estimated to be 1.5. Consequently, one hour IR ($HR_{IR}$) requires 1.5 working hours of a board-certified interventional radiologist who is capable and licensed to work independently. This formula contains provision for involvement of the Interventional Radiologist in patient preparation, case discussion, material selection, patient aftercare, and more.*

The following table provides a simplified overview of the principle of the calculation proposed in these guidelines for each radiological modality, and also for preparation for and participation in multidisciplinary team meetings (MDTs). These formulae are dedicated to routine in-hour service. For on-call and/or out-of-hour services different calculations, with additional requirements depending on the specific practice model, are needed. The calculations are based on 50 weeks of normal operation per year, excluding holiday periods.

## Staffing calculation – radiologists:

### Table 2 – Staffing calculation method: Radiologists

| Teaching setting yes / no | Basic unit | Conversion factor | Radiology service | Practice examples |
|---|---|---|---|---|
| | one hour room-time of the patients | **1.5** | **Interventional Radiology** | For example TIPSS: procedure time = 60–120 min. room time of the patient = 120–180 min. need for the interventionalist = 3–4.5 hours.<br><br>IR service = **5** days a week / **8** hours' patient room time = **2000** hours per year.<br>Based on our estimation **3000** hours should be covered.<br>Doctors working 40 hours per week, for 40 weeks a year = 1600 hours = **2 IR specialists** being able to work independently and unsupervised are required to cover the 3000 hours. |
| yes | one hour room-time of the patients | **1.5 + 1.0** | **Interventional Radiology** | 1.5 hr board certified + 1.0 hr resident |
| | | | | |
| | one hour room time of the MR unit | **1.5** | **Magnetic Resonance** | MR service = **5** days a week / **12** hours' patient room time = **3000** hours per year. Based on our estimation **4500** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **3 Board certified Radiologists** being able to work independently and unsupervised are required to cover the 4500 hours. |
| yes | one hour room time of the MR unit | **1.0 + 1.5** | **Magnetic Resonance** | 1.0 hr board certified + 1.5 hr resident |
| | | | | |

| Teaching setting yes / no | Basic unit | Conversion factor | Radiology service | Practice examples |
|---|---|---|---|---|
| | one hour room time of the CT unit | **1.5** | **Computed Tomography** | CT service = **5** days a week / **12** hours' patient room time = **3000** hours per year. Based on our estimation **4500** hours should be covered.<br>Doctors working 40 hours per week, for 40 weeks a year = **3** Board certified Radiologists being able to work independently and unsupervised are required to cover the 4500 hours. |
| yes | one hour room time of the CT unit | **1.0 + 1.5** | **Computed Tomography** | 1.0 hr board certified + 1.5 hr resident |
| | | | | |
| | one hour room time of the patients | **1.5** | **Interventional CT** | Interventional CT service = **5** days a week / **4** hours' patient room time = **1000** hours per year.<br>Based on our estimation **1500** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **1** Board certified Radiologists being able to work independently and unsupervised are required to cover the 1500 hours. |
| yes | one hour room time of the patients | **1.5 + 1.5** | **Interventional CT** | 1.5 hr board certified + 1.5 hr resident |
| | | | | |
| | one hour room time of the PET unit | **1.5** | **PET CT*** | PET service = **5** days a week / **12** hours' patient room time = **3000** hours per year. Based on our estimation **4500** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **3** Board certified Radiologists being able to work independently and unsupervised are required to cover the 4500 hours. |
| yes | one hour room time of the PET unit | **1.0 + 1.5** | **PET CT*** | 1.0 hr board certified + 1.5 hr resident |
| | | | | |

| Teaching setting yes / no | Basic unit | Conversion factor | Radiology service | Practice examples |
|---|---|---|---|---|
| | one hour running time of the respective X-Ray unit. | **0.5** | **X-Ray** | X-Ray service = **5** days a week / **8** hours' patient room time = **2000** hours per year. Based on our estimation **1000** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **less than 1** Board certified Radiologists being able to work independently and unsupervised are required to cover the 1000 hours. |
| yes | one hour running time of the respective X-Ray unit. | **0.5 + 0.5** | **X-Ray** | 0.5 hr board certified + 0.5 hr resident |
| | | | | |
| | one hour running time of the respective Fluoro unit | **1.0** | **Fluoro** | Fluoro service = **5** days a week / **4** hours' patient room time = **1000** hours per year. Based on our estimation **1000** hours should be covered Doctors working 40 hours per week, for 40 weeks a year = **0.625** Board certified Radiologists being able to work independently and unsupervised are required to cover the 1000 hours. |
| yes | one hour running time of the respective Fluoro unit | **1.0 + 1.0** | **Fluoro** | 1.0 hr board certified + 1.0 hr resident |
| | | | | |
| | one hour time of patient service | **1.0** | **Sono** | Sono service = **5** days a week / **8** hours' patient room time = **2000** hours per year. Based on our estimation **2000** hours should be covered Doctors working 40 hours per week, for 40 weeks a year = **1.25** Board certified Radiologists being able to work independently and unsupervised are required to cover the 2000 hours. |
| yes | one hour time of patient service | **1.0 + 1.0** | **Sono** | 1.0 hr board certified + 1.0 hr resident |
| | | | | |

| Teaching setting yes / no | Basic unit | Conversion factor | Radiology service | Practice examples |
|---|---|---|---|---|
| | one hour MDT-meeting time | **3.0** | **Multi-disciplinary team conference** | As example: **5 MDT** meetings per week = 2 hours each = 10 hours MDT per week = **500** hours per year.<br>Based on our estimation **1500** hours should be covered Doctors working 40 hours per week for 40 weeks a year = **1** board-certified radiologist being able to work independently and unsupervised is required to cover the 1500 hours. |

*Note: The EU-REST study has aimed to define education and training standards and appropriate workforce numbers for all relevant professional groups in all 27 EU Member States, trying to take account of the varying practices in different countries. As hybrid imaging practice varies across Europe, with PET/CT being performed/interpreted either by Nuclear Medicine Physicians or by Radiologists or by members of both specialties working collaboratively, staffing recommendations for PET/CT have been developed by both EANM and ESR experts as part of this study. Thus, depending on the practice in their specific setting, stakeholders can consult the recommendations of the respective specialty.

The staffing calculator in the table below can be downloaded using this link[8] and used by centres to define their current and future staffing requirements, depending on local working hours/days and other local variations.

**Table 3 – Staffing calculator for radiologists**

| modality | N° rooms / machines | room hours per day | room hours per week | room hours per year | staff needed | |
|---|---|---|---|---|---|---|
| IR | | | 0 | 0 | 0,0 | |
| MR | | | 0 | 0 | 0,0 | |
| CT | | | 0 | 0 | 0,0 | |
| I-CT | | | 0 | 0 | 0,0 | |
| XR | | | 0 | 0 | 0,0 | |
| Fluoro | | | 0 | 0 | 0,0 | |
| Sono | | | 0 | 0 | 0,0 | |
| MDT | | | 0 | 0 | 0,0 | |
| | | | | | | |

Using this simplified approach, if service hours are increased (e.g. expanding an 8-hours-per-day service to one provided for 12 hours per day), or the number of machines/rooms used to deliver a service increases, the staffing requirement can be very simply recalculated. Different workforce needs depending on varying case mix will be addressed by the calculation method

[8] https://www.eurosafeimaging.org/eu-rest/radiology-staffing-calculator

proposed. The concept of using conversion / multiplying factors provides the opportunity for adoption and continuous changes in the fast-evolving current practice of Radiology. Possible shifts in workforce needs due to the possible implementation of AI tools could be easily incorporated in the calculation of staffing needs based on the method provided.

### 4.1.2 Radiologists' education and training

These guidelines have been developed based on the recommendations of the European Society of Radiology (ESR) as defined in the European Training Curriculum (ETC) Levels 1-3, supported by expert opinion. The recommendations have been supported by 38 national radiology societies and numerous subspecialty radiology societies.

1. **Harmonisation of duration and content of training within the EU member countries**

A specialty training programme lasting 5 years, supported by continuing professional development, has already become a generally accepted European standard, and should be established in all countries. The EU Professional Qualifications Directive, which still recommends a minimum training period of 4 years, should be adapted accordingly.

The European Training Curriculum (ETC), as devised and continually updated by the European Society of Radiology (ESR), in cooperation with the relevant radiology subspecialty societies, should be established as a European-wide standard for radiology education and training. The comprehensive content of the ETC has been defined by the ESR in collaboration with all individual radiology subspecialities, and is continuously updated to ensure future competency-based requirements and practice complexity are supported. The ETC is consistent with the majority of current medically based curricula, and is structured according to required knowledge, skills, competences, and attitudes.

Any radiology education programme should define a minimum number of cases and procedures to be reported and/or performed in each subspecialty. Volume-based competency and a realistic case mix are important components. To ensure the acquisition of knowledge, skills and competences, a minimum number of ECTS (European Credit Transfer System – hours of teaching) should be defined.

A minimum requirement should be established for a combination of ECTS and practical training in radiation protection, safety and quality management within the ETC; this should be used in all EU member countries.

## 2. Harmonisation of training structure within the EU member countries

Coordinated and standardised Fellowship programmes after the end of the regular residency training should be established. Such Fellowships should generally last 1 year. Curricula for training in radiology subspecialties should be based on a combination of ETC Level III and specific subspecialty society sponsored curricula.

A minimum requirement should be established within these programmes for a combination of ECTs and case/procedure numbers for each subspecialty, based on the ETC; this should be used in all EU member countries.

## 3. Harmonisation of certification of completion of training within EU member countries

Achievement of the volume-based standard outlined in point 1 above is not, within and of itself, a sufficiently robust parameter to determine competence. Certification of completion of education currently varies across EU Member States, with some countries having formal certification following an examination, others determining competence following dialogue among colleagues, and other countries defining completion of training based on fulfilling a required length of time spent in training (3-5 years). The European Board of Radiology (EBR) has established the European Diploma in Radiology (EDiR), achieved by success in a formal standardised examination, taken after completion of formal time-based training; this diploma is fully endorsed by the UEMS and ESR and this formal certification has been recognised in several countries.

It is recommended that:

a. formal completion of training in radiology be marked by a harmonised and standardised examination in all European countries.

b. the European Diploma in Radiology (EDiR) be promoted as equivalent to the national or specialty examination in radiology or – in countries without such specialty examination – the EDiR should be established as a requirement for certification of completion of training.

c. In those countries which already have established examinations which must be passed to complete training, local evaluation of equivalence with the EDiR may be helpful to ensure harmonisation of standards.

## 4. Clear acknowledgement of trainees in workforce calculation

Trainees must be taken into account while calculating workforce needs, from both the trainee and trainer perspectives. Significant time and effort on behalf of both is required to bring the trainees to the necessary standard at graduation and should be integrated into workload calculations as discussed in the staffing guidelines. Teaching is time-consuming (on the part of the teacher); conversely, trainees can deal with some parts of routine work and can contribute positively to department outputs. With increasing trainee experience, less time investment by the teacher is required. In the interventional setting, however, continuous presence of the fully qualified radiologist (teacher) is needed.

### 5. Harmonisation of training centre evaluation within EU member countries

It is also essential that the quality of the experience gained by trainee radiologists is standardised and of an acceptable standard across training sites and countries. Quality assessment of training programmes and of clinical centres where training takes place is necessary and should be consistent with the European Training Assessment Programme (ETAP - a joint initiative of the European Board of Radiology - EBR and the European Union of Medical Specialists - UEMS Section of Radiology) standards.

The recommendation would be to establish the ETAP certificate as a prerequisite for training centre accreditation in Europe.

### 6. Harmonisation of continuous professional development

Continuous professional development is essential to ensure skills and competences are maintained and further developed to meet the requirements of future practice and should be mandated.

The recommendations are:

a. to establish the EACCME as the European currency for CME credits, and to accept these credits in all countries as proof for continuous medical education.

b. to establish a minimum number of CME credits which need to be obtained in a defined period of time to prove continuous medical education, and to use this number in all European countries.

## 4.2 Nuclear Medicine Physicians

### 4.2.1 Nuclear Medicine Physicians' staffing

Defining the workforce and needs for nuclear medicine (NM) physicians across the EU27 is a difficult if not impossible task.

There are several reasons for this:

- Firstly, the status of NM is very diverse across Europe, depending on equipment availability, sustainable delivery of radiopharmaceuticals, quality assurance programmes, development of new technologies and treatments etc.

- Secondly, the Internal Growth Product (IGP) varies considerably across the EU27 and the proportion of it dedicated to healthcare as well. In addition, the part of healthcare provision dedicated to NM is highly variable.
- Thirdly, due to huge differences in training and education, expertise varies across countries.
- Fourthly, the definition of NM as a separate specialty also varies across the EU27, with specialists in some countries being either pure NM physicians, combined internists and NM physicians, nuclear radiologists or, in Scandinavia, even clinical physiologists with competence in NM.
- Finally, the issues of radiation protection, although based on the Council Directive 2013/59/Euratom (BSSD), were translated into national law in different ways, leading to differences, e.g., in the way recently implemented treatments are dealt with as far as radiation protection measures are concerned.
- NM is rapidly evolving, and the staffing needs will undoubtedly change, with growing indications of hybrid imaging and the recent explosion of radionuclide therapy, especially using radioligands.

Three options for staffing guidelines (EU-wide, national and local), were considered, with the first two considered not to be possible given the large divergence of practice and professional status. Data from IAEA, UNSCEAR, OECD and EUROSTAT based on data from Member States, are also summarised in the report, but are incomplete, and not totally consistent. The IAEA document "A model to assess staffing needs in Nuclear Medicine" considers the needs for small, medium and large size departments, and for university and non-university-based settings, acknowledging the different needs in a range of settings. This comprehensive document covers 5 objectives:

1. determining adequate staffing levels
2. determining optimal staff deployment
3. justifying needs
4. assessing system risks and identifying quality improvements and
5. improving personnel effectiveness.

The report has an associated secure web-based system on their International Research Integration System (IRIS) platform for the **calculation of staffing needs depending on the activities and infrastructure of a particular department** (see Figure 5 *Steps used in the IAEA tool to assess staffing needs in nuclear medicine* in Annex 5). Following data entry, the tool automatically calculates the required professional staff for the specific practice considered.

The model is based on a standard workload of 1640 hours annually but does not account for any local variation.

Staffing needs should encompass not only performing NM procedures as such but also other tasks that are intrinsically part of the profession, i.e. teaching and training, in academic or non-academic centres, clinical research and development, as well as the expanding active participation in multidisciplinary consultations, especially in oncological care.

The practice of nuclear medicine requires a team approach, and the calculation of FTEs should be based on each clinical activity and the time requirement of each involved professional. At an institution/department level, calculating the staffing needs can be performed using the IAEA table establishing *"Weights assigned to attending Nuclear Medicine physicians"*. This table presents the number of time units (each of 15 minutes) for various procedures in NM according to their complexity and involvement of the physician. This IAEA table takes already into account the most recent developments in the specialty, such as hybrid PET imaging (with CT or MRI) and radioligand therapy. Considering the rapid development of the latter, it is most likely that the workload for NM physicians will significantly increase in the coming years, requiring more FTEs and hence a call for more physicians to choose NM as a specialty after graduation as Medical Doctors.

For the purposes of this report only the weighting for the nuclear medicine physician is considered whilst acknowledging that the weighting for nurses for certain therapy procedures such as 177Lu]-labelled peptides for neuroendocrine tumours can be six times higher (see example in the EU-REST Guidelines, Annex 5, 2.2.3). The table below shows the adapted weighting for nuclear medicine physicians for specific procedures. This table, however, does not take into account the necessary involvement of other professionals, such as dual-trained radiologists or anaesthetists for example, and also the additional aspects of clinical practice including patient and team communication and case discussion, quality assurance practices and education/training.

The table below shows the weights assigned to attending nuclear medicine physicians (adapted from the IAEA list).

**Table 4 – Weights assigned to attending NM physicians**

| Type of procedure | Number of time units |
|---|---|
| **Single Photon procedures** | |
| Cardiovascular | 5 |
| Endocrine | 3 |
| Gastrointestinal | 1 |
| Genitourinary | 2 |
| Oncology | 2 |
| Neurology | 2 |
| Pulmonary | 2 |
| Skeletal | 3 |
| Consultation | 2 |
| Multidisciplinary consultations* | 4 |
| **PET, PET-CT and PET-MR**** | |
| Oncology | 6 |
| Cardiac | 6 |
| Neurology | 6 |
| **Therapy** | |
| Thyroid benign | 6 |
| Thyroid malignant | 14 |
| Bone palliation | 6 |
| Neuroendocrine tumours | 24 |
| Radiosynovectomy | 2 |
| Prostate cancer (PSMA) | 24 |
| Selective internal radiation therapy (SIRS) | 10 |

*Added to the IAEA's list [10]
** Adapted from the IAEA list [10]

Note: The EU-REST study has aimed to define education and training standards and appropriate workforce numbers for all relevant professional groups in all 27 EU Member States, trying to take account of the varying practices in different countries. As hybrid imaging practice varies across Europe, with PET/CT being performed/interpreted either by Nuclear Medicine Physicians or by Radiologists or by members of both specialties working collaboratively, staffing recommendations for PET/CT have been developed by both EANM and ESR experts as part of this study. Thus, depending on the practice in their specific setting, stakeholders can consult the recommendations of the respective specialty.

Whilst it is acknowledged that the IAEA model has limitations relating to type of practice and procedures carried out, it can serve as a basis until a more robust model can be developed. The calculation of nuclear medicine physician staffing requirements must take local infrastructure and practices into account.

The recommendation is to use the available sources (IAEA, OECD, EUROSTAT or UNSCEAR) as a basis for **building a robust EU27 Member State registry**, able to identify current and potential future shortages, as well as other parameters including age, gender, European or extra-European mobility, issues related to mutual recognition of diplomas/titles in EU27 etc.

It is recommended that the IAEA’s **IRIS tool be confronted with actual data** to evaluate its reliability in terms of resources, at local level, i.e., individual institutions, as a potential separate follow-up action upon completion of the EU-REST study.

### 4.2.2 Nuclear Medicine Physicians’ education

There are very considerable differences in the professional recognition, education/training, duration and qualification of nuclear medicine physicians across the 27 Member States crating major challenges that need to be overcome in the future.  Two documents were identified that provided guidance with respect to education/training: Training requirements for the speciality of Nuclear Medicine (UEMS – revision October 2023) where the EU 27 Member States are represented and the IAEA TECDOC series no. 1883 Training curriculum for Nuclear Medicine Physicians aimed at the international profession.  There is a variation in the recommended duration of an education programme between the two documents but with a convergence relative to content.

It is recommended that the period of training should be a minimum of four but **preferably five calendar years.**

The curriculum must include clinical training, theoretical education as well as qualification in radiation protection that will guarantee the safe use of radioactive materials (which are specific to professionals working in nuclear medicine) for both the patient and staff. It is recommended to follow the UEMS syllabus. The nuclear medicine physician will also need to be able to interpret hybrid imaging and to be able to integrate NM imaging with other radiological examinations.

**Content of the training**

a) Theory

   All NM trainees should undergo a basic theoretical curriculum that should account for 20-30 ECTS. This education is divided into two sections, i.e., scientific principles and clinical applications.

b) Clinical applications

Clinical training (of at least one year) should cover as many disciplines as possible, to the extent of what is available in the relevant country. The content of the training is detailed in the IAEA and UEMS documents (see EU-REST

D11). The content is described both qualitatively (type of procedures) and quantitatively (number of procedures). In toto, this represents an average of ~3,000 documented procedures. It is advised that **the performed procedures be registered on a continuous basis, in an electronic format (training log), so that the supervisor and the trainee can regularly**, e.g., on a 6-month basis, **monitor progression and the way objectives are reached.** This can also be shared with a representative of the accreditation body, for online continuous evaluation. During the clinical training, the candidate should also actively take part in oncological multidisciplinary consultations and develop communication skills.

**At least 100 therapeutic procedures** should be performed during the entire curriculum and should be as diverse as possible, combining benign diseases as well as outpatient and inpatient cancer patients.

To support future evidence-based practice, it is advised that the trainee be engaged in some research activity, including a presentation at a national or international conference or a publication in a peer-reviewed journal. Some countries may also require a thesis at the end of the training, based on literature analysis, methodological issues and personal research.

Finally, the importance of mandatory continuing professional development (CPD) and life-long learning should be emphasised.

### Assessment of the training and education programme

Currently, there is no uniform manner to evaluate the achievements of a trainee. Assessment of the education programme currently can be at local, national, sub-national or international level. All such options are acceptable, provided a similar level of knowledge and competency is achieved. This document does not intend to propose a top-down solution. Nevertheless, some criteria have to be enforced to qualify a medical doctor as an NM specialist. The main competences are:

- Basic knowledge of theoretical background, including radiation protection issues.
- Advanced knowledge of clinical in vivo imaging procedures, such as described in the UEMS and IAEA documentation.
- Advanced knowledge of therapeutic applications, at least those available in a particular EU27 country.

The best and simplest option is a nationally based evaluation, ideally through a commission of the Ministry of Health that will eventually grant the certification. Separately, certification for Radiation Protection (RP) should be issued by the competent authority. The EU-REST study consortium recommends that both should be given at the same time, by a common commission dealing with competencies in the specialty but also the relevant competencies in RP.

#### Body for certification

The body for certification should be centralised within each of the EU27 countries and ideally be the responsibility of the Member State's Ministry of Health. Where this is not possible, a centralised certification can be sought, such as through the EANM/UEMS/EBNM training end exam (https://uems.eanm.org/fellowship-examination/).

#### Accreditation of trainers and training centres

The training centre shall be chosen amongst those that are able to offer the widest operating workforce and range of activities. This does not mean that all activities must be available there, but partnerships may exist or be established with other centres for additional training. The accreditation of training centres and those responsible shall be validated by a centralised body.

The **main recommendations** are:

- Nuclear medicine societies (EANM in coordination with national societies) to establish a knowledgeable status of the current curriculum for the specialty of NM.
- UEMS, national societies and national regulators to collaborate on harmonising the curriculum amongst the EU27, taking into consideration differences in equipment and IGP between the Member States.
- Professional societies to support clinical centres in organising practical cross-country mobility in order to give all medical doctors in the EU27 equal access to the specialty of NM.

## 4.3 Radiation Oncologists

### 4.3.1 Radiation Oncologists' staffing

The calculation of staffing needs depends on the activities and infrastructure of a particular department.

Radiotherapy requires a team approach and recommendations from the main professional organisations such as ESTRO, ASTRO and the IAEA are to use an activity-based model for calculating staffing requirements, allowing for greater flexibility in matching specific skill sets with activity in the context of future practice.

Whereas all radiation oncologists are educated/trained in radiotherapy, in some countries they are also licensed to prescribe systemic anti-cancer therapies, with clinical oncology being the recognised speciality. This creates difficulty when estimating workload indicators for radiation oncology alone. There is also a very wide range of equipment availability and techniques in different clinical settings, resulting in divergent levels of complexity and associated radiation oncologist input. Practice and therefore staffing requirements in a small centre are very different to those in a large academic setting.

In published literature and existing radiation oncologist staffing guidelines, the main indicator is the number of patients treated by a radiation oncologist annually. This approach, whilst simple to apply, does not reflect the additional requirements resulting from new technology such as the MR-linac, Proton units and more complex techniques including SBRT, IORT and adaptive radiotherapy with, at the same time, radiotherapy moving away from routine procedures and towards individualised or personalised treatment approaches. Future application integrating tumour biology into treatment will further add to the complexity. Radiation Oncologists are now spending a larger percentage of time at multidisciplinary meetings (ensuring optimum integration of radiotherapy into the patient treatment pathway) and in non-radiotherapy activities included administration, teaching and research. Based on these factors most reports agree that an approach based on simple number of patients per radiation oncologist can only provide a very rough estimate of staffing requirements and cannot be relied upon to ensure quality and safe practice.

In defining the number of patients per radiation oncologist three European reports were considered: ESTRO-QUARTS (updated in ESTRO-HERO) and the European Organisation into Research and Treatment of Cancer (EORTC) relating to activity in clinical trials. Five national reports were considered (UK, Italy, France, Hungary and Spain) and seven international reports from four organisations/professional societies (the IAEA, USA-ACR, USA-ASTRO & RANZCR) and three national reports (Pakistan, Japan and Korea). The national reports represented countries who had developed their own guidelines and those who had adapted the ESTRO-HERO or IAEA approach to meet their local situation. Detailed tables of the results are given in the appendices.

Staffing recommendations of many European countries range between 130–300 patients per radiation oncologist per year. The IAEA recommends 200-250 patients per radiation oncologist, with no more than 25–30 patients under treatment by a single radiation oncologist at any one time.

The recommendation of the EU-REST Consortium is that 200 patients per radiation oncologist be used as the main benchmark with modification of this number based on the criteria defined below.

- Annual number of patients treated per radiation oncologist.
- Type of the department (service hospital/training institute, hospital located/standalone centre).
- Patient status and treatment intent
- Treatments used in the department (IMRT, SBRT, SRS, brachytherapy, IORT, TBI, TSEI, paediatric treatments, chemotherapy administration, etc.).
- Teaching and training activities.
- Part-time employment of radiation oncologists.
- Administrative tasks.
- Geographical distribution.

The impact of these parameters and the level of change on the benchmark number of 200 patients should be calculated at national, regional and department level. We suggest considering a separate European project and a task force to estimate the impact of these parameters on staffing levels and to update staffing estimations regularly.

Additionally, updated staffing guidelines including recent radiotherapy techniques such as online adaptive radiotherapy and stereotactic radiotherapy, and also taking into account possible impacts from Artificial Intelligence (AI) are needed.

### 4.3.2 Radiation Oncologists' education/training guidelines

The ESTRO 4th edition of the core curriculum is recommended and has received wide support from the clinical oncology and radiation oncology community reflecting differing practice across the Eu 27 countries, has been endorsed by 29 National Societies and adopted as the European Training Requirement (ETR) for Radiation Oncology/Radiotherapy by the UEMS. A duration of 5 years' training is recommended, with both academic and clinical components (at least 80% of the time needs to be spent in a clinical environment).

Currently there is no standardisation of licensing to practise as a radiation oncologist. Licensing should be based on an objective assessment of the completion of a training programme that complies with national guidelines.

Institutes where education/training is sited should undergo regular inspection and accreditation to ensure trainees are exposed to a wide range of current technology and techniques, pathology services, imaging and clinical genetics. It is recommended that a programme director is in place together with medical, physics and radiobiology teaching staff. Research is key to ensure future competence and to contribute to evidence-based practice in the future. Regular audit of teaching programmes and clinical training centres is necessary to ensure a consistent standard across education programmes. Trainees should maintain a learning portfolio for the duration of training to ensure competency in all aspects of practice and to demonstrate progress throughout the duration of the programme.

Detail of curriculum content, a list of infrastructure that training institutes should have in place, and guiding principles for assessment of training centres are provided in the Staffing and education/training guidelines (Annex 5).

## 4.4 Medical Physicists / Medical Physics Experts

### 4.4.1 Medical Physicists/Medical Physics Experts' staffing

Medical physicists have a critical role in ensuring the safe and effective use of ionising radiation for diagnosis and treatment. They are responsible for the protection of patients, staff and the public in the medical use of ionising radiation. In the diagnostic setting the medical physicist contributes to the quality control and calibration of diagnostic imaging equipment, the monitoring of radiation doses and image quality and to the optimisation of diagnostic and/or interventional procedures. In addition, in the nuclear medicine setting, they contribute to patient dosimetry in metabolic therapy. Medical physicists are also involved in research and education and consultation in multidisciplinary team meetings. Given the complexity of practice and the depth of knowledge required the EC defined the Medical Physics Expert (MPE) in 2013/59/EURATOM governing the safe use of radiation in medicine. In some settings the medical physics expert also functions as the radiation protection expert and where these functions are carried out by different staff members close liaison between them is essential. Despite this legal requirement there is still a shortage of MPEs in some countries, reflecting a lack of standardisation in radiation protection practice across the Member States. These recommendations, therefore, aim to advance in the harmonisation of quality and safety standards for the use of ionising radiation in medical practices across Europe, aligning with European directives and reflect on staffing levels of medical physicists necessary to achieve this.

According to the EU-REST survey, with data from 26 out of 27 Member States, there is an average of 21 MPEs (or professions in charge of the MPE's duties) per million inhabitants in Europe (see Annex 4: Report on data collection and analysis, Figure 13).

A significant percentage of medical physicists were in the over 50+ age category, also underpinning the need for increasing education/training to sustain staffing levels for the future.

An analysis of the literature on European and international guidelines for workforce have informed the recommendations made in this report on the factors to consider when estimating the medical physicists staffing requirements. This includes the EFOMP Policy Statement 7.1 published in 2016 which presents guidelines for the roles, responsibilities, and status of the MPE, together with recommended minimum staffing levels. This report includes the mathematical formulation used to estimate the numbers of FTE MPEs which can be summarised as:

$$Full\ time\ equivalent\ MPE = N_{sum}\,\varepsilon = \left(\textstyle\sum_0^6 N_x\right)\varepsilon$$

where $N_1$ to $N_6$ are the estimated numbers of FTE medical physics experts required for each of the following six factors:

1. equipment-dependent
2. patient-dependent
3. radiation protection-related
4. service-related
5. training-related
6. academic teaching and research-related

Factor ε compensates for the efficiency of scale for small or large clinics. Detailed explanations of the use of the mathematical formulation are given in the appendices.

An example of factors to estimate the $N_x$ of full-time equivalents for MPEs in radiotherapy as published by EFOMP[9] and based on the European Commission RP 174 guidelines on MPEs[11] is provided below:

[9] Evans, Christofides and Brambilla. The European Federation of Organisations for Medical Physics. Policy Statement No. 7.1: The roles, responsibilities and status of the medical physicist including the criteria for the staffing levels in a Medical Physics Department approved by EFOMP Council on 5th February 2016. Physica Medica 32 (2016): 533. http://dx.doi.org/10.1016/j.ejmp.2016.03.001

**Table 5 – Example of factors to estimate the no. of FTEs of MPEs in radiotherapy**

| Subjects | MPE full time equivalent |
|---|---|
| *Equipment dependent factors per item* | |
| Linear accelerator (multi-mode) (per unit) | 0.6 |
| Linear accelerator (single-mode)/cobalt (per unit) | 0.2 |
| Major items | 0.2 |
| Minor items | 0.1 |
| Other items | 0.05 |
| *Patient dependent factors* | |
| Conventional (2D) external beam radiotherapy (per 100 procedures) | 0.05 |
| 3D conformal radiotherapy (per 100 procedures) | 0.2 |
| Special techniques (per 100 procedures) | 0.4 |
| Brachytherapy (per 100 procedures) | 0.4 |

Based on the evidence from the EU-REST study, and seeking a harmonisation of quality and safety standards across Europe, in accordance with the requirements of the 2013/59/EURATOM Directive, the study consortium makes the following recommendations on factors relating to staffing calculations.

7. The latest published recommendation by EFOMP (currently the policy statement 7.1)9 in agreement with international recommendations should be adopted as the reference document for comparison on staffing levels.

8. Medical physics departments may include other professionals such as dosimetrists or medical physics assistants and engineers working under the supervision of MPEs. If this is the case, the staffing guidelines should include these resources as a factor to be taken into account in the total time needed to develop the different activities.

9. These algorithms to calculate the FTEs of MPEs included in the EFOMP recommendation[9] should be revised at least every five years depending on changes in technology and practice. In particular, the impact on workforce of aspects such as hadron radiotherapy, the emergence of dose management systems in diagnostic and interventional radiology and the increasing workload in advanced radionuclide therapy should be evaluated by scientific societies and updated if needed.

The EU-REST study authors further propose the following additional recommendations to Member States and national and European scientific organisations relating to professional recognition, roles and responsibilities.

1. The medical physics expert, with level 8 in the European qualification framework, is the qualified professional to assume the competences in radiation physics applied to medical exposures, in accordance with

the 2013/59/EURATOM directive10 and the European Commission guidelines for medical physics experts, radiation protection no. 17411. Member states shall consider this profession in the assessment of the workforce.

2. The MPE as defined in the Directive 2013/59 shall be the professional to supervise and assume the responsibilities of the Radiation Protection activities in hospitals, including patients, working staff, members of the public and visitors to the hospitals. The MPE shall, where appropriate, liaise with the radiation protection expert (RPE). The RPE in hospital settings should be an MPE, since medical physicists have the highest level of radiation physics knowledge and training.
3. Member states should have a registry of their active MPEs, managed by the competent authority and updated at least on a yearly basis, including information on age, gender, and the main field of practice (radiotherapy, diagnostic & interventional radiology, nuclear medicine), for proper planning of future workforce needs and for the promotion of gender equality in the profession. Coordination with national scientific societies is recommended to achieve this objective.
4. A common training and recognition scheme for medical physics experts should be established to facilitate their mutual recognition across Europe, in order to foster professional mobility and knowledge sharing for new technologies between Member States.

### 4.4.2 Medical Physicists/Medical Physics Experts' education/training

EFOMP published the core curriculum for the medical physicist expert (MPE) in radiotherapy together with ESTRO in 2021, for the MPE in nuclear medicine together with EANM in 2013, and for the MPE in diagnostic and interventional radiology with ESR in 201112. These curricula align with the European Commission guidelines on MPE RP 17411, but also extend beyond these guidelines to provide comprehensive education and training for Medical Physics Experts as the sole profession to practice independently in the field of medical physics. Two of the curricula are currently under revision.

[10]COUNCIL DIRECTIVE 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom

[11]European Commission (2014). European guidelines for medical physics experts. Radiation protection 174. doi: 10.2833/18393.

[12] https://www.efomp.org/index.php?r=fc&id=core-curricula (accessed on 5 August 2024)

There are still countries where no education/training for medical physicists is in place, and there is a wide variation in duration of programmes in countries where education has been established. Since 2019, EFOMP has promoted the approval of training and registration schemes of its National Member Organisations in Europe. As a result of the EFOMP campaign, in August 2024 41% of the EU members have obtained approval for their training and registration schemes following the European Commission and EFOMP recommendations. In spite of the tremendous progress made in the last years, there is still much work to do in Europe to harmonise the level of education and training at European level and the recognition of MPE as a health profession. EFOMP together with ESTRO, EANM, and ESR are investigating the possibility of developing a “single combined Core Curriculum for all three MPE specialties” once the CCs for MPE in Nuclear Medicine and in Radiology will be revised. In this way, the total length of the training for MPE in the three disciplines can be clearly defined.

## Recommendations

1. In accordance with the Directive 2013/59/Euratom, to practise independently in the field of medical physics in Europe, the MPE accredited level (EQF8) should be achieved. All Member States should provide education and training programmes and registration schemes for this goal.
2. Member states should converge in their education and training programmes for MPEs, seeking the standardisation of the safety and quality standards in the medical practices involving ionising radiation at European level. The updated core curricula and pathways proposed by EFOMP (mentioned above) for MPEs should be the reference for the education and training programmes for the Member States, which could be summarised as follows:
    a. Minimum requirements to access the education and training for MPEs: a BSc degree predominantly in Physics plus an MSc degree in Physics or Medical Physics (BSc + MSc 300 ECTS, including in total at least 180 ECTS in Fundamental Physics and Mathematics).
    b. Education and training for MPEs: duration of at least 4 years to obtain the competences (CanMEDS roles) to become an independent specialist. Training in one or more subspecialties of Medical Physics should be available. The training must be conducted in a hospital/healthcare facility accredited by the competent authority. Training facility and quality of the MPE training should be regularly audited by the competent authority.

c. The MPE trainee must be appointed as a paid resident, with assigned duties under the supervision of a qualified MPE.

d. Continuing professional development (CPD) shall be compulsory as recommended by EFOMP.

e. Professionals should be registered before starting independent practice. The register should be managed by the national competent authority, which should coordinate this effort with the national scientific society.

3. A common core curriculum and career pathway for the profession of MPE encompassing all subspecialties is instrumental in harmonising MPE education and training standards across Europe. This approach ensures consistency in the competences required to become an MPE, thereby standardising quality and safety for the medical applications involving ionising radiation. Furthermore, this initiative streamlines the recognition of the MPE profession in EU Member States where it has yet to be formalised.

## 4.5 Radiographers

### 4.5.1 Radiographers' staffing

The European Federation of Radiographer Societies (EFRS) represents Radiographer Societies with members working in diagnostic imaging, radiotherapy and nuclear medicine. The Radiography profession continues to develop in line with changes in practice, providing new opportunities to radiographers to extend their scope of practice through new and advanced roles which improve patient outcomes, provide more effective and less invasive procedures for patients and increase the efficiency of delivery of radiography services.

Calculating the workload of a radiographer is complex. There are no agreed definitions for the number of imaging/therapy examinations and the number of pieces of imaging/therapy equipment required per population which might be used to calculate the workload for each radiographer. There are very few examples from countries of guidance on the optimal number of radiographers per modality area and these few examples lack consensus. This becomes increasingly complex with the changing roles of radiographers, who are taking on new extended and advanced roles in many countries, with the aim of improving radiography services and providing better patient-centred care.

These factors must be considered when calculating radiographer staffing requirements.

The literature review identified very limited numbers of publications discussing calculation of radiography staffing levels but highlighted the importance of advanced practice and career progression to sustain an effective workforce for the future. These aspects must be factored into the calculation for staffing requirements.

There is a wide variation across Europe of the number of radiographers licenced to work, relating in part to the fulfilment of the role by members of different professions in some countries who are not included in the EFRS, and therefore for whom data are not available.

In most countries the percentage of radiographers over 50 years of age is high, with implications for future practice.

To address the main challenge of establishing a practical guideline for the calculation of a Radiographer workforce, a **workload-based approach is being proposed.** This type of approach helps to ensure that the correct number of people with the right skills are in the right place at the right time and with the right attitude. It takes account of shift work and considers issues of cost.

Conventional methods to determine staffing requirements include calculating population-to-staff ratios (for example, X number of Radiographers per 10,000 population), recommended staff- modality numbers (e.g. two Radiographers per MRI scanner), facility-based staffing standards (for example, X number of Radiographers and Y number of health professionals for a health facility) or hierarchical staffing ratios (e.g. five radiographers per radiologist). Using this method however fails to consider the local demand for services, the current and evolving roles and responsibilities of radiographers and the availability of other professional members of the team. The increasing integration of AI must also be considered with its potential impact on future practice.

Based on these factors it was decided to use a radiographer staffing framework as proposed by Bam et al (2022). This is a workload-based approach consisting of 7 steps that determine the required number of FTE radiographers for each modality or group of modalities. Clinical and non-clinical activities and working conditions are considered. The seven steps in the process are:

1. Establishing the staffing purpose and focus
2. Collecting basic data
3. Determining available working time
4. Developing a task or activity list

5. Assigning an activity time and frequency of occurrence to each activity
6. Determining the (workload and) required FTEs
7. Analysing and interpreting the results.

A detailed explanation for each step can be found in Annex 5.

An extract from a worked example for mammography is given in the table below:

**Table 6 – Template for calculating workload per modality, calculated with an example for Mammography**

| Activity<br>It is important to identify and list each activity related to the modality, together with their associated frequency and mean time estimates | Clinical (C) or<br>Non-clinical (NC) | Activity frequency (AF)<br>(per annum) | Mean time estimate for examination<br>(MTE)<br>(hours) | Workload (hours)<br>= (AF x MTE) |
|---|---|---|---|---|
| Mammogram | C | 2542.8 | 0.359 | 912.865 |
| Monthly mammography staff meeting | NC | 12 | 1.042 | 12.504 |
| **Total workload for modality (∑) (hours per annum)** | | | | **925.369** |

Teleoperations represent an alternative practice model that may offer some patients better access to imaging and alternative working models for Radiographers. However, any procedure should be carried out by both trained and qualified remote and onsite Radiographers in close contact and communication with each other. Current national legislation must be followed and authorised personnel must not be replaced by unqualified professionals.

## Summary of Recommendations

1. To implement a workload-based approach to estimate staffing levels, following the process outlined above.
2. To implement a harmonised framework for the calculation of the Radiographer workforce across EU Member States.
3. To have this data published centrally by the EC, and additionally by relevant professional organisations, and widely publicised by interested parties, to facilitate a more comprehensive evaluation of the EU Radiographer workforce.
4. To implement comprehensive national registries for Radiographers across EU Member States.

5. To implement national structures for the annual review of workforce data in collaboration with education and training providers to facilitate planning.
6. To promote increased diversity in entry to the profession, through novel access routes / widening participation initiatives to train as a Radiographer and enter practice across EU Member States.
7. To recognise additional and emerging essential roles for Radiographers across EU Member States, inclusive of extended and advanced practice, together with emerging specialisms.
8. To implement initiatives to facilitate the advancement and development of the Radiographer workforce, to establish these roles with appropriate education, training, and governance structures.

### 4.5.2 Radiographers' education and training

Radiography education must reflect developments across professional practice. The EFRS represents radiographers working in the three disciplines: medical imaging, nuclear medicine and radiotherapy with some Member States incorporating the three disciplines within one education/training programme. Continuing professional development is essential in maintaining a competent workforce and research should be integral to all programmes to support evidence-based practice for the future. Patient safety and communication are key skills of professional practice and clinical placement is an essential component of any education programme. Diverse approaches to teaching and learning and alternative pathways into education are important to facilitate learners.

Duration of education programmes can range from 2 - 4 years depending on whether the qualification is in a single discipline or combined. Radiation protection is integral to the education/training and not specified independently. Quality management, quality improvement and safety additional to radiation protection are important components of an education programme. A BSc is recognised as an entry qualification to the profession.

**Recommendations**

- To implement diverse pathways into education and training programmes for radiographers in all EU Member States
- To ensure that opportunities exist for all aiming to train as radiographers to do so through the implementation of appropriate access programmes.

- To recognise EQF Level 6 (Bachelors) programmes of 180 ECTs as the minimum standard for entry to the profession in EU Member States.
- ensure that both dedicated programmes in medical imaging, nuclear medicine, or radiotherapy, together with programmes combining two or three of these branches of the profession, encompass all core theoretical content and clinical experiences for each branch, with clinical activities making up a minimum of 25% of the programme ECTs within recognised / approved training centres which are subject to regular audit.
- To establish diverse approaches to teaching, learning, and assessment which are practice-based and focused on true clinical scenarios, inclusive of appropriate clinical simulation activities to support and enhance traditional clinical education.
- To create programme structures which also facilitate completion on a part-time basis.
- To ensure student radiographers receive equal treatment as other healthcare students in terms of consideration for payments linked to their clinical training.
- To establish minimum required curricular content at European level related to radiation protection, quality management, safety, and related professional topics, for programmes across all Member States.
- To clearly identify the development of evidence-based practice and research skills throughout curricula.
- To ensure that mandatory CPD and the importance of life-long learning are recognised within programmes, and that opportunities exist for all radiographers to engage in such activity.
- To establish core curricula, which are evidence-based and aligned with recognised frameworks, fit for purpose, consider the future of the profession, and are reviewed regularly, at a national level.
- To implement national programme accreditation systems.
- To establish national certification / licensing requirements and systems for individuals completing accredited programmes with ongoing licensing requirements for professionals.
- To recognise the need for additional postgraduate education and training for radiographers undertaking specialist / expert roles.

Significant variability in the education and training of Radiographers for entry to the profession across Europe still exists. It is thus essential that data and metrics are regularly and uniformly collected (this could be done by national authorities and/or professional societies) at both the national / EU Member States and European levels, to facilitate more accurate monitoring of the varying approaches to education and training, encourage the harmonisation of aspects of education and training where appropriate, and better facilitate and promote the free movement of the Radiographer workforce across Europe to better balance workforce supply and demand.

## 4.6 Radiation Therapists (RTTs)

### 4.6.1 Radiation Therapists' staffing

These guidelines have been developed based largely on the literature review completed as part of drafting guidelines for staffing and education/training as well as from additional resources identified through professional organisations. The EU-REST survey results from the data collection and analysis were identified as being 'non-usable' by the work package leaders for the survey, due to the absence of available data, and therefore are not referred to in these guidelines.

Full details of the different models recommended by professional and/or national organisations, and the literature on which these recommendations are based, are given in Annex 5.

The recommendation given based on the findings of the review and on professional expert opinion should be an **activity-based model**. This approach has sufficient flexibility inbuilt to facilitate clinics with a range of equipment and practices in calculating the appropriate workforce for their setting and the number of radiation therapists necessary for quality and safe practice. It moves away from a defined task for each profession, and considers instead how activities in current and future practice can evolve depending on the skill-sets available, creating a safer and more-efficient and -effective service, opportunity for role development and career progression. The activity-based model encompasses clinical practice, research and innovation, quality and risk management, education and management.

As a starting point to ensure accurate and safe practice staffing levels can be calculated based on the following criteria:

- A radiation therapist must **never** work alone during treatment simulation and treatment delivery. A minimum of two radiation therapists is always required during these procedures.
- The number of full-time, part-time and locum/cover staff currently working

- Whether the department runs on single or multiple shifts which must include a time calculation to cover for staff breaks and shift crossover discussion.
- Scheduled maintenance, downtime and replacement need to be included as they will impact on treatment delivery and will require temporary introduction of additional working slots.
- Additional time and support for continuous professional development activities for radiation therapists must be factored into staffing levels.
- Dedicated radiation therapist management roles must also be considered in overall staffing levels.

In estimating staffing requirements at a local level two approaches are necessary:

1. The optimal number of radiation therapists necessary for accurate and safe practice
2. A detailed analysis of the current staff cohort. This will provide a baseline on which additional roles can be added as appropriate to practice.

The following areas of practice be considered when planning the Radiation Therapist workforce are proposed:

1. **Clinical Practice:** This includes Radiation Therapists working specifically in clinical roles on treatment units, simulation suites (CT, MRI, PET), treatment planning and brachytherapy as well as those working in advanced or consultant advanced practice roles. Consideration must be given to the ongoing development of staff with new technology such as Surface Guided Radiation Therapy (SGRT) as well as opportunities for release continuing professional development/education, a statutory body requirement in many jurisdictions and required for lifelong learning.
2. **Research and Innovation:** This includes Radiation Therapists in specific research or clinician-scientist roles, as well as those advanced and consultant Radiation Therapists where research is one of their pillars of practice.
3. **Quality and Risk Management:** Radiation Therapists can be specialists in these roles, and Radiation Therapists engaged in clinical practice play a vital role in quality management and quality improvement processes within radiation oncology departments. Accurate preparation and treatment delivery is central to quality and safety in ensuring the prescribed dose is delivered to the tumour with minimum dose to the surrounding tissues and organs at risk.  This is inherently quality and risk management as integral part of practice with the specialist role acting at a higher departmental

practice level. Practicing accurately and safety is also key in order to adhere to accreditation standards. Radiation Therapists play a significant part of internal audit processes and in updating standard operating procedures.

4. **Education:** Every Radiation Therapist is engaged in the education of student Radiation Therapists, and many are also engaged in the education of trainee Radiation Oncologists and other allied health professionals. In the majority of accredited training and education centres, there is typically at least one Radiation Therapist student per work area at any given time. Therefore, education constitutes a significant workload for Radiation Therapists every day. Radiation Therapists are also involved in educating patients and carers about the procedures and processes involved in the practice of radiation therapy daily. Calculating staffing requirements will also inform the student recruitment requirement to ensure continuity of service delivery.
5. **Management:** While there are dedicated managerial roles within each department, all Radiation Therapists have managerial duties within their own context, encompassing time and resource management as well as human resource management, be these more junior or student Radiation Therapists. Patient side effect management and supportive care provision, which is a mainstay of the profession of radiation therapy is often overlooked in workforce planning and patient throughput.
6. **Leadership:** Every Radiation Therapist has the capacity as a leader, within their own context. Leadership and Management should be separated as not all leaders are managers and not all managers are leaders. Radiation Therapists have the ability to act as role models for students, advocate for patients and the profession of radiation therapy and this is an important area within the profession that should be acknowledged.

Every department is unique in its size, workflow, and practices. To determine the workforce necessary for any individual department, the percentage time per area of practice above must be quantified along with specification of the working day in that department (e.g. 8 hour or 10 hour). Those calculating workforce numbers must be cognisant that Radiation Therapists never work alone in clinical duties for safety reasons. As per the literature, we recommend that an additional 20% FTE of the total calculated above is required to cover all Radiation Therapist leave.

### Forward planning

For consistency of service in the future and to inform education institutes of the potential future student intake the centre must also consider

- Equipment and any planned expansion

- Evolving staff roles and responsibilities as described previously.
- Attrition and retirements

### 4.6.2 Radiation Therapists' education and training

These guidelines have been developed based on the results of the EU-REST survey circulated as part of the data collection and analysis, but given the limited data collected in the survey, primarily on the literature review completed as part of drafting guidelines for staffing and education/training, the requirements relating to education and training in radiation protection as defined in European legislation and from additional resources identified through local, national, and international experience and professional recommendations. Currently the majority of education programmes available have minimal radiotherapy content. The ESTRO and the IAEA have recommended curricula and provide comprehensive detail on the education and training requirements for Radiation Therapists to ensure quality and safe practice and these form the basis for the education and training recommendations in this report.

**Recommendations**

- A dedicated education/training programme meeting the specific requirements for radiation therapists is essential for safe and accurate practice. Completion of second level education is a requirement and a programme duration of 3 years is recommended. Education should be sited in an academic setting with strong links to clinical departments.
- Clinical practice should be compulsory with 20-30% of the programme dedicated to as wide a clinical experience as possible.
- Radiation protection of patients, staff and the public should be integrated into the curricula and content should also reflect the wider concept of clinical radiation protection of patients undergoing radiotherapy.
- Academic and clinical assessment should be in place and education programmes should be competency-based.
- Academic and clinical sites should be accredited and audited regularly
- Radiation protection should be a core component of the education programme and should include knowledge of the existing legislation as it applies to patients, staff and the general public.
- Continuous radiotherapy-specific professional development should be supported.

- Detailed indicative education content is given in the EU-REST Staffing and education/training guidelines (see Annex 5) and the EU-REST Project conclusions and recommendations (see Annex 6).

## 4.7 Summarised overview of training curricula / guidelines per professional group

**Table 7 – Overview of training curricula/guidelines per professional group**

| Considered guidelines / recommended training curricula | Recommended min. training duration | Other |
|---|---|---|
| **Radiologists** | | |
| ESR European Training Curriculum for Radiology | 5 years | Dedicated workforce calculation model for the teaching situation is proposed |
| **Nuclear Medicine Physicians** | | |
| • Training requirements for the specialty of Nuclear Medicine, UEMS (2023)<br>• Training Curriculum for Nuclear Medicine Physicians, IAEA (2019) | minimum of 4 years, preferably 5 calendar years | harmonised certification across the EU-27 |
| **Radiation Oncologists** | | |
| ESTRO Core Curriculum (CC) for Radiation Oncologists/ Radiotherapists, 4th edition, 2019 | 5 years full time or an equivalent period of training, at least 80% of the time to be spent in a clinical environment | Every EU country has its own official regulations for the training of radiation oncologists, however, these regulations comply with the standards set by UEMS. |
| **Medical Physics Experts** | | |
| Core curricula published by EFOMP (in collaboration with ESR/EANM/ESTRO)<br>• Core curriculum for Medical Physics Experts (MPE) in Radiotherapy (2022)<br>• Curriculum for education and training of Medical Physicists in Nuclear Medicine, Recommendations from the EANM Physics Committee, the EANM Dosimetry Committee and EFOMP (2013), update about to be published)<br>• Core Curriculum for Medical Physicists in Radiology (2011, update in progress) | Min. requirements to access MPE education and training: BSc degree predominantly in Physics + MSc degree in Physics or Medical Physics (BSc + MSc 300 ECTS, incl. in total at least 180 ECTS in Fundamental Physics and Mathematics).<br><br>MPE education and training: min. of 4 years to obtain competences (Can MEDS roles) to become an independent specialist | CC are endorsed by majority of EU countries' national medical physics professional organisations.<br><br>Registration by the competent authority for independent practice.<br><br>Compulsory and accredited continuing professional development. |

| Considered guidelines / recommended training curricula | Recommended min. training duration | Other |
|---|---|---|
| **Radiographers** | | |
| EFRS White Paper on the Future of the Profession Radiographer Education, Research, and Practice (RERP): 2021-2031<br>EFRS (2020) Radiation Protection Officer (RPO) role descriptor for Radiographers | EQF Level 6 (Bachelors) programmes of 180 ECTS as the minimum standard for entry to the profession in EU Member States.<br>The total course duration incorporates between 180 ECTS to 240 ECTs over a period ranging between 2 to 4 years depending on whether the qualification is single (medical imaging, nuclear medicine, and radiotherapy only) or combined. | |
| **Radiation Therapists (RTT)** | | |
| Recommended ESTRO Core Curriculum for RTTs (Radiation TherapisTs) – 3rd edition, 2011 – supplemented by:<br>• European Higher Education Area Level 6 Benchmarking document for Radiation TherapisTs | EQF Level 6 (Bachelors) programmes of 180 ECTS as the minimum standard for entry to the profession in EU Member States<br><br>3-4 years | |
| The European Society for Radiotherapy and Oncology (ESTRO) European Higher Education Area levels 7 and 8 postgraduate benchmarking document for Radiation TherapisTs (RTTs)<br>Mary Coffey, Michelle Leech, on behalf of the ESTRO Radiation TherapisT Committee<br>A handbook for the education of radiation therapists (RTTs). Training Course Series no. 58. International Atomic Energy Agency Vienna, 2014. | Postgraduate | |

# 5. Project conclusions and recommendations

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## 5.1 Conclusions

The following conclusions can be drawn from the findings from the EU-REST study:

### 1. Lack of data

The project has revealed a general lack of existing metrics about workforce availability for all relevant professional groups, and an absence of any widely-applicable future-proofed standards for appropriate staffing levels.

### 2. Profession-specific differences

Approaches to calculating staffing needs differ between the professional groups for many reasons. Among these are the diversity of the roles and responsibilities of the professions (in terms of current experience, complexity of tasks, expected pace of scientific and technological developments, and type and extent of collaboration with related professions), the differences among the professions in terms of how their specific workload is and should be measured, potential future developments in professional activities and variations in the amount, quality and applicability of existing data which could be used for benchmarking.

### 3. Terminology of professions covered

The differentiation between Radiation Therapists and Radiographers in Radiation Therapy revealed certain ambiguities. The differing viewpoints, as outlined by Consortium partners ESTRO and EFRS, and also raised by the WHO and other stakeholders, are summarised in Section 1.1, Terminology and professions considered.

## 5.2 Recommendations

The recommendations arising from the EU-REST project will be summarised below under two main headings: 1. General recommendations, applying to all relevant professional groups and 2. Profession-specific recommendations.

### 5.2.1 General recommendations

These comprise recommendations which are applicable to all professional groups covered by the EU-REST project. Some of these are also highlighted individually, as they apply to specific professional groups, in later sections.

#### 1. National Registries

A. Due to the above-mentioned general lack of existing metrics about workforce availability for all relevant professional groups, and an absence of any widely applicable future-proofed standards for appropriate staffing levels, it is recommended that **each EU Member State should maintain a central registry for each professional group, and for equipment relevant to the performance of their work. Each Member State should ensure (ideally uniform) high quality of the data, including information on the**

- Number of professionals (and, if possible, number of full-time equivalents)
- Age and gender profile of professionals (to allow for planning of training positions for future staff, retirement replacements, etc.)
- Appropriate qualifications needed for inclusion in the registry, and for licensing for independent practice

B. Such registries should, ideally, operate on common standards across all EU Member States, to ensure a meaningful cross-comparison of data. To provide for this, the definitions used to collate and verify the data contained within these registries should be common for all Member States. Data maintained in such registries should be shared through the EC, to facilitate the collation and maintenance of EU-wide data. The establishment of national registries (as outlined in 1A above) should be undertaken immediately, with harmonisation of standards and definitions, and sharing of data across the EU to follow subsequently, once practical experience in establishment and maintenance of registries has been accumulated in Member States.

#### 2. Continuing professional development (CPD)

CPD in radiation protection is already required under the Basic Safety Standards Directive (BSSD), which has been transposed into national law in each Member State.

**Mandated CPD should also include techniques and knowledge relevant to each professional group, beyond radiation protection issues.** The exact methodology and requirements for CPD for each group is a matter for each Member State, but adoption of the general principle of its being mandated should be accepted by each state.

### 3. Adoption vs. adaptation of guidelines

The clear recommendation from the EU-REST consortium is that each Member State should adopt the recommendations, which will encourage uniformity of standards and practice and, thereby, ultimately improve patient safety. If adoption of the guidelines is not possible in certain settings for justified reasons, relevant countries might adapt the proposed guidelines to make them applicable in their national context. The extent of such adaptation should, however, be limited.

Fundamentally, consortium members believe that **adoption of recommendations by all Member States in a uniform manner would likely be more beneficial than adaptation of the recommendations. Adoption should be the goal of the study and the European Commission.**

### 4. Harmonisation of training

For each professional group, **harmonisation of training across all 27 EU Member States** (in terms of duration, curriculum, and certification of successful completion) is desirable, and should be supported. This would benefit interchangeability of qualifications across Member States, and facilitate mobility of relevant professionals.

## 5.2.2 Profession-specific recommendations

These are discussed and explained in greater detail in Section 4 and in Annex 6 of this Final Report.

Specific recommendations are briefly summarised here, for ease of reference.

### Radiologists

#### Radiologists' Staffing guidelines – summarised

A basic unit defined by hour of machine/system/activity, which is multiplied by a specific conversion factor, was defined for each Radiological modality (i.e. MR, CT, Interventional Radiology, etc.). This can be multiplied by the working hours of the respective machine, to derive the necessary radiologist staffing requirement. The calculations are based on 50 weeks of normal operation per year, excluding holiday periods.

## Staffing calculation – radiologists:

**Table 8 – Staffing calculation method: Radiologists**

| Teaching setting yes / no | Basic unit | Conversion factor | Radiology service | Practice examples |
|---|---|---|---|---|
| | one hour room-time of the patients | **1.5** | **Interventional Radiology** | For example TIPSS: procedure time = 60–120 min. room time of the patient = 120–180 min. need for the interventionalist = 3–4.5 hours.<br>IR service = **5** days a week / **8** hours' patient room time = **2000** hours per year.<br>Based on our estimation **3000** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = 1600 hours = **2 IR specialists** being able to work independently and unsupervised are required to cover the 3000 hours. |
| yes | one hour room-time of the patients | **1.5 + 1.0** | **Interventional Radiology** | 1.5 hr board certified + 1.0 hr resident |
| | | | | |
| | one hour room time of the MR unit | **1.5** | **Magnetic Resonance** | MR service = **5** days a week / **12** hours' patient room time = **3000** hours per year. Based on our estimation **4500** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **3 Board certified Radiologists** being able to work independently and unsupervised are required to cover the 4500 hours. |
| yes | one hour room time of the MR unit | **1.0 + 1.5** | **Magnetic Resonance** | 1.0 hr board certified + 1.5 hr resident |
| | | | | |
| | one hour room time of the CT unit | **1.5** | **Computed Tomography** | CT service = **5** days a week / **12** hours' patient room time = **3000** hours per year. Based on our estimation **4500** hours should be covered.<br>Doctors working 40 hours per week, for 40 weeks a year = **3** Board certified Radiologists being able to work independently and unsupervised are required to cover the 4500 hours. |

| Teaching setting yes / no | Basic unit | Conversion factor | Radiology service | Practice examples |
|---|---|---|---|---|
| yes | one hour room time of the CT unit | **1.0 + 1.5** | **Computed Tomography** | 1.0 hr board certified + 1.5 hr resident |
| | | | | |
| | one hour room time of the patients | **1.5** | **Interventional CT** | Interventional CT service = **5** days a week / **4** hours' patient room time = **1000** hours per year.<br>Based on our estimation **1500** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **1** Board certified Radiologists being able to work independently and unsupervised are required to cover the 1500 hours. |
| yes | one hour room time of the patients | **1.5 + 1.5** | **Interventional CT** | 1.5 hr board certified + 1.5 hr resident |
| | | | | |
| | one hour room time of the PET unit | **1.5** | **PET CT*** | PET service = **5** days a week / **12** hours' patient room time = **3000** hours per year. Based on our estimation **4500** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **3** Board certified Radiologists being able to work independently and unsupervised are required to cover the 4500 hours. |
| yes | one hour room time of the PET unit | **1.0 + 1.5** | **PET CT*** | 1.0 hr board certified + 1.5 hr resident |
| | | | | |
| | one hour running time of the respective X-Ray unit. | **0.5** | **X-Ray** | X-Ray service = **5** days a week / **8** hours' patient room time = **2000** hours per year. Based on our estimation **1000** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **less than 1** Board certified Radiologists being able to work independently and unsupervised are required to cover the 1000 hours. |
| yes | one hour running time of the respective X-Ray unit. | **0.5 + 0.5** | **X-Ray** | 0.5 hr board certified + 0.5 hr resident |
| | | | | |

| Teaching setting yes / no | Basic unit | Conversion factor | Radiology service | Practice examples |
|---|---|---|---|---|
| | one hour running time of the respective Fluoro unit | **1.0** | **Fluoro** | Fluoro service = **5** days a week / **4** hours' patient room time = **1000** hours per year. Based on our estimation **1000** hours should be covered Doctors working 40 hours per week, for 40 weeks a year = **0.625** Board certified Radiologists being able to work independently and unsupervised are required to cover the 1000 hours. |
| yes | one hour running time of the respective Fluoro unit | **1.0 + 1.0** | **Fluoro** | 1.0 hr board certified + 1.0 hr resident |
| | | | | |
| | one hour time of patient service | **1.0** | **Sono** | Sono service = **5** days a week / **8** hours' patient room time = **2000** hours per year. Based on our estimation **2000** hours should be covered Doctors working 40 hours per week, for 40 weeks a year = **1.25** Board certified Radiologists being able to work independently and unsupervised are required to cover the 2000 hours. |
| yes | one hour time of patient service | **1.0 + 1.0** | **Sono** | 1.0 hr board certified + 1.0 hr resident |
| | | | | |
| | one hour MDT-meeting time | **3.0** | **Multi-disciplinary team conference** | As example: **5 MDT** meetings per week = 2 hours each = 10 hours MDT per week = **500** hours per year.<br>Based on our estimation **1500** hours should be covered Doctors working 40 hours per week for 40 weeks a year = **1** board-certified radiologist being able to work independently and unsupervised is required to cover the 1500 hours. |

*Note: The EU-REST study has aimed to define education and training standards and appropriate workforce numbers for all relevant professional groups in all 27 EU Member States, trying to take account of the varying practices in different countries. As hybrid imaging practice varies across Europe, with PET/CT being performed/interpreted either by Nuclear Medicine Physicians or by Radiologists or by members of both specialties working collaboratively, staffing recommendations for PET/CT have been developed by both EANM and ESR experts as part of this study. Thus, depending on the practice in their specific setting, stakeholders can consult the recommendations of the respective specialty.

## Radiologists' education/training guidelines – summarised

### 1. Harmonisation of duration and content of training within the EU member countries

- 5-year specialty training programme
- Amendment of EU Professional Qualifications Directive to reflect 5-year duration of training
- European Training Curriculum (ETC) to be established as a European-wide standard for radiology education and training.

### 2. Harmonisation of training structure within the EU member countries

- Coordinated and standardised Fellowship programmes after the end of the regular residency training should be established. Such Fellowships should generally last 1 year.
- Curricula for training in radiology subspecialties should be based on a combination of ETC Level III and specific subspecialty society sponsored curricula.
- A minimum requirement should be established within these programmes for a combination of ECTS (European Credit Transfer System - hours of teaching) and case/procedure numbers for each subspecialty, based on the ETC; this should be used in all EU member countries.
- A minimum requirement should be established for a combination of ECTS and practical training in radiation protection, safety and quality management within the ETC; this should be used in all EU member countries.

### 3. Harmonisation of certification of completion of training within EU member countries

- Formal completion of training in radiology should be marked by a harmonised and standardised examination in all European countries.
- The European Diploma in Radiology (EDiR) be promoted as equivalent to the national or specialty examination in radiology or – in countries without such specialty examination – the EDiR should be established as a requirement for certification of completion of training.
- In those countries which already have established examinations which must be passed to complete training, local evaluation of

equivalence with the EDiR may be helpful to ensure harmonisation of standards.

4. **Clear acknowledgement of trainees in workforce calculation**

   - Trainees must be taken into account while calculating workforce needs.

5. **Harmonisation of training centre evaluation within EU member countries**

   - The European Training Assessment Programme (ETAP, a joint initiative of the European Board of Radiology – EBR and the European Union of Medical Specialists – UEMS Section of Radiology) certificate should be established as a prerequisite for training centre accreditation in Europe.

6. **Harmonisation of continuous professional development**

   - The EACCME should be established as the European currency for CME credits; these credits should be accepted in all countries as proof of continuous medical education.
   - A minimum number of CME credits should be established which need to be obtained in a defined period of time to prove continuous medical education; this number should be used in all European countries.
   - Both of these recommendations regarding CPD should apply to all medical doctors covered by this project (with specialty-specific variations, as needed)

## Nuclear Medicine Physicians

### Nuclear Medicine Physicians' Staffing guidelines – summarised

The first recommendation is to use the available sources (IAEA, OECD, EUROSTAT or UNSCEAR) as a basis for **building a robust EU27 Member State registry**, able to identify current and potential future shortages, as well as other parameters including age, gender, European or extra-European mobility, issues related to mutual recognition of diplomas/titles in EU27 etc.

It is recommended that the IAEA's **IRIS tool be confronted with actual data** to evaluate its reliability in terms of resources, at local level, i.e., individual institutions, as a potential separate follow-up action upon completion of the EU-REST study.

### Nuclear Medicine Physicians' Education/training guidelines - summarised

The period of training should be a minimum of four but **preferably five calendar years**.

The curriculum must include clinical training, theoretical education as well as qualification in radiation protection that will guarantee the safe use of radioactive materials for both the patient and staff.

Content of the training, principles for assessment of the training and education programme (https://www.uems.eu/european-training-requirements), and for evaluating the achievements of trainees are proposed.

The body for certification should be centralised within each of the EU27 countries and ideally be the responsibility of the Member State's Ministry of Health. Where this is not possible, a centralised certification can be sought, such as through the EANM/UEMS/EBNM training end exam (https://uems.eanm.org/fellowship-examination/).

Training centres should be chosen amongst those that are able to offer the widest operating workforce and range of activities. Partnerships may exist or be established with other centres for additional training. The accreditation of training centres and those responsible should be validated by a centralised body.

Additional **recommendations to the EU** are:

- Establish a knowledgeable status of the current curriculum for the specialty of NM.
- Harmonise the curriculum amongst the EU27, taking into consideration differences in equipment and IGP between the Member States.
- Professional societies to support clinical centres in organising practical cross-country mobility in order to give all medical doctors in the EU27 equal access to the specialty of NM.

## Radiation Oncologists

### Radiation Oncologists' staffing guidelines – summarised

The recommendation of the EU-REST Consortium is that 200 patients per radiation oncologist be used as the main benchmark with modification of this number based on the criteria defined below.

- Annual number of patients treated per radiation oncologist.
- Type of the department (service hospital/training institute, hospital located/standalone centre).
- Patient status and treatment intent
- Treatments used in the department (IMRT, SBRT, SRS, brachytherapy, IORT, TBI, TSEI, paediatric treatments, chemotherapy administration, etc.).
- Teaching and training activities.
- Part-time employment of radiation oncologists.
- Administrative tasks.
- Geographical distribution.

#### Radiation Oncologists' education/training guidelines – summarised

- The ESTRO 4th edition of the core curriculum is recommended.
- A duration of 5 years' training is recommended, with both academic and clinical components (at least 80% of the time needs to be spent in a clinical environment).
- Licensing should be based on an objective assessment of the completion of a training programme that complies with national guidelines.
- Institutes where education/training is sited should undergo regular inspection and accreditation.
- It is recommended that a programme director is in place together with medical, physics and radiobiology teaching staff.
- Trainees should maintain a learning portfolio for the duration of training.
- The importance of mandatory continuing professional development (CPD) and life-long learning should be emphasised.

### Medical Physics Experts

#### Medical Physicists/Medical Physics Experts' staffing guidelines – summarised

1. The MPE, with level 8 in the European qualification framework, is the qualified professional to assume the competences in radiation physics applied to medical exposures, in accordance with the 2013/59/EURATOM directive and the European Commission

guidelines for medical physics experts, radiation protection no. 174. The concept of radiation physics includes both, ionising and non-ionising radiation. Member states should consider this profession in the assessment of the workforce.

2. The Medical Physics Expert (MPE) as defined in the directive 2013/59/EURATOM should be the healthcare professional to supervise and assume the responsibilities for radiation protection activities in hospital settings, including patients, working staff, members of the public and visitors. The Radiation Protection Expert (RPE) in hospital settings should be an MPE, since medical physicists have the highest level of radiation physics knowledge and training.

3. The latest published recommendation by EFOMP (currently the EFOMP policy statement 7.1) in agreement with international recommendations should be adopted as the reference document for comparison of staffing levels for MPEs.

4. Medical physics departments may include other professionals such as dosimetrists or medical physics assistants and bioengineers working under the supervision of MPEs. If this is the case, the staffing guidelines should include these resources as a factor to be taken into account in the total time needed to develop the different activities.

5. Member states should have a registry of their active MPEs, managed by the competent authority and updated at least on a yearly basis, including information on age, gender, and the main field of practice (radiotherapy, diagnostic & interventional radiology, nuclear medicine), for proper planning of future workforce needs and for the promotion of gender equality in the profession. Coordination with national scientific societies is recommended to achieve this objective.

6. A common training and recognition scheme for MPEs should be established to facilitate their mutual recognition across Europe, in order to foster professional mobility and knowledge sharing for new technologies between Member States.

7. The algorithms to calculate FTEs of MPEs included in the EFOMP recommendation should be revised at least every five years depending on changes in technology and practice. In particular, the impact on workforce of aspects such as hadron radiotherapy, the emergence of dose management systems in diagnostic and interventional radiology and the increasing workload in advanced radionuclide therapy should be evaluated by scientific societies and updated if needed.

## Medical Physicists/Medical Physics Experts' education/training guidelines – summarised

1. In accordance with the Directive 2013/59/Euratom, to practise independently in the field of medical physics in Europe, the MPE accredited level (EQF8) should be achieved. All Member States should provide education and training programmes and registration schemes for this goal.

2. Member states should converge in their education and training programmes for MPEs, seeking the standardisation of the safety and quality standards in the medical practices involving ionising radiation at European level. The updated core curricula and pathways proposed by EFOMP (in coordination with other scientific organisations such as ESTRO, EANM, and ESR) for MPEs should be the reference for the education and training programmes for the Member States, which could be summarised as follows:

   (a) Minimum requirements to access the education and training for MPEs: a BSc degree predominantly in Physics plus an MSc degree in Physics or Medical Physics (BSc + MSc 300 ECTS, including in total at least 180 ECTS in Fundamental Physics and Mathematics).

   (b) Education and training for MPEs: duration of at least 4 years to obtain the competences (CanMEDS roles) to become an independent specialist. Training in one or more subspecialties of Medical Physics should be available. The training must be conducted in a hospital/healthcare facility accredited by the competent authority. Training facility and quality of the MPE training should be regularly audited by the competent authority.

   (c) The MPE trainee must be appointed as a paid resident, with assigned duties under the supervision of a qualified MPE.

   (d) Continuing professional development (CPD) shall be compulsory as recommended by EFOMP.

   (e) Professionals should be registered before starting independent practice. The register should be managed by the national competent authority, which should coordinate this effort with the national scientific society.

3. A common core curriculum and career pathway for the profession of MPE encompassing all subspecialties is instrumental in harmonising MPE education and training standards across Europe. This approach ensures consistency in the competences required to become an MPE, thereby standardising quality and safety for the medical applications involving ionising radiation. Furthermore, this initiative

streamlines the recognition of the MPE profession in EU Member States where it has yet to be formalised.

## Radiographers

Radiographers include the three branches of the profession recognised at the European level (Medical Imaging, Nuclear Medicine, and Radiation Therapy).

### Radiographers' staffing guidelines – summarised

## Recommendations

1. To implement a workload-based approach to estimate staffing levels, as explained above and in Annex 5.
2. To implement a harmonised framework for the calculation of the Radiographer workforce across EU Member States, and,
3. To have this data published centrally by the EC, and additionally by relevant professional organisations, and widely publicised by interested parties, to facilitate a more comprehensive evaluation of the EU Radiographer workforce.
4. To implement comprehensive national registries for Radiographers across EU Member States, and,
5. To implement national structures for the annual review of workforce data in collaboration with education and training providers to facilitate planning, and,
6. To promote increased diversity in entry, through novel access routes / widening participation initiatives to train as a Radiographer and go on to the profession across EU Member States.
7. To recognise additional and emerging essential roles for Radiographers across EU Member States, inclusive of extended and advanced practice together with emerging specialisms, and,
8. To implement initiatives to facilitate the advancement and development of the Radiographer workforce, to establish these roles with appropriate education, training, and governance structures.

## Radiographers' education/training guidelines – summarised

### Recommendations

- To implement diverse pathways into education and training programmes for radiographers in all EU Member States
- To ensure that opportunities exist for all aiming to train as radiographers to do so through the implementation of appropriate access programmes.
- To recognise EQF Level 6 (Bachelors) programmes of 180 ECTs as the minimum standard for entry to the profession in EU Member States.
- To ensure that both dedicated programmes in medical imaging, nuclear medicine, or radiotherapy, together with programmes combining two or three of these branches of the profession, encompass all core theoretical content and clinical experiences for each branch, with clinical activities making up a minimum of 25% of the programme ECTs within recognised / approved training centres which are subject to regular audit.
- To establish diverse approaches to teaching, learning, and assessment which are practice-based and focused on true clinical scenarios, inclusive of appropriate clinical simulation activities to support and enhance traditional clinical education.
- To create programme structures which also facilitate completion on a part-time basis.
- To ensure student radiographers receive equal treatment as other healthcare students in terms of consideration for payments linked to their clinical training.
- To establish minimum required curricular content at European level related to radiation protection, quality management, safety, and related professional topics, for programmes across all Member States.
- To clearly identify the development of evidence-based practice and research skills throughout curricula.
- To ensure that mandatory CPD and the importance of life-long learning are recognised within programmes, and that opportunities exist for all radiographers to engage in such activity.
- To establish core curricula, which are evidence-based and aligned with recognised frameworks, fit for purpose, consider the future of the profession, and are reviewed regularly, at a national level.
- To implement national programme accreditation systems.

- To establish national certification / licensing requirements and systems for individuals completing accredited programmes with ongoing licensing requirements for professionals.
- To recognise the need for additional postgraduate education and training for radiographers undertaking specialist / expert roles.

Significant variability in the education and training of Radiographers for entry to the profession across Europe still exists. It is thus essential that data and metrics are regularly and uniformly collected at both the national / EU Member States and European levels, to facilitate more accurate monitoring of the varying approaches to education and training, encourage the harmonisation of aspects of education and training where appropriate, and better facilitate and promote the free movement of the Radiographer workforce across Europe to better balance workforce supply and demand.

## Radiation Therapists (RTTs)

### Radiation Therapists' staffing guidelines – summarised

- A radiation therapist must never work alone during treatment simulation and treatment delivery. A minimum of two radiation therapists is always required during these procedures.
- The number of full time, part time and locum/cover staff currently working
- Whether the department runs on single or multiple shifts which must include a time calculation to cover for staff breaks and shift crossover discussion.
- Scheduled maintenance, downtime and replacement need to be included as they will impact on treatment delivery and will require temporary introduction of additional working slots.
- Additional time and support for continuous professional development activities for radiation therapists must be factored into staffing levels.
- Dedicated radiation therapist management roles must also be considered in overall staffing levels.

### Forward planning

The centre must also consider:

- Equipment and any planned expansion
- Evolving staff roles and responsibilities as described previously.

- Attrition and retirements

### Radiation Therapists' education/training guidelines – summarised

Recommendations

- A dedicated education/training programme meeting the specific requirements for radiation therapists is essential for safe and accurate practice. Completion of second level education is a requirement and a programme duration of 3 years is recommended. Education should be sited in an academic setting with strong links to clinical departments.
- Clinical practice should be compulsory with 20-30% of the programme dedicated to as wide a clinical experience as possible
- Academic and clinical assessment should be in place
- Academic and clinical sites should be accredited and audited regularly
- Radiation protection should be a core component of the education programme and should include knowledge of the existing legislation as it applies to patients, staff and the general public
- Continuous radiotherapy-specific professional development should be supported

## 5.3 Barriers, risks and potential alleviation of barriers to implementation of recommendations

1. The recommendation of mandatory CPD (beyond the BSSD) could be a barrier to implementation of the EU-REST guidelines for certain Member States, as this will require some resourcing (both the facilitate the performance of mandatory CPD, and to verify its performance).
2. The role of the European Commission (EC) in enforcing the adoption of the staffing and education/training guidelines, including national registries of professionals and equipment, by the Member States, is limited due to the lack of relevant legislation. Nevertheless, it is believed by the consortium that the guidelines proposed under the present EU-funded study will contribute to improving the situation in EU Member States, if supported as appropriate standards by the EC. The extent to which this will be done will depend on the individual countries' needs and possibilities for improvement, and also on the support provided for promulgation of these proposed standards by EC agencies.

3. Stakeholder consultation revealed perceptions of potential barriers which could inhibit implementation of these guidelines and recommendations as follows:

   (a) Financial issues

   (b) Issues relating to the political and governmental frameworks within individual member States

   (c) Issues relating to a lack of relevant students/trainees in specific professional groups

   (d) Issues relating to a lack of training capacity for trainees in specific professional groups

   (e) The lack of recognition of MPEs as a specific healthcare profession in certain countries

4. Suggestions of ways to overcome barriers included:

   (a) Dialogue with policy makers

   (b) Implementation of guidelines via national authorities, professional societies or legislation within individual Member States

   (c) Incorporation of guidelines into training curricula / university practice

   (d) Raising awareness of issues among students, relevant professions and professional societies, including via webinars, scientific journal publications etc.

   (e) Implementing financial changes relating to payment, reimbursement and funding of training

# Annex 1: Consortium, Advisory Board, Peer Review Group

## Consortium members

| Organisation | First Name | Last Name |
|---|---|---|
| ESR – consortium lead | Boris | Brkljačić |
| | Adrian | Brady |
| | Christian | Loewe |
| | Graciano | Paulo |
| | François | Jamar |
| ESR – project office | Monika | Hierath |
| | Martina | Szucsich |
| ESTRO | Cristina | Garibaldi |
| | Mary | Coffey |
| | Yavuz | Anacak |
| | Pedro | Lara |
| | Michelle | Leech |
| | Nuria | Jornet |
| EFRS | Jonathan | McNulty |
| | Francis | Zarb |
| EFOMP | Dimitris | Visvikis |
| | Csilla | Pesznyak |
| | Irene | Polycarpou |
| | Roberto | Sanchez |

## Advisory Board members

| Organisation | First name | Last name |
|---|---|---|
| EuroSafe Imaging | Guy | Frija |
| EANM | Michel | Koole* |
| ESC/EAPCI | Dariusz | Dudek |
| ESNR | Naci | Kocer |
| CIRSE | Elias | Brountzos |
| E.C.O. | Mike | Morissey |
| Patient representation | Erik | Briers |
| IAEA | Lisbeth | Cordero Mendez** |
| IAEA | Diana | Paez |

| Organisation | First name | Last name |
|---|---|---|
| HERCA | Barbara | Godthelp |
| UEMS | Paolo | Ricci |
| Representative RPE/RPO/MPE Study | Gabriel Lazaro | Pavel*** |
| Representative MARLIN | Gianfranco | Brusadin*** |
| WHO | Ferid | Shannoun**** |

*Starting October 2023, successor to Michael Lassmann
**Starting February 2024, successor to Katherine Wakeham
***Starting June 2023
**** Starting February 2024

## Peer Review Group members

| Organisation | First name | Last name |
|---|---|---|
| ESR | Michael | Fuchsjäger |
| ESTRO | Kim | Benstead |
| EANM | Roland | Hustinx |
| EFRS | Charlotte | Beardmore |
| EFOMP | Luis | Brualla Gonzalez |
| IAEA | Vesna | Gershan* |

*Starting January 2024, successor to Jenia Vassileva

# Annex 2: List of stakeholders

## Stakeholder categories

1. European professional societies (ESR, EANM, EFOMP, EFRS, ESTRO, EAPCI, CIRSE, etc.)
2. European organisations/networks: UEMS, HERCA, CPME (standing committee of European doctors), and E.C.O.
3. International organisations: IAEA, WHO
4. National professional societies in EU-27 (radiology, NM, radiotherapy, radiography, medical physics, others)
5. National Medical associations in EU-27
6. Ministries of Health of EU-27 countries
7. Ministries of Education (and Science) of EU-27 countries
8. National Licensing bodies (mostly medical chambers) and bodies responsible for continuing professional education/development
9. National competent authorities in radiation protection (EU-27)
10. Academia (clinicians)
11. Industry: COCIR, EFPIA (European Federation of Pharmaceutical Industries and Associations), Nuclear Medicine Europe
12. Patient organisations – Patient advisory groups/committees of EU professional societies (e.g. ESR-PAG) or organisations such as E.C.O.

## Organisations per stakeholder category

**Table 9 – Organisations per stakeholder category**

| SH category | SH organisation | Source of contact / no of contacts (where relevant |
|---|---|---|
| 1 | ESR | Contractor provides relevant ESR Board/Committee members to be consulted |
| 1 | EFOMP | Contractor provides relevant EFOMP Board/Committee members to be consulted |
| 1 | EFRS | Contractor provides relevant EFRS Board/Committee members to be consulted |

| SH category | SH organisation | Source of contact / no of contacts (where relevant |
|---|---|---|
| 1 | ESTRO | Contractor provides relevant ESTRO Board/Committee members to be consulted |
| 1 | EANM | Advisory Board member provides any additional EANM contacts to be consulted |
| 1 | CIRSE | Advisory Board member provides any additional CIRSE contacts to be consulted |
| 1 | EAPCI | Advisory Board member provides any additional EAPCI contacts to be consulted |
| 2 | UEMS | Advisory Board member (President of Radiology Section) to forward to other relevant UEMS sections/contacts |
| 2 | HERCA | Advisory Board member |
| 2 | CPME | President, Secretary General |
| 2 | E.C.O. | Advisory Board member |
| 3 | IAEA | Advisory Board member |
| 3 | WHO | Advisory Board member |
| 4 | National professional societies: Radiology | ESR has an up-to-date database of all EU-27 national societies that will be used for EU-REST stakeholder consultations (Presidents, Quality and Safety committee delegates, Education Committee delegates, secretariats) |
| 4 | National professional societies: Medical Physics | EFOMP has an up-to-date database of all EU-27 national societies that will be used for EU-REST stakeholder consultations |
| 4 | National professional societies: Radiographers | EFRS has an up-to-date database of all EU-27 national societies that will be used for EU-REST stakeholder consultations |
| 4 | National professional societies: Radiation oncologists, RTTs | ESTRO has an up-to-date database of all EU-27 national societies that will be used for EU-REST stakeholder consultations |
| 4 | National professional societies: Nuclear medicine physicians | EANM has an up-to-date database of all EU-27 national societies that will be used for EU-REST stakeholder consultations |
| 5 | National medical associations | Outreach via UEMS for medical doctors; contacts obtained via EU-REST Pre-Survey; |
| 6 | National ministries of health | Contacts obtained via EU-REST Pre-Survey and Main Survey |
| 7 | National ministries of education (and science) | Contacts obtained via EU-REST Pre-Survey and Main Survey |
| 8 | National licensing bodies and bodies responsible for CPD | Outreach via UEMS; national licensing bodies for Radiographers, RTTs, Medical Physics Experts to be provided by national societies of EFRS, ESTRO, EFOMP; contacts obtained via EU-REST Pre-Survey |
| 9 | National competent authorities in radiation protection | Outreach via HERCA Advisory Board member; contacts available from Pre-Survey and previous projects |
| 10 | Academia | Consortium selected 56 universities in EU Member States (ensuring representation from each Member State) from the list of "Best Global Universities for Radiology, Nuclear Medicine and Medical Imaging" established by US News following a transparent methodology (available at https://www.usnews.com/education/best-global-universities/radiology-nuclear-medicine-medical-imaging) |

| SH category | SH organisation | Source of contact / no of contacts (where relevant |
|---|---|---|
| 11 | COCIR | Secretary General, President |
| 11 | EFPIA | Director General |
| 11 | Nuclear Medicine Europe | Contact from the SIMPLERAD project |
| 12 | ESR-PAG | Chair |
| 12 | E.C.O. | E.C.O. Patient Advisory Committee |

# Annex 3: Analysis of guidelines for education and training per profession

## Analysis of guidelines for education and training for Radiologists

**Table 10 – European education and training curricula for Radiologists and interventional Neuroradiologists**

| | Parameter | European Training Curriculum for Radiology (ETC) | Standards for European training requirements in interventional neuroradiology |
|---|---|---|---|
| **Criteria to enter the education and training programme** | Minimum entry level to education and training programme | degree in medicine | board certification |
| **Structure of the education and training programme** | Duration of the training | 5 | 1 (diagnostic) + 2 (IR) years |
| | Is the Core Curriculum competency-based? | yes | yes |
| | Which are the average percent of time during specialty training spent on theoretical (classroom teaching etc.) and practical (patient contact, practical work & supervised service delivery)? | 90 - 100% practical work | yes |
| | Are methods to access competencies described? | no | not in detail |
| | How should completion of specialty (full professional) training achieved? | finishing 5 years of training; final board examination AND/OR European Diploma in Radiology (EDIR) as provided by the European Board of Radiology (EBR) | by time and proven skills (case numbers) |

| | Parameter | European Training Curriculum for Radiology (ETC) | Standards for European training requirements in interventional neuroradiology |
|---|---|---|---|
| | Should the trainees be paid? | yes | not specified |
| **Content of the education and training programme with a focus on radiation protection, quality management and safety** | Topics included (Radiation protection for staff, Radiation protection for patients / general public Radiation protection legislation, Quality & safety management (Q&S) Good research practice, Palliative care (if answering for Radiation Oncology), Artificial intelligence theory and applications for radiation protection and Q&S | All | not specified |
| | Do the core components of the curriculum provide the content necessary to understand the effect of radiation on tissue in order to ensure safe clinical practice? | yes | since after board specification, not content of this training |
| | How many ECTS / hours are dedicated to radiation protection? | not specified | not specified |
| | How many ECTS /hours are dedicated to quality management and safety? | not specified | not specified |
| **Certification** | Which professional / educational / regulatory body defines the core curriculum? | ESR | not specified |
| | By whom is the education and training delivered? | Local Institutions | accredited training centres |
| | Is clinical training compulsory? | yes | yes |
| | Is a graduate from the education programme licensed to practice independently? | yes - after passing the board exams | yes |
| | Is specific certification required in radiation protection (separate from full certification to practice in the professional group)? | no | not specified |

| | Parameter | European Training Curriculum for Radiology (ETC) | Standards for European training requirements in interventional neuroradiology |
|---|---|---|---|
| | After certification, should continuing professional development / continuing education mandatory for the selected medical specialty? | yes | yes |
| **Training centre** | Should training centres be formally certified / assessed / audited? | yes | yes |
| **Comments** | | Updated in 2020<br>ETC of the European Society of Radiology, supported by 38 member societies, 15 sub-societies and allied-sciences societies, endorsed by UEMS, supported by another 28 societies outside Europe | Issued in 2020<br>Guidelines by the Division of Neuroradiology/ Section of Radiology European Union of Medical Specialists (UEMS), in cooperation with the Division of Interventional Radiology/UEMS, the European Society of Neuroradiology (ESNR), and the European Society of Minimally Invasive Neurological Therapy (ESMINT) |

### Table 11 – Current situation of education and training of Radiologists in the US

| | Parameter | Radiology Training in the US (American Board of Radiologists) |
|---|---|---|
| **Criteria to enter the education and training programme** | Minimum entry level to education and training programme | Degree in medicine (MD) |
| **Structure of the education and training programme** | Duration of the training | 4, followed by subspecialty fellowship |
| | Is the Core Curriculum competency-based? | yes |
| | Which are the average percent of time during specialty training spent on theoretical (classroom teaching etc.) and practical (patient contact, practical work & supervised service delivery)? | Not specified |
| | Are methods to access competencies described? | no |

| | Parameter | Radiology Training in the US (American Board of Radiologists) |
|---|---|---|
| | How should completion of specialty (full professional) training achieved? | finishing 4 years of training; final board examination, followed by subspecialty fellowship |
| | Should the trainees be paid? | yes |
| **Content of the education and training programme with a focus on radiation protection, quality management and safety** | Topics included (Radiation protection for staff, Radiation protection for patients / general public<br>Radiation protection legislation, Quality & safety management (Q&S)<br>Good research practice, Palliative care (if answering for Radiation Oncology), Artificial intelligence theory and applications for radiation protection and Q&S | All |
| | Do the core components of the curriculum provide the content necessary to understand the effect of radiation on tissue in order to ensure safe clinical practice? | yes |
| | How many ECTS / hours dedicated to radiation protection | not specified |
| | How many ECTS / hours dedicated to quality management and safety | not specified |
| **Certification** | Which professional / educational / regulatory body defines the core curriculum? | American Board of Radiology |
| | By whom is the education and training delivered? | Not specified |
| | Is clinical training compulsory? | yes |
| | Is a graduate from the education programme licensed to practice independently? | Yes - after passing the certification exams |
| | Is specific certification required in radiation protection (separate from full certification to practice in the professional group)? | no |
| | After certification, should continuing professional development / continuing education mandatory for the selected medical specialty? | yes |
| **Training centre** | Should training centres be formally certified / assessed / audited? | Not specified |
| **Comments** | | |

# Analysis of guidelines for education and training for Radiation Oncologists

**Table 12 – Core curriculum for Radiation Oncologists**

| | Parameter | Core curriculum for Radiation Oncologists Issued by ESTRO in 2019 |
|---|---|---|
| **Criteria to enter the education and training programme** | Minimum entry level to education and training programme | Not specified. We can assume a MD diploma as the minimum requirement |
| **Structure of the education and training programme** | Duration of the training | 5y full time or an equivalent period part-time. |
| | Is the Core Curriculum competency-based? | Yes |
| | Which is the average percent of time during specialty training spent on theoretical (classroom teaching etc.) and practical (patient contact, practical work & supervised service delivery)? | At least 80% of the programme should be spent in clinical work including time in education. |
| | Are methods to access competencies described? | Yes |
| | How should completion of specialty (full professional) training achieved? | Licensing should be based on objective assessment of completion of a training programme that fulfils the national guidelines. |
| | Should the trainees be paid? | Not specified |
| **Content of the education and training programme with a focus on radiation protection, quality management and safety** | Topics included: (Radiation protection for staff, Radiation protection for patients / general public<br>Radiation protection legislation, Quality & safety management (Q&S)<br>Good research practice, Palliative care (if answering for Radiation Oncology),<br>Artificial intelligence theory and applications for radiation protection and Q&S | All except Artificial Intelligence theory and applications for radiation protection and Q&S |
| | Do the core components of the curriculum provide the content necessary to understand the effect of radiation on tissue in order to ensure safe clinical practice? | Yes |
| | How many ECTS / hours dedicated to radiation protection | Not specified |

| | Parameter | Core curriculum for Radiation Oncologists Issued by ESTRO in 2019 |
|---|---|---|
| | How many ECTS / hours dedicated to quality management and safety | Not specified |
| **Certification** | Which professional / educational / regulatory body defines the CC? | ESTRO |
| | By whom is the education and training delivered? | Training centres accredited by national authority |
| | Is clinical training compulsory? | Yes, after registration |
| | Is a graduate from the education programme licensed to practice independently? | Yes, after registration |
| | Is specific certification required in radiation protection (separate from full certification to practice in the professional group)? | Yes, for some countries |
| | After certification, should continuing professional development / continuing education mandatory for the selected medical specialty? | Yes, for some countries |
| **Training centre** | Should training centres be formally certified / assessed / audited? | Yes |
| **Comments** | | Many European and non-European countries follow or adapt this CC with several variations |

### Table 13 – Current situation of education and training of Radiation Oncologists in Europe and abroad

| | Parameter | RANZCR RO training programme Australia/NZ | IAEA Syllabus for training of RO – 2009 |
|---|---|---|---|
| **Criteria to enter the education and training** | Minimum entry level to education and training programme | MBBS degree or equivalent, registered medical practitioner, need 2 years of residency-internship in an approved hospital | Graduate from a medical school |
| **Structure of the education and training** | Duration of the training (years) | 5 years | 3y minimum – this should be considered as minimum, not optimum |

| | Parameter | RANZCR RO training programme Australia/NZ | IAEA Syllabus for training of RO – 2009 |
|---|---|---|---|
| | Is the Core Curriculum competency-based? | Yes | Yes |
| | Which is the average percent of time during specialty training spent on theoretical (classroom teaching etc.) and practical (patient contact, practical work & supervised service delivery)? | 4 hours per week is “protected time” which is part of non-clinical time | Not stated |
| | Are methods to access competencies described? | Yes | Yes |
| | How should completion of specialty (full professional) training achieved? | Two steps exam | Not stated |
| | Should the trainees be paid? | Not stated | Not stated |
| **Content of the education and training programme with a focus on radiation protection, quality management and safety** | Topics included: (Radiation protection for staff, Radiation protection for patients / general public<br>Radiation protection legislation, Quality & safety management (Q&S)<br>Good research practice, Palliative care (if answering for Radiation Oncology), Artificial intelligence theory and applications for radiation protection and Q&S? | All except Artificial Intelligence theory and applications for radiation protection and Q&S | • Radiation protection for staff<br>Trainees are encouraged to take part in clinical research studies ongoing in the department |
| | Do the core components of the curriculum provide the content necessary to understand the effect of radiation on tissue in order to ensure safe clinical practice? | Yes | Yes |
| | How many ECTS / hours are dedicated to radiation protection? | Not specified | Not specified |
| | How many ECTS / hours are dedicated to quality management and safety? | Not specified | Not specified |
| **Certification** | Which professional / educational / regulatory body defines the core curriculum? | RANZCR | IAEA |
| | By whom is the education and training delivered? | RANZCR | Not specified |
| | Is clinical training compulsory? | Yes | Yes |

| | Parameter | RANZCR RO training programme Australia/NZ | IAEA Syllabus for training of RO – 2009 |
|---|---|---|---|
| | Is a graduate from the education programme licensed to practice independently? | Yes | Not specified |
| | Is specific certification required in radiation protection (separate from full certification to practice in the professional group)? | No | Not specified |
| | After certification, should continuing professional development / continuing education mandatory for the selected medical specialty? | Yes | Not specified |
| **Training centre** | Should training centres be formally certified / assessed / audited? | Yes | Not specified |
| **Comments** | | Australia and NZ training guidelines. Very nicely described with several associated policy documents - websites | Old document – 2009. Syllabus targets all countries including LMICs. Thus, training requirements are kept in minimum. |

# Analysis of guidelines for education and training for Nuclear Medicine Physicians

**Table 14 – European education and training curriculum for NM Physicians**

| | Parameter | UEMS/EBNM (2015)* | IAEA (2019) |
|---|---|---|---|
| **Criteria to enter the education and training programme** | Minimum entry level to education and training programme | degree in medicine | degree in medicine |
| **Structure of the education and training programme** | Duration of the training | proposed 4-5 | Minimum is 3 years with potential additional years (+1 or 2) |
| | Is the Core Curriculum competency-based? | yes | Yes |
| | Which is the average percent of time during specialty training spent on theoretical (classroom teaching etc.) and practical (patient contact, practical work & supervised service delivery)? | Not specified, roughly 80% practical work | First of 3 years is mainly theoretical, the rest mixed. Approx. 60% practical, not only in NM but also in the referring specialties |
| | Are methods to access competencies described? | yes, in details | Yes, as a table |
| | How should completion of specialty (full professional) training achieved? | Passing the Fellowship of the EBNM is optional<br>National or nationally approved exam is recommended | Nothing is compulsory. There is a form for evaluation of each education/training year with non-continuous variables evaluation (§II.5-8) |
| | Should the trainees be paid? | Not specified | Not specified |
| **Content of the education and training programme with a focus on radiation protection, quality management and safety** | Topics included (Radiation protection (RP) for staff, RP for patients / general public<br>RP legislation, Quality & safety management (Q&S)<br>Good research practice, Artificial intelligence theory and applications for RP and Q&S | All except AI theory and applications for radiation protection and Q&S | Yes, AI not mentioned |
| | Do the core components of the curriculum provide the content necessary to understand the effect of radiation on tissue in order to ensure safe clinical practice? | yes | Yes |

| | Parameter | UEMS/EBNM (2015)* | IAEA (2019) |
|---|---|---|---|
| | How many ECTS / hours are dedicated to radiation protection? | not specified | not specified (IAEA does not use ECTS) |
| | How many ECTS / hours are dedicated to quality management and safety? | not specified | not specified (IAEA does not use ECTS) |
| **Certification** | Which professional / educational / regulatory body defines the core curriculum? | UEMS | This remains the prerogative of the Member States |
| | By whom is the education and training delivered? | local institutions | The IAEA is not in the position to grant any certification. This remains the role of the local authorities/institutions |
| | Is clinical training compulsory? | yes | yes |
| | Is a graduate from the education programme licensed to practice independently? | yes - after passing the board exams | yes, provided national authorisation |
| | Is specific certification required in radiation protection (separate from full certification to practice in the professional group)? | yes, but delivered by the local competent authority | yes, proposed but not endorsed by IAEA |
| | After certification, should continuing professional development / continuing education mandatory for the selected medical specialty? | Not specified | yes |
| **Training centre** | Should training centres be formally certified / assessed / audited? | yes | yes |
| **Comments** | | An update of the CC is being prepared and will be submitted to the General Assembly of UEMS-NM in October 2023 | The IAEA CC in NM is intended to be applied worldwide. EU27 are probably more requiring. But in some EU27 with moderate WHO income, this could serve as a good basis. |

*Note: Version available at the time of analysis during the early stages of the EU-REST study. The ETR have meanwhile been updated (October 2023 – https://www.uems.eu/european-training-requirements)

# Analysis of guidelines for education and training for Medical Physicists

**Table 15 – Core curricula for Medical Physicists in Radiotherapy, Radiology and NM**

| | Parameter | RP 174, European guidelines for MPE issued by EC in 2014 | Core Curriculum for MPE in RT Issued by ESTRO/EFOMP in 2021 | Clinical training for MP in RT issued by IAEA in 2009 | Core Curriculum for MP in RAD issued by EFOMP/ ESR in 2011 | Clinical training for MP in RAD issued by IAEA in 2010 | Core Curriculum for MP in NM Issued by EFOMP/EANM in 2013 | Clinical training for MP in NM issued by IAEA in 2011 |
|---|---|---|---|---|---|---|---|---|
| **Criteria to enter the education and training programme** | Minimum entry level to the education and training program | BSc degree, predominantly in physics, followed by an MSc degree in Medical Physics or Medical equivalent | BSc degree, predominantly in physics, followed by an MSc degree in Physics or Medical Physics (BSc + MSc including in total at least 180 ECTS focused on fundamental physics and mathematics) | University degree in physics, engineering or equivalent physical science and a postgraduate level in medical physics (or equivalent). | Not specified | University degree in physics, engineering or equivalent physical science and a postgraduate level in medical physics (or equivalent). | University degree in Medical Physics (or equivalent) | University degree in physics, engineering or equivalent physical science and a postgraduate level in medical physics (or equivalent). |
| **Structure of the education and the training programme** | Duration of the education and training programme | 2y clinical training + 2y advanced clinical training (in one specialty of Medical Physics) | 4y | 2y minimum clinical training | Not specified | 2y minimum clinical training | Not specified | 2y minimum clinical training |
| | Is the Core Curriculum competency-based? | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

| | Parameter | RP 174, European guidelines for MPE issued by EC in 2014 | Core Curriculum for MPE in RT Issued by ESTRO/EFOMP in 2021 | Clinical training for MP in RT issued by IAEA in 2009 | Core Curriculum for MP in RAD issued by EFOMP/ ESR in 2011 | Clinical training for MP in RAD issued by IAEA in 2010 | Core Curriculum for MP in NM Issued by EFOMP/EANM in 2013 | Clinical training for MP in NM issued by IAEA in 2011 |
|---|---|---|---|---|---|---|---|---|
| | Which is the average percent of time during specialty training spent on theoretical (classroom teaching etc.) and practical (patient contact, practical work & supervised service delivery)? | Not specified | At least 50%, but preferably 75%, spent in a hospital to acquire competences and skills that are most relevant to clinical work. | Not specified | Not specified | Not specified | Not specified | Not specified |
| | Are methods to access competencies described? | No | Yes | Yes | No | Yes | No | Yes |
| | How should completion of specialty (full professional) training achieved? | Postgraduate and residency to get certification of MPE in Medical Physics specialty (one or more) | Postgraduate and residency to get certification of MPE in Medical Physics specialty (one or more) | Postgraduate and residency | Not specified | Postgraduate and residency | Not specified | Postgraduate and residency |
| | Should the trainees be paid? | Yes | Yes | Not specified | Yes | Not specified | Not specified | Not specified |

| | Parameter | RP 174, European guidelines for MPE issued by EC in 2014 | Core Curriculum for MPE in RT Issued by ESTRO/EFOMP in 2021 | Clinical training for MP in RT issued by IAEA in 2009 | Core Curriculum for MP in RAD issued by EFOMP/ ESR in 2011 | Clinical training for MP in RAD issued by IAEA in 2010 | Core Curriculum for MP in NM Issued by EFOMP/EANM in 2013 | Clinical training for MP in NM issued by IAEA in 2011 |
|---|---|---|---|---|---|---|---|---|
| **Content of the education and training programme with a focus on radiation protection, quality management and safety** | Topics included: (Radiation protection for staff, Radiation protection for patients/ general public Radiation protection legislation, Quality & safety management (Q&S) Good research practice, Palliative care (if answering for Radiation Oncology), Artificial intelligence theory and applications for radiation protection and Q&S | All except AI theory and applications for radiation protection and Q&S | All | All except AI theory and applications for radiation protection and Q&S | All except AI theory and applications for radiation protection and Q&S | All except AI theory and applications for radiation protection and Q&S | All except AI theory and applications for radiation protection and Q&S | All except AI theory and applications for radiation protection and Q&S |
| | Do the core components of the curriculum provide the content necessary to understand the effect of radiation on tissue in order to ensure safe clinical practice? | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | How many ECTS / hours dedicated to radiation protection | Not specified | 5 ECTS | 5-10% of the total ECTS | Not specified | 10-15% of the total ECTS | Not specified | 15% of the total ECTS |

| | Parameter | RP 174, European guidelines for MPE issued by EC in 2014 | Core Curriculum for MPE in RT Issued by ESTRO/EFOMP in 2021 | Clinical training for MP in RT issued by IAEA in 2009 | Core Curriculum for MP in RAD issued by EFOMP/ ESR in 2011 | Clinical training for MP in RAD issued by IAEA in 2010 | Core Curriculum for MP in NM Issued by EFOMP/EANM in 2013 | Clinical training for MP in NM issued by IAEA in 2011 |
|---|---|---|---|---|---|---|---|---|
| | How many ECTS /hours dedicated to quality management and safety | Not specified | 5 ECTS | 7-12% of the total ECTS | Not specified | 10-15% of the total ECTS | Not specified | 5% of the total ECTS |
| **Certification** | Which professional / educational / regulatory body defines the CC? | EC | ESTRO/EFOMP | IAEA | EFOMP/ESR | IAEA | EFOMP/EANM | IAEA |
| | By whom the education and training is delivered? | Academic and clinical staff | Academic and clinical staff | Academic and clinical staff | Academic and clinical staff | Academic and clinical staff | Academic and clinical staff | Academic and clinical staff |
| | Is clinical training compulsory? | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Is a graduate from the education programme licensed to practice independently? | No, they need also the clinical training | No, they need also the clinical training | No, they need also the clinical training | No, they need also the clinical training | No, they need also the clinical training | No, they need also the clinical training | No, they need also the clinical training |

| | Parameter | RP 174, European guidelines for MPE issued by EC in 2014 | Core Curriculum for MPE in RT Issued by ESTRO/EFOMP in 2021 | Clinical training for MP in RT issued by IAEA in 2009 | Core Curriculum for MP in RAD issued by EFOMP/ ESR in 2011 | Clinical training for MP in RAD issued by IAEA in 2010 | Core Curriculum for MP in NM Issued by EFOMP/EANM in 2013 | Clinical training for MP in NM issued by IAEA in 2011 |
|---|---|---|---|---|---|---|---|---|
| | Is specific certification required in radiation protection (separate from full certification to practice in the professional group)? | Not specified | In those European countries where the MPE certificate automatically implies a full qualification as a radiation protection expert, the amount of ECTS (5) should be increased. | Not specified | No | Not specified | Yes | Not specified |
| | After certification, should continuing professional development / continuing education mandatory for the selected medical specialty? | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Training centre** | Should training centres be formally accredited / assessed / audited? | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Comments** | | | Updated in 2021 | | To be soon updated | | Under reviewing | |

**Table 16 – Current situation of education and training for Medical Physicists in Europe and the US**

| | Parameter | Europe | CAMPEP accreditation for Master in Medical Physics | CAMPEP accreditation for residency in Medical Physics |
|---|---|---|---|---|
| **Criteria to enter the education and training programme** | Minimum entry level to education and training programme | BSc in physics or related sciences to MSc in medical physics, physics or related sciences | University degree in physics or equivalent | Master in Medical Physics or PhD |
| **Structure of the education and the training programme** | Duration of the training (years) | 1 to 5 years (median 3 years with 50% dedicated to RT) | 2 | 2 |
| | Is the Core Curriculum competency-based? | Yes for 16/20 national training schemes | | Yes |
| | Which is the average percent of time during specialty training spent on theoretical (classroom teaching etc.) and practical (patient contact, practical work & supervised service delivery)? | most commonly 25%/75% | 100% theoretical | 100% practical and self-study |
| | Are methods to access competencies described? | Yes | | |
| | How should completion of specialty (full professional) training achieved? | Postgraduate and Residency | This master + clinical residency | Master + clinical residency |
| | Should the trainees be paid? | Residents paid in 17 of 20 countries | | |

| | Parameter | Europe | CAMPEP accreditation for Master in Medical Physics | CAMPEP accreditation for residency in Medical Physics |
|---|---|---|---|---|
| **Certification** | Which professional / educational / regulatory body defines the core curriculum? | Mostly the Ministry of Health or Education, or the national Medical Physics organisation, or in some countries by university. | CAMPEP | |
| | By whom is the education and training delivered? | In most of the countries by academic and medical physicists in the hospitals. | | |
| | Is clinical training compulsory? | Yes | | Yes |
| | Is a graduate from the education programme licensed to practice independently? | Yes, after registration | No | Yes |
| | Is specific certification required in radiation protection (separate from full certification to practice in the professional group)? | In some countries Yes | No | No |
| | After certification, should continuing professional development / continuing education mandatory for the selected medical specialty? | Yes | | Yes |
| **Training centre** | Should training centres be formally certified / assessed / audited? | Yes | Yes | Yes |
| **Comments** | | 11/20 National Societies need to revise their CC. The entrance level, duration and contents of the current training programs still show significant variations across Europe. | | |

# Analysis of guidelines for education and training for Radiation Therapists

**Table 17 – Core curriculum and relevant documents for Radiation Therapists in Europe**

| | Parameter | IAEA: A Handbook for the Education of Radiation Therapists (RTTs) – 2014 | **CC for RTTs issued by ESTRO in 2011 EQF 6** | **ESTRO Benchmarking document for Radiation TherapisTs Related to EQF 6 – 2014** | IAEA: A Handbook for the Education of Radiation Therapists (RTTs) – 2018 |
|---|---|---|---|---|---|
| **Criteria to enter the education and training programme** | Minimum entry level to education and training programme | Completed secondary level education<br>School leaving certificate including mathematics, life sciences and physical sciences is recommended | Not specified but implied as it is recommended at degree level | Bachelor level education which would indicate completion of secondary school education required for entry | This benchmarking document relates to postgraduate practice so an initial qualification in radiation therapy is a requirement |
| **Structure of the education and the training programme** | Duration of the training | Minimum of 2 years but three years is recommended with 4 years where possible | Minimum of three years | Bachelor degree level is recommended – usually a minimum of 3 years | Not specified and dependent on the aim of the course developed and the qualification associated with it. |
| | Is the Core Curriculum competency-based? | Yes | Yes | This benchmarking document defines the competencies that a core curriculum should ensure are met. The knowledge and skills underpinning the competences are defined and should be reflected in the curriculum | Yes, the competences of the identified areas of advanced practice are given together with the associated knowledge and skills to enable achievement of the specific competences |

| | Parameter | IAEA: A Handbook for the Education of Radiation Therapists (RTTs) – 2014 | **CC for RTTs issued by ESTRO in 2011 EQF 6** | **ESTRO Benchmarking document for Radiation TherapisTs Related to EQF 6 – 2014** | IAEA: A Handbook for the Education of Radiation Therapists (RTTs) – 2018 |
|---|---|---|---|---|---|
| | Which is the average percent of time during specialty training spent on theoretical (classroom teaching etc.) and practical (patient contact, practical work & supervised service delivery)? | The percentage of time spent in academic and clinical settings will vary with the duration of the course. Clinical placement is a requirement but can be challenging where resources are limited. The widest possible clinical placement is recommended and student mentors/ educators are recommended. Detailed charts are provided with academic and clinical breakdown depending on duration of the programme | 20-30% of the curriculum should be dedicated to radiotherapy specific clinical education and clinical educators should be in place | Not specified | Not specified but it is implied in the skills acquisition component |
| | Are methods to access competencies described? | Yes | Yes | Yes, the knowledge and skills underpinning the competences are described | No |
| | How should completion of specialty (full professional) training achieved? | Certification, Diploma or Degree depending on duration of the programme and the centre where education is provided | Diploma or degree would be appropriate for a course of 3 years duration | Degree | Certification, diploma or degree depending on the specific competence and the purpose for which it is being acquired |

| | Parameter | IAEA: A Handbook for the Education of Radiation Therapists (RTTs) – 2014 | **CC for RTTs issued by ESTRO in 2011 EQF 6** | **ESTRO Benchmarking document for Radiation TherapisTs Related to EQF 6 – 2014** | IAEA: A Handbook for the Education of Radiation Therapists (RTTs) – 2018 |
|---|---|---|---|---|---|
| | Should the trainees be paid? | Not included in the document | Not addressed in this document | Not discussed in this document | Not discussed but as this is a post graduate course it is highly likely that students will be working |
| **Content of the education and training programme with a focus on radiation protection, quality management and safety** | Topics included: (Radiation protection for staff, Radiation protection for patients / general public<br>Radiation protection legislation, Quality & safety management (Q&S)<br>Good research practice, Palliative care (if answering for Radiation Oncology), Artificial intelligence theory and applications for radiation protection and Q&S | All included depending on the type of course offered and the duration it can be more superficial or in depth<br><br>Research is included in the 3 and 4 year programmes | All except Artificial intelligence theory and applications for radiation protection and Q&S | All competences necessary for a graduate to start to work in a radiotherapy department as an RTT are included together with the knowledge and skills necessary to achieve these competences | These topics are not necessarily included in this document as it defines specific areas of competency that a postgraduate student would focus on. It is assumed that the basic core curriculum would have included these topics. Higher level knowledge and skills in these areas would be specified in the Quality Management component |
| Data cell | Do the core components of the curriculum provide the content necessary to understand the effect of radiation on tissue in order to ensure safe clinical practice? | Yes | Yes | Yes | Yes |

| | Parameter | IAEA: A Handbook for the Education of Radiation Therapists (RTTs) – 2014 | **CC for RTTs issued by ESTRO in 2011 EQF 6** | **ESTRO Benchmarking document for Radiation TherapisTs Related to EQF 6 – 2014** | IAEA: A Handbook for the Education of Radiation Therapists (RTTs) – 2018 |
|---|---|---|---|---|---|
| Data cell | How many ECTS / hours are dedicated to radiation protection? | Defined in terms of competence and curricula content and defined by the education centre providing the education and the duration of the programme | There is a detailed description of the competence and content required to achieve this but not a breakdown of the actual ECTs/hours as again this would be defined by the course provided. The CC gives broader recommendations | This is not included in this document | Not the purpose of this document |
| Data cell | How many ECTS / hours are dedicated to quality management and safety? | See above | See above | | |
| **Certification** | Which professional / educational / regulatory body defines the CC? | IAEA | ESTRO | This document supports the development of core curricula rather than being a core curriculum in itself | This document also supports the concept of advanced practice which would require national acceptance |
| | By whom is the education and training delivered? | Education centre in each country where medical professional education is sited | Education centre and associated clinical departments | Not defined in this document | College or Education Institution |
| | Is clinical training compulsory? | Yes | Yes | Not defined in this document | The required skills will define the clinical training component |
| | Is a graduate from the education programme licensed to practice independently? | Yes | Yes | If a graduate reaches the defined competences then they are competent to practice independently | Yes |

| | Parameter | IAEA: A Handbook for the Education of Radiation Therapists (RTTs) – 2014 | **CC for RTTs issued by ESTRO in 2011 EQF 6** | **ESTRO Benchmarking document for Radiation TherapisTs Related to EQF 6 – 2014** | IAEA: A Handbook for the Education of Radiation Therapists (RTTs) – 2018 |
|---|---|---|---|---|---|
| | Is specific certification required in radiation protection (separate from full certification to practice in the professional group)? | No but in some countries, it may be an independent requirement | No, it is fully integrated into the defined competences and curriculum content | Not defined in this document | No |
| | After certification, should continuing professional development / continuing education mandatory for the selected medical specialty? | Yes | Yes | Yes | |
| **Training centre** | Should training centres be formally certified / assessed / audited? | Yes | Yes, this is recommended | Yes, but not discussed in this document | |
| **Comments** | | These are guidelines for centres then to define what is possible for them to put in place. Recommendations for minimum standards are given and then detail on what would additional content should be included | This is a recommended core curriculum | This benchmarking document defines the core competences that should be expected of a graduate RTT and is therefore a tool with which to develop the curricula necessary to meet these competences. It is also a guide for governments to set standards of practice and professional requirements | |

## Table 18 – Current situation of education and training for Radiation Therapists in Europe and abroad

| | Parameter | Europe | Canada | Australia | USA ASRRT 2019 for revision |
|---|---|---|---|---|---|
| **Criteria to enter the education and training** | Minimum entry level to education and training programme | Varies across countries but most would require completion of second level education | Completed second level education | Completed second level education | Post-secondary education college credits in defined topics: Mathematics and reasoning, communication, humanities, information systems, social sciences, natural sciences |
| **Structure of education and training programme** | Duration of the training (years) | From a few weeks to four years | 3-4 years | 3-4 years depending on education centre | 3 years |
| | Is the Core Curriculum competency-based? | In some countries | Yes | Yes | Yes |
| | Which is the average percent of time during specialty training spent on theoretical (classroom teaching etc.) and practical (patient contact, practical work & supervised service delivery)? | Varies from none to 20 – 35% | ≥ 30% | ≥ 30% | Not specified |
| | Are methods to access competencies described? | Varies across countries | Yes | Yes | no |
| | How should completion of specialty (full professional) training achieved? | Not specified | Examination of the professional society | Degree award | Associate degree |
| | Should the trainees be paid? | Not specified | | | Not specified |
| **Certification** | Which professional / educational / regulatory body defines the core curriculum? | Not specified | Canadian Association of Medical Radiation Technologists (CAMRT) | Australian Society of Medical Imaging and Radiation Therapy (ASMIRT) | ASRT |

| | Parameter | Europe | Canada | Australia | USA ASRRT 2019 for revision |
|---|---|---|---|---|---|
| | By whom is the education and training delivered? | Not specified | Not specified | | |
| | Is clinical training compulsory? | Not in all countries | Yes | | Yes |
| | Is a graduate from the education programme licensed to practice independently? | In some countries an additional clinical placement and examination is required | Yes | Yes | Not in all states |
| | Is specific certification required in radiation protection (separate from full certification to practice in the professional group)? | In some countries this is a requirement in particular where this is not included in the basic education programme | Integrated into the academic programme | No, it is integrated into the programme | No, it is integrated into the programme |
| | After certification, should continuing professional development / continuing education mandatory for the selected medical specialty? | Yes, and it is mandatory in the majority of countries | Yes | Yes | Yes |
| **Training centre** | Should training centres be formally certified / assessed / audited? | Yes, but they are not in many instances | Yes | Yes | Not specified |
| **Comments** | | | Canada has well established degree programmes in radiation therapy based on competencies | As Canada, Australia has well established programmes and requirements for graduate competences | |

# Analysis of guidelines for education and training for Radiographers

**Table 19 – European training curriculum for Radiographers**

| | Parameter | European Training Curriculum (ETC) (based on the EFRS publications described in section 2.1.2) |
|---|---|---|
| **Criteria to enter the education and training programme** | Minimum entry level to education and training programme | Can vary; normally EQF Level 4 or Level 5 required for admission.<br>Some may consider accepting other levels of qualification and may take into consideration the qualification, clinical experience and other activities, including (CPD), undertaken which together may be seen as being equivalent to meeting the entry requirements. |
| **Structure of the education and training programme** | Duration of the training | Total course duration: 180 ECTS or 210 ECTS<br>or 240 ECTS (1 ECTS = 25-30 study hours)<br><br>Varies between 2.5 to 4 years |
| | Is the Core Curriculum competency-based? | Yes<br>Knowledge – Skill – Competencies (KSC) |
| | Which is the average percent of time during specialty training spent on theoretical (classroom teaching etc.) and practical (patient contact, practical work & supervised service delivery)? | Clinical placement to be 25% minimum of<br>course duration.<br>Clinical placements should ideally constitute a minimum of 25% of the total ECTS.<br>Between 51 and 60 ECTS of practical training for students in the skills lab and in clinical practice during their programmes. |
| | Are methods to access competencies described? | Partially |
| | How should completion of specialty (full professional) training achieved? | Bachelors Degree (EQF Level 6) |
| | Should the trainees be paid? | Not specified |

| | Parameter | European Training Curriculum (ETC) (based on the EFRS publications described in section 2.1.2) |
|---|---|---|
| **Content of the education and training programme with a focus on radiation protection, quality management and safety** | Topics included (Radiation protection for staff, Radiation protection for patients / general public<br>Radiation protection legislation, Quality & safety management (Q&S)<br>Good research practice, Palliative care (if answering for Radiation Oncology), Artificial intelligence theory and applications for radiation protection and Q&S | The education institution when designing the curriculum are required to ensure the Knowledge, Skills, and Competences as defined in the benchmark document EQF 6 are met across imaging, radiotherapy and nuclear medicine. |
| | Do the core components of the curriculum provide the content necessary to understand the effect of radiation on tissue in order to ensure safe clinical practice? | yes |
| | How many ECTS / hours are dedicated to radiation protection? | not specified |
| | How many ECTS / hours are dedicated to quality management and safety? | not specified |
| **Certification** | Which professional / educational / regulatory body defines the core curriculum? | EFRS provides benchmarking framework for knowledge, skills, and competences to inform a core curriculum, however, the curricula themselves are designed by educational institutions within national regulatory or professional body frameworks. |
| | By whom is the education and training delivered? | Higher Education Institutions (HEI) |
| | Is clinical training compulsory? | Yes. Certain KSCs are clinical practice-focused |
| | Is a graduate from the education programme licensed to practice independently? | Yes |
| | Is specific certification required in radiation protection (separate from full certification to practice in the professional group)? | no |
| | After certification, should continuing professional development / continuing education mandatory for the selected medical specialty? | yes |
| **Training centre** | Should training centres be formally certified / assessed / audited? | Yes (as per EQF Quality Framework requirements) |
| **Comments** | | The EFRS EQF level 6 Benchmarking document is currently under revision |

**Table 20 – Current situation of education and training for Radiographers in Europe and abroad**

| | | National Curriculum (EU) | | Non-EU National CC | | | Europe (non-European Society) |
|---|---|---|---|---|---|---|---|
| | **Parameter** | Assessment of radiographers' competencies from the perspectives of radiographers and radiologists: a cross-sectional survey in Lithuania (2017) | Informing radiography curriculum development: The views of UK radiology service managers concerning the 'fitness for purpose' of recent diagnostic radiography graduates (2017) | ACR Radiologic Technologist: CT (2022) | The ASRT Practice Standards for Medical Imaging and Radiation Therapy (2021) | JRCNMT Accreditation Standards For Nuclear Medicine Technologist Education (2014) | An evaluation of the educational requirements to practise radiography (2018) |
| **Criteria to enter the training** | minimum entry level to training programme | Not specified | Not specified | ARRT registered (RT) and radiography (R) and/or computed tomography (CT) certified and/or NMTCB registered (CNMT)*** and/or unrestricted state license; Documented training and experience in CT; Documented training and experience in operating CT equipment and radiation physics and protection. Passing an advanced examination for CT certification is recommended | Not specified | Not specified | Not specified |

| | | National Curriculum (EU) | | Non-EU National CC | | | Europe (non-European Society) |
|---|---|---|---|---|---|---|---|
| **Structure of the training** | duration of the training | Not specified | Not specified | Not specified | Not specified | Not specified | 2-4 years/ 120 -240 ECTS |
| | is the Core Curriculum competency-based? | Yes | Not specified | Not specified | Yes | Yes | Yes (KSC) |
| | Which is the average percent of time during specialty training spent on theoretical (classroom teaching etc.) and practical (patient contact, practical work & supervised service delivery)? | Not specified | Not specified | Not specified | Not specified | Not specified | Not specified |
| | Are methods to access competencies described? | Partially | No | No | Partially | Partially | No |
| | How should completion of specialty (full professional) training achieved? | Not specified | Not specified | Not specified | Various degrees | Not specified | Bachelors Degree (EQF Level 6) |
| | Should the trainees be paid? | Not specified | Not specified | Not specified | Not specified | Not specified | Not specified |

| | | National Curriculum (EU) | | Non-EU National CC | | | Europe (non-European Society) |
|---|---|---|---|---|---|---|---|
| **Content of the training with a focus on radiation protection, quality management and safety** | Topics **NOT included:** Radiation protection (RP) for staff, RP for patients / general public<br>RP legislation, Quality & safety management (Q&S)<br>Good research practice, Palliative care (if answering for Radiation Oncology), Artificial intelligence theory and applications for radiation protection and Q&S? | Only selected competence areas discussed | Only generic Knowledge, Skills, and Competences listed rather than RP specific. | Not specified | Only selected competence areas discussed | Only selected competence areas discussed | Only selected competence areas discussed |
| | Do the core components of the curriculum provide the content necessary to understand the effect of radiation on tissue in order to ensure safe clinical practice? | Not specified | Not specified | Not specified | Not specified | Not specified | Not specified |
| | How many ECTS / hours dedicated to radiation protection | Not specified | Not specified | Not specified | Not specified | Not specified | Not specified |
| | How many ECTS / hours dedicated to quality management and safety | Not specified | Not specified | Not specified | Not specified | Not specified | Not specified |

| | | National Curriculum (EU) | | Non-EU National CC | | | Europe (non-European Society) |
|---|---|---|---|---|---|---|---|
| | Which professional / educational / regulatory body defines the CC? | | The Health and Care Professions Council (HCPC) / College of Radiographers | ARRT / ACR | ARRT | JRCNMT | National regulators |
| **Certification** | by whom the education and training is delivered? | Not specified | HEI | Not specified | Not specified | HEI | HEI |
| | Is clinical training compulsory? | Not specified | Not specified | Not specified | Yes | Yes | Yes |
| | Is a graduate from the education programme licensed to practice independently? | Not specified | Yes | Not specified | Yes | Yes | Not specified |
| | Is specific certification required in radiation protection (separate from full certification to practice in the professional group)? | Not specified | Not specified | Not specified | Not specified | Not specified | Not specified |
| | after certification, should continuing professional development / continuing education mandatory for the selected medical specialty? | Not specified | Not specified | Yes | Not specified | Not specified | Not specified |
| **Training centre** | Should training centres be formally certified / assessed / audited? | Not specified | Not specified | Not specified | Not specified | Yes | Not specified |

| | | National Curriculum (EU) | | Non-EU National CC | | | Europe (non-European Society) |
|---|---|---|---|---|---|---|---|
| **Comments** | | The aim of the study was to evaluate radiographers' professional competence from the perspectives of radiographers and radiologists by applying the Radiographers' Competence Scale (RCS). | The study aimed to critically evaluate the fitness for purpose of newly qualified diagnostic radiography. | ACR criteria for radiological technologists performing CT examinations | | | The aim of this study was to identify the commonalities and discrepancies in national regulation of radiography. |

# Annex 4: Final report on the data collection and analysis

# Final report on the data collection and analysis (Project Deliverable 4)

Service contract HADEA/2022/OP/0003

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# Disclaimer

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# List of Abbreviations

| | |
|---|---|
| **BSSD** | Basic Safety Standards Directive (Council Directive 2013/59/Euratom) |
| **COCIR** | European Trade Association representing the medical imaging, radiotherapy, health ICT and electromedical industries |
| **CPD** | Continuing Professional Development |
| **EANM** | European Association of Nuclear Medicine |
| **EC** | European Commission |
| **EFOMP** | European Federation of Organizations in Medical Physics |
| **EFRS** | European Federation of Radiographer Societies |
| **ESR** | European Society of Radiology |
| **ESTRO** | European Society for Radiotherapy and Oncology |
| **E&T** | Education and Training |
| **EU** | European Union |
| **HERCA** | Heads of the European Radiological protection Competent Authorities |
| **ICT** | Information and Communication Technology |
| **na** | when used in the tables in this report, na means “data not available”, including survey responses indicating “don’t know” |
| **NMP** | Nuclear Medicine Physician |
| **RP** | Radiation protection |
| **RT** | Radiotherapy |
| **SGQS** | Steering Group on Quality and Safety |
| **UEMS** | European Union of Medical Specialists |
| **WP** | Work Package |

# 1. Introduction

The Tender entitled ‘EU-REST’ (European Union Radiation, Education, Staffing & Training) started on 1 September 2022 and will last until 31 August 2024.

The study aims to provide an analysis of workforce availability, education, and training needs to ensure quality and safety aspects of medical applications involving ionising radiation in the EU and foresees the development of staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications in the EU Member States.

The study will meet the following specific objectives:

- Collect and analyse data on workforce availability, education, and training needs to ensure quality and safety aspects of medical applications involving ionising radiation, as well as related stakeholder mapping;
- Draft guidelines for staffing and education/training for medical and other professionals involved in medical radiation applications in Member States and related stakeholder consultation;
- Develop conclusions and recommendations on EU workforce availability, education, and training needs for the quality and safety of medical applications involving ionising radiation and related stakeholder consultation.

WP1 aims to collect up-to-date data on staffing, education, and training of the key professional groups involved in ensuring radiation safety and quality of medical radiation applications in Member States. The collected data will cover the areas of radiology, radiotherapy, nuclear medicine (and other medical practices independently utilising ionising radiation, from a staffing, education, and training standpoint), with an emphasis on procedures delivering high(er) radiation doses to patients and/or staff either for diagnostic and treatment purposes.

The work will cover the main categories of staff falling under BSSD’s definitions of ‘practitioner’, ‘medical physics expert’ and staff carrying ‘practical aspects of medical radiological procedures’, including staff dealing with reporting and learning from adverse radiological events.

The study will identify and map the various stakeholders that will be consulted on the staffing and education/training guidelines proposed by WP2 as well as on the project’s conclusions and recommendations developed under WP3.

This report builds upon the data collection and analysis methodology defined in Task 1.1 and reported in Deliverable 1 (Report on the data collection and analysis methodology), which has been approved by the European Commission/HADEA, and provides a draft report on the data collection and analysis carried out under Tasks 1.2 and 1.3.

# 2. Summary of Data Collection

The methodology for the data collection and analysis was developed by Task 1.1 under the lead of A. Brady and submitted in November 2022 as Deliverable D1 and approved by the European Commission/Executive Agency, as confirmed by HaDEA in an update meeting on 9th March 2023. Deliverable D2 builds on the agreed methodology and describes how data collection, data cleaning and analysis have been implemented.

## 2.1 Data Collection

The study aims to provide an analysis of workforce availability, education, and training needs to ensure quality and safety aspects of medical applications involving ionising radiation in the EU and foresees the development of staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications in the EU Member States.

### 2.1.1 Target groups

Following a preliminary definition of the target groups in the tender application, the below professional groups were finally targeted by the Main Survey:

A. Medical Doctors
- i) Radiologists
- ii) Radiation Oncologists (also known as Clinical Oncologists and, in some countries, Radiotherapists, distinct from (B.iii) and (C) below)
- iii) Nuclear Medicine physicians

B. Radiographers (known by a variety of terms, including RTT, Technologists etc.)
- i) Diagnostic & Interventional Radiology (including Ultrasound, where this is performed by Radiographers)
- ii) Nuclear Medicine
- iii) Radiation Therapists / Radiotherapy / Radiation Oncology (if this group of workers fall under the category of Radiographers in your country)

C. Radiation Therapists (known as RTT, Radiotherapy Technologist, RTT Nurse or Therapeutic Radiographer in some countries, distinct from (A.ii) above) (if this group of workers are independent from the category of Radiographers - as listed in (B.iii) above - in the relevant country)

i) Radiotherapy / Radiation Oncology

(It was agreed that Radiographers and Radiation Therapists will be addressed separately in the Main Survey, where country-specific information suggests this is appropriate.)

D. Medical Physicists (including Radiation Protection Advisors, Radiation Protection Experts & Medical Physics Experts, depending on categorisation in each country)

i) Diagnostic & Interventional Radiology
ii) Nuclear Medicine
iii) Radiotherapy / Radiation Oncology

For radiation protection training requirements also:

E. Other professions using ionising radiation (focusing on high-dose procedures): Some other medical specialists and professions utilise ionising radiation in the performance of their work.

### 2.1.2 Target countries and recipients

The target countries were the 27 EU Member States.

The targeted recipients of the Main Survey were

- National Professional / Scientific Societies
- National Health Authorities
- National Radiation Protection Authorities
- Licensing Authorities (e.g. Medical Councils or Chambers etc.)

The different professional societies at the European level involved with the project (ESR, ESTRO, EFOMP, EFRS, and EANM as an advisory board member) have up to date databases of national professional societies concerning the professional categories A-D described in section 2.1.1. Based on this database, a pre-survey was distributed to gather up-to-date information on the relevant authorities/professional bodies in the EU 27 countries responsible for staffing, education and training issues (see section 2.1.3 below). At the same time this pre-survey was circulated to the SAMIRA Steering Group on Quality and Safety (SGQS) by the European Commission.

### 2.1.3 Pre-Survey

The short Pre-Survey (see Annex 1) was implemented in English using the online survey tool SurveyMonkey. The online version of the Pre-Survey was circulated among the consortium members, the Advisory Board, and Peer Review Group in early October 2022 and a further internal meeting was held on 13th October to revise the Pre-Survey's wording and functionality to ensure it would function as intended. The EC/HaDEA subsequently approved the Pre-Survey on 13th October. The consortium members ESR, EFOMP, EFRS and ESTRO, as well as Advisory Board Member EANM, distributed the link to the Pre-Survey, along with a PDF version of the Pre-Survey to appropriate national contacts in mid-October with a deadline of 27th October 2022. This was subsequently extended to 3rd November 2022 in a reminder notice. The Pre-Survey was also distributed to members of the SAMIRA Steering Group on Quality and Safety (SGQS) by the EC with the same deadlines.
The Pre-Survey was asking for information and contact details for those bodies which would be expected to be able to provide information on workforce numbers, education and training requirements etc. The professions targeted by the pre-survey were categories A-D outlined in section 2.1.1 above.
A total of 109 responses were received, including at least one from all EU27 countries as shown in the pie-chart (Fig. 1) below.

**Figure 1 – Responses to Pre-Survey by country**

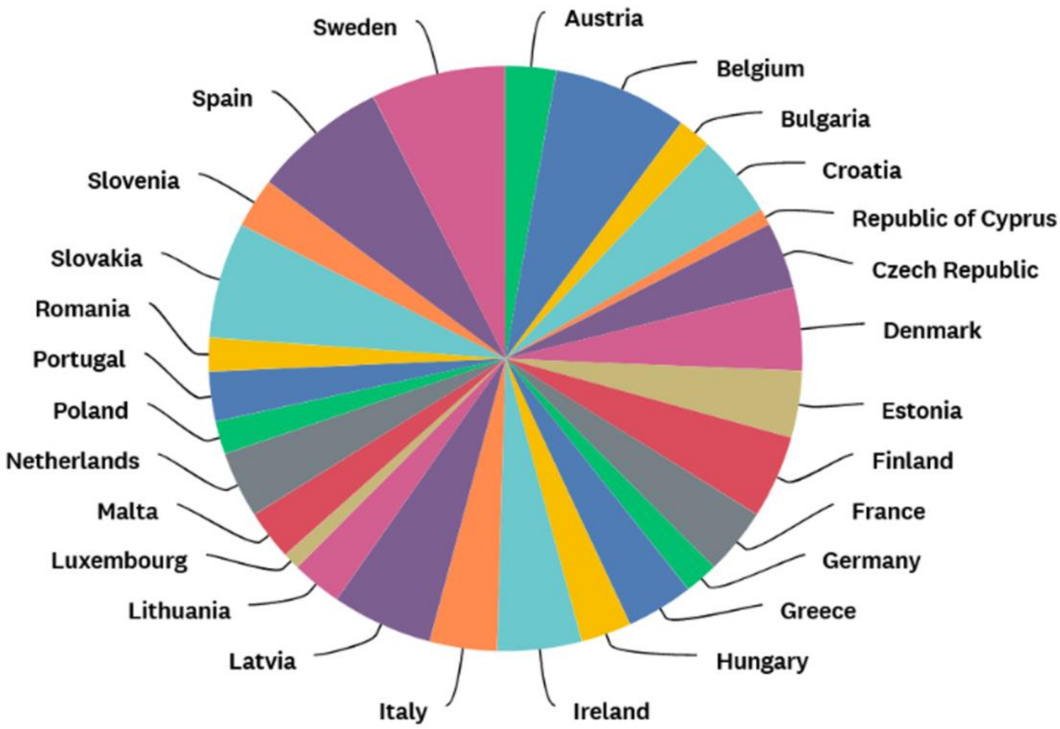


**Table 1 – Pre-Survey Responses by profession**

| Answer choices | Responses | |
|---|---|---|
| Medical doctor (Radiologist, Radiation Oncologist, and/or Nuclear Medicine physician) | 45.87% | 50 |
| Radiographer/Radiation Therapist | 20.18% | 22 |
| Medical Physicist | 29.36% | 32 |
| Other profession using ionising radiation (focusing on high-does procedures), please specify | 4.59% | 5 |
| **TOTAL** | | **109** |

Around 40% of respondents only partially completed the Pre-Survey or were only able to provide partial answers. After analysis of the incomplete responses, appropriate follow-up was conducted e.g. personal contacts at national societies were asked to verify/complete answers.

The Pre-Survey generated 273 contacts of relevant authorities/professional bodies in the EU 27 countries responsible for staffing, education and training issues.

Based on the responses received to the Pre-Survey and subsequent follow-up activities to complement the data, a database of the relevant contacts for each Member State was set up for the distribution of the Main Survey.

### 2.1.4 Main Survey implementation

The main survey (included in D2: Draft Report on the Data Collection and Analysis as Annex 2) was implemented in English on SurveyMonkey. The choice of the tool was motivated by its user-friendly interface and associated functionalities (facilitating choices from drop-down menus and free-text responses to each question as most appropriate). It was divided into four sections related to

- education and training (including CPD/Continuing Education)
- workforce availability
- workforce planning
- quality and safety

An abbreviated version of the survey was made available for national radiation protection authorities in the EU27 focusing on the quality and safety elements only.

The online version was initially tested by 24 consortium members over a couple of days end of November 2022 in order to test the functionality. EC/HaDEA also provided feedback on the 1st of December 2022.

The survey was distributed

- to the different national organisations and competent authorities from the database established through the Pre-Survey in section 2.1.3 above
- to the EU27 national professional societies for Radiology/Nuclear Medicine/Radiotherapy/Radiography/Medical Physics through ESR, EANM, ESTRO, EFRS and EFOMP
- to the EU27 national radiation protection authorities through HERCA
- to the EU27 national medical associations/chambers through UEMS

It was initially distributed at the beginning of the week 49 (5th December 2022) with an initial period of 6 weeks for return of responses (1st deadline for receiving responses was set on the 16th of January 2023). A pdf version of the survey was also made available to a very limited number of responders that could not use the online survey version upon request. At least one response from 25 out of the 27 EU member countries targeted was received after this initial deadline (no responses from Austria and Luxembourg).

A total of 101 responses were received after this initial period expired, with variable response rates depending on the type of professionals or organisations as illustrated in table 2 below. More specifically the vast majority of responders were associated with national professional societies, while a very small rate of response was received from national competent authorities.

**Table 2 – Initial Main Survey responses by type of organisation**

| Answer choices | Responses | |
|---|---|---|
| National Profession / Scientific Society | 70.30 | 71 |
| National Health Authority | 7.92% | 8 |
| National Radiation Protection Authority | 3.96% | 4 |
| Licensing Authority (e.g. Medical Council or Chamber etc.) | 1.98% | 2 |
| Other (please specify) | 15.84% | 16 |
| **TOTAL** | | **101** |

Following removal of survey responses with no data, over half of the responses were on behalf of medical doctors (with almost half of them coming from radiologists) as shown in tables 3 and 4.

**Table 3 – Initial Main Survey responses by type of profession**

| Answer choices | Responses | |
|---|---|---|
| A. Medical Doctorsi) Radiologistsii) Radiation Oncologists (also known as Clinical Oncologists and, in some countries, Radiotherapists, distinct from (B.iii) and (C) below)iii) Nuclear Medicine physicians | 51.02% | 50 |
| B. Radiographers (known by a variety of terms, including Technologists etc.)i) Diagnostic & Interventional Radiology (including Ultrasound, where this is performed by Radiographers)ii) Nuclear Medicineiii) Radiation Therapists / Radiotherapy / Radiation Oncology (if this group of workers fall under the category of Radiographers in your country) | 14.29% | 14 |
| C. Radiation Therapists (known as RTT, Radiotherapy Technologist, RTT Nurse or Therapeutic Radiographer in some countries, distinct from (A.ii) above) (if this group of workers are independent from the category of Radiographers - as listed in (B.iii) above - in your country)i) Radiotherapy / Radiation Oncology | 5.10% | 5 |
| D. Medical Physicists (including Radiation Protection Advisors, Radiation Protection Experts & Medical Physics Experts, depending on categorisation in each country)i) Diagnostic & Interventional Radiologyii) Nuclear Medicineiii) Radiotherapy / Radiation Oncology | 28.57% | 28 |
| E. Other professions using ionising radiation (focusing on high-dose procedures): Some other medical specialists and professions utilise ionising radiation in the performance of their work. | 1.02% | 1 |
| **TOTAL** | | **98** |

**Table 4 – Initial Main Survey responses for medical doctors by specialty (following removal of incomplete answers)**

| Answer choices | Responses | |
|---|---|---|
| Radiologists | 45.83% | 22 |
| Radiation Oncologists | 33.33% | 16 |
| Nuclear Medicine Physicians | 20.83% | 10 |
| **TOTAL** | | **98** |

Following this initial period, a further extension of two weeks, until the 31st of January, was issued for the completion of responses in an attempt to increase the response rates. A new invitation email notifying this extension was sent out to the entire database. An additional 36 responses (12 from national professional societies, 10 from national health authorities, 8 from national radiation protection authorities, 2 from national licensing authorities and 4 others) were received at the end of this extended timeline. This corresponded to an increase of over 35% in the answers relative to the initial responses received.

An initial analysis of the survey results received showed a lack of responses for certain professional categories (notably Nuclear Medicine physicians and Radiation Oncologists) from specific countries. A final extension of three further weeks was issued, until the 19th of February, to allow members of the consortium to target specific key persons within the professional categories and countries in order to obtain further responses (first phase of the data cleaning process described in more detail in section 2.2).

At the end of this process a total of 186 responses of various levels of completeness were received, including a few respondents who completed the pdf version of the survey (table 5A). More specifically, concerning the responses from medical doctors, all specialities considered, an increase of nearly a factor of 2 was achieved in terms of the number of responses received during the final extension period. Considering the individual specialties, the increases in the response rates in this final extension period relative to the number of initial responses received were 72%, 94% and 50% for radiologists, radiation oncologists and nuclear medicine physicians, respectively. This represents a significant increase in the response rates of all medical specialties and in terms of proportion especially of radiation oncologists. Out of the final number of responses for all medical specialties (84), 45.1% (38), 37% (31) and 17.9% (15) were received from radiologists, radiation oncologists and nuclear medicine physicians, respectively. In terms of the other professional categories, the responses received corresponded to 15%, 7%, 35% for radiographers, RTTs and MPEs, respectively. In terms of authorities providing responses, the percentage of responses coming from national professional / scientific societies decreased from 70% to 62%, for national authorities it remained practically unchanged at 7.5%, and for national radiation protection authorities it more than doubled from 4% to 10.8%. Thanks to the extended response period the contribution from national authorities slightly increased relative to national professional societies, although it remains largely small.

In terms of data collection, the large majority of responses came from national professional / scientific societies rather than national authorities, which is a point to be discussed. It most probably reflects the fact that national professional societies have more up-to-date registers of the workforce in the different categories evaluated in this study. In terms of responses from medical doctor specialties, the lowest number of responses (14/27 EU countries) was received from the nuclear medicine physicians section, which is most probably a result of the different practices currently in place in the different Member States concerning the field of nuclear medicine. More specifically, in certain countries the activity in nuclear medicine is carried out by radiologists with a specialisation in nuclear medicine. In the case of radiation oncologists 19 out of the 27 EU Member States responded to the survey, also eventually highlighting certain disparities in the practices within this professional category relative to non-radiation oncologists. The largest proportion of responses among clinical specialities was provided by radiologists (23/27 EU countries). In terms of professionals other than those in medical specialties, medical physicists' responses were received from all EU27 countries apart from Luxembourg, which was up until recently not a member of EFOMP. In terms of radiographers, responses were received from 21 out of 27 EU countries. Finally, responses from RTTs were received only from 7 countries given that this subspecialty is not independent from radiographers in most EU27 countries. Therefore, although in certain professional categories a limited number of responses have been received, these reduced numbers mostly reflect the large diversity of practices within the different EU Member States in certain professional categories targeted by this survey. A more complete picture can therefore most probably only be provided by supplementary national investigations within these specific Member States.

### 2.1.5 Overview of responses obtained

The numbers of Main Survey responses collected from all countries in the EU27 are summarised in table 5A below and reflect the status before data cleaning.

## Table 5A – Detailed overview of Main Survey responses (prior to data cleaning)

| | | | | Answers provided on behalf of | | | | | Professions for which the answers were provided | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Responses full version | Responses abbr version (Q&S) | **Total responses** | National professional/scientific soc | National Health Authority | National RP Authority | Licensing Authority | Other | Radiologists | Radiation Oncologists | NM Physicians | Radiographers | RTTs (where indep from Radiographers) | Medical Physicists | Other | combined response for all Professions | no selection made/no data provided |
| **Austria** | 7 | 0 | **7** | 3 | 1 | 0 | 2 | 1 | 3 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Belgium** | 8 | 1 | **9** | 5 | 2 | 1 | 0 | 1 | 1 | 2 | 2 | 0 | 2 | 2 | 0 | 0 | 0 |
| **Bulgaria** | 6 | 1 | **7** | 6 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 3 | 1 | 1 | 0 | 0 | 0 |
| **Croatia** | 3 | 1 | **4** | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| **Cyprus** | 5 | | **5** | 2 | 1 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| **Czechia** | 6 | | **6** | 5 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 2 | 0 | 0 | 0 |
| **Denmark** | 6 | | **6** | 4 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 3 | 0 | 0 | 0 |
| **Estonia** | 8 | | **8** | 6 | 1 | 0 | 0 | 1 | 1 | 2 | 1 | 2 | 0 | 1 | 0 | 0 | 1 |
| **Finland** | 4 | 1 | **5** | 4 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 2 | 0 | 0 | 0 |
| **France** | 5 | | **5** | 5 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 |
| **Germany** | 8 | | **8** | 6 | 0 | 0 | 0 | 2 | 2 | 1 | 1 | 1 | 0 | 3 | 0 | 0 | 0 |
| **Greece** | 4 | | **4** | 3 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Hungary** | 6 | 2 | **8** | 5 | 0 | 2 | 0 | 1 | 2 | 1 | 1 | 0 | 1 | 1 | 0 | 2 | 0 |
| **Ireland** | 6 | | **6** | 4 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 1 | 1 | 2 | 0 | 0 | 0 |
| **Italy** | 15 | | **15** | 10 | 1 | 0 | 0 | 4 | 1 | 7 | 0 | 2 | 3 | 2 | 0 | 0 | 0 |
| **Latvia** | 2 | | **2** | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Lithuania** | 6 | 1 | **7** | 4 | 0 | 1 | 0 | 2 | 2 | 2 | 0 | 1 | 0 | 2 | 0 | 0 | 0 |
| **Luxembourg** | 0 | 1 | **1** | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **Malta** | 7 | | **7** | 3 | 2 | 0 | 0 | 2 | 1 | 1 | 0 | 3 | 0 | 2 | 0 | 0 | 0 |
| **Netherlands** | 10 | 1 | **11** | 7 | 0 | 1 | 0 | 3 | 1 | 3 | 1 | 1 | 1 | 3 | 0 | 1 | 0 |
| **Poland** | 6 | | **6** | 4 | 1 | 1 | 0 | 0 | 2 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Portugal** | 4 | | **4** | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 |
| **Romania** | 10 | | **10** | 4 | 0 | 1 | 0 | 5 | 2 | 1 | 0 | 0 | 4 | 3 | 0 | 0 | 0 |
| **Slovakia** | 9 | 3 | **12** | 4 | 0 | 4 | 0 | 4 | 2 | 1 | 1 | 2 | 0 | 5 | 0 | 0 | 1 |
| **Slovenia** | 5 | 2 | **7** | 5 | 0 | 2 | 0 | 0 | 3 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| **Spain** | 9 | 1 | **10** | 6 | 1 | 1 | 0 | 2 | 5 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| **Sweden** | 4 | 2 | **6** | 3 | 1 | 2 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 3 | 0 | 0 | 0 |
| **Total** | **169** | **17** | **186** | **115** | **14** | **20** | **3** | **34** | **38** | **31** | **15** | **28** | **13** | **53** | **1** | **4** | **3** |

The response rates per country per target group addressed (National professional/scientific society, National Health Authority, National RP Authority, Licencing Authority, Other) and per profession are provided in table 5B. Multiple responses from one and the same country are counted as 1.

## Table 5B – Response rates for Main Survey (prior to data cleaning)

| | **Answers provided on behalf of** | | | | | | **Professions for which the answers were provided** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | National professional /scientific soc | National Health Authority | National RP Authority | Licensing Authority | Other | % of res-ponding target groups per country | Radiologists | Radiation Oncologists | NM Physicians | Radio-graphers | RTTs (where indep from Radiographers) | Medical Physicists | Other | % of res-ponding professional groups p. country |
| **Austria** | 1 | 1 | 0 | 1 | 1 | 80% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 71% |
| **Belgium** | 1 | 1 | 1 | 0 | 1 | 80% | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 71% |
| **Bulgaria** | 1 | 1 | 0 | 0 | 0 | 40% | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 57% |
| **Croatia** | 1 | 0 | 1 | 1 | 1 | 80% | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 43% |
| **Cyprus** | 1 | 1 | 0 | 0 | 1 | 60% | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 29% |
| **Czechia** | 1 | 1 | 0 | 0 | 0 | 40% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 71% |
| **Denmark** | 1 | 1 | 0 | 0 | 1 | 60% | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 57% |
| **Estonia** | 1 | 1 | 0 | 0 | 1 | 60% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 71% [1] |
| **Finland** | 1 | 0 | 1 | 0 | 0 | 40% | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 57% |
| **France** | 1 | 0 | 0 | 0 | 0 | 20% | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 57% |
| **Germany** | 1 | 0 | 0 | 0 | 1 | 40% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 71% |
| **Greece** | 1 | 0 | 1 | 0 | 0 | 40% | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 57% |
| **Hungary** | 1 | 0 | 2 | 0 | 1 | 80% | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 71% |
| **Ireland** | 1 | 0 | 0 | 0 | 1 | 40% | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 71% |
| **Italy** | 1 | 1 | 0 | 0 | 1 | 60% | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 71% |
| **Latvia** | 1 | 0 | 0 | 0 | 0 | 20% | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 29% |
| **Lithuania** | 1 | 0 | 1 | 0 | 1 | 60% | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 57% |
| **Luxembourg** | 0 | 0 | 1 | 0 | 0 | 20% | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 14% |
| **Malta** | 1 | 1 | 0 | 0 | 1 | 60% | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 57% |
| **Netherlands** | 1 | 0 | 1 | 0 | 1 | 60% | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 86% |
| **Poland** | 1 | 1 | 1 | 0 | 0 | 60% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 71% |
| **Portugal** | 1 | 0 | 0 | 0 | 0 | 20% | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 43% |
| **Romania** | 1 | 0 | 1 | 0 | 1 | 60% | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 57% |
| **Slovakia** | 1 | 0 | 1 | 0 | 1 | 60% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 71% [1] |
| **Slovenia** | 1 | 0 | 1 | 0 | 0 | 40% | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 57% [1] |
| **Spain** | 1 | 1 | 1 | 0 | 1 | 80% | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 43% |
| **Sweden** | 1 | 1 | 1 | 0 | 0 | 60% | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 57% |
| **Resp. rate per responder type, all countries** | **96%** | **44%** | **56%** | **7%** | **59%** | | **85%** | **70%** | **52%** | **78%** | **26%** | **93%** | **4%** | |

[1] One additional answer was received for "medical doctor" without specification Radiologists/Radiation Oncologists/NM Physicians.

## 2.2 Data Cleaning

The responsibilities for data cleaning were assigned as follows:
Coordination and oversight of data cleaning: D. Visvikis (as T2.2 lead)
Radiologists: B. Brkljačić, C. Loewe
Radiographers: J. McNulty
Nuclear medicine physicians: F. Jamar
Radiation Oncologists and RTTs: M. Leech, Y. Anacak, N. Jornet
Medical Physicists: D. Visvikis

The data of the survey was extracted from SurveyMonkey in Excel file format. At the beginning of the process all responses were included in one Excel file. For readability purposes Excel files containing all survey responses per professional category were also produced. The data cleaning process started the week of the 6th of February with a first priority being to identify missing and/or partial responses per professional category and per country. Working group members, supported by the project office and the offices of the European societies, worked through personal contacts to get the missing information. This process led to an ultimate extension of the survey completion process to the 19th of February.

An online meeting of WP1 was held on 17th February to agree on the further methodology and responsibilities of the cleaning process following closure of the survey.

The second phase of the data cleaning process started the week of the 20th of February. The participants from each professional category participating in WP1 shared between them the data cleaning work for each of the target groups (defined in section 2.1.1 above). They decided to work on the Excel files with the survey responses dedicated to each professional category. The process was completed by all different working groups on the 15th of March and the final dataset was transferred for the analysis process to T1.3 lead on the 20th of March.

The following instructions were given to the project members engaged in the process.

- The purpose of the data cleaning process was not to verify the correctness of the responses.
- Our objective at the end of the cleaning process was to indicate one response from each source (national authority, national society) to be used in the analysis.

- In the case of multiple answers provided by professional societies or national authorities we first highlighted the ones that were more complete.
- As a second step the multiple responses within each professional category per country and source (national authority or national society) were compared with the most complete response for consistency purposes, and substantial differences were highlighted. In these cases the participants in the data cleaning process were asked to get in contact with the relevant person within each national society or authority and clarify these differences as well as make enquiry as to who is the person who should have filled out the survey on behalf of this organisation.
- At the end of this process one of the responses was kept for each of the national societies and for each of the 6 professional categories per country that had provided responses.
- At the same time, in the very few cases where responses were also available from the national authorities, a single such response was also kept per country and professional category for the analysis, as it was considered of interest to highlight (despite the very small sample size) differences between the national authorities and national society responses.

Upon completion of the cleaning process, the project members participating in the cleaning process returned one Excel file per professional category to the Task 1.2 lead. Upon request from the Task 1.3 lead G. Paulo, a single Excel file merging the cleaned data for all professional categories was provided on the 22nd of March.

Following a first check of the cleaned data by the Task 1.3 lead, efforts through personal contacts continued to obtain missing data from some countries, in order to allow at least a basic analysis across all EU27 countries, such as the number of practicing professionals per targeted category of staff. This effort was led by G. Paulo and M. Hierath from the project office, and continued until mid-April, in parallel with the data analysis. In addition, in a few cases where Main Survey data appeared incorrect, additional enquiries were sent to the respondent or another contact person from the same field in the respective country. As an example, Bulgaria reported 2,000 RTTs in practice, which appeared incorrect. Following outreach to the President of the Bulgarian Society of Radiographers, the number was corrected to 1,200 Radiographers, as in Bulgaria Radiographers work in diagnostic radiology, nuclear medicine and radiotherapy.

### 2.2.1 Overview of responses obtained

The numbers of Main Survey responses collected from all countries in the EU27 are summarised in table 6A below and reflect the status after data cleaning.

## Table 6A – Detailed overview of Main Survey responses (after data cleaning)

| | **Total responses** | National professional /scientific | National Health Authority | National RP Authority | Licensing Authority | Other | Radiologists | Radiation Oncologists | NM Physicians | Radiographers | RTTs (where indep from Radiographers) | Medical Physicists | Other | combined response for all Professions | no selection made/no data provided |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Austria** | **6** | 3 | 1 | 0 | 2 | 0 | 2 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Belgium** | **7** | 5 | 2 | 0 | 0 | 0 | 1 | 2 | 2 | 0 | 1 | 1 | 0 | 0 | 0 |
| **Bulgaria** | **4** | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| **Croatia** | **3** | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| **Cyprus** | **2** | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **Czechia** | **5** | 5 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Denmark** | **4** | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Estonia** | **5** | 4 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Finland** | **4** | 4 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| **France** | **3** | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| **Germany** | **5** | 4 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Greece** | **4** | 3 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Hungary** | **5** | 4 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| **Ireland** | **4** | 3 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| **Italy** | **5** | 4 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| **Latvia** | **2** | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Lithuania** | **4** | 3 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Luxembourg** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Malta** | **4** | 1 | 2 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Netherlands** | **6** | 4 | 0 | 0 | 0 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| **Poland** | **6** | 4 | 1 | 1 | 0 | 0 | 2 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Portugal** | **3** | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Romania** | **4** | 2 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| **Slovakia** | **6** | 4 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 2 | 0 | 0 | 0 |
| **Slovenia** | **3** | 3 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **Spain** | **4** | 2 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| **Sweden** | **4** | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Total** | **112** | **81** | **11** | **3** | **3** | **14** | **24** | **20** | **15** | **20** | **7** | **25** | **0** | **1** | **0** |

The response rates per country per target group addressed (National professional/scientific society, National Health Authority, National RP Authority, Licencing Authority, Other) and per profession after data cleaning are provided in table 6B. Multiple responses from one and the same country are counted as 1.

## Table 6B – Response rate for Main Survey (after data cleaning)

| | Target group (society/authority) covered by answers (1 = yes, 0 = no) | | | | | | Profession covered by answers (1 = yes, 0 = no) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | National professional/ scientific soc. | National Health Authority | National RP Authority | Licensing Authority | Other | % of responding target groups per country | Radiologists | Radiation Oncologists | NM Physicians | Radio-graphers | RTTs (where indep from Radiographers) | Medical Physicists | Other | combined response for all Professions | no selection made/no data provided | % of res-ponding professional groups per country |
| **Austria** | 1 | 1 | 0 | 1 | 0 | 60% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 71% |
| **Belgium** | 1 | 1 | 0 | 0 | 0 | 40% | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 71% |
| **Bulgaria** | 1 | 1 | 0 | 0 | 0 | 40% | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 57% |
| **Croatia** | 1 | 0 | 0 | 1 | 1 | 60% | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 29% 1) |
| **Cyprus** | 1 | 1 | 0 | 0 | 0 | 40% | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 29% |
| **Czechia** | 1 | 0 | 0 | 0 | 0 | 20% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 71% |
| **Denmark** | 1 | 1 | 0 | 0 | 0 | 40% | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 57% |
| **Estonia** | 1 | 0 | 0 | 0 | 1 | 40% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 71% |
| **Finland** | 1 | 0 | 0 | 0 | 0 | 20% | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 57% |
| **France** | 1 | 0 | 0 | 0 | 0 | 20% | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 43% |
| **Germany** | 1 | 0 | 0 | 0 | 1 | 40% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 71% |
| **Greece** | 1 | 0 | 1 | 0 | 0 | 40% | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 57% |
| **Hungary** | 1 | 0 | 0 | 0 | 1 | 40% | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 71% |
| **Ireland** | 1 | 0 | 0 | 0 | 1 | 40% | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 57% |
| **Italy** | 1 | 0 | 0 | 0 | 1 | 40% | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 71% |
| **Latvia** | 1 | 0 | 0 | 0 | 0 | 20% | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 29% |
| **Lithuania** | 1 | 0 | 0 | 0 | 1 | 40% | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 57% |
| **Luxembourg** | 0 | 0 | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| **Malta** | 1 | 1 | 0 | 0 | 1 | 60% | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 57% |
| **Netherlands** | 1 | 0 | 0 | 0 | 1 | 40% | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 86% |
| **Poland** | 1 | 1 | 1 | 0 | 0 | 60% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 71% |
| **Portugal** | 1 | 0 | 0 | 0 | 0 | 20% | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 43% |
| **Romania** | 1 | 0 | 0 | 0 | 1 | 40% | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 57% |
| **Slovakia** | 1 | 0 | 1 | 0 | 1 | 60% | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 71% |
| **Slovenia** | 1 | 0 | 0 | 0 | 0 | 20% | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 43% |
| **Spain** | 1 | 1 | 0 | 0 | 1 | 60% | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 43% |
| **Sweden** | 1 | 1 | 0 | 0 | 0 | 40% | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 57% |
| **Response rate per responder type, all countries** | 96% | 33% | 11% | 7% | 44% | | 81% | 70% | 52% | 74% | 26% | 85% | 0% | 4% | 0% | |

1) One additional answer for all professions was received

# 3. Summary of Data Analysis

The results obtained from the Main Survey and cleaned according to the methodology described in the previous section will be presented by profession according to the specifications of the tender, namely:

(a) data on staffing, education and training of the key professional groups involved in ensuring radiation safety and quality of medical radiation practices in Member States.

(b) the collected data should cover the areas of radiology, radiotherapy, nuclear medicine and other medical practices utilising ionising radiation, with an emphasis on procedures delivering high(er) radiation doses to patients and/or staff.

(c) The work shall cover the main categories of staff falling under BSSD's definitions of 'practitioner', 'medical physics expert' and staff carrying 'practical aspects of medical radiological procedures', including staff dealing with reporting and learning from adverse radiological events.

General data about Member States' population and numbers of hospitals and hospital beds were added to facilitate data comparison. Data from Luxembourg are missing, since the authorities and professional organisations contacted have not replied (only one highly incomplete response was received, which was removed during data cleaning).

## 3.1. European Member States characterisation

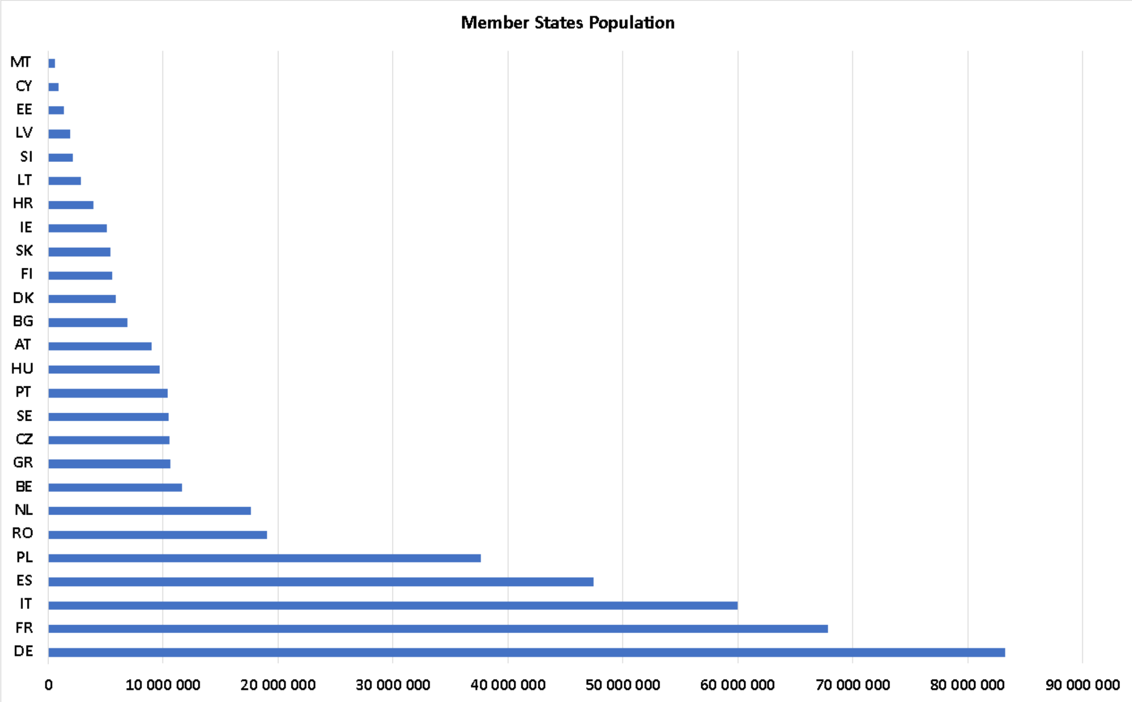
To facilitate tables and figures, the EU country codes will be used as per below:

| | |
|---|---|
| Austria | AT |
| Belgium | BE |
| Bulgaria | BG |
| Croatia | HR |
| Cyprus | CY |
| Czechia | CZ |
| Denmark | DK |
| Estonia | EE |
| Finland | FI |

| | |
|---|---|
| France | FR |
| Germany | DE |
| Greece | GR |
| Hungary | HU |
| Ireland | IE |
| Italy | IT |
| Latvia | LV |
| Lithuania | LT |
| Malta | MT |
| Netherlands | NL |
| Poland | PL |
| Portugal | PT |
| Romania | RO |
| Slovakia | SK |
| Slovenia | SI |
| Spain | ES |
| Sweden | SE |

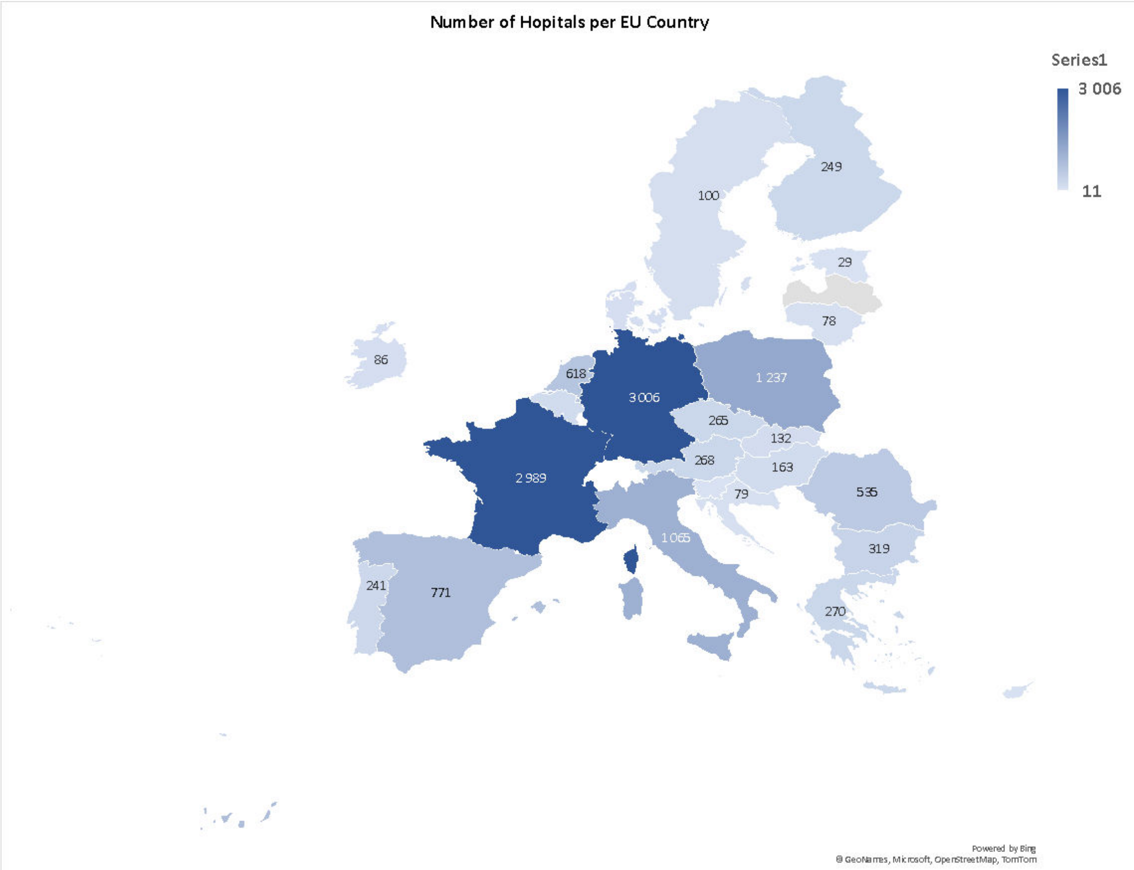
The European Union is composed by 27 countries with a total population of 447 million people. As mentioned, this section covers data from the 26 countries that replied to the survey (missing data from Luxembourg).

### Figure 2 – Population of EU Member States for which Main Survey data were obtained




To serve the health needs of its 447 million inhabitants, the EU has approximately 13,000 hospitals, distributed per Member State as indicated in the following figure (source: OECD.STAT):

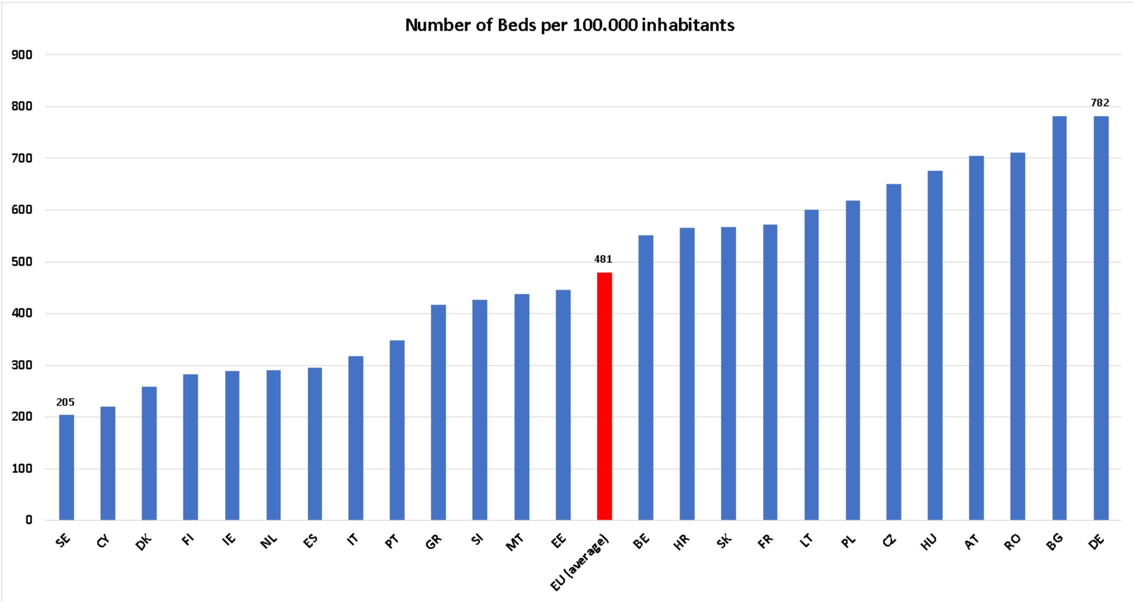
**Figure 3 – Number of hospitals in EU Member States for which Main Survey data were obtained**




As expected, the number of hospitals across each Member State is related to the size of the population and considering the type of health system in each country this may not be a good indicator to analyse workforce availability.

For that objective, the number of hospital beds per 100,000 inhabitants is much more useful (Fig 4).

**Figure 4 – Number of hospital beds per 100,000 inhabitants**




Thirteen EU countries have a lower number of hospital beds than the EU average (481), with Sweden, Cyprus and Denmark amongst those with the lowest numbers (<260/100,000). Bulgaria and Germany have the highest number of hospital beds (>750/100,000).

## 3.2 Radiologists in Europe

According to the results from the Main Survey, there are 60,771 radiologists in Europe, with a ratio of 127 radiologists per 1,000,000 inhabitants. For the countries that provided the age profile (nº=17), approximately 19% (8,356) of radiologists will retire in the next 5 years and 45% are over 51 years old.

The specialty training in radiology (residency) varies from 4 to 6 years, with an average of 4.9 years. The training in radiation protection during residency varies from 2 weeks or less to up to 16-24 weeks and the majority of countries (13) require specific certification in Radiation Protection, with mandatory continuous professional development in 8 of them (Table 7).

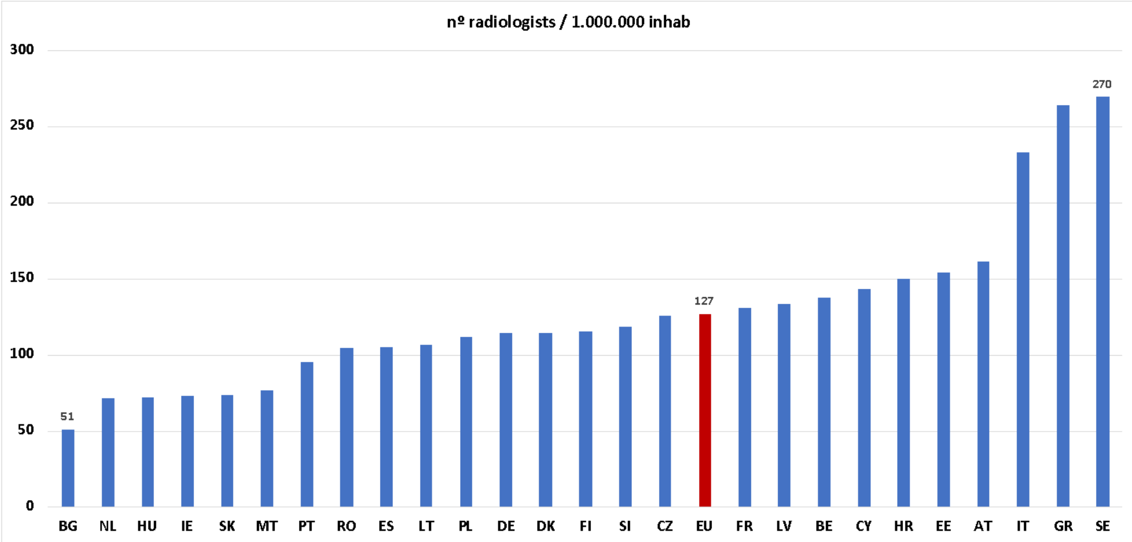
**Table 7 – Training requirements for Radiologists**

| Country | Speciality Training (years) | Training in RP (weeks) | Specific certification required in RP? | CPD in RP mandatory |
|---|---|---|---|---|
| AT | 5,25 | 2 or less | Yes | Yes |
| BE | 5,00 | | Yes | Yes |
| BG | 4,00 | 2 or less | Yes | |
| HR | 5,00 | 2 or less | No | Yes |
| CY | na | na | na | na |
| CZ | 5,00 | na | No | na |
| DK | 5,00 | na | No | na |
| EE | 4,00 | 4-12 | No | Yes |
| FI | 5,00 | 2-4 | Yes | na |
| FR | 5,00 | na | Yes | Yes |
| DE | 5,00 | Don't know | Yes | Yes |
| GR | 4,50 | 2-4 | No | na |
| HU | 5,00 | 2 or less | Yes | Yes |
| IE | 5,00 | 2-4 | No | na |
| IT | 4,00 | 4-12 | No | na |
| LV | na | na | na | na |
| LT | 6,00 | none | Yes | na |
| MT | 5,00 | 2-4 | No | na |
| NL | 5,00 | 2-4 | Yes | No |
| PL | 5,00 | 2 or less | Yes | na |
| PT | na | na | na | na |
| RO | 5,00 | 16-24 | Yes | na |
| SK | 5,00 | 2 or less | Yes | na |
| SI | 5,00 | 2-4 | Yes | Yes |
| ES | 4,00 | 2-4 | Yes | na |
| SE | 5,50 | na | No | na |

Note: na = no answer

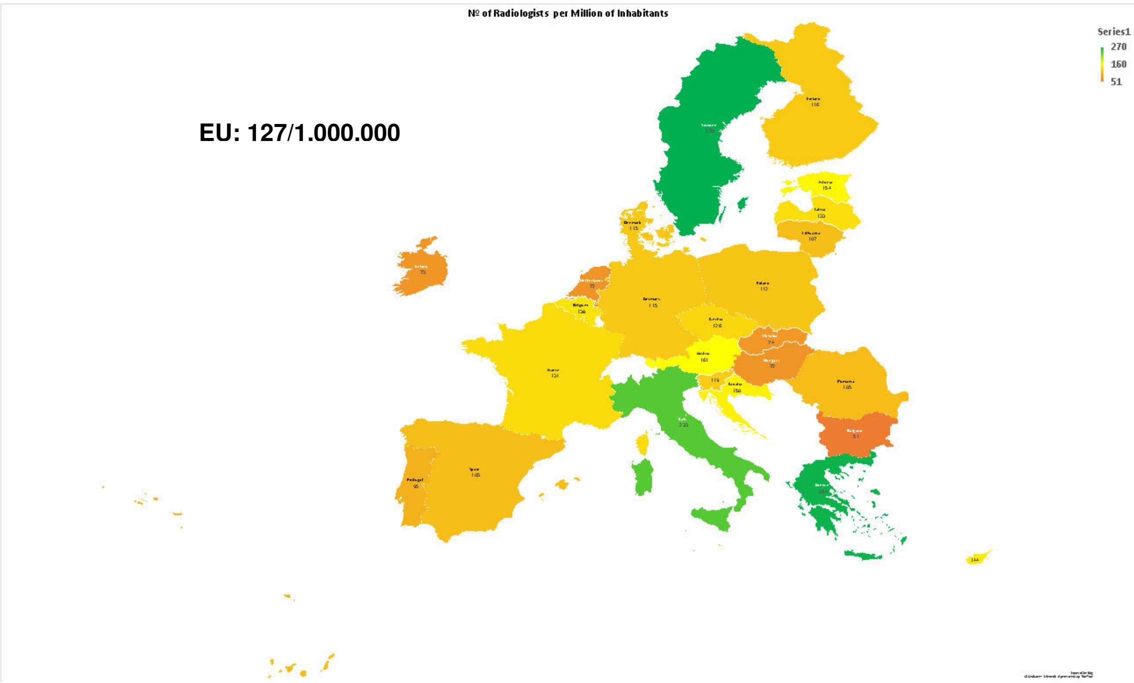
The number of radiologists varies significantly between Member States. Bulgaria presents the lowest number (51/M) and Sweden the highest (270/M), with the average EU value of 127/M (Fig. 5).

**Figure 5 – Number of Radiologists per 1 million inhabitants**




The colour map shows the geographical distribution of radiologists across Europe, evidencing the 16 countries with a density of radiologists lower than the EU average (dark orange) and the 10 above EU average, with IT, GR and SE (green) having a significantly higher number amongst all.

**Figure 6 – Geographical distribution of Radiologists**




Regarding radiologist workforce availability perspectives, there are nine countries (HR, CZ, EE, FR, HU, IT, LT, PL, SE) that will lose a higher share of the workforce to retirement in the next 5 years than the EU average (19%), considering the retirement age of 66 years. LT presents the highest value (35%) – see table 8.

**Table 8 – Radiologists' age profile**

| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| AT | 145 | 10% | 60% | 40% |
| BE | | | | |
| BG | 18 | 5% | 75% | 25% |
| HR | 128 | 22% | 56% | 44% |
| CY | | | | |
| CZ | 343 | 26% | 43% | 57% |
| DK | | | | |
| EE | 49 | 24% | 41% | 59% |
| FI | | | | |
| FR | 1 960 | 22% | 39% | 61% |
| DE | | | | |
| GR | 280 | 10% | 55% | 45% |
| HU | 140 | 20% | 45% | 55% |
| IE | 37 | 10% | 60% | 40% |
| IT | 2 800 | 20% | 50% | 50% |
| LV | | | | |
| LT | 105 | 35% | 45% | 55% |
| MT | 2 | 5% | 90% | 10% |
| NL | 189 | 15% | 60% | 40% |
| PL | 882 | 21% | 51% | 49% |
| PT | | | | |
| RO | | | | |
| SK | | | | |
| SI | 45 | 18% | 57% | 43% |
| ES | 500 | 10% | 65% | 35% |
| SE | 733 | 26% | 47% | 53% |
| **EU** | **8 356** | **19%** | **55%** | **45%** |

It is important to highlight the fact that in CZ, EE, FR, HU, IT, LT, and SE more than 50% of the Radiologists are over 51 years old. From these countries, special attention should be given to countries like CZ, HU, LT, since their numbers of radiologists per million of inhabitants is lower than the EU average.

When questioned if there are sufficient qualified practitioners to fill all available vacancies, 3 countries (DE, IE, ES) replied “no”.

## 3.3 Radiation Oncologists in Europe

According to the results from the Main Survey, there are 7,246 radiation oncologists in Europe, with a ratio of 19 radiation oncologists per 1,000,000 inhabitants. For the countries that provided the age profile (nº=16), approximately 13% (538) of radiation oncologists will retire in the next 5 years and 38% are over 51 years old.

The specialty training in radiation oncology (residency) varies from 2 to 5.25 years, with an average of 4.5 years. The training in radiation protection during residency varies from 2 weeks or less until 16-24 weeks and the majority of countries (11) require specific certification in radiation protection, with mandatory continuous professional development in only 3 of them (Table 9).

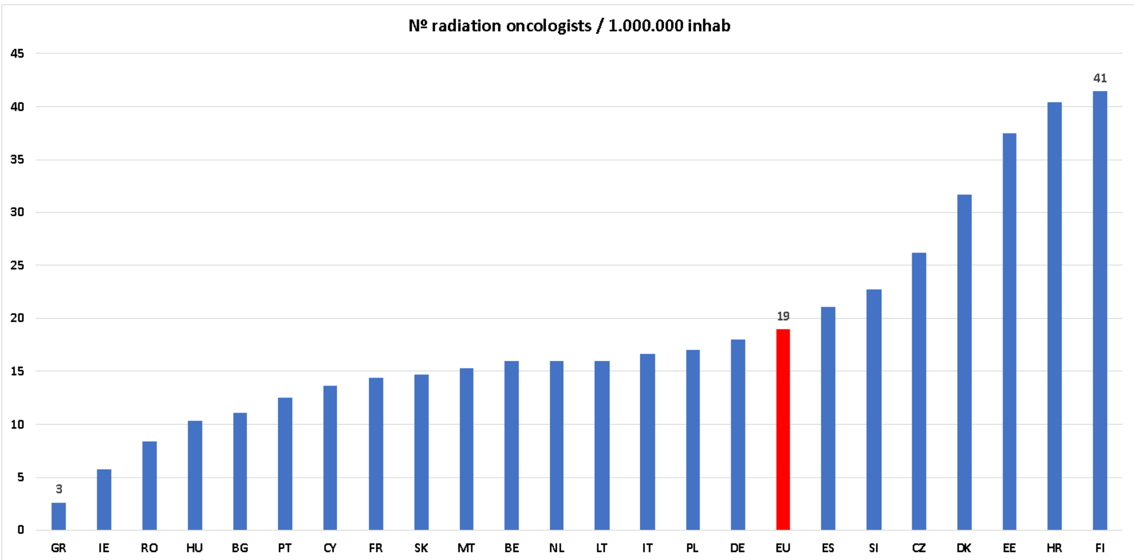
**Table 9 – Training requirements for Radiation Oncologists**

| Country | Speciality Training (years) | Training in RP (weeks) | Specific certification required in RP? | CPD in RP mandatory |
|---|---|---|---|---|
| AT | 5,25 | <2 | Yes | No |
| BE | 5,00 | <2 | Yes | na |
| BG | na | na | na | na |
| HR | na | na | na | na |
| CY | na | na | na | na |
| CZ | 5,00 | na | Yes | na |
| DK | na | na | na | na |
| EE | 4,00 | na | No | na |
| FI | 5,00 | 2-4 | Yes | na |
| FR | na | na | na | na |
| DE | 5,00 | <2 | Yes | Yes |
| GR | 4,00 | <2 | No | na |
| HU | 4,00 | 2-4 | Yes | na |
| IE | 5,00 | <2 | No | na |
| IT | 4,00 | 2-4 | No | na |
| LV | na | na | na | na |
| LT | 2,00 | <2 | Yes | Yes |
| MT | 5,00 | 16-24 | No | na |
| NL | 4,50 | 2-4 | Yes | No |
| PL | 5,00 | <2 | Yes | na |

| Country | Speciality Training (years) | Training in RP (weeks) | Specific certification required in RP? | CPD in RP mandatory |
|---|---|---|---|---|
| PT | na | na | na | na |
| RO | na | na | na | na |
| SK | 5,00 | <2 | No | na |
| SI | 5,00 | <2 | Yes | Yes |
| ES | 4,00 | 4-12 | yes | na |
| SE | na | na | na | na |

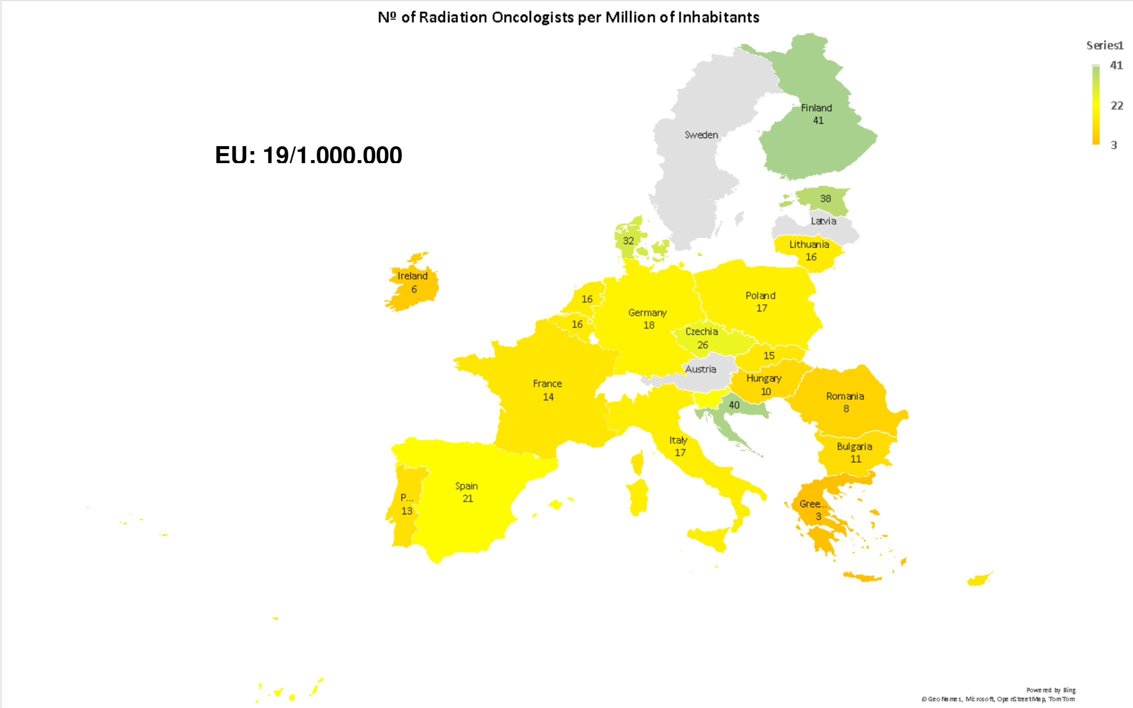
The number of radiation oncologists varies significantly between Member States. Greece presents the lowest number (3/M) and Finland the highest (41/M), with the average EU value of 19/M (Fig. 7).

**Figure 7 – Number of Radiation Oncologists per 1 million inhabitants**




The colour map shows the geographical distribution of radiation oncologists across Europe, evidencing the 16 countries with a density of radiation oncologists lower than the EU average (dark orange) and the 7 above (yellow and light green), with EE, HR and FI (dark green) having a significantly higher number amongst all. Data are missing for AT, LV and SE.

### Figure 8 – Geographical distribution of Radiation Oncologists




Regarding radiation oncologist's workforce availability perspectives, there are six countries (HR, CY, CZ, EE, HU, ES) that will lose a higher share of the workforce to retirement in the next 5 years than the EU average (13%), considering the retirement age of 66 years. EE presents the highest value (60%).

### Table 10 – Radiation Oncologists' age profile

| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| AT | | | | |
| BE | | | | |
| BG | | | | |
| HR | 22 | 14% | 52% | 48% |
| CY | 4 | 22% | 61% | 39% |
| CZ | 80 | 29% | 43% | 57% |
| DK | | | | |
| EE | 30 | 60% | 50% | 50% |
| FI | | | 55% | 45% |
| FR | | | | |
| DE | | | | |
| GR | 3 | 10% | 50% | 50% |
| HU | 20 | 20% | 70% | 30% |

| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| IE | 1 | 5% | 65% | 35% |
| IT | 100 | 10% | 45% | 55% |
| LV | | | | |
| LT | 2 | 5% | 75% | 25% |
| MT | 0 | 0% | 100% | 0% |
| NL | 37 | 13% | 67% | 33% |
| PL | 32 | 5% | 55% | 45% |
| PT | | | | |
| RO | | | | |
| SK | 4 | 5% | 65% | 35% |
| SI | 3 | 7% | 78% | 22% |
| ES | 200 | 20% | 55% | 45% |
| SE | | | | |
| **EU** | **538** | **13%** | **62%** | **38%** |

It is important to highlight the fact that in CZ, EE, GR and IT, more than 50% of the radiation oncologists are over 51 years old. This situation is critical for GR and IT, since their number of specialists per million of inhabitants is lower than the EU average.

When questioned if there are sufficient qualified practitioners to fill all available vacancies, 10 countries (AT, CY, CZ, EE, DE, HU, PL, SK, SI, ES) replied “no”.

## 3.4 Nuclear Medicine Physicians in Europe

According to the results from the Main Survey, there are 6,116 nuclear medicine physicians (NMP) in Europe, with a ratio of 13 NMPs per 1,000,000 inhabitants. For the countries that provided the age profile (nº=6), approximately 15% (59) of NMPs will retire in the next 5 years and 41% are over 51 years old.

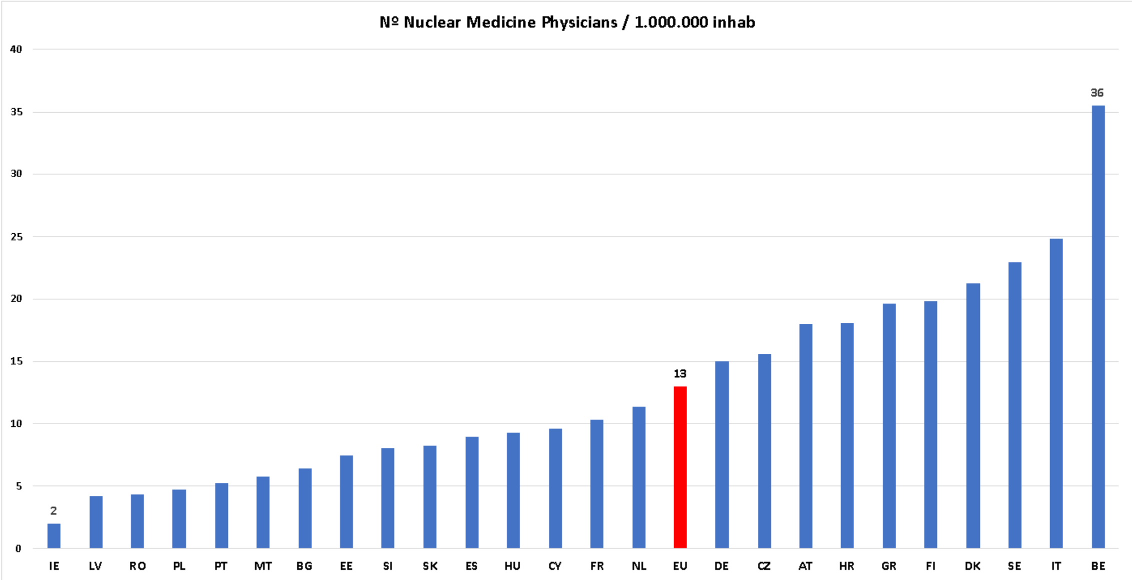
The specialty training for NMPs (residency) varies from 4 to 5.25 years, with an average of 4.7 years. The training in radiation protection during residency varies from 2 weeks or less to 28-52 weeks and the majority of countries (9) require specific certification in radiation protection, with mandatory continuous professional development in 9 of them (table 11).

### Table 11 – Training requirements for Nuclear Medicine Physicians

| Country | Speciality Training (years) | Training in RP (weeks) | Specific certification required in RP? | CPD in RP mandatory |
|---|---|---|---|---|
| AT | 5,25 | 2-4 | No | No |
| BE | 5,00 | 28-52 | Yes | Yes |
| BG | na | na | na | na |
| HR | 4,00 | 16-24 | Yes | Yes |
| CY | na | na | na | na |
| CZ | 4,00 | na | Yes | Yes |
| DK | 5,00 | 2-4 | No | No |
| EE | 5,00 | 2-4 | Yes | Yes |
| FI | na | na | na | na |
| FR | 4,00 | <2 | Yes | Yes |
| DE | 5,00 | <2 | Yes | Yes |
| GR | na | na | na | na |
| HU | 4,75 | 2-4 | Yes | Yes |
| IE | na | na | na | na |
| IT | na | na | na | na |
| LV | na | na | na | na |
| LT | na | na | na | na |
| MT | na | na | na | na |
| NL | 5,00 | 4-12 | Yes | Yes |
| PL | 5,00 | na | Yes | Yes |
| PT | 4,00 | 16-24 | No | No |
| RO | na | na | na | na |
| SK | 5,00 | <2 | No | No |
| SI | na | na | na | na |
| ES | 4,00 | <2 | na | na |
| SE | 5,00 | na | No | No |

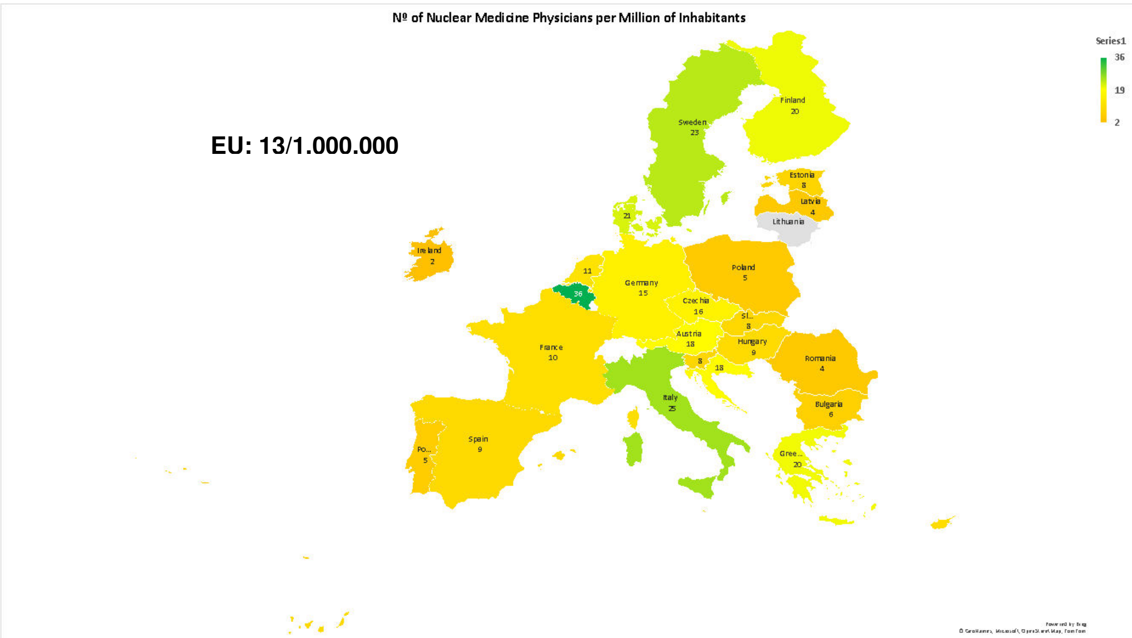
The number of NMPs varies significantly between Member States. Ireland presents the lowest number (2/M) and Belgium the highest (36/M), with the average EU value of 13/M (Fig. 9). Data are missing for LT.

**Figure 9 – Number of Nuclear Medicine Physicians per 1 million inhabitants**




The colour map shows the geographical distribution of NMPs across Europe, evidencing the 15 countries with a density of NMPs lower than the EU average (dark orange) and the 10 above EU average (yellow and light green), BE (dark green) having a significantly higher number amongst all. Data from LT is missing.

**Figure 10 – Geographical distribution of Nuclear Medicine Physicians**




Regarding NMP workforce availability perspectives (table 12), there are two countries (HR, DK) that will lose a higher share of the workforce to retirement in the next 5 years than the EU average (15%), considering the retirement age of 66 years.

**Table 12 – Nuclear Medicine Physicians' age profile**

| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| AT | | | | |
| BE | | | | |
| BG | | | | |
| HR | 14 | 20% | 50% | 50% |
| CY | | | | |
| CZ | | | | |
| DK | 25 | 20% | 55% | 45% |
| EE | 1 | 10% | 40% | 60% |
| FI | | | | |
| FR | | | | |
| DE | | | | |
| GR | | | | |
| HU | 9 | 10% | 65% | 35% |
| IE | | | | |
| IT | | | | |
| LV | | | | |
| LT | | | | |
| MT | | | | |
| NL | | | | |
| PL | | | | |
| PT | 6 | 10% | 75% | 25% |
| RO | | | | |
| SK | 5 | 10% | 67% | 33% |
| SI | | | | |
| ES | | | | |
| SE | | | | |
| **EU** | **59** | **15%** | **59%** | **41%** |

It is important to highlight the fact that in HR and EE more than 50% of the NMPs are over 51 years old. This situation is critical for EE, since their number of specialists per million of inhabitants is lower than the EU average.

When questioned if there are sufficient qualified practitioners to fill all available vacancies, 6 countries (AT, HR, CZ, DE, PL and PT) replied “no”.

## 3.5 Radiographers in Europe

According to the results from the Main Survey, there are 171,306 radiographers in Europe, with a ratio of 385 radiographers per 1,000,000 inhabitants. For the countries that provided the age profile (nº=17), approximately 7% (10,270) of radiographers will retire in the next 5 years and 30% are over 51 years old.

The educational programmes for radiographers range from 2 to 4 years, with an average of 3.2 years. The training in radiation protection during the educational programmes varies from 2 weeks to 52 weeks and the majority of countries (11) require specific certification in radiation protection, with mandatory continuous professional development in 19 of them (table 13).

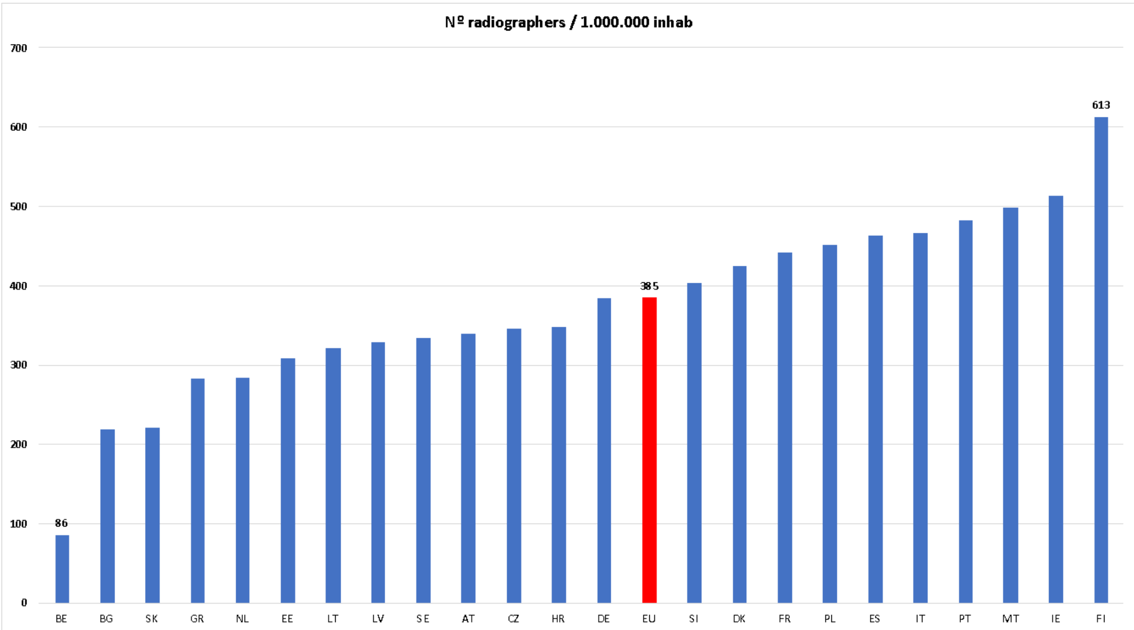
**Table 13 – Training requirements for Radiographers**

| Country | Educational programme (years) | Training in RP (weeks) | Specific certification required in RP? | CPD in RP mandatory |
|---|---|---|---|---|
| AT | 3 | 16-24 | No | Yes |
| BE | 3 | na | na | na |
| BG | 3 | 28-52 | Yes | Yes |
| HR | 3 | 16-24 | Yes | Yes |
| CY | na | na | na | na |
| CZ | 3 | na | Yes | Yes |
| DK | 4 | 2-4 | No | Yes |
| EE | 4 | 52 | No | Yes |
| FI | 3 | na | No | Yes |
| FR | 3 | 2-4 | Yes | Yes |
| DE | 3 | 16-24 | Yes | Yes |
| GR | 4 | 16-24 | Yes | No |
| HU | na | na | na | na |
| IE | 4 | na | na | na |
| IT | 3 | <2 | No | Yes |
| LV | 3 | 52 | Yes | Yes |
| LT | 3 | 16-24 | No | Yes |
| MT | 4 | 52 | No | Yes |
| NL | 4 | na | na | na |
| PL | 3 | na | Yes | Yes |
| PT | 4 | 52 | No | Yes |
| RO | na | na | na | na |
| SK | 3 | na | No | Yes |
| SI | 3 | 4-12 | Yes | Yes |

| Country | Educational programme (years) | Training in RP (weeks) | Specific certification required in RP? | CPD in RP mandatory |
|---|---|---|---|---|
| ES | 2 | na | na | na |
| SE | 3 | 52 | Yes | Yes |

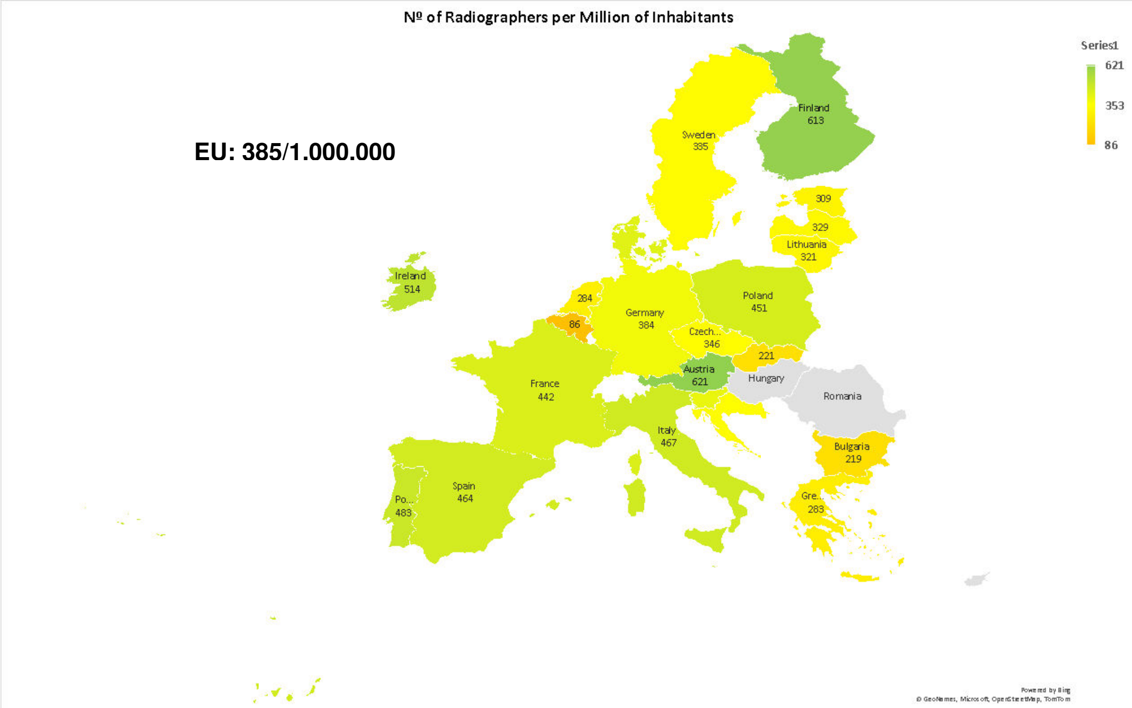
The number of radiographers varies significantly between Member States. Belgium presents the lowest number (86/M) and Finland the highest (613/M), with the average EU value of 385/M (Fig. 11).

**Figure 11 – Number of Radiographers per 1 million inhabitants**




The colour map shows the geographical distribution of radiographers across Europe, evidencing the 13 countries with a density of radiographers lower than the EU average (dark orange to yellow) and the 10 above EU average (light green), with FI (dark green) having a significantly higher number amongst all. Data from CY, HU and RO is missing.

**Figure 12 – Geographical distribution of Radiographers**




Regarding radiographer workforce availability perspectives (table 14), eleven countries (CZ, DK, EE, FI, GR, IT, LV, LT, PL and SI) will lose a higher share of the workforce to retirement in the next 5 years than the EU average (7%), considering the retirement age of 66 years. PL and SI present the highest value (20%). This might be critical for CZ, EE, GR, LV and LT as their numbers of radiographers per million of inhabitants are lower than the EU average.

**Table 14 – Radiographers' age profile**

| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| AT | 446 | 8% | 72% | 28% |
| BE | | | | |
| BG | | | | |
| HR | | | | |
| CY | | | | |
| CZ | 510 | 14% | 61% | 39% |
| DK | 250 | 10% | 70% | 30% |
| EE | 62 | 15% | 71% | 29% |
| FI | 578 | 17% | 66% | 34% |
| FR | 0 | 0% | 76% | 24% |
| DE | 1600 | 5% | 80% | 20% |
| GR | 300 | 10% | 50% | 50% |

| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| HU | | | | |
| IE | 130 | 5% | 85% | 15% |
| IT | 2240 | 8% | 72% | 28% |
| LV | 62 | 10% | 65% | 35% |
| LT | 90 | 10% | 50% | 50% |
| MT | 8 | 3% | 90% | 10% |
| NL | | | | |
| PL | 3400 | 20% | 65% | 35% |
| PT | 250 | 5% | 85% | 15% |
| RO | | | | |
| SK | | | | |
| SI | 170 | 20% | 60% | 40% |
| ES | | | | |
| SE | 175 | 5% | 80% | 20% |
| **EU** | **10270** | **7%** | **70%** | **30%** |

It is important to highlight the fact that in GR and LT more than 50% of the Radiographers are over 51 years old. This situation is critical for both countries, since their numbers of professionals per million of inhabitants are lower than the EU average.

### 3.5.1 Radiation Therapists in Europe

Considering that in some EU countries there is an independent profession for radiation therapists (RTT), referred to also as radiographers in radiotherapy, the Main Survey included RTTs as a separate profession and gave respondents the opportunity to provide data on this profession in the EU.

Unfortunately, only 3 countries provided the numbers of active RTTs: BE (544); HU (150) and NL (1,000). Responses for RTTs were also received from IE, IT, RO, however they were largely incomplete and could not be considered for analysis. The data provided for BG were inaccurate as described in section 2.2.

## 3.6 Medical Physicists in Europe

According to the results from the Main Survey, there are 9,259 medical physicists (MPs) (including Radiation Protection Advisors, Radiation Protection Experts & Medical Physics Experts, depending on the categorisation in each country) in Europe, with a ratio of 21 MP per 1,000,000 inhabitants. In the present report on data collection and analysis, the term “Medical Physicist” is therefore used, while it is recognised that the 2013/59/EURATOM Directive defines the term Medical Physics Expert (MPE). No distinction between the different medical specialities withing medical physics was made (radiology, radiotherapy, nuclear medicine).

For the countries that provided the age profile (nº=15), approximately 9% (629) of MPs will retire in the next 5 years and 22% are over 51 years old.

The speciality training programmes for MPs vary from 1 to 5 years, with an average of 3 years. The training in radiation protection during the educational programme varies from none to 52 weeks and the majority of countries (11) require specific certification in radiation protection, with mandatory continuous professional development in 7 of them (table 15). The wide range in terms of numbers of years reported is likely to reflect variations in understanding among respondents, with some conflating basic degree training with specific MP training (those reporting longer durations), and others considering specific MP training as separate from the time required for a required basic degree (those reporting shorter durations).

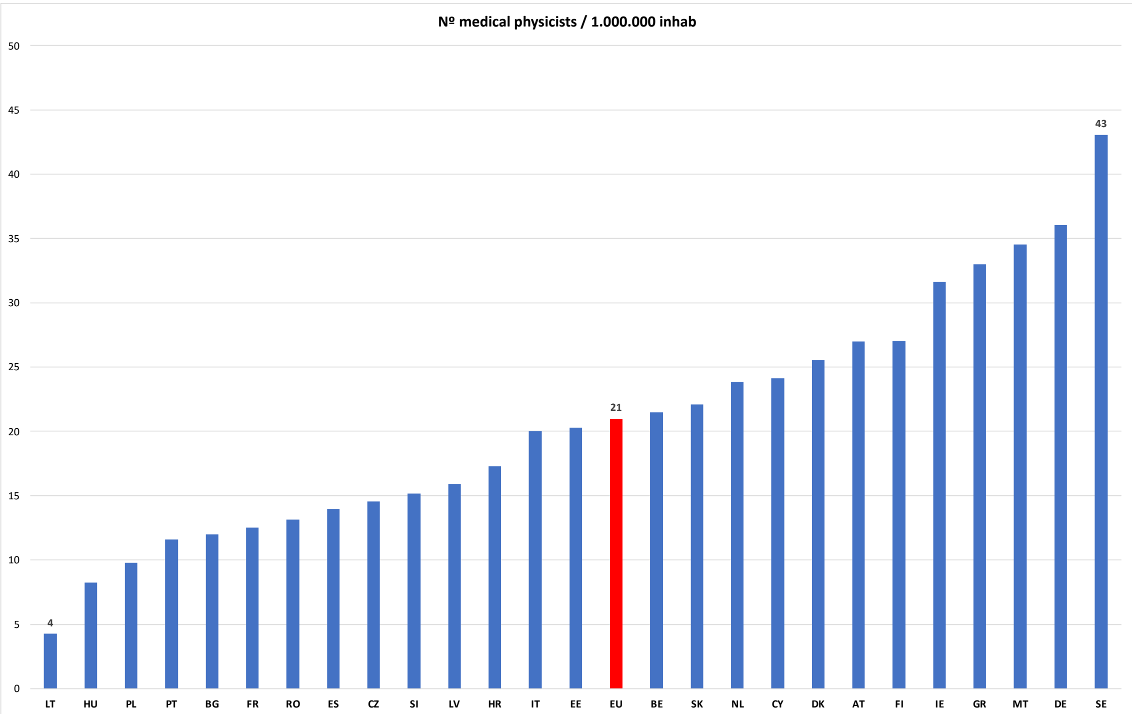
**Table 15 – Training requirements for Medical Physicists**

| Country | Speciality Training (years) | Training in RP (weeks) | Specific certification required in RP? | CPD in RP mandatory |
|---|---|---|---|---|
| AT | 3,00 | <2 | Yes | Yes |
| BE | 1,00 | na | Yes | Don't know |
| BG | 5,00 | <2 | na | na |
| HR | na | na | na | Yes |
| CY | 1,00 | na | na | na |
| CZ | 5,00 | na | Yes | na |
| DK | 3,00 | 2-4 | na | na |
| EE | 2,00 | na | No | No |
| FI | 5,00 | >52 | Yes | na |
| FR | 2,50 | none | na | na |
| DE | 5,00 | >52 | Yes | na |
| GR | 2,00 | 12-24 | No | Yes |
| HU | 4,00 | 4-12 | Yes | Yes |
| IE | 2,00 | na | No | No |
| IT | 3,00 | >52 | No | na |
| LV | na | none | na | na |
| LT | 2,00 | 16-24 | Yes | na |
| MT | 2,00 | 16-24 | No | na |
| NL | 4,00 | 28-52 | Yes | No |

| Country | Speciality Training (years) | Training in RP (weeks) | Specific certification required in RP? | CPD in RP mandatory |
|---|---|---|---|---|
| PL | na | na | Yes | na |
| PT | 4,00 | na | na | No |
| RO | 2,00 | na | na | Yes |
| SK | 2,00 | 16-24 | No | Yes |
| SI | na | 16-24 | Yes | na |
| ES | 3,00 | 16-24 | Yes | Yes |
| SE | 5,00 | na | na | na |

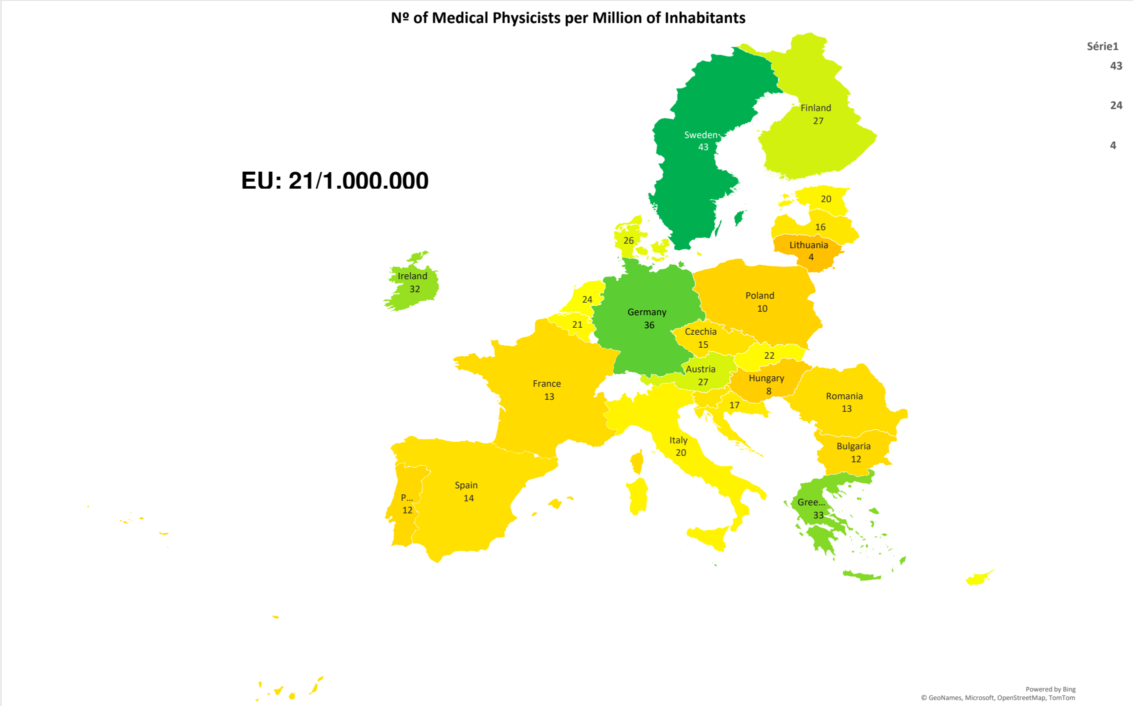
The number of MPs varies significantly between Member States. Lithuania presents the lowest number (4/M) and Sweden the highest (43/M), with the average EU value of 21/M (Fig. 13)

**Figure 13 – Number of medical physicists per 1 million inhabitants**




The colour map shows the geographical distribution of MPs across Europe, evidencing the 14 countries with a density of MPs lower than the EU average (dark orange) and the 12 above EU average (yellow and light green), with SE (dark green) having a significantly higher number amongst all.

**Figure 14 – Geographical distribution of Medical Physicists**




Regarding MP workforce availability perspectives (table 16), there are seven countries (AT, CZ, EE, DE, HU, IT, and NL) that will lose a higher share of the workforce to retirement in the next 5 years than the EU average (9%), considering the retirement age of 66 years. This might be critical for CZ, EE, HU and IT as their numbers of MPs per million inhabitants are lower than the EU average.

**Table 16 – Medical Physicists' age profile**

| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| AT | 31 | 13% | 64% | 36% |
| BE | 13 | 5% | 75% | 25% |
| BG | 2 | 2% | 72% | 28% |
| HR | 1 | 1% | 89% | 11% |
| CY | | | | |
| CZ | 21 | 14% | 69% | 31% |
| DK | 8 | 5% | 80% | 20% |
| EE | 3 | 10% | 80% | 20% |
| FI | 8 | 5% | 85% | 15% |
| FR | 26 | 3% | 85% | 15% |
| DE | 300 | 10% | 75% | 25% |
| GR | | | | |

| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| HU | 8 | 10% | 70% | 30% |
| IE | | | | |
| IT | 168 | 14% | 62% | 38% |
| LV | 0 | 0% | 95% | 5% |
| LT | | | | |
| MT | | | | |
| NL | 42 | 10% | 65% | 35% |
| PL | | | | |
| PT | | | | |
| RO | 0 | 0% | 98% | 2% |
| SK | | | | |
| SI | | | | |
| ES | | | | |
| SE | | | | |
| **EU** | **629** | **9%** | **78%** | **22%** |

.

It is important to highlight the fact that in AT and IT more than 35% of MPs are over 51 years.

## 3.7 Workforce overview in Europe

The data are presented in a manner so as to reflect the overall situation in areas and topics covered at EU and national level, which we think is reader-friendly and takes into account the wide variety of professional situations per country and at the EU level. In table 17, absolute numbers of hospitals and different professionals are presented per EU Member State, showing the population numbers of each country as well as total EU numbers. To demonstrate the heterogeneity in the EU, table 18 compares five EU Member States that have approximately the same population of ten million inhabitants and analyses their workforce distribution. In table 19, standardised population results per 1 million inhabitants are shown to facilitate the comparison between countries, with average values presented for the EU (average, median, min, max) and difference factor (ratio between maximum and minimum values).

Table 17 indicates the absolute numbers per country and profession, giving an overview of the workforce situation in Europe.

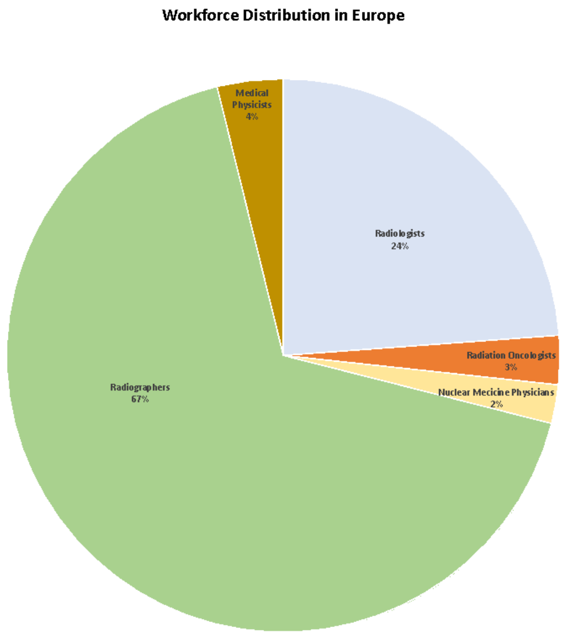
**Table 17 – Workforce figures per profession by country**

| country | Popul-ation (eurostat) | nº hos-pitals | Radio-logists | Radia-tion Onco-logists | NM Physi-cians | Radio-graphers | Medical Physi-cists | Total nº profes-sionals |
|---|---|---|---|---|---|---|---|---|
| AT | 8 978 929 | 268 | 1 447 | | 160 | 5 572 | 239 | 7 418 |
| BE | 11 631 136 | 163 | 1 600 | 186 | 413 | 1 000 | 250 | 3 449 |
| BG | 6 838 937 | 319 | 350 | 76 | 44 | 1 500 | 82 | 2 052 |
| HR | 3 879 074 | 79 | 581 | 157 | 70 | 1 350 | 67 | 2 225 |
| CY | 1 244 000 | 85 | 130 | 17 | 12 | | 30 | 189 |
| CZ | 10 516 707 | 265 | 1 321 | 276 | 164 | 3 643 | 153 | 5 557 |
| DK | 5 873 420 | 90 | 674 | 186 | 125 | 2 500 | 150 | 3 635 |
| EE | 1 331 796 | 29 | 205 | 50 | 10 | 411 | 27 | 703 |
| FI | 5 548 241 | 249 | 642 | 230 | 110 | 3 400 | 150 | 4 532 |
| FR | 67 842 582 | 2989 | 8 907 | 979 | 700 | 30 000 | 850 | 41 436 |
| DE | 83 237 124 | 3006 | 9 535 | 1 537 | 1 249 | 32 000 | 3 000 | 47 321 |
| GR | 10 603 810 | 270 | 2 800 | 28 | 208 | 3 000 | 350 | 6 386 |
| HU | 9 689 010 | 163 | 700 | 100 | 90 | | 80 | 970 |
| IE | 5 060 005 | 86 | 370 | 29 | 10 | 2 600 | 160 | 3 169 |
| IT | 59 983 122 | 1065 | 14 000 | 1 000 | 1 491 | 28 000 | 1 200 | 45 691 |
| LV | 1 884 000 | | 250 | | 8 | 620 | 30 | 908 |
| LT | 2 805 998 | 78 | 300 | 45 | | 900 | 12 | 1 257 |
| MT | 520 971 | 11 | 40 | 8 | 3 | 260 | 18 | 329 |
| NL | 17 590 672 | 618 | 1 262 | 282 | 200 | 5 000 | 420 | 7 164 |
| PL | 37 654 247 | 1237 | 4 200 | 642 | 180 | 17 000 | 369 | 22 391 |
| PT | 10 361 831 | 241 | 987 | 130 | 55 | 5 000 | 120 | 6 292 |
| RO | 19 038 098 | 535 | 2 000 | 160 | 83 | | 250 | 2 493 |
| SK | 5 434 712 | 132 | 400 | 80 | 45 | 1 200 | 120 | 1 845 |
| SI | 2 107 180 | 29 | 250 | 48 | 17 | 850 | 32 | 1 197 |
| ES | 47 432 805 | 771 | 5 000 | 1 000 | 425 | 22 000 | 650 | 29 075 |
| SE | 10 452 326 | 100 | 2 820 | | 244 | 3 500 | 450 | 7 014 |
| **EU Total** | **447 540 733** | **12 878** | **60 771** | **7 246** | **6 116** | **171 306** | **9 259** | **254 698** |

According to the results of the survey, there are approximately 255,000 health professionals directly involved in the use of ionizing radiation in Europe, with DE, IT and FR having the highest numbers of them, in line with the fact that they also have larger populations. However, although IT has a lower population compared to FR, it has a higher number of health professionals (45,691 *vs* 41,436).

Radiographers are by far the largest group (67%), followed by Radiologists (24%), Medical Physicists (4%), Radiation Oncologists (3%) and Nuclear Medicine Physicians (2%) – see Fig. 15.

**Figure 15 – Health professionals directly using ionising radiation and their numbers in %**




As an exercise to analyse the workforce distribution, 5 EU countries that have approximately the same population (10M) are compared and their workforce distribution is analysed: CZ, GR, HU, PT, SE (table 18).

**Table 18 – Workforce distribution in 5 countries with similar population**

| country | Radiologists | Radiation Oncologists | Nuclear Mecicine Physicians | Radiographers | Medical Physicists |
|---|---|---|---|---|---|
| Czechia | 1 321 | 276 | 164 | 3 643 | 153 |
| Greece | 2 800 | 28 | 208 | 3 000 | 350 |
| Hungary | 700 | 100 | 90 | | 80 |
| Portugal | 987 | 130 | 55 | 5 000 | 120 |
| Sweden | 2 820 | | 244 | 3 500 | 450 |

This table clearly shows the huge heterogeneity in the number of workforce availability for the different health professionals involved in the use of ionising radiation in these 5 countries.

For Radiologists the difference between the lowest and the highest value amounts to a factor of ≈4.

For Radiation Oncologists the difference between the lowest and the highest number is by a factor of ≈10.

For Nuclear Medicine Physicians the difference between the lowest and the highest is by a factor of ≈4.

For Radiographers the difference between the lowest and the highest is by a factor of ≈2, being the professional group with the lowest difference.

For Medical Physicists the difference between the lowest and the highest is by a factor of ≈6.

While the health system organisation might help to explain some of the discrepancies found, there are certainly other variables that justify these differences that should be analysed in future studies.

In table 19, standardised population results (per 1,000,000 inhabitants) are shown to facilitate the comparison between countries with EU average, median, min, max and dif factor (ratio between max and min values).

**Table 19 – Standardised workforce overview per 1 million inhabitants**

| country | Radiologists | Radiation Oncologists | Nuclear Medicine Physicians | Radiographers | Medical Physicists |
|---|---|---|---|---|---|
| AT | 161 | | 18 | 621 | 27 |
| BE | 138 | 16 | 36 | 86 | 21 |
| BG | 51 | 11 | 6 | 219 | 12 |
| HR | 150 | 40 | 18 | 348 | 17 |
| CY | 144 | 14 | 10 | | 24 |
| CZ | 126 | 26 | 16 | 346 | 15 |
| DK | 115 | 32 | 21 | 426 | 26 |
| EE | 154 | 38 | 8 | 309 | 20 |
| FI | 116 | 41 | 20 | 613 | 27 |
| FR | 131 | 14 | 10 | 442 | 13 |
| DE | 115 | 18 | 15 | 384 | 36 |
| GR | 264 | 3 | 20 | 283 | 33 |
| HU | 72 | 10 | 9 | | 8 |
| IE | 73 | 6 | 2 | 514 | 32 |
| IT | 233 | 17 | 25 | 467 | 20 |
| LV | 133 | | 4 | 329 | 16 |
| LT | 107 | 16 | | 321 | 4 |
| MT | 77 | 15 | 6 | 499 | 35 |
| NL | 72 | 16 | 11 | 284 | 24 |
| PL | 112 | 17 | 5 | 451 | 10 |
| PTI | 95 | 13 | 5 | 483 | 12 |
| RO | 105 | 8 | 4 | | 13 |

| country | Radiologists | Radiation Oncologists | Nuclear Medicine Physicians | Radiographers | Medical Physicists |
|---|---|---|---|---|---|
| SK | 74 | 15 | 8 | 221 | 22 |
| SI | 119 | 23 | 8 | 403 | 15 |
| ES | 105 | 21 | 9 | 464 | 14 |
| SE | 270 | | 23 | 335 | 43 |
| **EU mean** | **127** | **19** | **13** | **385** | **21** |
| **# countries lower than mean** | **16** | **16** | **15** | **12** | **14** |
| **EU median** | **115** | **16** | **10** | **384** | **21** |
| **# countries lower than median** | **13** | **11** | **11** | **11** | **13** |
| **min** | **51,2** | **2,6** | **2,0** | **86,0** | **4,3** |
| **max** | **269,8** | **41,5** | **35,5** | **621,0** | **43,1** |
| ***dif factor*** | **5,3** | **15,7** | **18,0** | **7,2** | **10,1** |

The highlighted cells in each country line indicate that the value is lower than the EU average (16 countries for Radiologists, 16 for Radiation Oncologists, 15 for Nuclear Medicine Physicians, 12 for Radiographers and 14 for Medical Physicists).

## 3.8 Discussion of workforce overview in Europe

To our knowledge, this is the first study aimed at characterising: a) the workforce availability of health professionals involved in the use of ionising radiation for diagnostic and therapeutic procedures and b) the corresponding education & training in radiation protection.

Our results clearly demonstrate that for both elements, there is huge heterogeneity between Member States and professions, which will obviously have an impact on healthcare delivery and the level of knowledge, skills and competences in radiation protection.

The results show that clear guidance and metrics about workforce availability for the professions involved in the use of ionising radiation is needed, as a tool to harmonise the access of patients to these professionals in Europe, thereby contributing to overall improvement of the quality of healthcare delivered. The lack of such guidance and metrics, and also of standards of practice, makes it difficult to define good practices from existing models.

Although the European Directive 2013/51/EURATOM clearly states in article 18 that “Member States shall ensure that practitioners and the individuals involved in the practical aspects of medical radiological procedures have adequate education, information and theoretical and practical training for the purpose of medical radiological practices, as well as relevant competence in radiation protection”, there is great heterogeneity in the way each Member State applies this in practice, despite the guidance defined by the MEDRAPET project.

As concluded in the results of WP7 of the EURAMED rocc-n-roll project (https://doi.org/10.1186/s13244-022-01271-y): “*E&T in RP is of paramount importance for health professionals and researchers to acquire and develop knowledge, skills and competences in the field of RP to protect patients and staff from the dangers arising from the exposure to ionising radiation. Although several projects have been developed in the past years related to E&T in RP, the SWOT analysis showed a clear lack of real and effective implementation of RP principles in daily practice […]. To achieve success, governance structures and strong leadership are key as is the full exploitation of existing resources however equally, appropriate financial support is essential to permit our professions to work collaboratively to achieve a pan European radiation protection training network which is sustainable and accredited across multiple national domains.”*

## About Radiologists

For Radiologists, the number of professionals per million inhabitants varies from 51 (Bulgaria) to 270 (Sweden), with the EU average being 127. There is a lack of evidence to explain the reasons behind this huge heterogeneity. Some of the causes may be associated with the type of organisation of each country’s healthcare system and practice (private, public or mix of both), the existence of teleradiology practice and the fact that in some countries, there is a role extension with radiologists also being responsible for activities in nuclear medicine.

Radiologist speciality training in Europe is (to some extent) harmonised; however, education and training (E&T) in radiation protection (RP) shows large variations (from less than 2 weeks to 24 weeks). In most countries, specific certification in radiation protection is required, but the answers to the question asking “if CPD in RP is mandatory” were scarce, and therefore not suitable for analysis.

The fact that 45% of Radiologists in Europe are over 51 years old emphasises the urgent need to set in place an action plan to engage younger generations into this medical specialty.

### About Radiation Oncologists

For Radiation Oncologists/Clinical Oncologists, the number of professionals per million inhabitants varies between 3 (Greece) and 41 (Finland), with the EU average being 19. This heterogeneity might be related to the fact that clinical oncologists also deliver systemic anti-cancer therapies while in some countries there are other medical oncologists that provide the systemic therapies.

The Radiation Oncologist speciality training in Europe is somehow harmonised (except for Lithuania where it is only 2 years), however the E&T in RP varies considerably (from less than 2 weeks, to 24). In most of the countries specific certification in RP is required, but the answers to the question “if CPD in RP is mandatory” were scarce and therefore not possible to analyse.

The majority (62%) of Radiation Oncologists in Europe are under 51 years old, and in all countries less than 30% of the workforce will retire in 5 years (except for Estonia where this value is 60%, where an action plan should be developed to attract younger generations to this medical speciality).

### About Nuclear Medicine Physicians

For NMP, the number of professionals per million inhabitants ranges from 2 (Ireland) to 36 (Belgium) with the EU average being 13. This heterogeneity might be related to the fact that in some countries, the role of Nuclear Medicine Physicians is fulfilled by other health professionals (e.g. Radiologists).

From the countries that have replied, the NMP speciality training is somehow harmonised, however E&T in RP varies considerably (from less than 2 weeks to 52). In some of the countries specific certification in RP is required, but the answers to the question “if CPD in RP is mandatory” were scarce and therefore not possible to analyse.

The majority (59%) of NMP in Europe is under 51 years old, and in all countries the share or workforce that will retire in 5 years is under 20%.

### About Radiographer and RTT’s

For Radiographers and RTT’s, the number of professionals per million inhabitants varies from 86 (Belgium) to 613 (Finland) with the EU average being 385. This huge heterogeneity was already known, as several studies have related that fact, since in some countries the E&T was only established recently and therefore other professionals took over the Radiographer/RTT role.

Also, the duration of the E&T programme is very diverse (from 2 to 4 years) and in some countries (ES, DE) the programmes are not included in the higher education system.

Unfortunately, the survey did not provide information about the field of activity of Radiographers (Radiology, Nuclear Medicine or Radiotherapy).

The Radiographer/RTT's E&T in RP varies from less than 2 to 52 weeks. In most of the countries specific certification in RP is required, CPD in RP is mandatory.

The great majority (70%) of Radiographers/RTTs in Europe are under 51 years old, and in all countries the retirement perspectives in 5 years is under 20%.

### About Medical Physicists

For Medical Physicists, the number of professionals per million of inhabitants varies from 4 (Lithuania) to 43 (Sweden) with the EU average being 21. This huge heterogeneity was already known from other EU projects, due to the fact that there is a lack of Medical Physicists particularly in Diagnostic imaging.

The Medical Physicist speciality training in Europe is very heterogeneous (from 1 to 5 years) and the same applies to E&T in RP (from less than 2 to more than 52 weeks). One of the reasons that might justify this heterogeneity is the existence of different concepts related to Medical Physicist and Medical Physics Expert. In most of the countries specific certification in RP is required, but the answers to the question "if CPD in RP is mandatory" were scarce and therefore not possible to analyse.

Unfortunately, the survey did not provide information about the field of activity of Medical Physicists (Radiology, Nuclear Medicine, or Radiotherapy).

The great majority (78%) of Medical Physicists in Europe are under 51 years old, and in all countries less than 14% of the MP workforce is expected to retire in the next 5 years.

# 4. Medical Imaging and Radiotherapy Equipment Availability in Europe

Data on the availability of medical imaging and radiotherapy equipment in European Member States is a relevant piece of information, in addition to health professionals' workforce availability.

However, the available official data about equipment availability (EUROSTAT and OECD reports) are inconsistent, potentially leading to erroneous analysis and conclusions if relied upon.

Through the Main Survey of this study an attempt was made to collate equipment availability information to overcome this limitation, but unfortunately the data received were scarce and, to some extent, also inconsistent with the official reports available, showing that there is an urgent need for Member States to create and maintain high-quality national registries and for the European Commission to support the development of a strategy to implement a central registry based on these national registries, to allow realistic and real-time access to this very important information, in order to assist health policy makers to make decisions based on reliable data.

Nevertheless, the experts of this study considered it relevant to present the data obtained through the survey (when available) and to complete it with the data from EUROSTAT.

## 4.1 Diagnostic Radiology Equipment

Data for diagnostic radiology equipment includes CT, MRI, Plain radiography, Mammography, Mobile Radiology, and Angiography/Interventional suites. Table 20 gives an overview of the available equipment (from data reported in the Main Survey), including the numbers of pieces of equipment per million inhabitants, to allow easier comparison among countries. CT, MRI and Mammography equipment are the modalities with the greatest amount of data available. The highlighted cells in the tables for these types of equipment correspond to the countries with numbers of pieces of equipment lower than the EU average.

## Table 20 – Diagnostic Radiology equipment

| Coun-try | population (eurostat) | CT Scan-ners | CT Scanners/ million inhab. | MRI Scan-ners | MRI Scanners/ million inhab. | Diagnos-tic radio-graphy units | Diagnostic radio-graphy units/ million inhab. | Mammo-graphy units | Mammo-graphy units/ million inhab. | Mobile radio-logy units | Mobile radiology units/ million inhab. | Angio-graphic / interventional suites | Angio-graphic / interven-tional suites/ million inhab. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AT | 8 978 929 | 233 | 26 | 178 | 20 | | | | | | | | |
| BE | 11 631 136 | 283 | 24 | 134 | 12 | 1342 | 115 | 445 | 38 | 1009 | 87 | 221 | 19 |
| BG* | 6 838 937 | 281 | 41 | 80 | 12 | | | 214 | 31 | | | | |
| HR | 3 879 074 | 95 | 24 | 65 | 17 | 418 | 108 | 147 | 38 | 168 | 43 | 50 | 13 |
| CY* | 1 244 000 | 34 | 27 | 18 | 14 | | | 52 | 42 | | | | |
| CZ | 10 516 707 | 193 | 18 | 118 | 11 | 1728 | 164 | 113 | 11 | 888 | 84 | 744 | 71 |
| DK | 5 873 420 | 173 | 29 | 85 | 14 | 456 | 78 | 96 | 16 | 307 | 52 | 68 | 12 |
| EE | 1 331 796 | 28 | 21 | 22 | 17 | | | 15 | 11 | | | 11 | 8 |
| FI* | 5 548 241 | 94 | 17 | 169 | 30 | | | 171 | 31 | | | | |
| FR | 67 842 582 | 1285 | 19 | 1130 | 17 | | | | | | | | |
| DE* | 83 237 124 | 1586 | 19 | 1072 | 13 | | | 405 | 5 | | | | |
| GR* | 10 603 810 | 468 | 44 | 359 | 34 | | | 736 | 69 | | | | |
| HU | 9 689 010 | 203 | 21 | 144 | 15 | 627 | 65 | 198 | 20 | | | 27 | 3 |
| IE* | 5 060 005 | 101 | 20 | 78 | 15 | | | 82 | 16 | | | | |
| IT* | 59 983 122 | 2229 | 37 | 1857 | 31 | | | 2098 | 35 | | | | |
| LV* | 1 884 000 | 71 | 38 | 30 | 16 | | | 53 | 28 | | | | |
| LT* | 2 805 998 | 87 | 31 | 40 | 14 | | | 51 | 18 | | | | |
| MT | 520 971 | 9 | 17 | 5 | 10 | | | 6 | 12 | | | 2 | 4 |

| Coun-try | population (eurostat) | CT Scan-ners | CT Scanners/ million inhab. | MRI Scan-ners | MRI Scanners/ million inhab. | Diagnos-tic radio-graphy units | Diagnostic radio-graphy units/ million inhab. | Mammo-graphy units | Mammo-graphy units/ million inhab. | Mobile radio-logy units | Mobile radiology units/ million inhab. | Angio-graphic / interventional suites | Angio-graphic / interven-tional suites/ million inhab. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NL* | 17 590 672 | 256 | 15 | 233 | 13 | | | | | | | | |
| PL | 37 654 247 | 928 | 25 | 441 | 12 | 3908 | 104 | 595 | 16 | | | 1950 | 52 |
| PT* | 10 361 831 | 189 | 18 | 107 | 10 | | | 129 | 12 | | | | |
| RO* | 19 038 098 | 368 | 19 | 227 | 12 | | | 171 | 9 | | | | |
| SK | 5 434 712 | 114 | 21 | 62 | 11 | 2101 | 387 | 89 | 16 | | | 48 | 9 |
| SI* | 2 107 180 | 40 | 19 | 28 | 13 | | | 31 | 15 | | | | |
| ES* | 47 432 805 | 949 | 20 | 863 | 18 | | | 765 | 16 | | | | |
| SE* | 10 452 326 | 293 | 28 | 191 | 18 | | | 198 | 19 | | | | |
| | **447 540 733** | **10590** | **25** | **7736** | **16** | **10580** | **146** | **6860** | **23** | **2372** | **67** | **3121** | **21** |

*Data from Eurostat

Data extracted from the survey and from EUROSTAT reveal that there are 10,590 CT scanners in Europe, with an average of 25 CTs per million inhabitants.

The great majority of the surveyed countries (17) show values below that number. Greece (44) and Bulgaria (41) are the countries with the highest numbers of CT scanners. Netherlands (15) has the lowest number of CT scanners per million of inhabitants. The asterisks ("*") in the table represent countries with data extracted from EUROSTAT.

Regarding MRI, there are 7,736 MRI scanners in Europe, with an average of 16 MRI per million inhabitants.

Also, the great majority of countries (17) show values below that number. Greece (34), Italy (31) and Finland (30) are the countries with the highest numbers of MRI scanners. Portugal (10) has the lowest number of MRI scanners per million inhabitants.

There are 6,860 mammography units available in Europe, with an average of 23 units per million inhabitants.

The majority of countries (14) show values below that number. Greece (69) is the country with the highest number of units available by far. Germany (5) has the lowest number of mammography units per million inhabitants.

Considering the limited data for the other modalities, it is not possible to make specific analyses.

## 4.2 Nuclear Medicine Equipment

Data for nuclear medicine equipment includes Gamma cameras, SPECT, SPECT CT, PET, PET/CT, PET/MR and Cyclotrons. Table 21 gives an overview of the available equipment, including the number of pieces of equipment per million inhabitants, to allow easier comparison. Gamma cameras and PET scanners are the equipments with most data available. The highlighted cells of the tables for these pieces of equipment correspond to the countries with a number of pieces of equipment lower than the EU average.

## Table 21 – Nuclear Medicine equipment

| Coun-try | Popula-tion (eurostat) | Gamma came-ras | Gamma cameras/ million inhab. | SPECT came-ras | SPECT cam-eras/ million inhab. | SPECT/ CT came-ras | SPECT/ CT came-ras/ million inhab. | PET scan-ners | PET scan-ners/ million inhab. | PET/CT scanners | PET/CT scan-ners/ million inhab | PET/ MR | PET/ MR/ million inhab. | Cyclo-trons | Cyclo-trons/ million inhab. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AT | 8 978 929 | 60 | 6,7 | 39 | 4,3 | 54 | 6,0 | 33 | 3,7 | 24 | 2,7 | 1 | 0,1 | 4 | 0,4 |
| BE | 11 631 136 | 15 | 1,3 | 87 | 7,5 | 155 | 13,3 | | | 33 | 2,8 | | | 8 | 0,7 |
| BG* | 6 838 937 | 22 | 3,2 | | | | | 8 | 1,2 | | | | | | |
| HR | 3 879 074 | 12 | 3,1 | 8 | 2,1 | 8 | 2,1 | | | 5 | 1,3 | | | 1 | 0,3 |
| CY* | 1 244 000 | 12 | 9,6 | | | | | 1 | 0,8 | | | | | | |
| CZ | 10 516 707 | 28 | 2,7 | 39 | 3,7 | 42 | 4,0 | | | 17 | 1,6 | 2 | 0,2 | 2 | 0,2 |
| DK | 5 873 420 | 29 | 4,9 | 14 | 2,4 | 37 | 6,3 | 2 | 0,3 | 45 | 7,7 | 4 | 0,7 | 10 | 1,7 |
| EE | 1 331 796 | 3 | 2,3 | 2 | 1,5 | 3 | 2,3 | 3 | 2,3 | 3 | 2,3 | | | | |
| FI* | 5 548 241 | 42 | 7,6 | | | | | 16 | 2,9 | | | | | | |
| FR | 67 842 582 | | | | | | | | | | | | | | |
| DE* | 83 237 124 | 478 | 5,7 | | | | | 163 | 2,0 | | | | | | |
| GR* | 10 603 810 | 139 | 13,1 | | | | | 14 | 1,3 | | | | | | |
| HU | 9 689 010 | | | | | | | | | | | | | | |
| IE* | 5 060 005 | 29 | 5,7 | | | | | 9 | 1,8 | | | | | | |
| IT* | 59 983 122 | 470 | 7,8 | | | | | 216 | 3,6 | | | | | | |
| LV* | 1 884 000 | 6 | 3,2 | | | | | 2 | 1,1 | | | | | | |
| LT* | 2 805 998 | 8 | 2,9 | | | | | 2 | 0,7 | | | | | | |
| MT | 520 971 | 3 | 5,8 | 1 | 1,9 | | | | | 2 | 3,8 | | | 1 | 1,9 |

| Coun-try | Popula-tion (eurostat) | Gamma came-ras | Gamma cameras/ million inhab. | SPECT came-ras | SPECT cam-eras/ million inhab. | SPECT/ CT came-ras | SPECT/ CT came-ras/ million inhab. | PET scan-ners | PET scan-ners/ million inhab. | PET/CT scanners | PET/CT scan-ners/ million inhab | PET/ MR | PET/ MR/ million inhab. | Cyclo-trons | Cyclo-trons/ million inhab. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NL* | 17 590 672 | 120 | 6,8 | | | | | 84 | 4,8 | | | | | | |
| PL | 37 654 247 | 157 | 4,2 | | | 50 | 1,3 | 40 | 1,1 | 34 | 0,9 | 3 | 0,1 | 7 | 0,2 |
| PT* | 10 361 831 | 60 | 5,8 | 60 | 5,8 | 10 | 1,0 | | | 18 | 1,7 | | | 3 | 0,3 |
| RO* | 19 038 098 | 54 | 2,8 | | | | | 14 | 0,7 | | | | | | |
| SK | 5 434 712 | 32 | 5,9 | 6 | 1,1 | 9 | 1,7 | 8 | 1,5 | 1 | 0,2 | | | 1 | 0,2 |
| SI* | 2 107 180 | 17 | 8,1 | | | | | 3 | 1,4 | | | | | | |
| ES* | 47 432 805 | 139 | 2,9 | | | | | 14 | 0,3 | | | | | | |
| SE* | 10 452 326 | 76 | 7,3 | | | | | 24 | 2,3 | | | | | | |
| | **447 540 733** | **2 011** | **5,4** | **256** | **3,4** | **368** | **4,2** | **656** | **1,8** | **182** | **2,5** | **10** | **0,3** | **37** | **0,7** |

*Data from Eurostat

Data extracted from the survey and EUROSTAT reveal that there are 2,011 Gamma cameras in Europe, with an average of 5.4 per million of inhabitants.

The majority of countries (11) show values below that number. Greece (13.1) is the country with the highest number of Gamma cameras installed. Belgium (1.3) has the lowest number. The asterisks ("*") in the table mark countries with data extracted from EUROSTAT.

Regarding PET scanners, there are 656 installed scanners in Europe (from the 19 countries where data is available), with an average of 1.8 PET scanners per million inhabitants.

Also, the majority of countries (12) show values below that number. Netherlands (4.8), Austria (3.7) and Italy (3.6) are the countries with the highest numbers of PET scanners. Denmark (0.3) has the lowest number of PET scanners per million of inhabitants.

Considering the limited data for the other modalities, it is not possible to perform specific analyses.

## 4.3 Radiotherapy Equipment

The survey tried to gather data for several types radiotherapy equipment available in the market; however the responses were limited, and therefore a proper characterisation of equipment availability was not possible. EUROSTAT data gives some indication about the total numbers of radiotherapy units available, facilitating limited analysis as shown below.

Table 22 gives an overview of the available equipment, including the number of pieces of equipment per million inhabitants, to allow easier comparison. The highlighted cells of the tables for these types of equipment correspond to the countries with equipment numbers lower than the EU average.

## Table 22 – Radiotherapy equipment

| Coun-try | population (eurostat) | Linear accelerators | Linear accelerators/ million inhab. | Brachytherapy/ intraoperative units | Brachytherapy/ intraoperative units/ million inhab. | Particle therapy units | Particle therapy units/ million inhab. | Cobalt units | Cobalt units/ million inhabitantes | Total RT units | Total RT units/ million inhab. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AT* | 8 978 929 | | | | | | | | | 51 | 5,7 |
| BE | 11 631 136 | 103 | 8,9 | 49 | 4 | 1 | 0,1 | | | 153 | 13,2 |
| BG* | 6 838 937 | | | | | | | | | 69 | 10,1 |
| HR* | 3 879 074 | | | | | | | | | 26 | 6,7 |
| CY | 1 244 000 | 5 | 4,0 | 2 | 2 | | | | | 7 | 5,6 |
| CZ | 10 516 707 | 54 | 5,1 | 15 | 1 | 1 | 0,1 | 4,0 | 0,4 | 74 | 7,0 |
| DK | 5 873 420 | 55 | 9,4 | 7 | 1 | 3 | 0,5 | | | 65 | 11,1 |
| EE | 1 331 796 | 6 | 4,5 | 2 | 2 | | | | | 8 | 6,0 |
| FI* | 5 548 241 | | | | | | | | | 57 | 10,3 |
| FR* | 67 842 582 | | | | | | | | | 762 | 11,2 |
| DE* | 83 237 124 | | | | | | | | | 394 | 4,7 |
| GR* | 10 603 810 | | | | | | | | | 72 | 6,8 |
| HU* | 9 689 010 | | | | | | | | | 46 | 4,7 |
| IE | 5 060 005 | 38 | 7,5 | 8 | 2 | | | | | 46 | 9,1 |
| IT* | 59 983 122 | | | | | | | | | 445 | 7,4 |
| LV* | 1 884 000 | | | | | | | | | 11 | 5,8 |
| LT | 2 805 998 | 11 | 3,9 | 4 | 1 | | | | | 15 | 5,3 |
| MT | 520 971 | | | | | | | | | 4 | 7,7 |
| NL | 17 590 672 | 134 | 8 | 24 | 1 | 3 | 0,2 | | | 161 | 9,2 |

| Coun-try | population (eurostat) | Linear accelerators | Linear accelerators/ million inhab. | Brachytherapy/ intraoperative units | Brachytherapy/ intraoperative units/ million inhab. | Particle therapy units | Particle therapy units/ million inhab. | Cobalt units | Cobalt units/ million inhabitantes | Total RT units | Total RT units/ million inhab. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PL | 37 654 247 | 174 | 4,6 | 60 | 2 | 1 | 0,0 | | | 235 | 6,2 |
| PT* | 10 361 831 | | | | | | | | | 47 | 4,5 |
| RO* | 19 038 098 | | | | | | | | | 76 | 4,0 |
| SK | 5 434 712 | 24 | 4,4 | 7 | 1 | | | 1,0 | 0,2 | 32 | 5,9 |
| SI | 2 107 180 | 12 | 5,7 | 2 | 1 | | | 0,0 | | 14 | 6,6 |
| ES* | 47 432 805 | | | | | | | | | 254 | 5,4 |
| SE* | 10 452 326 | | | | | | | | | 66 | 6,3 |
| | **447 540 733** | **616** | **6,0** | **180** | **1,6** | **9** | **0,2** | **5** | **0,3** | **3190** | **7,2** |

*Data from Eurostat

According to the data extracted from the survey and EUROSTAT, there are 3,190 radiotherapy units in Europe, with an average of 7.2 units per million of inhabitants.

The majority of countries (17) have a number of units below the EU average. Belgium (13.2) is the country with the highest value, with Portugal (4.5) and Romania (4.0) having the lowest.

# 5. Discussion of Medical Imaging and Radiotherapy Equipment Availability in Europe

Although the scope of the EU-REST study is mainly about education, training and workforce availability, an additional attempt was made to characterise the numbers of pieces of medical imaging and radiotherapy equipment in Europe. Despite the efforts made, the level of responses was very limited and, in some cases, contradictory to the data published by EUROSTAT, the OECD and COCIR (European Trade Association representing the medical imaging, radiotherapy, health ICT and electromedical industries). Therefore, any firm conclusion made based on this data is likely be misleading and confounding.

Nevertheless, the exercise undertaken is of substantial importance, in particular in calling the attention of the European Commission to the urgent need to develop a strategy to create a centralised repository of medical imaging and radiotherapy equipment, with verifiable, reliable and consistent data. This approach would be in line with article 60 of the Directive 2013/51/EURATOM, where it is requested that Member States must ensure “b) an up-to-date inventory of medical radiological installation is available to competent authority”. As is the case with the need to establish uniform methods of enumerating workload for the professional groups covered by the EU-REST study (which will be explored and explained in Deliverable 11: Staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications), such a repository will need to define exactly how each type of equipment is counted, and how ambiguity will be avoided. While such definitions and methodology are outside the scope of the EU-REST study, it would be a fruitful area for further study and collaborative work in the future, to facilitate ever-closer union among EU Member States in terms of uniform data collection and inter-country comparison.

# 6. Study Limitations

This study includes limitations inherent to all projects dependent on surveys, namely a variable (and non-compellable) response rate, and the use of a single language (English) which has the potential of conflicting interpretations of the questions, due to the fact that the great majority of EU countries do not use English as a first language.

It is also important to highlight the fact that the organisations/entities from each Member State which were responsible for replying to these surveys indicate a high level of "survey tiredness", as there are several EU projects running at the same time, in some cases searching for the same type of information from the same people. We fear that this may have led to incomplete or absent responses from some respondents to some questions. While extensive efforts were made during the cleaning phase of the survey data to fill gaps in supplied responses (see Deliverable 2: Draft Report on the Data Collection and Analysis), these were, inevitably, only of limited success. In the absence of any compellability, no tools remain available to the study consortium to supply data which may be desirable, but which were not provided as we followed the pre-defined and pre-agreed methodology of the study.

# 7. Future Actions

The consortium believes it would be desirable in the future that Member States should create and maintain updated data in a centralised registry (preferably in digital format), containing all data on workforce of the professions involved in the use of ionising radiation, including staffing guidelines and demographics characteristics (this is explored further in Deliverable 11: Staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications). Such national registries would benefit policy makers and hospital managers, and also contribute to the level of data quality for EU reports/research.

These national registries, or separate, similar ones, should also collate data regarding relevant equipment available in EU member countries. This would improve comparability between countries and assist in defining minimum standards which should apply across the EU. These registries would need to be based on uniform methods of counting workload and equipment availability, with uniform methods of evaluating the relevant numbers across all contributing countries. The present study showed that such data was difficult to obtain, often not reliable and subject to large variations across different countries. Comparability of currently available data is limited by the diversity of these data; uniformly populated registries would be a great step forward for the future.

# Annex 5: Staffing and education/training guidelines

# Staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications (Project deliverable 11)

Service contract HADEA/2022/OP/0003

Authors: F. Zarb, Y. Anacak, A. Brady, B. Brkljačič, M. Coffey, C. Garibaldi, F. Jamar, N. Jornet, P. Lara, M. Leech, C. Loewe, J. McNulty, G. Paulo, R. Sanchez, D. Visvikis, I. Polycarpou, M. Hierath, M. Szucsich

# Disclaimer

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# List of Abbreviations

| | |
|---|---|
| **AB** | Advisory Board |
| **ACI** | Accreditation Council in Imaging |
| **ACR** | American College of Radiology |
| **AI** | Artificial Intelligence |
| **ART** | Adaptive Radiation Therapy |
| **ASTRO** | American Society for Radiation Oncology |
| **BSSD** | Basic Safety Standards Directive (Council Directive 2013/59/Euratom) |
| **CC** | Core Curriculum |
| **CEEAO** | Central-Eastern European Academy of Oncology |
| **CME** | Continuing Medical Education |
| **CPD** | Continuing Professional Development |
| **DEGRO** | Deutsche Gesellschaft für Radioonkologie (German Society of Radiation Oncology) |
| **DEXA** | Dual Energy X-Ray Absorption |
| **DRL** | Diagnostic Reference Level |
| **EANM** | European Association of Nuclear Medicine |
| **EBNM** | European Board of Nuclear Medicine |
| **EBR** | European Board of Radiology |
| **EC** | European Commission |
| **ECTS** | European Credit Transfer System |
| **ED** | Emergency Department |
| **EDIR** | European Diploma in Radiology |
| **EFOMP** | European Federation of Organizations in Medical Physics |
| **EFRS** | European Federation of Radiographer Societies |

| | |
|---|---|
| **EORTC** | European Organisation for Research and Treatment of Cancer |
| **EPA** | Entrustable Professional Activities |
| **EQF** | European Qualifications Framework |
| **ESCO** | European Skills, Competences, Qualifications and Occupations |
| **ESMIT** | European School of Multimodality Imaging & Therapy |
| **ESR** | European Society of Radiology |
| **ESTRO** | European Society for Radiotherapy and Oncology |
| **ETAP** | European Training Assessment Programme |
| **ETC** | European Training Curriculum |
| **ETR** | European Training Requirement |
| **EU** | European Union |
| **FTE** | Full-time equivalent |
| **GNI** | Gross National Income |
| **HCW** | Health Care Workforce |
| **HEI** | Higher Education Institutions |
| **HERCA** | Heads of the European Radiological protection Competent Authorities |
| **HERO** | Health Economics in Radiation Oncology |
| **IAEA** | International Atomic Energy Agency |
| **IGRT** | Image Guided Radiation Therapy |
| **IMRT** | Intensity-Modulated Radiation Therapy |
| **IOMP** | International Organisation for Medical Physics |
| **IORT** | Intraoperative Radiation Therapy |
| **IR** | Interventional Radiology |
| **IRIS** | International Research Integration System |
| **JASTRO** | Japanese Society for Radiation Oncology |

| | |
|---|---|
| **KOSTRO** | Korean Society of Radiation Oncology |
| **LLE** | Live Education Events |
| **LMIC** | Low- and middle-income country |
| **MBBS** | Bachelor of Medicine, Bachelor of Surgery |
| **MCQ** | Multiple Choice Question |
| **MDM** | Multidisciplinary Team Meeting |
| **MI** | Medical Imaging |
| **MPE** | Medical Physics Expert |
| **MR-RT** | Magnetic Resonance guided Radiation Therapy |
| **NM** | Nuclear Medicine |
| **NMO** | National Member Organisation |
| **NRS** | National Registration Scheme |
| **OECD** | Organisation for Economic Co-operation and Development |
| **PET** | Positron Emission Tomography |
| **PRG** | Peer Review Group |
| **PSMA** | Prostate-Specific Membrane Antigen |
| **QA** | Quality Assurance |
| **QUIRO** | Qualitäts- und Innovationssicherung in der Radioonkologie (quality and innovation assurance in radiation oncology) |
| **RANZCR** | Royal Australian and New Zealand College of Radiologists |
| **RCR** | Royal College of Radiologists |
| **RIS** | Radiology Information System |
| **RO** | Radiation Oncologist |
| **ROESCG** | Radiation Oncology Education Collaborative Study Group |
| **ROPA** | Radiation Oncology Practice Accreditation |
| **RP** | Radiation protection |

| | |
|---|---|
| **RPE** | Radiation Protection Expert |
| **RT** | Radiotherapy |
| **RTT** | Radiation Therapist |
| **SBRT** | Stereotactic Body Radiation Therapy |
| **SEOR** | Sociedad Española de Oncología Radioterápica |
| **SFRO** | Société Française de *Radiothérapie* Oncologique |
| **SGRT** | Surface Guided Radiation Therapy |
| **SIRS** | Selective internal radiation therapy |
| **SPECT** | Single-Photon Emission Computed Tomography |
| **SRS** | Stereotactic Radiosurgery |
| **TBI** | Total Body Irradiation |
| **TQC** | Total Quality Culture |
| **TSEI** | Total Skin Electron Irradiation |
| **UEMS** | European Union of Medical Specialists |
| **VMAT** | Volumetric Modulated Arc Therapy |
| **WISN** | *Workload Indicators of Staffing Need* |
| **WP** | Work Package |

# 1. Introduction

The Tender entitled ‘EU-REST’ (European Union Radiation, Education, Staffing & Training) commenced on 1 September 2022 and will continue until 31 August 2024.

The study aims to provide an analysis of workforce availability, education, and training needs to ensure quality and safety aspects of medical applications involving ionising radiation in the European Union (EU) and foresees the development of staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications in the EU Member States.

The study will meet the following specific objectives:

- Collect and analyse data on workforce availability, education, and training needs to ensure quality and safety aspects of medical applications involving ionising radiation, as well as related stakeholder mapping;
- Draft guidelines for staffing and education/training for medical and other professionals involved in medical radiation applications in Member States and related stakeholder consultation;
- Develop conclusions and recommendations on EU workforce availability, education, and training needs for the quality and safety of medical applications involving ionising radiation and related stakeholder consultation.

This first draft (v1) of Staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications was developed by the members of Task 2.4, Development of guidelines on staffing needs in medical radiation applications, education and training of this staff, led by F. Zarb, and was submitted to the Peer Review Group (PRG) and the Advisory Board (AB) under Task 2.5, External peer review of existing and proposed guidelines, led by C. Loewe.

The aim of these guidelines is to present the minimum requirements for staffing and education/training for all 27 EU Member States and to serve as a basis for countries and centres to improve their particular situation if needed.

The staffing and education/training guidelines cover the following professional groups as agreed by all consortium members at the commencement of the study and as confirmed by the EC:

- Radiologists

- Nuclear Medicine Physicians
- Radiation Oncologists
- Medical Physicists
- Radiographers
- Radiation Therapists (RTT)

The guidelines for the different professional groups follow a common approach while taking account of the specifics of the type of medical procedures and staff responsibilities in question.

These guidelines were developed in parallel to Task 3.1, Benchmarking of workforce availability and training, against guidelines from European professional societies as available, Eurostat statistics, data from OECD health reports, IAEA and WHO documents, and other international data available.

The guidelines are based on the following 3 pillars:

i. Existing practice across the 27 EU Member States
    - Each professional group aimed to identify consistencies/uniformity in current reasonably good practice from the data available, i.e. the results of the EU-REST survey and the literature review.
    - Lack of literature in this area is acknowledged, and whenever possible the establishment of these guidelines was on evidence-based research and evidence-based practice.

ii. Recommendations
    - Any recommendations were made to influence correct practice while reflecting minimum requirements.
    - Any recommendations are supported by authoritative literature, guidelines, evidence-based research, or consensus papers.

iii. Improvements
    - Any changes or improvements which are obvious and required, are supported by data from i and ii above and agreed by all consortium partners.

# 2. Staffing guidelines

The staffing guidelines were prepared by writing group members from each discipline and each profession, as practices differ greatly both between disciplines and within each discipline with respect to the roles and responsibilities of the individual professionals. The findings of the EU-REST survey among professional organisations, national societies, government agencies and regulators conducted under Task 1.2. as well as the literature review of national, EU and international staffing guidelines formed the basis of the guidelines on optimum staffing levels relative to the activities carried out. The guidelines take into account the level of equipment available, expected workload and the complexities of the practices undertaken.

Irrespective of size or complexity, an essential methodology to calculate the minimum number of staff in each profession for each discipline has been defined as a starting point. Additional staffing requirements can be defined using the presented methods, based on increasing complexity of work, workload, equipment levels and the introduction of new roles and responsibilities, as indicated in the EU-REST survey results and recommended in the literature. The aim was to provide guidelines on methods of calculating staffing needs, both for current practice but also for a future expansion of services or new roles. This will ensure long term applicability of the project outputs.

Despite the diversity of professions, certain similarities can be noted.

Workforce availability:

- The benefits of establishing national registries of professions, using uniform methods of data collection and collation, on professional competence and requirements for maintenance of registration. National regulatory bodies should be responsible for maintaining and regularly updating the registers and ensuring high quality of the data, which should include the relevant subspecialty, age, workplace, private vs public institution etc. Such registers should be publicly accessible and would facilitate the identification of staffing shortages and provide data on age profile and gender mix so that remedial and retention measures within the professions can be undertaken. Such national registries would also improve data quality and accessibility for EU reports and research. A central registry drawing on data from national registries would be a desirable ultimate outcome.

Workforce planning:

- Each profession recommended their own method for calculating staffing levels based on factors related to their profession.

Quality and safety:

Continuing professional development (CPD) in radiation protection is already mandated in all Member States under the BSSD. Broader CPD, covering professional skills, knowledge and competencies, should also be a requirement for all involved professional groups in Member States.

## 2.1 Radiologists

Authors: Adrian Brady, Boris Brkljačić, Christian Loewe (European Society of Radiology – ESR)

### 2.1.1 Introduction and overview of various existing methods of calculating radiologist numbers

#### Introduction

Measuring how much work is done by a radiologist is a far-from-simple task. Many efforts have been made in the past to define reproducible, accurate and scalable methods, with little or no success in achieving widespread acceptance. Among these methods have been:

1. Crude study numbers [1]. Somewhere between 10,000 and 20,000 procedure reports per annum was used as a benchmark for appropriate annual activity for an individual radiologist. This had some validity when radiology activity was mostly based on plain radiography but became meaningless once more-complex imaging modalities became commonplace. The amount of time required to report a plain radiograph (often <1 minute) bore no relationship to the time for a multiphasic CT or a multiparametric MR (potentially up to 1 hour) and counting these activities as representing the same output was not reasonable. An Irish National Workload review in 2011 described this method as "old-fashioned, discredited and [an] inappropriate misuse of data", and stated that such data "should not be used in an unfiltered and un-weighted manner" [2].
2. As cross-sectional imaging utilisation grew, attempts were made to stratify radiologists' activities depending on the modalities they were reporting, including recommendations issued in 1999 by the Royal College of Radiologists in the UK [3]. This document suggested appropriate workload for a notional half-day, varying according to the modality involved. However, it did not allow for radiologist activity which could not be measured in numbers of reports generated such as: multi-disciplinary

team (MDT) activity, procedural work, teaching, research, administration etc.

3. Relative Value Unit (RVU) measurements were developed in a number of countries (including the USA, Canada, Australia & New Zealand) in an effort to overcome some of the difficulties with earlier measurement methods [4,5]. Some (but not all) of these systems incorporated attempts to measure both technical and procedural elements of radiologist workload, making allowance for the time required, the complexity and the intensity of specific pieces of work, but all suffered from being primarily designed and used to determine reimbursement for work done, rather than to measure individual workload. RVUs focused purely on reporting time and took no account of other aspects of a radiologist's work.

4. Later methodologies were developed by academic bodies in some countries to make allowance for the non-reporting elements of a modern radiologist's work (as mentioned in item 2 above) [2,6,7]. These had limited local success in the countries in which they were developed, in terms of helping to re-define the scope of work of a radiologist, but had little overall impact on radiologist numbers, and no international penetration as general standards.

Evaluating all these methodologies, one cannot help but think of the tongue-twister "How much wood could a woodchuck chuck if a woodchuck could chuck wood?". Despite the fact that all these ideas mentioned above may each have seemed relevant and appropriate at the time, it became obvious that the wrong question was being asked, in an effort to provide a numerical answer that was unattainable, not representative of real-world radiological practice, and therefore doomed to failure.

A fundamental point that must be grasped is that no generally accepted/agreed definitions exist for

i. Number of examinations needed per population,
ii. Number of pieces of equipment needed per population,
iii. Appropriate per-radiologist reporting output.

In recent years, fortunately, awareness has grown of a number of significant pertinent aspects of considering radiology workload and radiology's impact on healthcare and well-being. Firstly, understanding has grown that the role of the radiologist goes far beyond the production of reports of imaging studies or the performance of interventional procedures [8], despite these being key components of radiologists' work. In particular, the intensification of involvement of radiologists in multi-disciplinary care of patients has emphasised radiologists' clinical input and role in promoting health and wellbeing, and optimising outcomes for patients. Secondly, the value-based radiology concept and movement is increasingly focusing on defining the value provided to patients on an individual basis, and to society in general, rather than assessing radiology's contribution based on activity volume alone [9,10-12].

Bearing all of this in mind, any guideline for appropriate workforce in radiology recommended as an outcome of the EU-REST study should attempt to incorporate the following elements:

1. Non-countable (by numbers of reports or other outputs) activity (e.g. MDT work, direct patient engagement etc.) must be provided for and appropriately recognised as valid and valuable. Indeed, a recent publication from the Netherlands has confirmed that employers of radiologists in that country are increasingly seeking applicants with teaching, research, and management skills, in addition to their clinical competencies [13].
2. Value contributions to individual patients and society in general must be considered.
3. If available, existing, and working guidelines from the EU 27 countries, should be included and/or adapted. Unfortunately, data collection as part of the EU-REST survey identified no such usable existing guideline. There is no uniform method used across a range of countries to determine workforce numbers in radiology. Many countries use local, bespoke methods, or have no specific method at all. In some instances, workforce provision is determined by "market forces": how many radiologists need to be hired to deal with the workload presented (and, sometimes, to optimise earnings for departments and radiologists individually), balanced in some way by how many trainees are produced each year, or how many potential employees are available.
4. If available, recommendations supported by authoritative literature / guidelines / research etc. should be incorporated and/or adapted. Again, unfortunately, data collection as part of the EU-REST review of existing literature identified no usable existing guideline.
5. Any guideline recommended should be adaptable at least for the short-to-medium term future. Medical and radiological practice is constantly in flux, as patterns of utilisation of investigative methods change and new tools become available. Adopting a guideline today which is outdated in five years is of little overall value.
6. Any guideline recommended should be adaptable for differences in practice and imaging availability between countries, and should be scalable, such that the guideline can be applied on a local, regional, national, or multi-national basis.

Therefore, given the unavailability of any existing guideline or workforce determination method which could fulfil the needs outlined above, we are faced with the need to propose a “new” method of determining workforce needs, based on calculable denominators which can be generalised across many countries and practice styles.

## Possible approaches to estimate / calculate workforce numbers

For radiologists, we considered a number of possible methods for calculating appropriate workforce numbers in some locations, with their pros and cons.

### 1. Based on population

On first glance, basing guidance on the number of radiologists needed to service a given population on that population’s size seems intuitive. If a population increases or decreases over time, it would seem sensible to plan to change radiologist numbers to match such changes. However, this is a very crude measure, and has many disadvantages.

One could attempt to adapt a population-based formula, to take account of the specific population demographics (age-profile, etc.), but this would not overcome some of the other difficulties with such a crude measurement system (Table 1).

**Table 1 – Pros and cons: Basing radiologist numbers on population**

| Pros | Cons |
|---|---|
| Applicable to all countries | Ignores age-profile demographics (young or old population etc.) |
| Avoids issues relating to public/private practice | Ignores variation in complexity between countries |
| Relatively simple to calculate | Slow to change, and assumes work practices don’t change with time (independently of population) |
| | Frequency of measuring population size (censuses) makes it difficult to adapt radiologist numbers quickly |
| | Numbers of radiologist training positions needed to meet population-based standard will always lag substantially behind actual population (given a minimum lead time for training new radiologists of at least 5 years) |

Section 2.1.2 of this document explores the issues underpinning the use of population as a measure for needed radiologist numbers in greater detail, as an illustrative example.

## 2. Based on workload

Again, this would seem at first glance to be a good basis for calculating workforce need. After all, a given amount of work should require a similar amount of time/effort in all EU Member States, assuming proper weighting could be determined and applied to different types of radiology work. However, even local attempts to use workload measures to determine workforce needs [1,2,6] have found large variability in how workload is calculated across different sites (often with a view to maximising apparent local/individual workload and/or income). If measurement of workload in radiology could be standardised, this could become a very effective denominator of staffing needs. But such standardisation does not exist at present. We believe the development of a standard method at EC level would be desirable, but doing so lies outside the scope of the EU-REST study and the SAMIRA framework. However, if such standardisation could be achieved in the future, then the basis for radiologist workforce calculation could be adapted to take account of it.

An additional factor is that the evolution and maturity of preventive medicine within any country may influence the number of imaging studies done. For example, if a lung cancer screening programme exists in any given country, or if cardiac CT is readily available and incorporated within clinical practice, the numbers of CT studies done, CT scanners and radiologists required will be higher than if these practices are not supported.

Other drawbacks of any crude workload-based calculation of radiologist need include (Table 2):

1. Regardless of the EU Working Time Directive (2003/88/EC), working conditions vary among countries and among centres within any one country. The numbers of days off per year, maximum working hours etc. all can influence the total number of radiologists required to deliver a certain amount of workload.
2. Determining needed radiologist numbers on the basis of numbers of studies reported alone takes no account of the substantial proportion of modern radiology practice that does not necessarily result in a countable output, such as a radiology report. One of the most important aspects of many radiologists' work is preparation for and participation in multidisciplinary team meetings (MDMs), with radiologists playing a significant direct role in decision-making for patient management. Additionally, patient advocacy groups are increasingly calling for direct access to radiologists to discuss their imaging [8,12-14]. Such direct

patient-radiologist engagement would be beneficial to all involved but would be ignored by workload measures based on the numbers of reports generated. Other aspects of radiologist work which are not easily counted by report numbers include interventional radiology (of variable complexity), supervision and teaching of trainees and other staff members, research etc.

3. There is huge interindividual variation in reporting performance in terms of numbers of studies, independent of the maturity and experience of the reporting radiologist [15]. The speed at which individuals work cannot and should not be fixed or mandated; radiology is not a factory production line.

4. The availability of infrastructure (workstations, IT infrastructure etc.) can influence reporting speed and productivity [15].

5. Organisational aspects of reporting environments can influence reporting efficiency (e.g. frequency of breaks during continuous periods of sustained concentration, frequency and numbers of interruptions, such as for phone calls, issues relating to patient management, protocol determination, justification etc.) [15].

**Table 2 – Pros and cons: Basing radiologist numbers on workload**

| Pros | Cons |
|---|---|
| Flexible to allow for differences in practices in different countries | Variability in how workload is counted between institutions |
| Adaptable for different institutions doing variably complex work | Difficulty incorporating some aspects of work (e.g. intervention, multi-disciplinary work, patient consultation) |
| Allows for relatively rapid response to changing practices or new techniques | Liable to “gaming” to increase apparent workload |
| Faster changes in workforce recommendations facilitated, relative to population-based standard | Requires consistent verifiable data from institutions, with uniformity of counting method |
| | Requires very granular data to be accurate (e.g. not all CTs can be counted in same way, CT brain takes much less time to interpret than multi-phase body CT) |
| | Depends on specifics of clinical and public health practice within any country |

## 3. Based on equipment or bed availability

Basing workforce needs on the number of pieces of relevant equipment, or on the number of patient beds available in hospitals, may be useful for some other medical specialists, but is less reliable as a basis for calculating radiologist needs.

With respect to hospital bed numbers, radiology is a specialty that provides services on both an in-patient and out-patient basis. Therefore, any attempt to link radiologist numbers to in-patient bed numbers would ignore out-patient work, which can, in some circumstances, form the majority of radiologist work. Additionally, in many developed countries, there is a substantial move towards managing many medical issues on a day-case or out-patient basis, which would once have required in-patient hospital admission, and also to speed up discharge of patients from in-patient hospital beds after procedural treatment. Nonetheless, many patients managed in these ways will require imaging and/or interventional radiology services, which may continue after their discharge from an in-patient bed. Thus, radiology activity is in no useful way reflected by in-patient bed numbers.

With respect to equipment availability, tying radiologist numbers to numbers of CT or MR scanners etc. takes no account of varying practices, complexity of medical work undertaken and utilisation of equipment. Usage of radiology equipment may be only during the normal 8-10 hour working day, or around the clock (on a full-service or reduced activity basis), often depending on staff availability and/or demand for services. Reimbursement policies within different countries may influence equipment numbers. The efficiency of patient throughput through radiology equipment may also vary between institutions. The complexity of cases in an institution may have a major impact on throughput: CT or MR units dealing with seriously ill, immobile patients may perform fewer examinations than one dealing mostly with ambulatory patients with less-complex presentations, yet the radiologist time required to interpret studies on complex patients may be much greater.

On a broader level, the number of pieces of equipment will depend to some extent on the general structure of the healthcare system within each country. Depending on geography, transport infrastructure, population distribution etc., imaging services may be widely distributed or concentrated within fewer, larger centres, and these factors will influence the total number of pieces of equipment needed to service the population (Table 3).

**Table 3 – Pros and cons: Basing radiologist numbers on equipment or bed availability**

| Pros | Cons |
|---|---|
| Allows for differences between high-level and lower-level services | Ignores usage patterns of equipment (e.g. 24-hour service, office hours only etc.) |
| Allows for rapid changes in required workforce as equipment availability changes | Usage of in-patient beds varies hugely among countries, depending on availability of beds, day-case access, and overall model of care |

| Pros | Cons |
|---|---|
| Faster changes in workforce recommendations facilitated, relative to population-based standard | Ignores variable efficiency in equipment utilisation (e.g. a department could be “rewarded” with additional staff by purchasing additional equipment, rather than utilising existing facilities more efficiently) |
| | Risks embedding inappropriately low equipping levels in a system, if availability is used at any particular point in time to determine necessary workforce. |
| | Does not automatically take into account greater time commitment for more-complex imaging studies |

### 2.1.2 Issues related to using population to determine radiologist staffing needs

OECD and WHO public reports primarily present data on healthcare in general and on the healthcare workforce (HCW) in different countries based on population calculations [16,17]. With respect to workforce, the most commonly used indicator is the density of the healthcare workforce (i.e. the number of active HCWs in an occupation divided by the population). The workforce density, usually presented per 10,000 people, is a simple measure useful for the basic comparisons between countries and different healthcare occupations. It is applicable to all countries and avoids issues relating to public/private practice. Thus, a seemingly logical step in drafting guidelines for appropriate numbers of radiologists would be to specifically calculate desirable numbers of radiologists based on the population of the country/region they are serving.

The latest OECD report demonstrates that in OECD member countries, health and social care systems employ more workers now than any other time in history. In 2019 one in every ten jobs (10%) was in health or social care, up from less than 9% in 2000. In Nordic countries and the Netherlands, more than 15% of all jobs are in health and social work. On average across OECD countries employment in health and social work increased by 49% between 2000 and 2019, outpacing all other sectors, even the service sector. In OECD countries the number of doctors increased considerably, from around 2.8 million in 2000 to 4.1 million in 2019 (an increase from 2.7 per 1,000 population in 2000 to 3.6 per 1,000 in 2019). Despite this overall trend, differences in doctor density across OECD European countries are large: Poland and Turkey have 2.5 doctors per 1,000 population, while Austria, Portugal and Greece have over 5 per 1,000. The growth in physician numbers in EU members states was also very variable: strong increases were observed in Austria, Spain, Sweden, and Denmark, while the number of doctors grew only modestly in France, Poland, and Slovakia. In most countries, the expressed concerns which governments are addressing relate primarily to shortages of general practitioners and doctors in rural and remote areas. Large scale trends, such as population ageing and technological change are expected to continue to play a key role in increasing the demand for workers in healthcare, and most national projections foresee considerable growth of the employment needs in health care sectors, as is the case in the USA, Australia, and Canada.

### Increasing demand for imaging

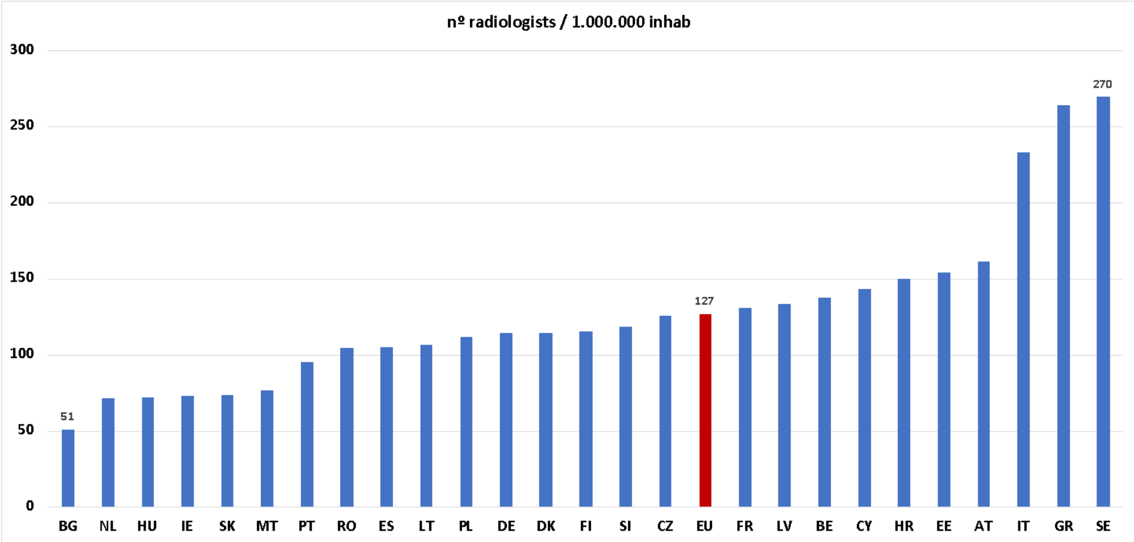
Radiology in the EU has, to some extent, followed these trends by increasing numbers of radiologists, to a variable extent, depending on the country. Nonetheless, many countries are increasingly unable to cope with the growing demand for imaging procedures, which generally far outstrips any population-based changes in radiologist numbers over time. Increasing numbers of imaging examinations in recent decades are attributed to advances in technology (enabling fast and reliable imaging), to the aging population (with more chronic diseases) and to the practice of defensive medicine (in part responsible for the fact that at least 20-30% of imaging procedures performed are not necessary and do not generate information that improves diagnosis or treatment, nor do they affect the patient's health). UNSCEAR data have shown a considerable annual growth in medical radiological examinations worldwide, with a 70% increase between 2000 and 2020 overall. In CT, the number of procedures and the collective dose have risen markedly between 2008 and 2020. The number of procedures has increased by about 80% and the collective dose has increased by around 70% [18].

Although the number of radiologists has also been increasing over time, in many countries the huge demand for imaging has not been matched by a similar rate of increase in the radiologist density, deepening the gap between the workforce availability and workforce requirement to deal with demands for imaging.

### Absolute numbers of radiologists per population (radiologist density)

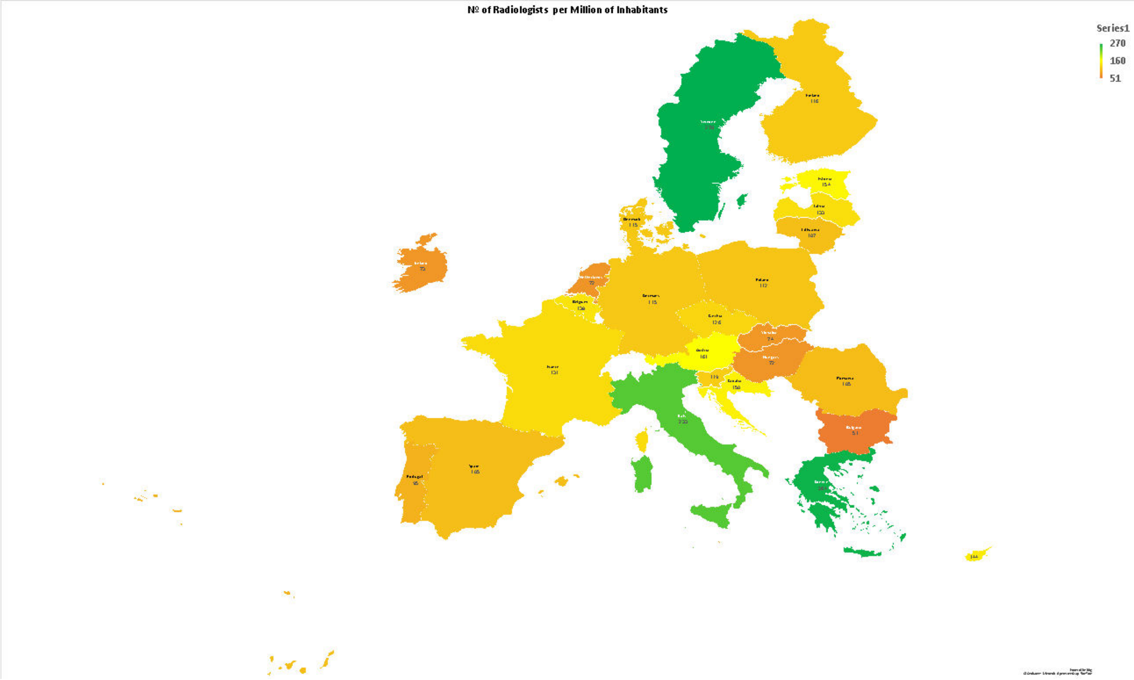
The EU-REST survey has provided data on the numbers of radiologists in EU Member States and their density. According to these data there are 60,771 radiologists in the EU-27, with an EU-wide ratio of 127 radiologists per 1,000,000 inhabitants (or 1.27 per 10,000 inhabitants). Bulgaria has the lowest number (51/million inhabitants) and Sweden the highest (270/million inhabitants) (Figure 1).

**Figure 1 – Number of radiologists per 1 million inhabitants**




The colour map in Figure 2 shows the geographical distribution of radiologists across Europe, evidencing the 16 countries with a density of radiologists lower than the EU average (dark orange) and the 10 above EU average, with Italy, Greece and Sweden having a significantly higher number amongst all. The EU-REST data regarding radiologist density is comparable with the overall WHO reports on health professional densities; the diversity within EU-27 countries is huge. Sweden and Greece have more than double the radiologist density than the EU average, while Bulgaria, the Netherlands, Hungary, Ireland, Slovakia, and Malta have almost half the EU average radiologist density. Bulgaria has 5.3 times fewer radiologists per population than Sweden. Thus, attempting to define an "ideal" radiologist density from existing EU data would be arbitrary, with no clear standard identifiable from existing numbers.

**Figure 2 – Geographical distribution of radiologists across Europe**




The colour map shows the geographical distribution of radiologists across Europe, evidencing the 16 countries with a density of radiologists lower than the EU average (dark orange) and the 10 above EU average, with Italy, Greece and Sweden (green) having a significantly higher number amongst all.

## Ageing of the radiologist workforce

The ageing of the healthcare workforce is a particular concern, especially in countries in which a significant percentage of the workforce is aged 55 years and older. These countries face the imminent challenge of replacing retiring workers. A WHO report shows that 13 of 44 countries that reported data on this issue have a workforce in which 40% of medical doctors are aged 55 or older.

Taking into account those 17 countries that provided an age profile in the EU-REST survey, approximately 19% (8,356) of the 60,771 EU radiologists will retire in the next 5 years and 45% are over 51 years old. The age ranges to be selected in the survey were: <30; 31-40; 41-50; 51-60; >61. Based on this age distribution, it was considered adequate to provide 1) a picture of retirement in 5 years (taking 66 years as a reference value, although the retirement age varies between countries) = potential immediate loss and 2) an overview of the impact considering the minimum age value of the 51-60 range = potential loss in the next 10 to 15 years, which would allow Member States and the EU as a whole to implement contingency measures.

The trend of ageing among the radiologist population is compatible with OECD data about medical doctors overall, where over one-third of doctors were above the age of 55 in 2019 (only 20% in 2000). The rapid ageing of all medical doctors is particularly visible in Italy, where the share of doctors above the age of 55 has increased from around 20% in 2000 to 56% in 2019, and in France where 14% of doctors in 2019 were over the age of 65. Nine EU member countries (Croatia, Czechia, Estonia, France, Hungary, Italy, Lithuania, Poland, Sweden) will lose over 20% of the radiologist workforce in the next 5 years due to retirement (considering the retirement age of 66 years), higher than the EU average (19%). Lithuania presents the highest value (35%) (Table 4).

**Table 4 – Radiologists' age profile**

| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| AT | 145 | 10% | 60% | 40% |
| BE | | | | |
| BG | 18 | 5% | 75% | 25% |
| HR | 128 | 22% | 56% | 44% |
| CY | | | | |
| CZ | 343 | 26% | 43% | 57% |
| DK | | | | |
| EE | 49 | 24% | 41% | 59% |
| FI | | | | |
| FR | 1 960 | 22% | 39% | 61% |
| DE | | | | |
| GR | 280 | 10% | 55% | 45% |
| HU | 140 | 20% | 45% | 55% |
| IE | 37 | 10% | 60% | 40% |
| IT | 2 800 | 20% | 50% | 50% |
| LV | | | | |
| LT | 105 | 35% | 45% | 55% |
| MT | 2 | 5% | 90% | 10% |
| NL | 189 | 15% | 60% | 40% |
| PL | 882 | 21% | 51% | 49% |
| PT | | | | |
| RO | | | | |
| SK | | | | |
| SI | 45 | 18% | 57% | 43% |
| ES | 500 | 10% | 65% | 35% |
| SE | 733 | 26% | 47% | 53% |
| **EU** | **8 356** | **19%** | **55%** | **45%** |

Looking a few more years ahead, in Czechia, Estonia, France, Hungary, Italy, Lithuania, Sweden, more than 50% of the radiologists are over 51 years old, indicating a high demand for replacements stretching at least 15 years into the future. Among those countries, special attention should be given to Czechia, Hungary and Lithuania, since they have an overall number of radiologists per million of inhabitants lower than the EU average.

### Full-time vs. part-time working, and scope of practice

Absolute radiologist density does not account for the actual time that radiologists work to deliver services, and how this relates to numbers of full-time equivalents (FTEs). Neither does it account for the variations in services delivered (scope of practice). The scope of radiologists' practice may differ widely within a single department and between different departments, depending on the type and quality of equipment used and type of radiological practice (US, CT, MRI, X-ray, diagnostic vs interventional radiology) performed, and the need for specific subspecialists. These variables must also be reflected in requirements for the specific subspecialised radiologist workforce. For instance, radiologists whose work encompasses interpretation of CT studies can read many more brain CTs per day than CTs of thorax-abdomen-pelvis. Radiologists performing US can perform many more thyroid US than complex Doppler examinations of peripheral arteries and veins.

Interventional radiologists performing complex procedures (e.g. EVARs, complex neurointerventions, complex hepatobiliary, urologic or vascular procedures) need different staffing levels compared to those performing mostly simpler interventions (drainages, biopsies etc.).

### Distribution of radiologists

OECD data have shown considerable differences in the density of doctors between urban and rural areas, with, for example, huge differences in Hungary, Slovakia, Lithuania, and Latvia. In many countries there is a particularly high concentration of doctors in national capital regions (Austria, Czechia, Greece, Hungary, Portugal, Slovakia). The same trends are present in radiology, and career opportunities and professional development are undoubtedly better in larger centres and academic institutions. Independent of staffing density guidelines, additional policies will be required in some countries to address this imbalance of distribution (e.g. providing financial incentives for radiologists serving in underserved areas, reorganising service delivery to improve working conditions of doctors working in more-remote areas, regulation of the choice of practice location for radiologists, etc.).

### Public vs private practice

ESR national society members report that radiology is an attractive profession in most EU states, and attracting young doctors to radiology does not seem to be the major problem. However, retaining radiologists in the public healthcare service is becoming difficult in many countries (notably, but not only, in France, Poland, Croatia, Slovenia), as private sector work often offers much higher income and a better work-life balance, while the majority of more complex procedures and emergency services are performed in the public sector.

### Effects of the COVID-19 pandemic

The COVID-19 pandemic has accelerated or exacerbated many already existing problems that also affect retention of radiologists within healthcare services. Increased international mobility, coupled with higher income availability in richer countries, has led to a drain of radiologists from East to West within Europe. Working-from-home practices introduced during the pandemic out of necessity have become the norm in many circumstances, and have influenced radiologists’ willingness to work long hours, out-of-hours shifts, etc. Part-time practice has been increasingly embraced by radiologists (and many other groups within and outside healthcare services), arising from changed experience of work-life balance during the pandemic.

### Influence of Artificial Intelligence (AI)

Nobody can yet reliably predict how AI will affect radiology practice, but changes will obviously happen [19]. AI has great potential to optimise workflow in radiology, including improvement in referral of patients for radiology procedures and assistance to radiologists in interpretation of many studies. Many commentators have suggested that AI may therefore reduce the numbers of radiologists needed in the future.

Conversely, findings identified by incorporation of AI-enabled algorithms into radiology reporting pathways may actually substantially increase workload for radiologists, as many more findings may need to be specifically evaluated and investigated or dismissed. We will need radiologists who are skilled in the use of AI and digital health tools in general, but how AI will affect the daily workflow of radiologists is impossible to predict with certainty at present. Therefore, staffing guidelines need to be flexible and adaptive.

### Conclusion

While using crude population numbers as a denominator to determine the numbers of radiologists needed to provide services within a country has the apparent advantage of simplicity, this section has analysed, and, we hope, demonstrated that such a crude method for determining a radiologist density guideline ignores many potentially confounding issues. Specifically, these include:

1. **The lack of any agreement on an appropriate radiologist density, given the very wide current variation among EU Member States.**
2. **The need to take account of changing demands for radiology services over time, independent of population numbers.**
3. **Varying age profiles of working radiologists among the EU 27.**
4. **Varying proportions of full-time and part-time work among radiologists.**
5. **Differing scopes of practices among institutions and countries.**
6. **The need to ensure equitable access to and distribution of radiologists for countries' entire populations, not just those living in larger urban centres.**
7. **Varying proportions of public and private practice, and the influences these variations have on workforce retention.**
8. **Mobility of workforce and changing work practices, accelerated since the COVID-19 pandemic.**
9. **The as-yet unknown future influence of AI on radiologist work patterns.**

## 2.1.3 ESR proposed method to estimate and calculate Radiology Workforce (Radiologists)

### Proposed approach to staffing guidelines

Given the issues outlined in the sections above, and to address the main challenge of establishing an adaptable, scalable guideline, we propose the use of **hour of machine/system/activity** as the basic unit.

*Several advantages are expected from this approach:*

- The idea behind this approach is to define the number of radiologists needed for each working hour of a certain type of Radiological machine (i.e. MRI, CT, US, angiography (DSA), conventional radiology (X-ray), fluoroscopy, and others) or non-reporting activity (such as participation in a Multidisciplinary Team Conference), including reporting time, and non-reporting duties.

- By this, a basic unit would be introduced that could be used as the basis for the further calculation of staffing needs. This basic unit would be multiplied by the running hours for the specific imaging system or activity. Based on the working hours a radiologist is allowed/contracted to work per year in a certain country / institution, the number of required full-time equivalents can be calculated.

  (In a publication by the Japanese College of Radiology, it was suggested to multiply the number of needed radiologists following a calculation as described above by a factor of 0.6, based on the assumption that about 60% of a radiologist’s working time is study reporting time [20]).
- This unit can also be used to calculate the need for additional workforce resulting from the planned expansion of an already existing modality/service, or to calculate the need for workforce in case of an increasing number of systems. Conversely, if there is a shift from one type of examination towards another (for example, as observed in the past, away from diagnostic invasive angiography to non-invasive CT angiography), possible reductions of staffing needs could also be estimated based on such basic units.
- These units can also easily be adapted to possible specific needs and duties at certain institutions. For example, in academic or teaching institutions, units could be multiplied by a pre-determined factor to take account of specific supervision/teaching/research etc. duties.
- In specific environments incorporating teaching/education, dedicated calculations can be provided to address the special circumstances. In the teaching setting, the time involvement of a fully trained, independently-practising radiologist is reduced (especially after the first few weeks) since their permanent presence is not always needed throughout an entire shift (assuming that some work is done by trainees). It is expected that the trainee may, for example, be running a list (e.g. in CT, MRI) (we believe this to be a crucial part of the learning process) and the fully-trained “teacher” joins in from time to time for case discussion etc. However, the total workforce (fully trained and trainees) needed in the teaching situation is increased since trainees plus fully-trained radiologists have to be assigned for each hour of service.
- These units can also easily be adapted according to changes in clinical practice. Availability of AI tools will certainly have an impact on the future work of radiologists, as discussed above. However, these tools may impact different fields and modalities more than others, and it remains unclear what the specific impact of AI availability will be. A basic unit as

proposed herein should provide flexibility to adapt workforce numbers as the impacts of new developments become clear.

Following the hypothesis that examinations which are time-consuming in image acquisition are also time-consuming in analysis and interpretation, such a basic unit would also be rather independent from the varying case mix in different imaging centres. Similar, the use of such a basic unit would be able to accommodate the needs for educational activities in academic centres, where the total number of examinations per hour might be lower than in centres which do not have an academic/educational function, based on the assumption of more complex cases and possibly more time-consuming examinations. Based in such differences in practice, calculated units can also – as described above – easily be multiplied by a certain factor.

**Based on above mentioned thoughts and assumptions, we propose the definition of one hour of system use as the basic unit, and we propose staffing requirements depending on modality as described in the following modality-specific sections.** The proposed calculations are based on 50 weeks of normal operation per year, excluding holiday periods.

## Interventional Radiology using digital subtraction angiography and fluoroscopy (IR)

### Explanation of the procedures

Under this term / category all vascular and non-vascular procedures performed under fluoroscopic guidance are included, under the general abbreviation IR.

The list of vascular procedures include neurovascular procedures (endovascular treatment of ischemic stroke, endovascular treatment of intracranial aneurysm, arteriovenous fistula and more), cardiovascular procedures (treatment of coronary artery disease, of aortic disease, of peripheral arterial disease, treatment of valvular diseases and much more) as well as embolisations in the non-oncological setting (bleeding embolisation) or in the oncological setting (tumour embolisation, radioembolisation, and more). Relatively newer procedures include endovascular treatment of acute pulmonary embolism by embolectomy and treatment of acute and chronic pelvic vein thrombosis.

The list of non-vascular procedures includes percutaneous biliary interventions, tumour ablations (microwave ablation, radiofrequency ablation, cryoablation, irreversible electroporation) as well as interventions in the intestinal and urogenital tract. Additionally, drainage, biopsies, and more are part of the spectrum of interventional radiology.

## Approach to staffing need calculation

Beside the fact that all these procedures represent minimally invasive procedures performed under fluoroscopic guidance, all these procedures also have in common the fact that the performing physician has to be in the room for the entire procedure. There are few steps during most procedures that can be delegated, and no teleradiological approach is possible.

It has to be underlined that this estimation focuses on the work in the fluoroscopic suite. Additional clinical work at ward level (in some institutions, IR and Neuro-IR have their own beds) or in outpatient clinics is not included.

The room time of each patient ≠ the procedure time

Before each procedure can start, the patient must be prepared and the devices to be used must be selected and made ready. These preparatory steps do not always require the presence of the treating physician (interventional radiologist).

The time required for changeover of patients between cases differs between different institutions, depending on process organisation and the complexity of cases performed; this could influence the calculation of staff needed. However, during this changeover period, the interventional radiologist would typically write the report of the previous procedure and prepare for the next one, including communicating with other staff members about the planned upcoming procedure and the devices needed.

In smaller institutions without full-time interventional services, the interventionalist may be involved in other diagnostic work aside from interventional procedures (for example reporting CT cases). Thus, the running hours of an IR service itself cannot be used as a basis for workforce calculation.

The above-described work-up and preparation time depends of course on the complexity of the respective procedures. However, based on the assumption of a certain mix of complexity an estimation is done as detailed below:

The basic unit as described above refers to the room-time of the patients.

**One hour IR ($HR_{IR}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour room-time of the patients.**

## Proposed calculation (IR)

Based on the assumption above, the staffing recommendations are as follows:

> **One hour IR ($HR_{IR}$) requires 1.5 working hours of a board-certified interventional radiologist who is capable and licensed to work independently.**

## Working example

As a practical example: the placement of a transjugular portosystemic shunt (TIPSS) typically requires a procedure time of 60 – 120 min. The room time of the patient will be between 120 and 180 min. Consequently, the need for the interventionalist will be 3 – 4.5 hours, to reflect the need for careful patient selection, communication / discussion with the referring physician, patient consent (ideally performed on the day before), checking the lab values, organising possible pre-treatment and writing the report. Additionally, time should remain available to check and organise the stock of devices needed.

If an IR service is running 5 days a week with 8 hours' patient room time a day, the total need would be to cover 2,000 hours per year. Doctors working 40 hours per week, for 40 weeks a year (following the assumption of The Gishen Ready reckoner [22] to reserve 12 weeks for leave, study leave, illness, meetings, machine breakdown or non-function) are working 1,600 hours per year. Based on the estimation above, 3,000 hours should be covered.

Following this calculation, for an IR service being busy 5 days a week for 8 hours, 2 IR specialists being able to work independently and unsupervised are required.

In the teaching setting, this demand on staff needed should be altered based on the need for continuous presence of a medical doctor being capable and licensed to work independently, to oversee all steps performed by a resident/fellow.

> **One hour IR ($HR_{IR}$) in the teaching situation requires 1.5 working hours of a board-certified interventional radiologist who is capable and licensed to work independently PLUS 1 working hour of a resident / fellow.**

These estimations and assumptions are dedicated to routine in-hour service. For on-call and/or out-of-hour services different calculations are needed.

## Magnetic Resonance Tomography / Imaging (MR)

### Explanation of the procedures

Under this term/category all diagnostic examinations and procedures performed using MR are included, such as Cardiac MR (CMR), MR angiography (MRA), MR spectroscopy (MRS) and much more.

MR examinations always consist of a carefully chosen and individualised combination of different techniques and sequences, which are selected based on the specific request and the clinical situation. The length of an MR examination depends on the number of sequences combined and thus on the clinical scenario, as well as on the system used. The specific equipment determines the acquisition length of each sequence and shows huge variation.

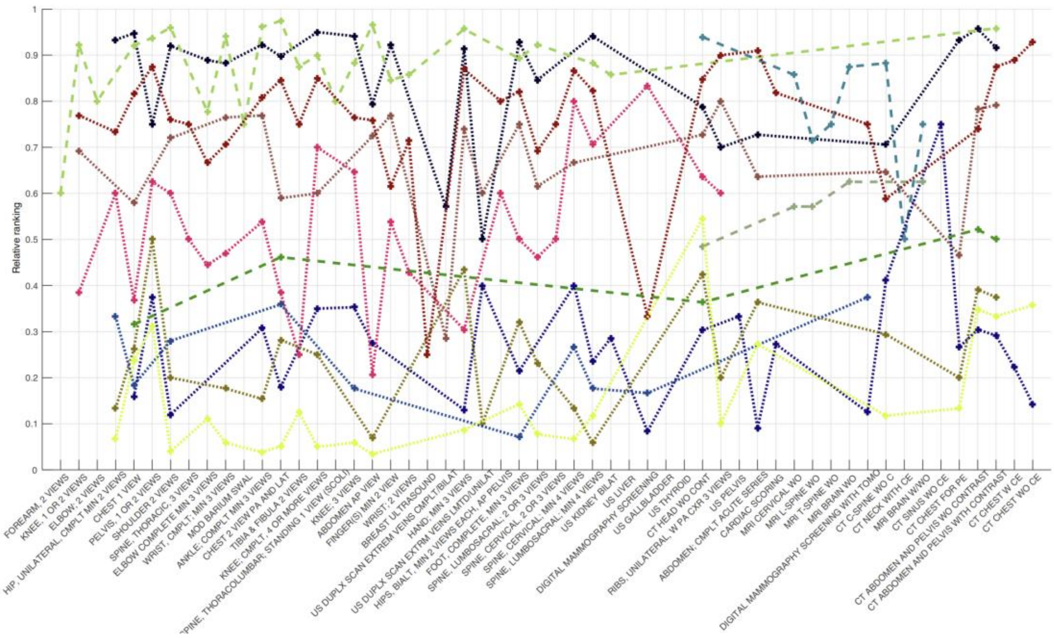
### Approach to staffing need calculation

In recent years, a significant reduction in the acquisition length has been observed thanks to technical developments, and there is an increasing trend towards short protocols, with the goals of optimising patient throughput and scanner use and of increasing patient comfort (by reducing potentially uncomfortable time lying in the scanner). Consequently, the number of examinations / patients per working day / working hours tends to continuously increase. However, the reporting time needed per study has not changed. Increased scanner efficiency thus results in an increased need for radiologist workforce, since the total workload for reporting and management is increased by the number of patients scanned.

There is no clear definition on how many examinations a radiologist can/should report per hour/day. Even within the same institutions and fields of expertise, large variations do exist.

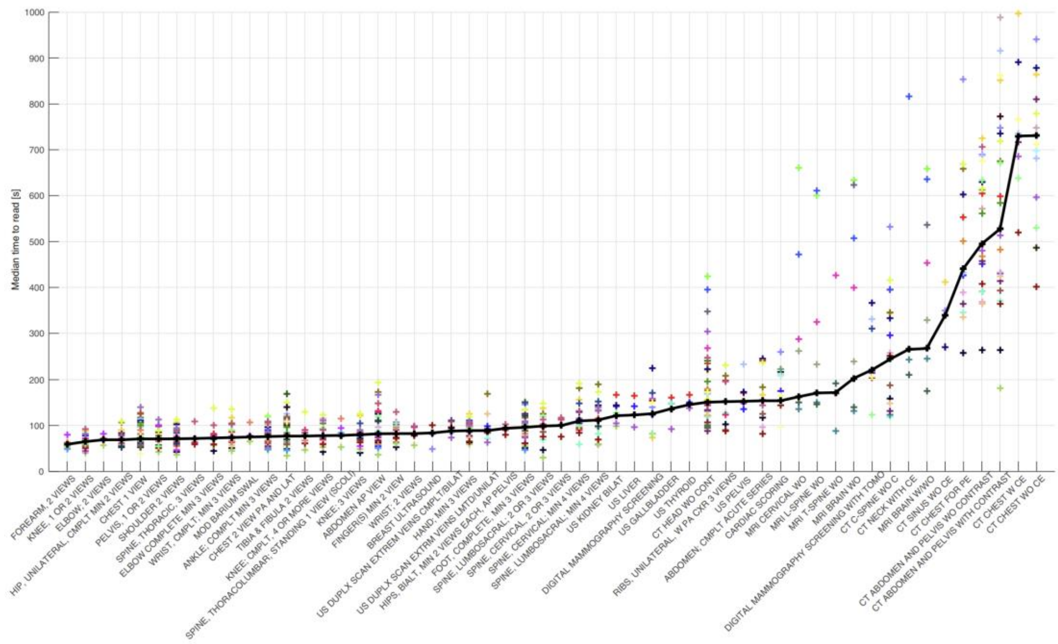
A study measuring the reporting time in the US demonstrated differences in the reporting time related to different examinations, but also to different radiologists [22] (Figures 3 and 4).

**Figure 3 – Relative rankings for time to read per procedure type and radiologist for radiologists considered to be consistent in their relative rankings.**




Dotted lines correspond to general radiologists and dashed to subspecialised

**Figure 4 – Median time to read per procedure type and radiologist, sorted according to overall median time to read per procedure type**




The thicker black line corresponds to the overall median time to read for all radiologists per procedure type.

In the same study, median reading times for some selected basic examinations were also obtained. For example, the median reading time for MR of the lumbar spine was 250 seconds, and for an MR of the brain without contrast material

301 seconds. However, based on the assumptions detailed above, it would be an incorrect simplification to expect radiologists to read 96 MR scans of the brain during an 8-hour working day (12 reports per hour). Just as the room time of a patient exceeds the actual scan time, the reading/reporting time is just one dimension of a radiologist's duty. Responsibilities regarding interaction with patients and referring physicians as well as with technicians about the study indication, optimised scan protocol and possible adaptation of the examination protocol according to possible unexpected findings also have to be taken into account.

<u>The scan time of each patient ≠ room time at MR unit</u>

Patient instruction, safety measures, patient positioning and initiating scanning, needs additional time. Consequently, the number of patients to be scanned per hour has not increased as much as expected as a result of faster acquisition time.

The above cited study from Japan estimated that every radiologist is able to read about 25 MR cases per working day.

**One hour MR ($HR_{MR}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour room time of the MR unit.**

### Proposed calculation (MR)

Based on the assumption above, the staffing recommendations are clear:

**One hour MR ($HR_{MR}$) requires 1.5 working hours of a board-certified radiologist who is capable and licensed to work independently.**

If an MR service is running 5 days a week with 12 hours' patient room time a day, the total need would be to cover 3,000 hours per year. Doctors working 40 hours per week, for 40 weeks a year (following the assumption of The Gishen Ready reckoner to reserve 12 weeks for leave, study leave, illness, meetings, machine breakdown or non-function [22]) are working 1,600 hours per year. Based on the estimation above, an equivalent of 4,500 hours should be covered.

Following this calculation, for an MR service being busy 5 days a week for 12 hours, 3 radiologists being able to work independently and unsupervised are required.

In the teaching setting, this demand on staff needed has to be modified based on the need for continuous teaching and instruction.

**One hour MR ($HR_{MR}$) in the teaching situation requires 1.5 working hours of a Resident plus 1 hour of a board-certified radiologist who is capable and licensed to work independently.**

These estimations and assumptions are dedicated to routine in-hour service. For on-call and/or out-of-hour services different calculations are needed.

## Computed Tomography (CT)

### Explanation of the procedures

Under this term / category all diagnostic examinations and procedures performed using CT are summarised. Cardiac CT (CCTA), CT angiography (CTA), CT of the brain (CCT) and body, and much more are included.

CT examinations frequently involve careful decisions regarding the need to inject iodinated contrast material or not. The fear of nephrotoxic injuries caused by iodinated contrast materials (contrast induced nephropathy, CIN) has decreased in recent years. Together with reduced iodine volumes needed for diagnostic purposes with modern CT scanners, there is a clear tendency towards broad use of contrast material in modern CT. Consequently, the contrast administration protocol and imaging phases obtained before, during and after contrast administration have to be selected for CT examinations. Additionally, image reconstruction plays a substantial role in modern CT scanning, given the huge amount of image data acquired with very high spatial resolution. CT reporting without image post-processing is not appropriate nowadays. Whereas the pure image acquisition in CT takes only a few seconds, the entire examination including patient preparation, contrast administration, and post-processing takes much longer. Furthermore, the difference in image acquisition time between a single body-part CT scan (for example CT of the brain) and a body CT (chest, abdomen & pelvis for oncologic staging purposes, for example) is negligible (almost always below one minute, other than in multiphase scanning involving deliberately delayed phases), but the difference in the post-processing and reporting time is much greater. Consequently, the acquisition/scan time cannot be used as a meaningful marker for workforce calculation in CT. In fact, the more advanced the scanner technology is, the shorter the acquisition time might be; but simultaneously, the higher the amount of data obtained will be, increasing post-processing and interpretation time.

### Approach to staffing need calculation

In recent years, significant improvements in scanner technology have led to new, previously impossible, applications (e.g. CT brain perfusion, CT organ perfusion, Cardiac CT, CT colonography, CT angiography etc.) and improved diagnostic accuracy. Simultaneously, the radiation dose exposure for most CT examinations has been reduced significantly. These technical innovations have led to new indications and consequently to increased requests for CT examinations.

As a result of the factors explained in the preceding paragraph, the reduction of scan/acquisition time has not led to a substantial increase in patient throughput. The number of examinations / patients per working day / working hours is more or less constant, whereas the extent of the imaging field of view and the number of images to be viewed have increased tremendously. As one example, a CT planning for a TAVI (transarterial aortic valve repair / implantation) needs a scanning time of less than one minute, but includes a CT angiography of the entire body from supraaortic arteries down to the groin; given the fact that such a TAVI procedure is usually performed in the elderly, such whole body CT angiography commonly reveals a significant number of extravascular unexpected findings and requires much longer reporting time as compared to acquisition time.

In the study cited in the MR section above, the median reading time for CT of the brain without contrast was about 150 seconds, and for a CT of the chest with contrast material was 730 seconds However, based on the assumptions detailed above, it would be an erroneous simplification to expect radiologists to read 192 CTs of the brain during an 8-hour working day (24 reports per hour), or 40 CTs of the chest during an 8-hour working day (5 reports per hour). Just as the room time of a patient exceeds the real scan time, the reading/reporting time is just one dimension of a radiologist’s duty. Responsibilities include interaction with patients and referring physicians, as well as with technicians about study indication, optimised scan protocol and possible adaptation of examination protocol according to possible unexpected findings; all these have to be taken into account.

<u>The scan time of each patient ≠ room time at CT unit</u>

Patient instruction, safety measures, patient positioning, IV access, and initiating scanning need additional time, as does whatever post-processing is needed. Consequently, the number of patients scanned per hour was not increased as much as expected based on the decreased acquisition time. All these factors contribute to the room time in a CT unit and to the basic workload unit described below:

**One hour CT ($HR_{CT}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour room time of the CT unit.**

### Proposed calculation (CT)

Based on the assumption above, the staffing recommendations are clear:

> **One hour CT ($HR_{CT}$) requires 1.5 working hours of a board-certified radiologist who is capable and licensed to work independently.**

If a CT service is running 5 days a week with 12 hours patient room time a day, the total need would be to cover 3,000 hours per year. Doctors working 40 hours per week, for 40 weeks a year (following the assumption of The Gishen Ready reckoner [22] to reserve 12 weeks for leave, study leave, illness, meetings, machine breakdown or non-function) are working 1,600 hours per year. Based on the estimation above, an equivalent of 4,500 hours should be covered.

Following this calculation, for a CT service being busy 5 days a week for 12 hours, 3 radiologists being able to work independently and unsupervised are required.

In the teaching setting, this calculation of staff needed has to be modified based on the need for continuous teaching and instruction.

> **One hour CT ($HR_{CT}$) in the teaching situation requires 1.5 working hours of a Resident plus 1 hour of a board-certified radiologist who is capable and licensed to work independently.**

These estimations and assumptions are dedicated to routine in-hour service. For on-call and/or out-of-hour services different calculations are needed.

## Interventional Computed Tomography (I-CT)

### Explanation of the procedures

Under this term/category all diagnostic and therapeutic procedures performed using CT as image guidance are summarised. Based on the recent introduction of hybrid machines combining CT scanners with incorporated Digital fluoroscopy-X-arms the relevance of CT guided interventional procedures (herewith addressed as I-CTs) will increase.

These examinations include CT guided diagnostic biopsies, drainages, CT guided ablations of benign and malignant tumours (using microwave, radiofrequency, irreversible electroporation, cryoablation) as well as pain management (CT guided infiltration and nerve blockade) as well as a large spectrum of procedures on the spine and musculoskeletal system.

Given the basic similarity of the procedures regarding the workforce requirement as compared to interventional procedures using DSA guidance, the basic calculations are similar.

The room time of each patient ≠ the procedure time

Before each procedure can be started, the patient has to be prepared and the devices to be used have to be selected and prepared. During these preparations, the treating physician (interventional radiologist) does not have to be present in the room.

The fact that the interchange time between two patients differs between different institutions depending on the process organisation and the complexity of cases performed could influence the calculation of staff needed. However, during this interchange time the interventional radiologist has to write the report of the previous procedure and prepare for the next one. Additionally, the interventional radiologist has to communicate with the other staff members about the planned upcoming procedure and the material (= devices) needed. In smaller institutions without a full-time interventional service, the interventionalist might be involved in other work aside interventional procedures (for example reporting CT cases), whereas the running hours of an IR service itself cannot be used as a basis for workforce calculation.

Above-described work-up and preparation time depends of course again on the complexity of the respective procedures. However, based on the assumption of a certain mix of complexity an estimation is performed as detailed below:

The basic unit as described above refers to the room time of the patients.

**One hour I-CT ($HR_{I-CT}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour room time of the patients.**

## Proposed calculation (I-CT)

Based on the assumption above, the staffing recommendations are as follows:

**One hour I-CT ($HR_{I-CT}$) requires 1.5 working hours of a board-certified interventional radiologist who is capable and licensed to work independently.**

If an I-CT service is running 5 days a week with 4 hours' patient room time a day, the total need would be to cover 1,000 hours per year. Doctors working 40 hours per week, for 40 weeks a year (following the assumption of The Gishen Ready reckoner to reserve 12 weeks for leave, study leave, illness, meetings, machine breakdown or non-function [22]) are working 1,600 hours per year. Based on the estimation above, 1,500 hours should be covered.

Following this calculation, for an I-CT service being busy 5 days a week for 4 hours, 1 IR specialist being able to work independently and unsupervised is required.

In the teaching setting, this demand on staff needed has to be doubled based on the need for continuous presence of a medical doctor being capable and licensed to work independently to oversee all steps performed by the resident/fellow.

> **One hour I-CT ($HR_{I-CT}$) in the teaching situation requires 1.5 working hours of a board-certified interventional radiologist who is capable and licensed to work independently PLUS 1.5 working hours of a resident / fellow.**

These estimations and assumptions are dedicated to routine in-hour service. For on-call and/or out-of-hour services different calculations are needed.

## Positron emission tomography (PET) (Hybrid Imaging)

### Explanation of the procedures

Under this term / category all diagnostic hybrid examinations and procedures performed using PET are summarised, including **PET/CT** and **PET/MRI**.

All PET examinations involve as a first step the choice of radiopharmaceutical (i.e. the radiotracer), which consists of a biologically active molecule that determines the biodistribution of the tracer, and the attached positron emitting radionuclide. Since decades, the most commonly used radiotracer has been 18F-FDG (fluorodeoxyglucose) for visualization of tissue glucose metabolism, which is most commonly used for imaging of cancers and their response to treatment. 18F-FDG can either be obtained from commercial sources (i.e. specialised vendors) for out-of-the-box use, or, if a cyclotron for radionuclide production is available, radiolabeling of FDG can be performed in-house.

The radiotracer is injected intravenously in liquid form as a bolus, followed by a saline flush. The post-injection delay, which is the time between the tracer injection and the actual PET imaging, depends on the biodistribution of the radiotracer (i.e., the time required for the tracer to reach and accumulate in its target tissue), which in turn is linked to the choice of radionuclide in terms of half-

life. With 18F-FDG, the standard post-injection delay is 60 min, a time during which the patient must lie still to prevent increased (physiologic) uptake in the musculature.

After the post-injection delay, PET/CT is performed with sequential PET and CT image acquisition, or, in the case of PET/MRI, simultaneous PET and MRI acquisition. Since PET/MRI is, however, still relatively rare outside of academic centres, this paper will not further explore its application and protocols. Total in-room time is approximately 30 min with standard PET/CT scanners, based on 3-6 bed positions with an image acquisition time of approximately 3 min per bed position for PET, depending on the scanner model and also the scan range. For oncologic imaging, which is the most common indication for PET, scans either cover the anatomy from (1) skull base to the mid-thigh, (2) vertex to mid-thigh, in cancers with a higher likelihood of brain metastases, or (3) vertex-to-toes. Total body PET systems, which enable imaging of the entire (or at least a very large) field of view in one acquisition without the need for different bed positions, have recently become available. While these scanners can markedly shorten the overall PET acquisition time and in-room time (to about 15 min) the number of current installations is still quite low, and therefore, these scanners cannot be regarded as clinical standard.

Whether intravenous contrast is used for the CT component of PET/CT (in which case procedures are comparable to those described in the CT section) and whether the CT scan is performed with a low-dose protocol for a basic anatomic correlation and PET attenuation correction, or a full dose protocol (comparable to standard diagnostic CT), is highly dependent on the institutional regulations as well as the respective country’s health legislation.

### Approach to staffing need calculation

Despite improvements and innovations in PET scanner technology that have led to improved spatial resolution and higher detector sensitivity (which can in turn be used to decrease the injected radiotracer dose, and therefore radiation exposure), major factors such as post-injection delay have remained unaffected by these technical developments.

Based on the above, approximately 16 patients could be scanned on a standard-of-care PET/CT device on an 8-hour day, assuming no no-shows or late cancellations, for example due to elevated blood glucose levels that preclude from PET scanning. While no data on average reading times exist for PET, reading times can be expected to be approximately 30 min, given that (1) PET scans are practically always whole-body (or even total body, head-to-toe) scans; the vast majority are oncologic cases, frequently of a high complexity level, and (3) both uptake measurements on PET (standardised uptake values, SUV) and lesion size measurements on the CT component need to be included in the report. In addition, as for CT, the reporting time is just one part of a radiologist’s duty; others include: establishing intravenous access, radiotracer injection, and interaction with patients and referring physicians, as well as with technicians about study indication, the scan protocol (anatomic range, contrast, and full/low-dose CT).

Analogous to CT, PET scan time of each patient ≠ room time at PET unit

Patient instruction, safety measures, patient positioning, IV access (if contrast is administered; otherwise can be removed post radiotracer injection), and initiating scanning need additional time, as does whatever post-processing is needed. These factors contribute to the room time in a CT unit and to the basic workload unit described below:

**One hour PET as the basic unit to be used as the basis for staffing guidelines refers to one hour room time of the PET unit.**

## Proposed calculation (PET)

Based on the assumption above, the staffing recommendations are clear:

**One hour PET requires 1.5 working hours of a board-certified PET trained radiologist / CT trained Nuclear Medicine Physician who is capable and licensed to work independently.**

If a PET service is running 5 days a week with 12 hours patient room time a day, the total need would be to cover 3,000 hours per year. Doctors working 40 hours per week, for 40 weeks a year (following the assumption of The Gishen Ready reckoner [22] to reserve 12 weeks for leave, study leave, illness, meetings, machine breakdown or non-function) are working 1,600 hours per year. Based on the estimation above, an equivalent of 4,500 hours should be covered.

Based on this calculation, for a PET service being busy 5 days a week for 12 hours, 3 radiologists being able to work independently and unsupervised are required.

In the teaching setting, this calculation of staff needed has to be modified based on the need for continuous teaching and instruction.

**One hour PET in the teaching situation requires 1.5 working hours of a Resident plus 1 hour of a board-certified PET trained radiologist / CT trained Nuclear Medicine Physician who is capable and licensed to work independently.**

These estimations and assumptions are dedicated to routine in-hour service. For on-call and/or out-of-hour services different calculations are needed.

# Plain X-Ray (XR)

## Explanation of the procedures

Under this term all conventional X-Ray examinations are summarised. These examinations are typically performed independently of direct supervision by the radiologist in charge. These examinations are highly standardised and usually do not require direct pre-acquisition interaction with the radiologists. Due to advances in other modalities, some of these X-Ray examinations have diminished in clinical relevance and frequency (for example plain radiograph of the abdomen in case of acute abdominal pain or in case of suspicion of urinary stones, plain radiograph of the skull, etc.), but in other fields plain X-Ray plays a role of unchanged importance (for example chest X-Ray, plain X-Ray in extremity trauma, etc.).

The reporting of these examinations is independent from the image acquisition, and interruptions due to acute requests or questions about indication and imaging technique are significantly less frequent when compared to other modalities (CT, MR).

The basic unit as described above refers to the running time of the respective X-Ray unit.

> **One hour XR ($HR_{XR}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour running time of the respective X-Ray unit.**

## Proposed calculation (XR)

Based on the assumption above, the staffing recommendations are as follows:

> **One hour XR ($HR_{XR}$) requires 0.5 working hours of a board-certified radiologist who is capable and licensed to work independently.**

If an XR service is running 5 days a week with 8 hours patient room time a day, the total need would be to cover 2,000 hours per year. Doctors working 40 hours per week, for 40 weeks a year (following the assumption of The Gishen Ready reckoner to reserve 12 weeks for leave, study leave, illness, meetings, machine breakdown or non-function [22]) are working 1,600 hours per year. Based on the estimation above, 1,000 hours should be covered.

Following this calculation, for an XR service operating 5 days a week for 8 hours, less than 1 full-time equivalent radiologists being able to work independently and self-responsible are required.

In the teaching setting, this demand on staff needs to be increased to allow a board-certified radiologist to oversee the reports performed by the resident/fellow.

**One hour XR ($HR_{XR}$) in the teaching situation requires 0.5 working hours of a board-certified radiologist who is capable and endorsed to work independently PLUS 0.5 working hour of a resident / fellow.**

These estimations and assumptions are dedicated to routine in-hour service. For on-call and/or out-of-hour services different calculations are needed.

### Fluoroscopy (Fluoro)

#### Explanation of the procedures

Under this term (Fluoro) all non-interventional examinations performed under fluoroscopy are summarised. The most relevant difference in comparison to interventional procedures (IR, see above) is the fact that no percutaneous access is required. This group of examinations (Fluoro) are most-commonly used to assess intestinal and/or urogenital structures after filling cavities (stomach, colon, bladder, ureters, and more) with contrast agents. These techniques allow for dynamic assessment of both morphology and function.

Although losing clinical relevance in some fields (for example the double contrast barium enema is performed in very few selected cases nowadays), in other applications fluoroscopic techniques are still of relevance (for example videofluoroscopy of swallowing).

The specific characteristic of these examinations can be described by their dynamic character; the assessment and consequently diagnosis is usually made “on the fly”, during the fluoroscopic examination. Thus, the continuous presence of the person in charge is required during the entire examination.

<u>The room time of each patient ≠ the examination time</u>

Before each examination can be started, the patient has to be prepared. During these preparations, the radiologist would commonly write the report of the previous examination and prepare for the next one.

The basic unit as described above refers to the room time of the patients.

**One hour Fluoro ($HR_{Flouro}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour time of patient service.**

### Proposed calculation (Fluoro)

Based on the assumption above, the staffing recommendations are as follows:

> **One hour Fluoro ($HR_{Fluoro}$) requires 1.0 working hour of a board-certified radiologist who is capable and licensed to work independently.**

The reporting of these examinations takes place during subsequent examinations (and is included in the calculation).

If a Fluoro service is running 5 days a week with 4 hours patient room time a day, the total need would be to cover 1,000 hours per year. Doctors working 40 hours per week, for 40 weeks a year (following the assumption of The Gishen Ready reckoner to reserve 12 weeks for leave, study leave, illness, meetings, machine breakdown or non-function [22]) are working 1,600 hours per year. Based on the estimation above, 1,000 hours should be covered.

Following this calculation, for a Fluoro service running 5 days a week for 4 hours, 0.625 radiologists being able to work independently and unsupervised are required.

In the teaching setting, this demand on staff needed has to be increased to allow a board-certified radiologist to oversee the procedures and reports performed by the resident/fellow.

> **One hour Fluoro ($HR_{Fluoro}$) in the teaching situation requires 1.0 working hours of a board-certified radiologist who is capable and endorsed to work independently PLUS 1 working hour of a resident / fellow.**

These estimations and assumptions are dedicated to routine in-hour service. For on-call and/or out-of-hour services different calculations are needed.

## Sonography / Ultrasound / Duplex/Doppler-Ultrasound (Sono)

### Explanation of the procedures

Under this term (Sono) all examinations using US technology are summarised, independently of the actual examination mode (B-mode, 3-D US, Duplex/doppler US, elastography, contrast-enhanced US). The specific characteristic of these examinations can be described by their dynamic character; the assessment and consequently the diagnosis is usually made “on the fly”, during the US examination. The continuous presence of the person in charge is required during the entire examination. In some countries/centres, selected US examinations are performed under standardised conditions by specially trained staff (Technicians, Radiographers, Sonographers) including vascular (duplex/doppler) US, US of the thyroid, etc. However, many examination types are performed by radiologists only, and in many countries, there are no sonographers. Consequently, US is still (and will remain) one of the central basic modalities in radiology and remains a central duty in most radiologist's clinical routine.

The following estimation is based on the assumption that the US is performed by radiologists and should be adapted according to local circumstances and situation. Even if the scanning for some studies is performed by sonographers, the images must be directly viewed, and the reports must be produced by radiologists.

The room time of each patient ≠ the examination time

Before each examination can be started, the patient has to be prepared. During these preparations, the radiologist may write the report of the previous examination and prepare for the next one.

The basic unit as described above refers to the room time of the patients.

**One hour Sono ($HR_{Sono}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour time of patient service.**

### Proposed calculation (Sono)

Based on the assumption above, the staffing recommendations are as follows:

**One hour Sono ($HR_{Sono}$) requires 1.0 working hour of a board-certified radiologist who is capable and licensed to work independently.**

The reporting of these examinations takes place during subsequent examinations (and is included in the calculation).

If a Sono service is running 5 days a week with 8 hours' patient room time a day, the total need would be to cover 2,000 hours per year. Doctors working 40 hours per week, for 40 weeks a year (following the assumption of The Gishen Ready reckoner to reserve 12 weeks for leave, study leave, illness, meetings, machine breakdown or non-function [22]) are working 1,600 hours per year. Based on the estimation above, 2,000 hours should be covered.

Following this calculation, for a Sono service being busy 5 days a week for 8 hours, 1.25 radiologists being able to work independently and self-responsible are required.

In the teaching setting, this demand on staff needs to be increased to allow a board-certified radiologist to oversee the reports performed by the resident/fellow.

> **One hour Sono ($HR_{Sono}$) in the teaching situation requires 0.5 working hours of a board-certified radiologist who is capable and licensed to work independently PLUS 1 working hour of a resident / fellow.**

These estimations assumptions are dedicated to routine in-hour service. For on-call and/or out-of-hour services different calculations are needed.

## Multidisciplinary Team Meeting (MDT)

### Explanation of the procedures

Multidisciplinary teams (MDT) are created in clinical medicine to bring together a group of healthcare professionals from different specialties in order to agree diagnoses and determine patients' treatment plans. One important function of such MDTs is to meet regularly to have an interdisciplinary discussion in order to optimise patient-centred medical care. Initiated in oncologic medicine, MDTs have also become established in many fields of clinical medicine, e.g. cardiology, vascular surgery/medicine, epilepsy care, inflammatory bowel disease, paediatrics etc.

As a consequence of the continuous increase in the technical capabilities and diagnostic accuracy of modern imaging, radiology is a central part of most such MDTs, and many MDT meetings take place in radiology departments with the active participation of (and frequently chairing by) radiologists.

With increasing specialisation in modern clinical medicine, the number of MDTs is continuously increasing, and the request for regular MDT meetings represents a disruptive change in the daily routine in clinical Radiological departments. The most time-consuming activity is the preparation of such MDT meetings. Given the fact that decisions of the highest importance for future patient care are made in such meetings, careful preparation and assessment of ALL available imaging data are required and expected from the participating radiologist. When calculating / estimating the workforce needed to cover such MDT meetings, the preparation time should be included, and a 2:1 approach (2 hours preparation for each 1 hour of MDT activity) is realistic.

The basic unit as described above refers to the room time of the patients.

> **One hour MDT ($HR_{MDT}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour MDT-meeting time.**

### Proposed calculation (MDT)

Based on the assumption above, the staffing recommendations are as follows:

> **One hour MDT ($HR_{MDT}$) requires 3 working hours of a board-certified radiologist who is capable and licensed to work independently.**

If there are 5 MDT meetings per week of 2 hours each, this would refer to 10 hours MDT per week, and 500 hours per year. Doctors working 40 hours per week, during 40 weeks a year (following the assumption of The Gishen Ready reckoner to reserve 12 weeks for leave, study leave, illness, meetings, machine breakdown or non-function [22]) are working 1,600 hours per year. Based on the estimation above, 1,500 hours should be covered.

Following this calculation, for 5 MDT meetings of 2 hours each per week (i.e. 20 hours preparation and 10 hours MDT activity), 1 board-certified radiologist being able to work independently and unsupervised is required.

## 2.1.4 Staffing Calculator

**Table 5 – Staffing calculator**

| modality | N° rooms / machines | room hours per day | room hours per week | room hours per year | staff needed | |
|---|---|---|---|---|---|---|
| IR | | | 0 | 0 | 0,0 | |
| MR | | | 0 | 0 | 0,0 | |
| CT | | | 0 | 0 | 0,0 | |
| I-CT | | | 0 | 0 | 0,0 | |
| XR | | | 0 | 0 | 0,0 | |
| Fluoro | | | 0 | 0 | 0,0 | |
| Sono | | | 0 | 0 | 0,0 | |
| MDT | | | 0 | 0 | 0,0 | |
| | | | | | | |

The staffing calculator in the table above can be downloaded using this link[13]. These calculations are based on 50 weeks of normal operation per year, excluding holiday periods.

13 https://www.eurosafeimaging.org/eu-rest/radiology-staffing-calculator

### 2.1.5 Recommendations

- One hour IR ($HR_{IR}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour room-time of the patients.
- One hour IR ($HR_{IR}$) requires 1.5 working hours of a board-certified interventional radiologist who is capable $HR_{IR}$ licensed to work independently.
- One hour IR ($HR_{IR}$) in the teaching situation requires 1.5 working hours of a board-certified interventional radiologist who is capable and licensed to work independently PLUS 1 working hour of a resident / fellow.
- One hour MR ($HR_{MR}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour room time of the MR unit.
- One hour MR ($HR_{MR}$) requires 1.5 working hours of a board-certified radiologist who is capable and licensed to work independently.
- One hour MR ($HR_{MR}$ in the teaching situation requires 1.5 working hours of a Resident plus 1 hour of a board-certified radiologist who is capable and licensed to work independently.
- One hour CT ($HR_{CT}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour room time of the CT unit.
- One hour CT ($HR_{CT}$) requires 1.5 working hours of a board-certified radiologist who is capable and licensed to work independently.
- One hour CT ($HR_{CT}$) in the teaching situation requires 1.5 working hours of a Resident plus 1 hour of a board-certified radiologist who is capable and licensed to work independently.
- One hour I-CT ($HR_{\mathbf{I-CT}}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour room time of the patients.
- One hour I-CT ($HRI_{CT}$) requires 1.5 working hours of a board-certified interventional radiologist who is capable and licensed to work independently.
- One hour I-CT ($HR_{\mathbf{I-CT}}$) in the teaching situation requires 1.5 working hours of a board-certified interventional radiologist who is capable and licensed to work independently PLUS 1.5 working hours of a resident / fellow.
- One hour PET as the basic unit to be used as the basis for staffing guidelines refers to one hour room time of the PET unit.
- One hour PET CT ($HR_{PET}$) requires 1.5 working hours of a board-certified PET trained radiologist / CT trained Nuclear Medicine Physician who is capable and licensed to work independently.
- One hour PET CT ($HR_{PET}$) in the teaching situation requires 1.5 working hours of a Resident plus 1 hour of a board-certified PET trained radiologist / CT trained Nuclear Medicine Physician who is capable and licensed to work independently.
- One hour XR ($HR_{XR}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour running time of the respective X-Ray unit.

- One hour XR ($HR_{XR}$) requires 0.5 working hours of a board-certified radiologist who is capable and licensed to work independently.
- One hour XR ($HR_{XR}$) in the teaching situation requires 0.5 working hours of a board-certified radiologist who is capable and endorsed to work independently PLUS 0.5 working hour of a resident / fellow.
- One hour Fluoro ($HR_{Fluoro}$) as the basic unit to be used as the basis for staffing
- One hour Fluoro ($HR_{Fluoro}$) requires 1.0 working hour of a board-certified radiologist who is capable and licensed to work independently.
- One hour Fluoro ($HR_{Fluoro}$) in the teaching situation requires 1.0 working hours of a board-certified radiologist who is capable and endorsed to work independently PLUS 1 working hour of a resident / fellow.
- One hour Sono ($HR_{Sono}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour time of patient service.
- One hour Sono ($HR_{Sono}$) requires 1.0 working hour of a board-certified radiologist who is capable and licensed to work independently.
- One hour MDT ($HR_{MDT}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour MDT-meeting time.
- One hour MDT ($HR_{MDT}$) requires 3 working hours of a board-certified radiologist who is capable and licensed to work independently.

While minor adaptations to local situations might be required in certain cases, the aim is to offer a single formula that is applicable in all EU-27 countries. Referring to one hour machine time as the basic unit should facilitate adaptation to local situations by slightly changing the conversion factor between machine hours and working hours for Radiologists.
Given the enormous variety of on-duty organisation among different countries, cities, and institutions, these calculations are for regular services, not for on-duty services. However, the formula is adaptable to on-duty services.

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## 2.2 Nuclear Medicine Physicians

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### 2.2.1 Introduction

Defining workforce for nuclear medicine (NM) physicians across the EU27 is a difficult if not impossible task.

There are several reasons for this:

- Firstly, the status of NM is very diverse across Europe, depending on equipment availability, sustainable delivery of radiopharmaceuticals, quality assurance programmes, development of new technologies and treatments etc.
- Secondly, the Internal Growth Product (IGP) in the EU27 varies considerably and the proportion of it dedicated to healthcare as well. In addition, the part of healthcare provision dedicated to NM is highly variable.
- Thirdly, due to huge differences in training and education, expertise varies across countries although major efforts are made, in particular through the EANM and ESMIT (European School of Multimodality Imaging & Therapy) as well as through IAEA channels to provide countries the opportunity to access high-level training and professional efficiency.
- Fourthly, the definition of NM as a separate specialty also varies across the EU27, with specialists in some countries being either pure NM physicians, combined internists and NM physicians, nuclear radiologists or, in Scandinavia, even clinical physiologists with competence in NM.
- Finally, the issues of radiation protection, although based on the Council Directive 2013/59/Euratom (BSSD), were translated into national law in different ways, leading to differences e.g., in the way recently implemented treatments are dealt with as far as radiation protection measures are concerned.

Nevertheless, this document provides recommended guidelines to be followed and, if appropriate, endorsed by the European institutions, and provides a basis for possible more precise specification of staffing needs in the future.

### 2.2.2 Overview

NM involves the use of radioactive drugs, called radiopharmaceuticals, for the diagnosis and treatment of numerous diseases.
Diagnostic activities include:

- Standard bi-dimensional scanning, such as renal, thyroid, bone, lung, digestive tract scintigraphy.
- More elaborated gamma imaging with the use of tri-dimensional scanning (SPECT), especially for bone, myocardial or oncological imaging, often complemented by an anatomic localisation technique using additional low-dose computed tomography (SPECT-CT).
- Positron emission tomography combined with either low-dose or diagnostic computed tomography (PET or PET/CT), using various diagnostic tracers such as F18-FDG, radiolabeled PSMA or somatostatin receptor ligands, to quote some of those that are at a routine level.
- Dual X-Ray densitometry for the assessment of bone density, which will not be dealt with in this document.
- In vitro testing (radioimmunoassay for instance), now more often performed by clinical biologists, is not dealt with in this document, either.

Therapeutic activities include:

- Standard therapies of thyroid disorders, either benign, usually performed on an ambulatory basis, or malignant (i.e., thyroid cancer for ablative treatment or treatment of more advanced disease), usually on an inpatient basis in the EU.
- Other standard therapies such as palliative treatment of bone pain in metastatic patients (e.g. [$^{153}$Sm]SmEDTMP) or the bone seeking agent as a antitumoral treatment of metastatic bone lesions in metastatic prostate cancer,[$^{223}$Ra]RaCl2), treatments of arthritis using radiation synoviorthesis or treatment of blood disorders using [$^{32}$P]phosphate.
- More sophisticated treatments, albeit of limited use, such as [$^{131}$I]MIBG (Iodine-131 meta-iodobenzylguanidine), in children with advanced neuroblastoma or patients with malignant pheochromocytoma or other neuroendocrine tumours.
- The most recently introduced radioligand therapies, for neuroendocrine tumours ([$^{177}$Lu]-somatostatin analogues) or metastatic castrate resistant prostate carcinomas (mCRPC) using [$^{177}$Lu]-labelled PSMA ligands.

This is the current status, but many other activities are expected to be developed in the years to come, for either diagnosis or treatment. Some of these developments are close to enter the clinical arena and are highly demanding for those who perform them.

The complexity of the tasks will guide the need for physician workforce. Below, two opposite situations are provided as examples:

1. Thyroid scan (not linked to a thyroid consultation): This will take 5-10 minutes for the physician to check the indication with the patient, perform the palpation and write a report that will in most cases not exceed 5-10 lines. All other steps of the procedure will be handled by a nurse and/or technologist.
2. Radioligand therapy for an mCRPC (metastatic castration-resistant prostate cancer) patient using [177Lu]Lu-PSMA: This kind of therapy will be very time-consuming for the physician, starting with the participation in the multidisciplinary consultation to confirm the indication, seeing the patient to perform physical examination, check for potential contraindications, explain the strategy and practical aspects as well as radiation protection issues. Beyond this, every course of treatment will involve among other things inserting a safe intravenous line, checking the activity of the radiopharmaceutical prepared by the radiopharmacist, inject the radiopharmaceutical and additional drugs if needed, perform at least one (but usually two time-points) imaging, ideally perform dosimetry in close collaboration with the MPE who validates the results, discharge the patient according to established recommendations laid down by the radiation protection expert (RPE). This kind of treatment is a team effort, and the physician will rely on other professionals, such as radiopharmacists, MPEs, nurses/technologists, and administrative staff. Nevertheless, the total time will be at least 6 hours for the first course and 3 hours for the additional ones.

It should be kept in mind that the reimbursement (wages) of the physician for NM procedures may not be in adequation with the time and efforts spent for each of them, leading to inequalities between physicians who perform simple, rapid, procedures and those who engage in more complicated ones.

### 2.2.3 Proposed method to estimate and calculate NM physician workforce

Considering all of the above statements, three options can be envisioned for staffing in NM: EU27 based, nationwide based and department based. The first two are unrealistic because they entirely depend on the provisions made to fund the discipline. They obviously differ greatly across EU countries and even within countries when considering academic hospitals, public hospitals, and private practice.

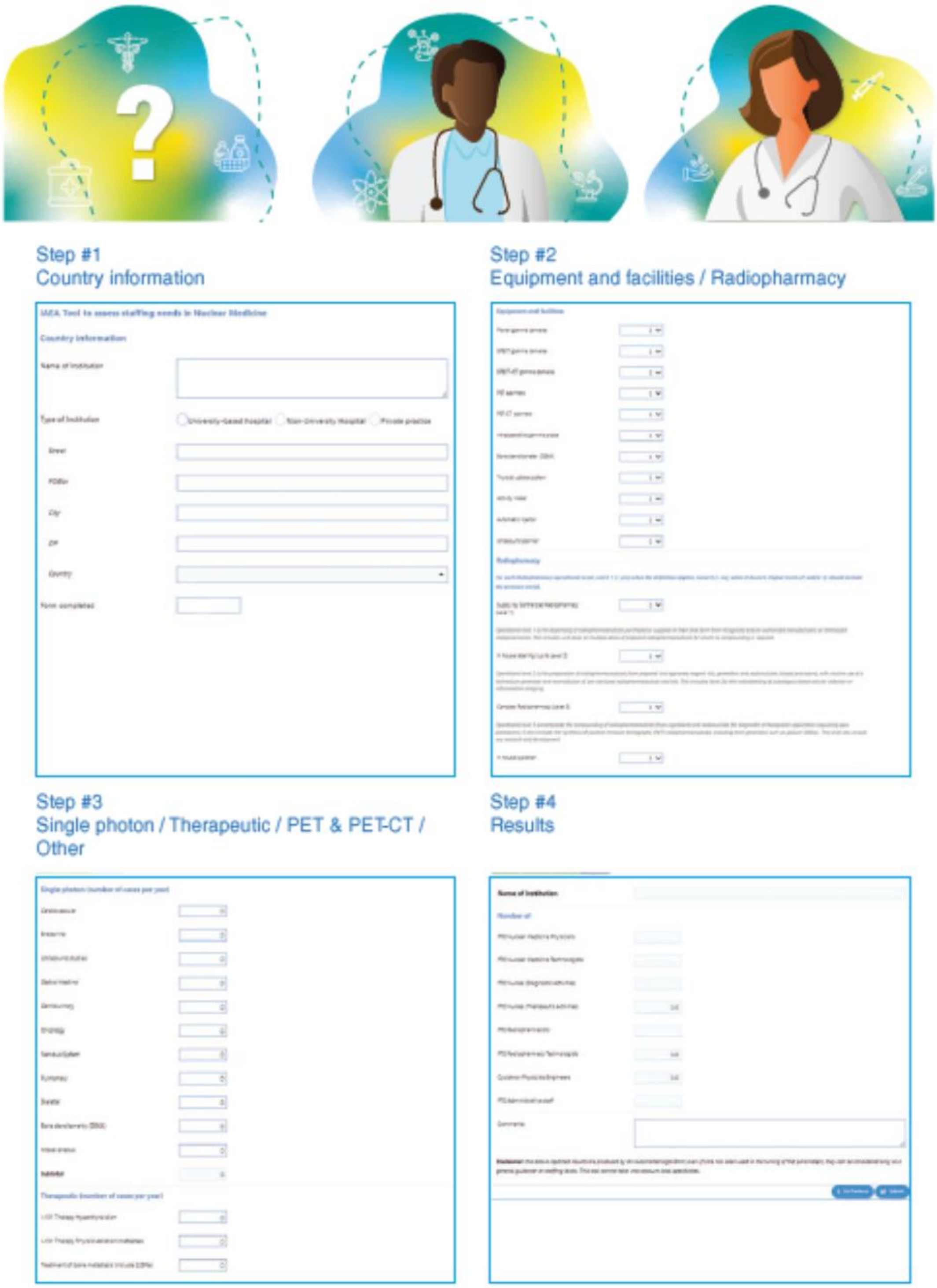
The EU27 would need better knowledge of the actual data, by enforcing a system that gives a clear picture of the situation. Data are available from IAEA, UNSCEAR, OECD and EUROSTAT. They are also summarised in this document, using data from Member States, which are, however, unfortunately incomplete, and probably not totally consistent.

The first step to define the workforce to be planned should ideally come from the European Commission in order to have sufficient knowledge of the existing workforce. This has been described in a number of countries, but usually without any perspective of what would be needed [1-8].

As far as the EU-REST study is concerned, only two countries outside the EU27 have made the effort to analyse what the needs would be in the coming years. A paper from the US showed that the access to the NM specialty was steadily declining but may be revived using reactivating training (including online) programmes [9]. The perspective is however not too bright. Another paper, initiated by the Turkish Ministry of Health, has established a real trend for the years to come, however setting the objectives for 2023 [10]. It is obvious that all countries in the EU27 should take a similar effort for the years 2025-2027.

The IAEA produced an important document entitled “A model to assess staffing needs in Nuclear Medicine” [11] that could serve as a solid basis for the purpose. In this report, they consider the needs for small, medium and large size departments and for university and non-university-based settings. They acknowledge the fact that the needs are different in these various situations. The model takes into consideration quality improvement by avoiding staff shortages and optimising staff effectiveness. Along with the written document, the IAEA also produced an online tool on their International Research Integration System (IRIS) platform [12]: This secured web-based system allows **a calculation of staffing needs depending on the activities and infrastructure of a particular department** (see Figure 5). After entering the required data, the tool automatically calculates the required staff for the various professions involved.

**Figure 5 – Steps used in the IAEA tool to assess staffing needs in nuclear medicine**




The model expresses the need for full time equivalent (FTE) staff operating a standard workload of 1,640 hours per year. This is usually considered the average working time taking into consideration annual leave, sick leave, and absences for training. It does, however, not take into account potential reductions of working hours that may exist in some countries, related to ageing or recuperation for off-business hours work.

The most relevant factor for the calculation of the needed FTEs is to weigh each clinical activity in terms of time to carry them out. A period of 15 minutes was set as an accepted standard, as suggested by the US Centers for Medicare and Medicaid Services [13]. The document describes the weights assigned for NM attending physicians, NM technologists and nurses. Here we only report the values assigned to NM physicians, keeping in mind that the workload can be considerably larger for nurses in the case of hospitalisation for complex therapies. For instance, based on a standard three-day hospitalisation time for radioligand therapy (e.g. [$^{177}$Lu]-labelled peptides for neuroendocrine tumours), the weight for the attending physician is set at 24 units whereas it is set at 152 units for the nurse. The latter figure comes from an internationally accepted determination following WHO recommendations [14].

Table 6 shows the weights assigned to the NM attending physician for typical NM activities, according to their complexity:

**Table 6 – Weights assigned to attending NM physicians**

| Type of procedure | Number of time units |
|---|---|
| **Single Photon procedures** | |
| Cardiovascular | 5 |
| Endocrine | 3 |
| Gastrointestinal | 1 |
| Genitourinary | 2 |
| Oncology | 2 |
| Neurology | 2 |
| Pulmonary | 2 |
| Skeletal | 3 |
| Consultation | 2 |
| Multidisciplinary consultations* | 4 |
| **PET, PET-CT and PET-MR**** | |
| Oncology | 6 |
| Cardiac | 6 |
| Neurology | 6 |
| **Therapy** | |
| Thyroid benign | 6 |
| Thyroid malignant | 14 |
| Bone palliation | 6 |
| Neuroendocrine tumours | 24 |
| Radiosynovectomy | 2 |
| Prostate cancer (PSMA) | 24 |
| Selective internal radiation therapy (SIRS) | 10 |

*Added to the IAEA's list [10]

** Adapted from the IAEA list [10]

It must be stressed that in the case of PET-CT or PET-MR, the involvement of duly trained radiologists is essential and has been taken into account in the calculations. Time units are average numbers: some cases may be simple and straightforward whereas others will need more physician time due to their complexity.

Note that the involvement of other medical specialists is not taken into account, e.g. anaesthesiologists, when required, or interventional radiologists for SIRS.

The clinical responsibilities of a NM physician are not limited to reporting patient procedures but include (modified from [10]):

- Interviewing patients.
- Reviewing the medical records to ensure the appropriateness and justification of a referral.
- Giving clear instructions to the staff to adequately perform procedures, keeping in mind both patient's and staff's safety.
- When necessary, tailoring protocols to the condition and needs of the patient.
- Interpreting the results of a diagnostic or therapeutic procedure, taking into account the clinical information, and providing proposal(s) for further action as far as possible.
- Providing training and education to junior medical staff and technical staff.
- Developing and reviewing Standard Operating Procedures (SoPs) on a regular basis.
- Attending multidisciplinary meetings.
- Discussing cases with referring physicians.
- Performing periodic audits of clinical activities.
- Contributing to the departmental quality management system and to internal and external audits.
- When in a managerial position, ensuring proper operation of the department and adherence to quality assurance.

A correction factor (multiplication) of 1.05 is used for university and other training hospitals, related to the time spent by the staff for clinical training taking into account that trainees themselves also contribute to clinical activity under supervision. This factor of 1.05 should be considered an average as junior residents may require more time for supervision, but senior residents are more

productive and in turn may play an important role in the supervision of juniors. For NM physicians, only the time for clinical duties is considered. In academic hospitals, some physicians may have important responsibilities outside of their clinical work, such as research, management, lectures, etc. The time dedicated to such tasks is not part of the FTE definition; depending on countries and institutions, these physicians must be considered part time with or without separate contracts with the hospital and university.
The IAEA's model has several limitations, as stated by the Agency itself, as for instance not being applicable to departments covering multiple work sites, not taking into account the details of available equipment, staffing dedicated to research or the specificity of some institutions, e.g., paediatric hospitals. Nevertheless, it has the merit to exist and may serve as a good basis for recommendations at EU level. It is recommended that the IRIS tool be confronted with actual data to evaluate its reliability in terms of resources, at local level, i.e. individual institutions, as a potential separate follow-up action of the EU-REST study.

### 2.2.4 Recommendations

The calculation of staffing needs depends on the activities and infrastructure of a particular department.

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## 2.3 Radiation Oncologists

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### 2.3.1 Introduction

Radiation oncology is a highly specialised branch of medicine, which requires a well-trained radiation oncologist as the team leader of a group of professionals using radiation to treat patients. Estimating the number of radiation oncologists required to provide a high-quality radiation oncology service has several challenges:

1. Radiation oncologists are specifically trained on treating patients with ionising radiation, either alone or in combination with other therapeutic modalities, for the treatment of patients with malignant or benign diseases. It may be practiced as an independent oncological specialty or may be integrated in the broader practice of clinical oncology. Regarding the complexity of the radiotherapy procedure, it is unlikely that other medical specialists use radiotherapy in their daily practice. In exceptional conditions some neurosurgeons treat patients using gamma-knife devices and some urologists and gynaecologists perform brachytherapy, however in most of these situations a radiation oncologist is also among the team members performing these procedures. The number of radiotherapy patients treated without an intervention of a radiation oncologist can be considered negligible. Thus, the number of patients who are treated with radiotherapy is a good indicator to estimate the staffing needs for radiation oncologists.
2. There are 1,174 radiotherapy centres of various sizes and configurations in the EU countries, and almost all radiation oncologists are employed in these centres [1]. A radiotherapy centre may be a part of a large education and training hospital employing dozens of radiation oncologists or it may be a stand-alone private radiotherapy centre with only 1-2 radiation oncologists employed. Whatever the structure of the radiotherapy centre, it is relatively easy to get staffing data of the radiation oncologists through communicating with these centres.
3. In some countries of Europe (Albania, Croatia, Denmark, Estonia, Finland, Norway, Sweden, and UK) clinical oncology is the main recognized specialty for the treatment of cancer patients, thus most of the radiotherapy is performed by clinical oncologists who also perform medical oncology applications. Clinical oncologists are licensed to deliver both

radiotherapy and chemotherapy which makes it extremely difficult to estimate the workload indicators solely for radiation oncology.

4. Part-time employment of radiation oncologists in more than one centre adds another uncertainty to staffing calculations, since it is very difficult to collect valid data from the centres and national authorities for that kind of employment.

5. Radiation oncology techniques and procedures are evolving rapidly, which usually requires extra time for the evaluation of patients, treatment planning and patient set-up. Today, in a modern radiotherapy department performing advanced techniques such as intensity modulated radiotherapy and volumetric arc therapy, an important fraction of the daily work of a typical radiation oncologist is spent in front of the treatment planning computer to perform contouring and plan evaluation. Furthermore, specialised radiotherapy techniques such as interstitial brachytherapy, intraoperative radiotherapy, total body irradiation, total skin electron beam irradiation, and paediatric radiotherapy always require extra workforce in the radiotherapy department. The treatment types and techniques used in the centre should be considered when estimating the workload in the staffing calculations.

6. The type of the radiotherapy centre is another factor impacting on the staffing of radiation oncologists. A large university department with a high load of academic work requires a larger number of radiation oncologists for teaching, training and research activities, a director for the management of the department and aides to help in administrative issues. On the other hand, in many cases a small private centre with a single linear accelerator can be easily managed by two radiation oncologists.

### 2.3.2 Current reports and guidelines for staffing levels for radiation oncologists

Several national and international organisations reported staffing levels and published guidelines for staffing of radiation oncologists. Traditionally the main indicator in estimating the number of radiation oncologists at the department or national level is the number of patients treated by a single radiation oncologist annually. This is a very simple method to use since the number of patients and radiation oncologists can easily be obtained. However, as radiation oncology evolves with the introduction of new treatment techniques such as IMRT, VMAT, SBRT and IORT, the development of new equipment such as MR-linac, radiation oncology processes become more complex, individualised, and demanding.

In the second decade of the 21$^{st}$ century a radiation oncologist spends more time for an individual patient starting from the multidisciplinary tumour board even before the arrival of the patient in the department. Initial consultation by evaluating a range of radiologic images, pathology, genetic and biochemistry reports occupy considerable time of daily practice. Although recent advances in automated contouring greatly reduced the time necessary for contouring tumour volumes and organs at risk, a typical radiation oncologist spends most of their time in front of the planning computer. Evaluation of patient set-up on the treatment couch and reviewing daily portal images are other time-consuming activities.

Most reports agree that a simple calculation of “patient numbers per radiation oncologist annually” can give only a rough estimate for the need for staffing. The radiotherapy techniques used in the department (IMRT, VMAT, SBRT, SRS, IORT, brachytherapy, TBI, TSEI, MR-linac), size and type of the institute (private/public, service hospital/training hospital), occupation pattern of the staff (full-time/part-time), non-radiotherapy activities (inpatient facility, chemotherapy administration) should be incorporated in the guidelines and calculations, which need to be updated regularly.

Below are the reports and the guidelines from European and global institutions:

### Europe

1. **ESTRO-QUARTS:** In 2005 the ESTRO-QUARTS study “Overview of national guidelines for infrastructure and staffing of radiotherapy ESTRO-QUARTS: Work package 1” was published [2]. The paper presented staffing guidelines for radiation oncologists from 18 European countries. National guidelines for the number of radiation oncologists were available in 17 countries, and in most of them the recommended number of radiation oncologists was expressed as the number of patients per radiation oncologist and varied between 1 per 150–350 patients (median and average 1 per 250 patients). In addition, the variations between university and non-university centres, and the other tasks in the field of oncology, such as administration of chemotherapy were pointed out. ESTRO-QUARTS recommended 1 oncologist per 250 patients for non-university centres where no chemotherapy is administered. In situations where other tasks (education, research, administration of chemotherapy) make up a significant part of the daily work, a lower number of patients per radiation oncologist was recommended. In addition, the increased complexity of treatments supported the use of a guideline of one radiation oncologist per 200–250 patients per year. It was stressed, however, that these are only crude guidelines and that the actual needs heavily depend on population structure, cancer incidence and treatment strategies, which differ between the various countries.
2. **ESTRO-HERO**: In 2014 another paper on guidelines for equipment and staffing “Guidelines for equipment and staffing of radiotherapy facilities in European countries: Final results of the ESTRO-HERO survey” was

published [3]. This document presented national criteria for staffing of radiation oncologists in 29 European countries. Guidelines for the number of radiation oncologists were present in 27/29 of responding countries (it was 18 in ESTRO-QUARTS, a decade earlier). Recommendations ranged from 130 to 300 patients per year which was slightly lower than that found in the QUARTS study where the range was 150–350 patients. This reduction is supposed to be due to the increase in treatment complexity and related time requirements observed in the past decade. Together with the above ESTRO-QUARTS paper, the ESTRO-HERO survey is the important and updated document for staffing in radiotherapy in Europe.

3. **EORTC:** In 2020 EORTC published “Development of staffing, workload and infrastructure in member departments of the European Organisation for Research and Treatment of Cancer (EORTC) radiation oncology group” [4], presenting the current staffing situation and the recommended guidelines for the staffing of radiation oncologists in EORTC member departments. There was a 7.4% decrease in the number of patients per radiation oncologist between the 2013 and 2019 surveys (from 242 to 225), and a pairwise analysis of staffing and workload levels on the 75 departments displayed an even greater decrease (-8.5%) from 234 to 214 ($p = 0.02$). The complexity of modern radiation therapy accounted for the changes in staffing and workload of the radiation oncology departments due to observation of a wider availability of more accurate, potentially less toxic, but time-demanding radiation therapy techniques in radiation oncology departments which are particularly dependent on highly skilled radiation oncologists and medical physicists. In 2014 the EORTC recommended 180-250 patients (maximum 300 per radiation oncologist annually) in its member centres; there was no update of these recommendations afterwards. It was concluded that growing patient numbers and the increasing complexity of radiation therapy techniques need to be counterbalanced by continuous adjustments of staffing and infrastructure in radiation oncology departments.

### Europe National

4. **UK:** The RCR published the “Clinical Oncology Workforce Census 2022” [5], where staffing in radiation oncology was analysed and projected for the future. Although the method to estimate the required number of clinical oncologists was not detailed, data presented were based on the number of clinical oncologists per 100,000 older population, which was 6.0 across the UK (3.1–10.5 depending on the regions). It was evident that there is a shortage of oncologists in the UK.

5. **Italy:** A report on the status of radiation oncology equipment, staffing and provision in the Lombardy region based on results of surveys between

2012-2016 was published in 2018 [6]. Radiation oncologists treated on average 152 patients per year (range 72-246 between centres).

6. **Hungary:** The status of radiotherapy was presented in a paper in 2015 [7]. The reference level of the number of patients treated by a radiation oncologist was 300. Hungarian radiation oncologists were treating 100-400 patients annually depending on the centre they were employed at. Only in 2 out of 12 Hungarian centres patient load per radiation oncologist was higher than 300. Workload was higher in large urban centres.

7. **France:** The SFRO published a White Book on Radiation Oncology in 2013 presenting the infrastructure and workload of radiation oncology professionals [8]. The need for a significant increase in the number of radiation oncologists due to the technological evolution of the specialty as well as for broadening the indications and the evolution of the mode of practice towards expertise in two to three body sites were stated. Geographical distribution of the centres and public/private employment were other contributing factors. However, no guidelines for human resources were presented.

8. **Spain:** The SEOR published a comprehensive report, a blue book for radiotherapy including guidelines, current situations, and projections for radiation oncologists [9]. The report stated that ESTRO-QUARTS recommendations cannot be applied to current and emerging complex radiotherapy techniques which require significantly more time for treatment planning and administration, and they do not take into consideration the application of special methods such as brachytherapy, intraoperative radiotherapy, total body irradiation or paediatric radiotherapy, either. The recommendation was to revise the ESTRO-QUARTS methods. The SEOR report presented a new calculation method including the contribution of radiation oncologists in training (1 full-time resident = 0.35 specialists), also administrative tasks and special radiotherapy techniques such as brachytherapy. Based on these estimates, SEOR recommended < 200 patients per radiation oncologist per year in general and between 150-200 for those performing special techniques. A deficit of 220 radiation oncologists in Spain was reported as a result.

### Outside of Europe

9. **IAEA:** In 2008 the IAEA published the document "Setting Up a Radiotherapy Programme", which defined personnel requirements for clinical radiation therapy [10]. The recommendations were one radiation oncologist-in-chief per programme, and one additional staff radiation oncologist for each 200-250 patients treated annually, as well as no more than 25-30 patients under treatment by a single physician at any one time. Higher numbers of predominantly palliative patients can be managed.

These guidelines are widely used in many countries and for IAEA projects as the benchmark for planning radiotherapy services. The IAEA document noted that advanced techniques will require more attention, skills, and time for radiotherapy planning. In 2015 the IAEA published the most comprehensive model to predict staffing requirements in radiation oncology departments, “Staffing in Radiotherapy: An Activity Based Approach” [11]. The quantitative algorithm of the model captures relevant activities across the entire radiation therapy workflow, related to patients, equipment, education, and non-clinical activities to predict the required staffing levels of the different radiation oncology professions. The output reflects the level of technological complexity and the services implemented. A staffing calculator in Excel is provided by the IAEA as well. However, advanced technologies including SBRT, particle therapy, robotic radiation therapy and MR-linac treatments are not included in the model and a revision is required.

10. **USA-ACR:** The ACR published the Radiation Oncology Practice Accreditation (ROPA) programme, where staffing levels were presented [12]. In all accredited facilities the mean number of patients per radiation oncologist was 221, whereas it was 189 in academic centres, main teaching hospitals and comprehensive cancer centres. The number of patients per radiation oncologist was increasing in parallel with the size of the facility (142 patients per RO in centres treating 200 or fewer patients and 277 patients per radiation oncologist in the facilities treating more than 600 patients).

11. **USA-ASTRO:** In 2019 ASTRO published the document “Safety is No Accident – a framework for quality radiation oncology care” which describes the requirements for workload, infrastructure and quality management [13]. The document states that staffing needs of each practice are unique and can vary greatly based upon the patient mix and the complexity of the services offered. Patient load, number of machines, staff absences, and satellite/affiliated practices can impact the management and staffing of full-time equivalent (FTE) employees, thus it is impossible to prescribe definitive staffing levels. The only recommendation is that the practice must have a minimum of one radiation oncologist present during treatment hours and a qualified radiation oncologist on-call 24 hours a day, seven days a week, to address patient needs and/or emergency treatments.

12. **Australia and New Zealand:** RANZCR produced and sponsored the publication of a series of documents on the staffing needs and guidelines for radiation oncologists in Australia and New Zealand (Baume report 2002, HealthConsult report 2009, The Radiation Oncology Reform Implementation Committee (RORIC) Report 2011, two RANZCR studies in 2011) and Allen Consulting Group report which ultimately resulted in “Tripartite National Strategic Plan for Radiation Oncology 2012-2022” [14].

Australia and New Zealand staffing calculations are based on 250 new patients per radiation oncologist per year. The target of the latest strategic plan is to close the gap between the current rate of radiotherapy under-utilisation (38.1%) and the target rate (52.3%) which represents the magnitude of the unmet need for radiation oncology services in Australia. The report noted an annual rise in cancer incidence, early retirement, declining interest, regional differences, and the largely unknown impact of new technology on staffing.

13. **Pakistan:** A report was published presenting national quantitative trends in radiation oncology between 2004-2009 including future projections for the number of radiation oncologists [15]. There were 439 patients per radiation oncologist in 2004, which increased to 549 patients per radiation oncologist RO in 2009. The report presented staffing projections for 2020 based on 250 patients per radiation oncologist as a benchmark.

14. **Japan:** JASTRO published the structure of radiotherapy in Japan based on institutional stratification in 2008 and compared the development of the situation with previous papers and the bluebook of radiotherapy in Japan [16]. Patient load was 247 patients annually per FTE radiation oncologist, where national/public hospitals treating >130 patients yearly had the highest patient load per radiation oncologist (343 patients/year). The report noted that in Japan, most institutions still rely on part-time radiation oncologists, and >60% of the institutions nationwide had fewer than one FTE radiation oncologist on their staff in 2005.

15. **Korea:** KOSTRO published the Status of the Infrastructure and Characteristics of Radiation Oncology in Korea in 2007 [17]. The guideline for staffing was 200 patients annually per radiation oncologist and the national figure was close to this (227) in 2004, however significant disparities existed among institutions, and radiation oncologists at the larger institutions were treating more patients. The annual patient load per radiation oncologist in the top 10 hospitals was 341, which was 58% higher than the average number (215) at other institutions.

In general, many reports presented national staffing levels and some of them also published the criteria for staffing. Many countries simply adapted the IAEA and ESTRO staffing guidelines as reference in country reports without developing their own guidelines (Table 7).

**Table 7 – International and national reports for staffing of radiation oncologists**

| Report | Guidelines | Actual situation | Future projection |
|---|---|---|---|
| **Europe** | | | |
| 1 ESTRO-QUARTS | Yes | | |
| 2 ESTRO-HERO | Yes | Yes | |

| Report | Guidelines | Actual situation | Future projection |
|---|---|---|---|
| 3 EORTC | Yes | Yes | |
| **Europe national** | | | |
| 4 RCR | | Yes | Yes |
| 5 Italy – Lombardy | | Yes | |
| 6 Hungary | Yes | Yes | |
| 7 France | | Yes | |
| 8 Spain | Yes | Yes | Yes |
| **Outside of Europe** | | | |
| 9 IAEA | Yes | | |
| 10 ACR | | Yes | |
| 11 ASTRO | Yes | | |
| 12 RANCZR | Yes | Yes | Yes |
| 13 Pakistan | Yes | Yes | Yes |
| 14 Japan | | Yes | |
| 15 Korea | Yes | Yes | |

## Table 8 – Current international and national guidelines and reported staffing levels for radiation oncologists across several countries

| | | Guideline (Pts/RO) | Actual (Pts/RO) | Contributing factors |
|---|---|---|---|---|
| ***Europe*** | | | | |
| 1 | ESTRO-QUARTS | • Recommended: 250<br>• Increasing complexity: 200-250<br>• National guidelines: 150-350 | | • University / non-university<br>• Complexity of treatment<br>• Chemotherapy administration |
| 2 | ESTRO-HERO | • National guidelines: 130-300 | • Pts/RO: 209 (100-349)<br>• RO/million pop:12.8 (2.5-30.9) | • Complexity of treatment<br>• Chemotherapy delivery<br>• GNI per capita |
| 3 | EORTC | • 1993: 300<br>• 2008: 250-300<br>• 2014: 180-250 (max 300) | • 1992: 316<br>• 2008: 258<br>• 2013: 242<br>• 2019: 225 | • Complexity of treatment |
| ***Europe National*** | | | | |
| 4 | RCR | | • Clinical oncologist per 100.000 pop. age >50<br>• National: 6<br>• Regional variations: 2.1 -10.2 | • Retirement<br>• Less than full time working<br>• Burnouts |
| 5 | Italy – Lombardy | | 152 (72-246) | |
| 6 | Hungary | 300 | 274 (100-400) | • Urban-rural difference |
| 7 | France | | 305 (+/- 93) | • Technologic evolution<br>• Broadening indications<br>• Geographical distribution<br>• Public/private employment |
| 8 | Spain | 150-200 | 241 | • Complex techniques<br>• Contribution of residents<br>• Administrative tasks |
| ***Outside of Europe*** | | | | |
| 9 | IAEA | 200-250 | | • Activity based algorithm<br>• Staffing calculator |
| 10 | ACR | | 212 (187-273) | • Academic/service institutes<br>• Number of patients |
| 11 | ASTRO | • 1 RO per department | | • Patient load,<br>• Number of machines<br>• Staff absences<br>• Satellite/affiliated practices<br>• 7/24 on-call presence |
| 12 | RANZCR | 250<br>• (535 RO required to cover RTU of 52.3%) | • Actual Total number: 499 | • Early retirement<br>• Declining interest<br>• Regional differences<br>• Rise in cancer incidence<br>• Impact of new technology |
| 13 | Pakistan | 250 | • 2004: 439<br>• 2009: 549 | • Public/private employment |
| 14 | Japan | | 247 (189-343) | • University vs other national/public hospitals<br>• Part-time employment |
| 15 | Korea | 200 | 227 (341 in large departments) | • Department size |

### 2.3.3 Recommendations

Regarding all reports above it is evident that there is no perfect and up-to-date guideline which can be applied and adapted in all settings. The most common method is the simple head count – number of patients per radiation oncologist, however staffing in radiation oncology is more than that, and any guideline to provide an appropriate number of radiation oncologists recommended as an outcome of the EU-REST study should be as simple as possible and incorporate the following elements:

- Annual number of patients treated per radiation oncologist
- Type of the department (service hospital/training institute, hospital located/standalone centre)
- Patient status and treatment intent
- Treatments used in the department (IMRT, SBRT, SRS, brachytherapy, IORT, TBI, TSEI, paediatric treatments, chemotherapy administration, etc.)
- Teaching and training activities
- Part-time employment of radiation oncologists
- Administrative tasks
- Geographical distribution

In Europe, the ESTRO-HERO survey revealed an average of 209 patients per radiation oncologist across European countries. **Based on this data we propose 200 patients per radiation oncologist (FTE) annually as the main benchmark and modifying this number according to the parameters listed above – complexity of the treatments, size of the centre, treatment modalities, chemotherapy, paediatric patients, teaching/training, geographical distribution, and administrative tasks.** The impact of these parameters and the level of change on the benchmark number of 200 patients should be calculated at national, regional and department level. We suggest considering a separate European project and a task force to estimate the impact of these parameters on staffing levels and to update staffing estimations regularly.

### 2.3.4 References

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## 2.4 Medical Physics Experts

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### 2.4.1 Introduction

Since the discovery of radioactivity and X-rays at the end of the $19^{th}$ century and their application in medicine, the need for ensuring the safe and responsible use of ionising radiations has slowly shaped the profession of medical physics. This was mainly driven by concerns on the potential health risks associated with radiation exposure to patients and medical professionals. Nowadays, medical physics experts play a critical role in the use of ionizing radiation for diagnosis and treatment. Their responsibilities encompass ensuring the safe and effective use of radiation and advanced technologies in healthcare systems. In particular, they are responsible for the radiation safety of professionals and the public whenever it can interfere with the patient diagnosis or treatment. In cancer treatment, medical physicist experts work in radiotherapy to design and optimize treatment plans and oversee the calibration and quality assurance of treatment equipment. In radiological imaging, medical physics experts contribute to the quality control and calibration of diagnostic imaging equipment, monitor radiation doses and image quality and contribute to the optimisation of diagnostic and/or interventional procedures. In nuclear medicine, they are in charge of the calibration and quality control of the diagnostic equipment and contribute to the patient dosimetry in metabolic therapy. They also help in the optimisation of diagnosis and therapeutic procedures. Medical Physics Experts (MPEs) often engage in research to develop new technologies, treatment techniques and imaging modalities. They often serve as consultants, working in multidisciplinary teams to provide expertise in radiation-related issues. It is not possible to address these tasks successfully without a deep knowledge in physics of radiation production and transport and also the complex technology used in these medical applications. This is why the European Commission, following the recommendations from the International Commission on Radiological Protection (ICRP), the International Atomic Energy Agency (IAEA)

and other scientific societies, has established the need for the MPE in the 97/43/Euratom and after in the 2013/59/Euratom directives [1,2].
The Medical Physics Expert has been defined by the 2013/59/Euratom directive as "*an individual or, if provided for in national legislation, a group of individuals, having the knowledge, training and experience to act or give advice on matters relating to radiation physics applied to medical exposure, whose competence in this respect is recognised by the competent authority*". In 2014, the European Commission also published the "Radiation protection number 174 European guidelines on medical physics expert" [3], where the roles, responsibilities, training and recognition schemes are described in detail, with the aim of helping the Member States to adapt their national regulations to include the medical physics expert to assure the safety and the quality of the medical procedures with ionising radiation. Among the key activities of MPEs described in RP174 and the 2013/59 directive are:

- Dosimetry measurements.
- Scientific problem solving.
- Patient safety/risk management including the analysis of events involving, or potentially involving, accidental or unintended medical exposures.
- Participation in the optimisation of medical procedures.
- Occupational and public radiation safety, including the surveillance of the medical radiological installations, the analysis of events involving, or potentially involving, accidental or unintended medical exposures and the selection of equipment required to perform radiation protection measurements.
- Quality management of diagnostic and therapy radiological equipment, radiation detectors, and dose calculation software (i.e., treatment planning systems for radiotherapy or dose monitoring systems for diagnostics). Participation in the preparation of technical specifications for the procurement of radiological medical equipment and installation design.
- Expert consultancy.
- Education of healthcare professionals (including medical physics trainees).
- Health technology assessment.
- Research and innovation.

Regarding radiation protection, and taking the aforementioned definition of the MPE from the 2013/59/EURATOM Directive, MPEs have the highest level of expertise in the area of radiation protection (EQF = 8), and are healthcare professionals recognised by the International Labour Office with full responsibility for the physical aspects of the patients' radiation protection. Moreover, MPE's core knowledge, skills and competences include those of the radiation protection expert, and the MPE also has the competences for the training of practitioners and other staff in relevant aspects of radiation protection. The European Commission RP 174 guidelines on medical physics expert [3] defines the "*occupational and public safety / risk management when there is an impact on medical exposure or own safety*" as one of the key activities of the MPE. The required actions that ensure the radiation protection of workers and members of the public are often strongly interconnected with those dedicated to the radiation protection of patients. For example, the radiation exposure of workers in nuclear medicine and interventional radiology is strongly related to the patient's absorbed dose. In this scenario, the responsibilities of the radiation protection expert to protect staff and the public from the harmful effects of ionising radiation may not be aligned with those of the responsibilities of the MPE to protect the patient; thus, the effectiveness of radiation protection depends on robust communication and liaison between radiation protection expert and MPE. In practice, MPEs in many European countries act also as radiation protection experts, taking full responsibility for the physical aspects of radiation protection in hospitals. Therefore, where the radiation protection expert is an MPE, the radiation protection management that includes all the actions necessary to ensure radiation protection for all, is simplified and more effective. For these reasons, all European medical physics societies, following the Malaga Declaration published in June 2023 [4], agree that "*The Medical Physics Expert (MPE) as defined in the directive 2013/59/EURATOM should be the healthcare professional to supervise and assume the responsibilities for radiation protection activities in hospital settings, including patients, working staff, members of the public and visitors. The Radiation Protection Expert in hospital settings should be an MPE, since medical physicists have the highest level of radiation physics knowledge and training*".

At the time of writing this document, there is still a lack of MPEs in many Member States, or they are partially deployed in others. From a survey published by EFOMP in 2021 [5], it was concluded that "six years after the publication of the RP174 guidelines for the MPE, these have not yet been (fully) implemented in most European countries", a situation that still persists 10 years after the publication of RP174 [3] and reflects different schemes of quality standards across Europe, which may jeopardise the optimal and safe use of ionising radiation in medical practice. The following sections provide an overview of the current status of Medical Physics Experts in Member States and present a set of recommendations to harmonise training and to guarantee workforce availability in the future years. These recommendations aim to advance in the harmonisation of quality and safety standards for the use of ionising radiation in medical practices across Europe, aligning with European directives.

### 2.4.2 Existing practice in medical physics experts workforce

The main source of information in this study is the survey performed by the EU-REST consortium [6]. For the sake of simplicity and to get as much information as possible, the stakeholders were asked to answer for any professional in their respective Member State in charge of the medical physics expert's duties, including Medical Physicists, Radiation Protection Advisors, Radiation Protection Experts and Medical Physics Experts, depending on the categorisation in each country. This variety of names and professions addressing the duties of MPEs is hardly conducive to the harmonisation of the profession and thus of safety and quality standards for the use of ionising radiation in medical applications in the European Union. In this regard, with the aim to reduce this ambiguity, in these guidelines, the term Medical Physics Expert as defined in the 2013/59/EURATOM directive [2] will be used in the discussion of the profession, avoiding the use of the term "medical physicist". From the EU-REST survey, with data from 26 out of 27 Member States, there is an average of 21 MPEs (or professions in charge of the MPE's duties) per million inhabitants in Europe. The whole picture is presented in Figure 6. However, there is an important difference in the number of MPEs per million inhabitants between Member States, with 13/M, 21/M, and 26/M as 25, 50 and 75% percentiles. The numbers show that six countries (25%) have 40% less medical physicists than the European average, with three of them having less than half of the average (Poland 10/M, Hungary 8/M and Lithuania 4/M). Five countries (Ireland, Greece, Malta, Germany, and Sweden) are 40% above the average. Another finding is the shortage of medical physics workforce in Europe and also worldwide, in some specific disciplines like diagnostic and interventional radiology or in nuclear medicine [9-14], therefore, not only the total number of MPEs available, but also their field of practice should be analysed.

**Figure 6 – No. of medical physicists / 1,000,000 inhabitants**

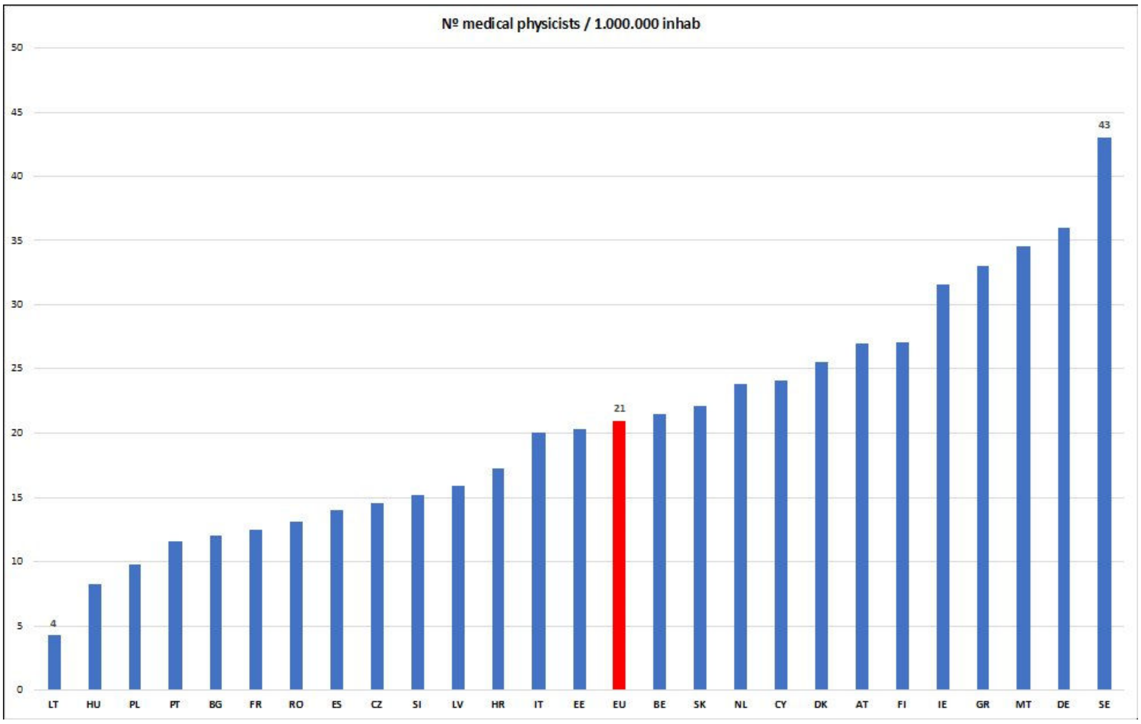
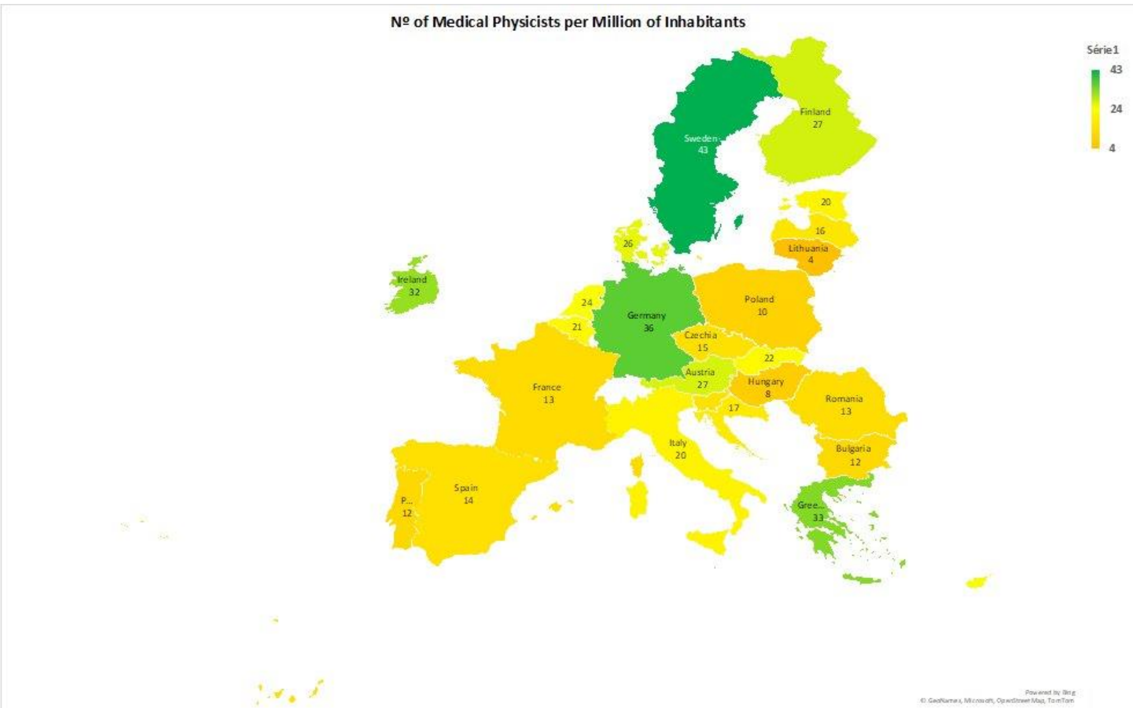



**Figure 7 – Geographical distribution of Medical Physicists**




Fifteen out of 27 Member States provided information about the age of MPEs, indicating that 7% of them will retire in the next five years. This aspect is essential for planning the workforce for the future. The following table shows the age profile obtained from the survey. There was no information about the gender profile.

**Table 9 – Age profile of MPEs in the EU**

| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| AT | 31 | 13% | 64% | 36% |
| BE | 13 | 5% | 75% | 25% |
| BG | 2 | 2% | 72% | 28% |
| HR | 1 | 1% | 89% | 11% |
| CY | | | | |
| CZ | 21 | 14% | 69% | 31% |
| DK | 8 | 5% | 80% | 20% |
| EE | 3 | 10% | 80% | 20% |
| FI | 8 | 5% | 85% | 15% |
| FR | 26 | 3% | 85% | 15% |
| DE | 300 | 10% | 75% | 25% |
| GR | | | | |
| HU | 8 | 10% | 70% | 30% |
| IE | | | | |
| IT | 168 | 14% | 62% | 38% |
| LV | 0 | 0% | 95% | 5% |
| LT | | | | |
| MT | | | | |
| NL | 42 | 10% | 65% | 35% |
| PL | | | | |
| PT | | | | |
| RO | 0 | 0% | 98% | 2% |
| SK | | | | |
| SI | | | | |
| ES | | | | |
| SE | | | | |
| **EU** | **629** | **9%** | **78%** | **22%** |

As a result of the analysis of European and international guidelines for workforce performed by the EU-REST consortium, European and international guides have been identified to estimate the minimum workforce required in a medical physics department to address an estimated workload based on:

(i) the range of applications of physics service to medicine,
(ii) the scale of organisational and management responsibilities (number of hospitals, population served),
(iii) the amount and complexity of equipment and procedures used in related clinical specialities,

(iv) the number of patients examined and treated in the relevant modalities and the complexities of these examinations or treatments,
(v) the load for formal teaching and training,
(vi) the level of participation in maintenance, development, research, and clinical trials.

The EFOMP Policy Statement 7.1 published in 2016 is an amalgamation and an update of the EFOMP Policy Statements No. 2, 4 and 7 [7]. It presents guidelines for the roles, responsibilities, and status of the medical physics expert together with recommended minimum staffing levels. These recommendations take into account the ever increasing demands for competence, patient safety, specialisation and cost effectiveness of modern healthcare services, the requirements of the European Union Council Directive 2013/59/Euratom laying down the basic safety standards for protection against the dangers arising from exposure to ionising radiation, the European Commission's Radiation Protection Report No. 174: "Guidelines on medical physics expert" [3], as well as relevant publications of the IAEA. The provided recommendations on minimum staffing levels are largely in agreement with those provided by the EC and the IAEA [8, 9]. General guidelines are given for the assessment of the whole time equivalent (WTE) of the total number of MPEs working in radiotherapy, nuclear medicine, and diagnostic & interventional radiology. The minimum number of MPEs for radiation protection of workers and members of the public are also provided. The mathematical formulation described in [8] to estimate the numbers of WTE MPEs can be summarised as:

$$Whole\ time\ equivalent\ MPE = N_{sum}\,\varepsilon = \left(\textstyle\sum_0^6 N_x\right)\varepsilon$$

where $N_1$ to $N_6$ are the estimated numbers of WTE medical physics experts required for each of the following six factors:

1. equipment dependent,
2. patient dependent,
3. radiation protection related,
4. service related,
5. training related,
6. academic teaching and research related.

A set of tables is provided in references [7, 8] to estimate these numbers ($N_x$). The factor ε compensates for the efficiency of scale for small or large clinics. Appreciable efficiencies can be achieved when a medical physics service is larger. For these reasons, an efficiency of scale could be applied for large medical physics services, and the total number of MPEs can be reduced by a factor ε calculated as follows:

$$\varepsilon = \begin{cases} 1 \;\; if \;\; N_{sum} \leq 4 \\ \frac{4+(N_{sum}-4)RF}{N_{sum}} \;\; if \;\; N_{sum} > 4 \end{cases}$$

The reduction factor (RF) ranges from 0.6 to 0.8 depending on the skill and expertise mix of medical physics staff, leading to a reduction of up to 40% in the whole time equivalent in the large and more expertise Medical Physics departments.

An example of factors to estimate the Nx of whole-time equivalents for MPEs in radiotherapy as published by EFOMP [7] and based on the European Commission RP 174 guidelines on MPEs [3] is provided below:

**Table 10 – Example of factors to estimate the no. of FTEs of MPEs in radiotherapy**

| Subjects | MPEs full time equivalent |
|---|---|
| ***Equipment dependent factors per item*** | |
| **Linear accelerator (multi-mode) (per unit)** | 0.6 |
| **Linear accelerator (single-mode)/cobalt (per unit)** | 0.2 |
| Major items | 0.2 |
| Minor items | 0.1 |
| Other items | 0.05 |
| Patient dependent factors | |
| Conventional (2D) external beam radiotherapy (per 100 procedures) | 0.05 |
| 3D conformal radiotherapy (per 100 procedures) | 0.2 |
| Special techniques (per 100 procedures) | 0.4 |
| Brachytherapy (per 100 procedures) | 0.4 |

If duties such as, for example, responsibilities regarding diagnostic and interventional radiology, nuclear medicine, occupational and public radiation protection, the training of health professionals and research activities are added, more staff should be planned using similar tables as provided by the EFOMP policy statement No. 7.1 [7] to obtain an estimation of the number of whole time equivalent MPEs required. This policy statement also provides a minimum number of MPEs for small medical physics departments. It is also recognised that a medical physics service cannot function effectively without staff fully or partially assigned to the medical physics service to help in specific tasks, such as radiation protection, dosimetry in radiotherapy or routine quality control tasks, supervised by an MPE.

It should be kept in mind that technology and medical practice are evolving continuously and therefore staff requirements will have to be adapted to new changes and times, therefore the information provided here should be taken as an example of the methodology to estimate staffing needs, and it will be necessary to consult the last updated information published by EFOMP.

### 2.4.3 Recommendations

Based on the evidence from the EU-REST study, and seeking a harmonisation of quality and safety standards across Europe, in accordance with the requirements of the 2013/59/EURATOM Directive, the study consortium makes the following recommendations for Member States and national and European scientific organisations, in order of importance:

1. The medical physics expert, with level 8 in the European qualification framework, is the qualified professional to assume the competences in radiation physics applied to medical exposures, in accordance with the 2013/59/EURATOM directive [2] and the European Commission guidelines for medical physics experts, radiation protection no. 174 [3]. Member states shall consider this profession in the assessment of the workforce.
2. The MPE as defined in the Directive 2013/59 shall be the professional to supervise and assume the responsibilities of the Radiation Protection activities in hospitals, including patients, working staff, members of the public and visitors to the hospitals. The MPE shall, where appropriate, liaise with the radiation protection expert.
3. The latest published recommendation by EFOMP (currently the policy statement 7.1) [7] in agreement with international recommendations should be adopted as the reference document for comparison on staffing levels.
4. Medical physics departments may include other professionals such as dosimetrists or medical physics assistants and engineers working under the supervision of MPEs. If this is the case, the staffing guidelines should include these resources as a factor to be taken into account in the total time needed to develop the different activities.
5. Member states should have a registry of their active MPEs, managed by the competent authority and updated at least on a yearly basis, including information on age, gender, and the main field of practice (radiotherapy, diagnostic & interventional radiology, nuclear medicine), for proper planning of future workforce needs and for the promotion of gender equality in the profession. Coordination with national scientific societies is recommended to achieve this objective.

6. A common training and registration scheme for medical physics experts should be established to facilitate their mutual recognition across Europe, in order to foster professional mobility and knowledge sharing for new technologies between Member States.
7. These algorithms to calculate the WTEs of MPEs included in the EFOMP recommendation [7] should be revised at least every five years depending on changes in technology and practice.

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## 2.5 Radiographers

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### 2.5.1 Introduction

The term Radiographer is inclusive of the three branches of the profession recognised at the European level (Medical Imaging, Radiotherapy and Nuclear Medicine).The Radiography profession (Medical Imaging, Nuclear Medicine and Radiation Therapy) has gone through significant challenges related to developments in imaging and treatment technologies, improvements in health care policies, and changes in population health needs, which have altered work practices for Radiographers and increased the demands on the Radiography workforce. The Radiography profession continues to develop in line with these changes, providing new opportunities to radiographers in extending their scope of practice through new and advanced roles which improve patient outcomes, providing more effective and less invasive procedures for patients and increasing the efficiency of delivery of radiography services [1].

The Radiography profession (Medical Imaging, Nuclear Medicine and Radiation Therapy) is essential in the delivery of up-to-date healthcare and will become even more important in the future, due to the development of new technologies such as artificial intelligence (AI), as well as shifts in population demographics and disease burden [2].

Calculating how much work is performed by a radiographer is complex. As already indicated in other professions, there are no agreed definitions for knowing the number of imaging/therapy examinations and the number of imaging/therapy equipment required per population to be able to calculate the workload for each radiographer. There are very few examples from countries of guidance on optimal number of radiographers per modality area and these few examples lacked consensus [8]. This gets even more complex with the changing roles of radiographers. Radiographers are taking on new extended and advanced roles with the aim of improving the radiography services and providing better patient-centred care.

The proposed guidelines of the EU-REST study for radiographers (Medical Imaging, Nuclear Medicine and Radiation Therapy) are based on the above considerations but can also include activities related to teaching, research, and management which are performed by radiographers and should be recognised as valid and valuable. Data collection as part of the EU-REST survey identified no harmonised method used across countries to determine radiography workforce.

This requires an adequate workforce, which can meet the requirements of today and tomorrow, based on current experience and research evidence to ensure radiation safety and quality of medical radiation applications.

### 2.5.2 Overview about various existing methods of calculating radiographer numbers

Research on methods of calculating Radiography staff numbers is scarce. After a careful analysis of published papers in the EU-REST study “Report on the Identification and Collection of Existing Guidelines” (Deliverable 6) the following outcomes are reported:

- The future workforce across medical imaging, nuclear medicine, and radiotherapy needs to cater for advanced practice to enhance services, provide career progression opportunities, and increase job satisfaction for Radiographers. In addition, one of these documents focuses on the need for adequate skills mix

- For the sources identified at a national level in Europe, all but one related to the UK. Topics touched upon include
  - workforce issues,
  - skills mix across care pathways,
  - staffing levels,
  - the workplace environment,
  - equipment availability,
  - changing roles for Radiographers,
  - workforce planning,
  - service delivery models,
  - clinical governance,
  - the impact of education and training,
  - quality management,
  - clinical audit on developing the workforce,
  - national registers for the radiographer workforce,
  - the number of current full-time equivalent (FTE) versus service needs, including per capita considerations,
  - the gender and age mix of the workforce,
  - future workforce needs including new skills and associated education and training demand,
  - the essential nature of clinical audit,
  - quality management in terms of staffing and the workforce,
  - challenging working patterns,
  - lack of flexibility in working terms and conditions,
  - lack of timely career progression,
  - financial, logistical, and political barriers to workforce,
  - service evaluation,
  - the slow development of enhanced skills mix,
  - the need for cultural change, with the attitudes and opinions of radiologists about radiographers were cited [1, 3-10].
- The views in the Netherlands discuss the increase in patient numbers presenting for radiotherapy being supported by a proportional growth in

equipment and workforce availability. Importantly, they highlight the need for expansion of existing departments rather than new ones, facilitating more rapid introduction of new technologies and sufficient subspecialisation of staff [11].

- Just one of the sources specified the need for two radiographers to be working per CT or MRI scanner with just one at a time required per general X-ray room or ultrasound room; numbers for other areas are not specified [8]. No method was specified as to how these numbers were achieved.

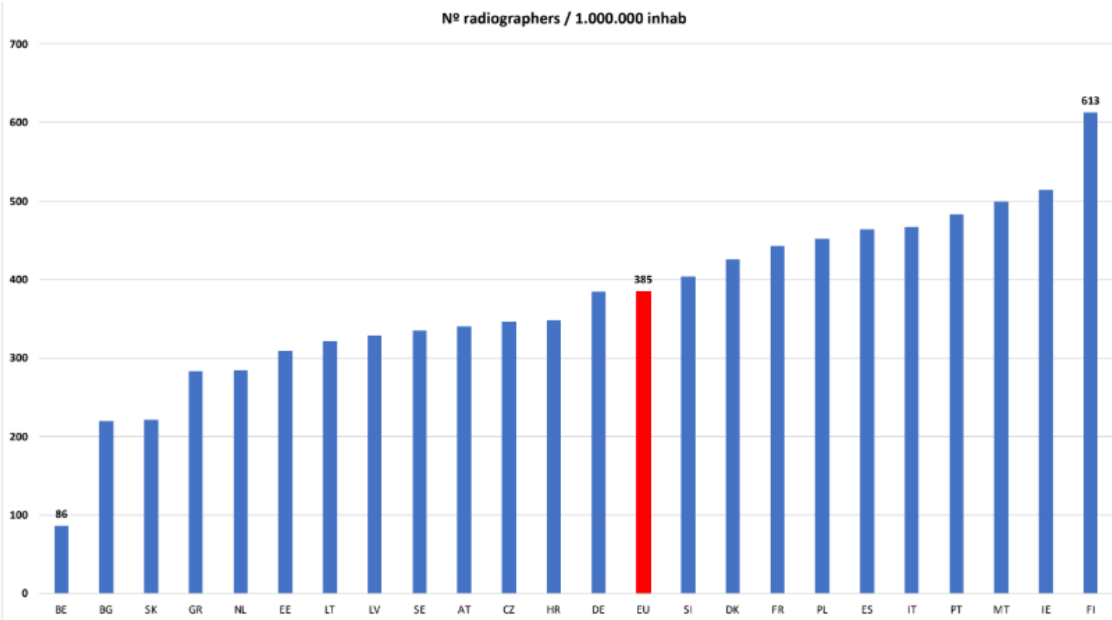
### 2.5.3 Issues related to using population to determine Radiography staffing needs

**Absolute numbers of Radiographers per population (Radiographer density)**

According to the results from the EU-REST survey, there are 171,306 radiographers in Europe licensed to work, with a ratio of 385 radiographers per 1,000,000 inhabitants. For the countries that provided the age profile (n=17), approximately 7% (10,270) of radiographers will retire in the next 5 years and 30% are over 51 years old.

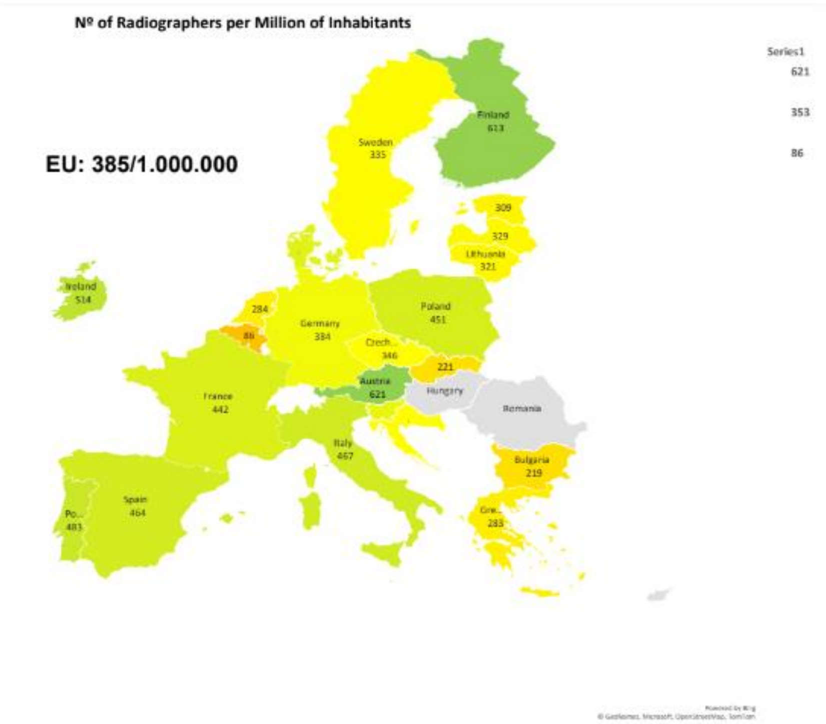
The number of radiographers varies significantly between Member States. Belgium presents the lowest number (86/M) however, this is likely due to the relatively recent recognition of the profession in Belgium where traditionally qualified nursing staff have, with some additional training, undertaken roles and responsibilities which more recently have come in line with other countries as part of the radiographers role. Thus, the data for Bulgaria (219/M) and Slovakia with 221/M would be better comparators. Finland has the highest (613/M), with the average EU value of 385/M (Figure 8).

**Figure 8 – Number of Radiographers per 1 million inhabitants**




The colour map (Figure 9) shows the geographical distribution of radiographers across Europe, evidencing the 13 countries with a density of radiographers lower than the EU average (dark orange to yellow) and the 10 above (light green), with FI (dark green) having a significantly higher number amongst all. Data from Cyprus, Hungary, Romania is missing.

**Figure 9 – Geographical distribution of Radiographers**



## Ageing of the Radiographer workforce

Regarding the radiographer's workforce availability perspectives (Table 11), there are eleven countries (CZ, DK, EE, FI, GR, IT, LV, LT, PL and SI) that will lose a higher share of the workforce to retirement in the next five years than the EU average (7%), considering the retirement age of 66 years. LT presents the highest value (35%). This might be critical for CZ, EE, GR, LV and LT as their number of radiographers per million of inhabitants is lower than the EU average.

It is important to highlight the fact that in GR and LT more than 50% of the Radiographers are over 51 years old. This situation is critical for both countries, since their number of professionals per million of inhabitants is lower than the EU average. France is an outlier, being one of the countries with lowest retirement ages.

**Table 11 – Radiographers' age profile**

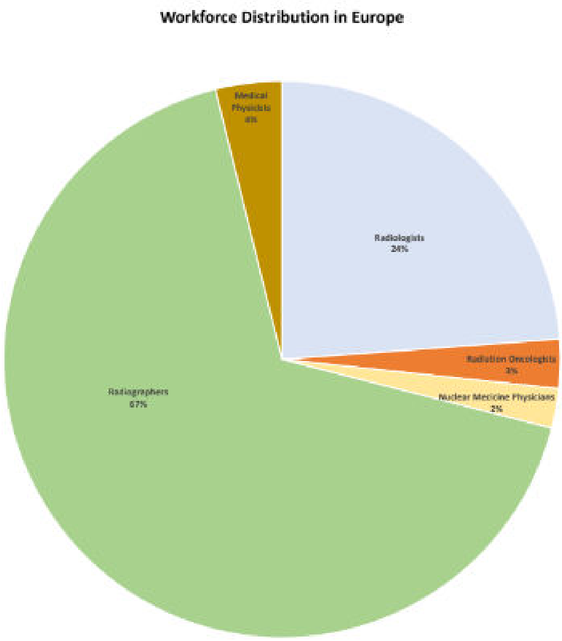
| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| AT | 446 | 8% | 72% | 28% |
| BE | | | | |
| BG | | | | |
| HR | | | | |
| CY | | | | |
| CZ | 510 | 14% | 61% | 39% |
| DK | 250 | 10% | 70% | 30% |
| EE | 62 | 15% | 71% | 29% |
| FI | 578 | 17% | 66% | 34% |
| FR | 0 | 0% | 76% | 24% |
| DE | 1600 | 5% | 80% | 20% |
| GR | 300 | 10% | 50% | 50% |
| HU | | | | |
| IE | 130 | 5% | 85% | 15% |
| IT | 2240 | 8% | 72% | 28% |
| LV | 62 | 10% | 65% | 35% |
| LT | 90 | 10% | 50% | 50% |
| MT | 8 | 3% | 90% | 10% |
| NL | | | | |
| PL | 3400 | 20% | 65% | 35% |
| PT | 250 | 5% | 85% | 15% |
| RO | | | | |
| SK | | | | |

| Country | Retirement in 5 years | % | <50 years old | >51 years old |
|---|---|---|---|---|
| SI | 170 | 20% | 60% | 40% |
| ES | | | | |
| SE | 175 | 5% | 80% | 20% |
| **EU** | **10270** | **7%** | **70%** | **30%** |

## Radiographer workforce overview in Europe

Radiographers (Medical Imaging, Nuclear Medicine and Radiation Therapy) are by far the largest group (67%), followed by Radiologists (24%), Medical Physicists (Medical Physics Experts, see 2.4.2) (4%), Radiation Oncologists (3%) and Nuclear Medicine Physicians (2%), see Figure 10.

**Figure 10 – Health professionals directly using ionising radiation and their numbers in %**




There are variations in the number of Radiographers available within countries, even in countries having a similar population. For Radiographers the difference from the lowest to the highest is by a factor of ≈2, being the professional group with the lowest variation. Still, because of these variations it is impractical to base Radiography workforce requirements on population demographics. Thus, a more accurate approach is required.

### 2.5.4 Recommendations for Workforce Planning for Radiographers

#### Proposed method to estimate and calculate the Radiographer Workforce

Having an appropriate and effective allocation of Radiographers is paramount to ensure an efficient service delivery in terms of cost, quality, and quantity [12]. It is imperative to tackle attrition due to burnout and work-related stress to retain radiographers within the workforce [13] and to ensure a safe working environment by managing and controlling potential sources of risks (radiation, musculoskeletal, psychosocial) [14-17], while providing opportunities for Radiographers to advance and expand their roles.

To address the main challenge of establishing a practical guideline for the calculation of a Radiographer workforce, a **workload-based approach is being proposed.** Workload based approaches are commonly used for micro-level planning like the WHO's Workload Indicators of Staffing Needs (WISN) method [18], where the goal of human resource management is to have:

responses to each question as most appropriate). It was divided into four sections related to

- the right number of people,
- with the right skills,
- in the right place,
- at the right time,
- with the right attitude,
- doing the right work,
- at the right cost
- with the right work output.

Conventional methods to determine staffing requirements include calculating population-to-staff ratios (for example, X number of Radiographers per 10,000 population), recommended staff-modality numbers (e.g. two Radiographers per MRI scanner), facility-based staffing standards (for example, X number of Radiographers and Y number of health professionals for a health facility) or hierarchical staffing ratios e.g. five radiographers per radiologist. These methods have serious disadvantages as they fail to consider: local variations in the demand for services; details of the varied work being undertaken by Radiographers; scope of practice; changing, extending, or advanced roles; availability of other professionals (e.g. radiologists, radiation oncologists, nuclear medicine physicians, medical physicists, and support staff); or indeed the use of solutions such as AI to support the work of Radiographers and potentially introduce efficiencies.

Health managers require a superior and efficient way to make staffing calculations, if they are to manage their valuable human resources effectively. The Workload Indicators of Staffing Need (WISN) is such a method [18]. WISN uses annual service statistics to assess workloads. The accuracy of the WISN method is thus determined by the accuracy of the statistics recorded. If a health facility keeps poor records, the WISN results will be inaccurate. The errors are almost always in the direction of under recording the workload, resulting in underestimating the staffing required by the facility. If such a method is adopted into general use, managers and Radiographers will soon realise that their staffing allocations are based on their annual service statistics. Record keeping is likely to improve, and the errors may even move in the direction of overreporting. The level of detail in the service statistics affects the precision of WISN results.

The radiographer staffing framework proposed by Bam et al. (2022) [19] comprises of a workload-based approach, (like WISN), and consists of seven steps that determine the number of full time equivalent (FTE) radiographers that are required for each modality, or group of modalities. Both clinical and non-clinical activities are considered, and guidance is provided on calculating staffing requirements to cover leave allowances. Several potential approaches to determining activity times are also discussed.

This framework provides a step-by-step guide to determine radiographer staffing requirements at the micro-level (institution / department level) based on current needs [19] and the use of such a structured approach nationally would serve to produce superior workforce planning data.

### Step 1: Establishing the staffing purpose and focus:

Establish a purpose or focus which impacts on the Radiography workforce's workload and capacity for which to plan staffing resources. Examples include: increases in demand, technological advances, and challenges in delivering a safe and efficient service. This first step facilitates agreement on the objectives of the resource planning and the specific challenges that are to be addressed [18].

### Step 2: Collect basic data:

The collection and analysis of all the variables to ensure an accurate understanding of the Radiography service (Medical Imaging, Nuclear Medicine, Radiotherapy). The previous calendar year's complete data for each workload component from each Radiography unit/facility involved is required [18]. In addition to collecting this data, it is recommended to take into account the list of basic data as defined by Isambert et al. (2015) [20]:

- the scope of activity of the department, including its organisation and management,
- the number and complexity of the equipment and procedures used,
- the number of patients cared for and the complexity of their treatments,
- the involvement in training and teaching,
- the level of participation in research and development,
- the level of training, experience, and skills of the personnel.

### Step 3: Determine available working time:

Calculating the available working time per FTE Radiographer per year as well as a leave allowance factor. Available working time is the time a health worker has available in one year to do his or her work, taking into account authorised and unauthorised absences. The available time per year is calculated using a formula proposed by the WHO (18):

$$AWT = A - (B + C + D + E)$$

- AWT is the total available working time,
- A is the number of possible working days in a year,
- B is the number of days off for public holidays in a year,
- C is the number of days off for annual leave in a year,
- D is the number of days off due to sick leave in a year,
- E is the number of days off due to other leave, such as training, etc., in a year.

The formula calculates the AWT in working days per year, which can be translated to working hours per year by multiplying the AWT in working days by the number of daily working hours.

$$AWT = [A - (B + C + D + E)] \times F$$

- F is the number of working hours in one day.

### Step 4: Develop a task or activity list:

Develop a comprehensive list of activities that constitute radiographers' workload (Table 12).

**Table 12 – Template for recording activity data, with examples**

| | | | | Time estimate (hours) | | | |
|---|---|---|---|---|---|---|---|
| Activity | Modality | Clinical (C) Non-clinical (NC) | Activity frequency (per annum) | Optimistic time (hours) | Most likely time (hours) | Pessi-mistic time (hours) | Mean time estimate for exami-nation (hours) |
| Mammogram | Mammography | C | 2542.8 | 0.359 | | | |
| Monthly mammo-graphy staff meeting | Mammography | NC | 12 | 0.750 | 1.00 | 1.500 | 1.042 |
| Chest radiography | Radiography | C | 204 | 0.159 | | | |
| Daily quality control | Radiography | NC | 2604.0 | 0.033 | 0.050 | 0.083 | 0.053 |

Table 12 represent a basic template for the comprehensive activity list, with some activities entered as examples.

The optimistic, most likely, and pessimistic time estimates are not used in the remainder of the calculations in the framework, instead these merely serve as inputs to calculate the mean time estimate.

### Step 5: Assign an activity time and frequency of occurrence to each activity:

Determining:

1. the time required to perform each activity in the comprehensive activity list,
2. the frequency of occurrence of each activity.

Particular attention should be given to determining the time required to perform each activity [21]:

- as the framework is workload-based, workload is calculated based on activity times and frequencies. The accuracy of the results depends on the accuracy of the activity times,

- various approaches to determining activity times have been defined in literature, these vary significantly in both the accuracy of the time estimates and the resources required to establish the time estimates,
- the process of establishing activity times could be rejected by staff members if not handled in a manner that is both inclusive and sensitive.

Standard work measurement is defined as “the time required by an average skilled operator, working at a normal pace, to perform a specified task using a prescribed method, allowing time for personal needs, fatigue, and delay” [22]. Allowances for personal needs, fatigue, and delay should be included in Step 6 of the framework and are not discussed in the remainder of this section. The process of determining activity times should be approached in the spirit of a “dynamic process of information generation” with feedback from the staff as well as management, to facilitate acceptance [23].

Activity frequency can be determined from historical data, most likely from the Radiology Information System (RIS), with accuracy improved by using large samples. It is important to determine whether any trend in demand is present (upward, downward, cyclical) to select the appropriate historical range accordingly.

### Step 6: Determine the (workload and) required FTEs:

A separate workload table is recommended for each modality where the workload associated with each of the activities of the modality can be calculated and totalled (Table 13) [24].

**Table 13 – Template for calculating workload per modality, calculated with an example for Mammography**

| Activity<br><br>It is important to identify and list each activity related to the modality, together with their associated frequency and mean time estimates | Clinical (C)<br><br>Non-clinical (NC) | Activity frequency (AF)<br><br>(per annum) | Mean time estimate for examination<br><br>(MTE)<br><br>(hours) | Workload (hours)<br><br>= (AF x MTE) |
|---|---|---|---|---|
| Mammogram | C | 2542.8 | 0.359 | 912.865 |
| Monthly mammography staff meeting | NC | 12 | 1.042 | 12.504 |
| **Total workload for modality (∑) (hours per annum** | | | | **925.369** |

The conversion of workload to theoretical FTEs, and of theoretical FTEs to actual FTEs, requires decisions related to determining:

- a realistic application level for staff members,
- a reasonable approach for rounding the theoretical FTE values to determine actual FTE values,
- the extent to which staff can be pooled across modalities, both when rounding theoretical FTE values to determine actual FTE values, and when determining the number of additional FTEs required to cover leave or absences.

When converting workload to FTEs, it is unrealistic to assume that staff can be utilised 100% of the time. A practical rate is recommended to be incorporated during the calculation of the required FTEs (an allowance of 20%, thus a utilisation rate (U) of 80% is a reasonably compromise for Radiographers) (19).

$$\text{Theoretical FTE} = \frac{\sum W}{A \times U} \quad \text{for each modality}$$

- U is the specified utilisation rate,
- A is the total available working time per year, in hours,
- Theoretical FTE is the theoretical number of FTEs required to execute the workload of the specific modality at the specified utilisation rate, not taking leave into account.

A formula is provided to incorporate an allowance for leave to calculate the number of FTEs required for a modality at a specified utilisation rate, inclusive of allowances to cover leave.

$$\text{FTE} = \text{Theoretical FTE} \times (1 + L)$$

- L is the leave relief factor = $\frac{H \times (D_p + D_s + D_a + D_o)}{A}$
  - $D_p$ is the average number of public holidays in a year that fall on days when the radiography practice is in operation,
  - $D_s$ is the average number of sick-leave days taken per employee per year,
  - $D_a$ is the average number of annual-leave days per employee per year,
  - $D_o$ is the average number of days off due to other leave, such as training, family responsibility leave, etc., per employee in a year,
  - H is the number of working hours in one day, excluding time allowed for breaks.

In translating the calculated number of theoretical FTEs to an actual number of FTEs, rounding up to a whole number is required [18].

In areas where radiographers cannot work alone, additional staff should be accounted for as required.

### Step 7: Analyse and interpret the results:

First the framework should be implemented to analyse:

- the difference between the current staffing levels and those calculated using the framework,
- the ratio of these numbers.

Only after the results of the framework have been subjected to analysis and interpretation, can appropriate staffing strategies be planned.

**The recommendations would be:**

- **To implement a harmonised framework for the calculation of the Radiographer workforce across EU Member States, and,**
- **To have this data published centrally by the EC, and additionally by relevant professional organisations, and widely publicised by interested parties, to facilitate a more comprehensive evaluation of the EU Radiographer workforce.**

## Workforce Availability and Planning

The creation of a nationally maintained central register for the profession (already found in some countries), with public accessibility so that people can access and verify the professional undertaking the ionising radiation procedure as having the required knowledge skills and competency to do so. Professional registration is important in identifying the professional delivering the radiography service, as in some countries there may be other professionals, who may be deemed competent by their local authority or their local services who may deliver radiography services under the supervision of a radiographer. Such a register should also include requirements for maintenance of registration. A speciality or sub-speciality register within the central register, acknowledging professionals with advanced practice in the field should also be considered. Maintenance of such a register should be under the responsibility of a national regulatory body (e.g. the Health and Care Professions Council in the UK and the Council for the Professions Complementary to Medicine in Malta). EU-level professional regulation for Radiographers, linked to knowledge, skills, and competency, may also be a future requirement.

Based on the collected data, there is a need for more recruitment in the profession and to also address retention issues. Some countries are in need more than others. Data on the number of FTEs should be gathered nationally on an annual basis and should be accessible to all stakeholders. Routine annual reporting and tracking across all settings, public and private, not just the number registered to practice should be performed. The proposed methodology for the calculation of FTEs is workload based and is more accurate than other metrics if the data is correctly reported. It is essential that such data is reviewed on an annual basis with those providing education and training programmes for Radiographers to facilitate pro-active management of new programmes, programme capacities, recruitment to programmes, and retention. There is a need to always project at least 5 years in the future as duration of training programmes for Radiographers can be up to 4 years.

All efforts should be made to provide equal opportunity for recruitment to all by encouraging gender profile mix and age profile mix. Data should be gathered nationally on an annual basis and tracking across all settings and should be accessible to all stakeholders.

**The recommendations would be:**

- **To implement comprehensive national registries for Radiographers across EU Member States, and,**
- **To implement national structures for the annual review of workforce data in collaboration with education and training providers to facilitate planning, and,**
- **To promote increased diversity in entry to the profession across EU Member States.**

## Workforce Planning: recognising additional essential roles

A detailed methodology has been presented for Radiographers which can be used to update and plan the future workforce based on known changes e.g. increasing exam numbers and estimated new developments. Such demands will require careful consideration of staffing / workforce numbers; however, it has already been recognised that over the next 10 years significant efforts must be made across all EU Member States to develop the following roles for Radiographers through: formal recognition, appropriate education and training, and appropriate recognition in workforce planning models.

Such additional / essential roles include, but are not limited to:

- **Clinical Research Radiographers:** clinical radiographers with protected time linked to research and innovation within the institution and to develop clinician-scientists within the profession. Such positions may involve joint appointments with HEIs).

- **Educators (clinically-based and HEI-based**): clinical radiographers recognised as clinical educators, with additional education and training, and with protected time linked to the education and training of students and staff. Additionally, within HEIs where the development of the academic workforce must not be neglected.
- **Leadership and Management:** the development of leadership and management capacity is essential for the profession. Significant opportunities exist for the profession service delivery, patient care, patient outcomes, and for national health systems, through further advancing radiographers in these domains.
- **Advanced Practitioners:** across the three branches of the profession, medical imaging, nuclear medicine, and radiotherapy, major opportunities exist to enhance patient care, patient outcomes, and service delivery through the appropriate development and implementation of advanced practice opportunities for radiographers which are underpinned by education, training, and evidence-based practice.
- **Quality, Quality Improvement and Risk Management Leads:** radiographers are perfectly places to take on leadership roles linked to quality and risk management in medical imaging, nuclear medicine, and radiotherapy. While this includes broad institutional roles it is also essential that radiographers hold roles including: Radiation Safety Officers, Magnetic Resonance Safety Officers, and Clinical Audit leads.

**The recommendations would be:**

- **To recognise additional and emerging essential roles for Radiographers across EU Member States, and,**
- **To implement initiatives to facilitate the development of the Radiographer workforce, to establish these roles with appropriate education, training, and governance structures.**

### 2.5.5 Recommendations

- Workload-based approach
- To implement a harmonised framework for the calculation of the Radiographer workforce across EU Member States, and,
- To have this data published centrally by the EC, and additionally by relevant professional organisations, and widely publicised by interested

parties, to facilitate a more comprehensive evaluation of the EU Radiographer workforce.

- To implement comprehensive national registries for Radiographers across EU Member States, and,
- To implement national structures for the annual review of workforce data in collaboration with education and training providers to facilitate planning, and,
- To promote increased diversity in entry to the profession across EU Member States.
- To recognise additional and emerging essential roles for Radiographers across EU Member States, and,
- To implement initiatives to facilitate the development of the Radiographer workforce, to establish these roles with appropriate education, training, and governance structures.

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## 2.6 Radiation Therapists (RTTs)

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### 2.6.1 Introduction

These guidelines have been developed based largely on the literature review completed as part of Work Package 2 (Drafting guidelines for staffing and education/training) as well as from additional resources identified through professional organisations. The EU-REST survey results from Work Package 1 (Data collection and analysis) were identified as being non-usable by the data analysts and therefore are not referred to in these guidelines.

### 2.6.2 Literature Review

**Our literature review in Work Package 2 revealed the following:**

In terms of the benchmarking method used to match workforce numbers to workload (activity and equipment availability), the ESTRO-HERO study [1] found that 20 of 27 countries indicated the number of Radiation Therapists per linear accelerator ranged from 2–6, 4 countries defined the numbers on annual patients or treatment delivered per Radiation Therapist. 14 of 25 countries based equipment levels on population and 13 of 25 national guidelines were based on the number of patients/treatment courses. In 14 countries the number of linear accelerator guidelines depend on the number of patients, treatment, or fractions with 7 being explicit.

- The EORTC [2] recommends more than 2 Radiation Therapists per treatment unit. Two Canadian papers [3,4] stated a staffing level of 1.1 FTEs per linear accelerator hours and 66 courses per Radiation Therapist FTE per year with their staffing models including time for other non-clinical duties such as administration, quality and safety and education. It is recommended to review staffing models on a regular basis to reflect changes in technology and practice. The Society and College of Radiographers in the United Kingdom recommend a figure based on staffing per linear accelerator hour for the entire service [5].
- The IAEA recommendations [6] are quite specific and based on equipment levels – Radiation Therapist supervisor: 1 per centre, Radiation Therapists: 2 per megavoltage unity up to 25 patients treated daily, 4 per megavoltage unit up to 50 patients treated daily, 2 for 500 patients simulated annually, brachytherapy as necessary. The IAEA recommends 100-150 patients per year per Radiation Therapist. The difficulty with this approach is that it fails to consider the level of complexity that is now a feature of modern radiation therapy.
    - A paper from Australia [7] based staffing numbers of an 8-hour day with a range of Radiation Therapists per linear accelerator operating between 1.3 and 1.39 with smaller centres requiring higher numbers of radiation therapists. They also included additional roles and responsibilities.
    - In terms of whether defined standards are used to determine workforce numbers, three papers addressed this topic, two from Canada [3,4] and a paper from Turkey [8] which used the IAEA staffing recommendations mentioned above. In one paper the workload was defined as the number of courses of radiation therapy delivered per year at each centre, divided by the number of FTE Radiation Therapists at that centre or courses per FTE. All FTEs were normalised to 1,950 hours per year, the most common number of hours worked by Radiation Therapists per year in the survey. Within the survey a range of staffing models was used to determine staffing levels including number of patient visits, number of linear accelerators, previous year's staffing, and availability of operating funds. Numbers were higher where more non-clinical (pre-treatment and treatment related) tasks were included. This included Radiation Therapists working in education, research, advanced practice, and support. The second paper discussed the model adopted in Ontario [4]. The recommendation made was 11 Radiation Therapists per linear

accelerator for a 10-hour working day. The model shows more specific tasks and responsibilities unlike the previous model. Details of the roles and responsibilities of staff in the five domains of practice are provided in this paper. The model includes 20% for vacation and sick leave consistent with the experience in Ontario.

- Three Radiation Therapist staffing models [9-11] described allocating staff depending on the number of linear accelerators in the department. One Australian study [9] used the Total Quality Culture (TQC) model which allowed for more autonomy for Radiation Therapists giving improved patient safety and increased Radiation Therapist work satisfaction. An Indonesian study [10] used the Markov model to estimate staffing across the hospital setting which addresses the problem of trying to provide for a growing population something that is relevant for radiotherapy in the future. Another paper [11] discussed the use of skill mix to address staff shortages.
- Full time equivalent (FTE) numbers were mentioned in two papers – one stating that most staff work full time with a range of 1.3–8.3 Radiation Therapists per linear accelerator and a second paper stating that Radiation Therapists worked 38.5 hours per week.
- With respect to gender-profile and age-profile mix one paper stated that the male: female ratio for Radiation Therapists was 10%-90% and a paper on the introduction of 12-hour shifts for Radiation Therapists showed no difference between genders and no difference for women with children, either, which might have been expected. No paper discussed an age-profile recommendation.
- No papers discussed the presence of a central registry or identified who was responsible, but this is a very specific question that would be better addressed to the stakeholders or the responsible government body.
- ith respect to workforce planning, only one paper referred to the consideration of the number of professionals involved in education/training and stated that ‘training criteria should be specified or be subject to approval, as appropriate, by the regulatory authority in consultation with the relevant professional bodies. Three papers [12-14] highlighted the need for increasing advanced practice roles for Radiation Therapists in the context of new developments relating to AI and changing practice. A paper from Turkey [7] discussing current status and future perspectives in radiation oncology facilities stated that they currently graduate 110 Radiation Therapists per year but given the increasing numbers of linear accelerators the requirement is 1,400.
- Two papers [15, 16] reported categories of tasks for different categories of employees. The first paper identified 16 categories of tasks and five categories of employees, reporting working instructions for the majority of

the routine tasks (>75%). The second [16] based on the DEGRO-QUIRO study did not state activities but calculated the number of hours per specialty spent on 'overhead' tasks. These were defined as 'real overheads' including administrative and management duties, QA, routine internal communication, compulsory events and communicating with authorities. 'Patient-related overheads' tasks related indirectly to patients such as creating and maintaining patient charts, studying findings, treatment planning, and patient guidance. 'Spurious overheads' are not really overheads but not a service provision, either. They include research, teaching, attending conferences, professional training, and CME. 'Other overheads' are tasks not included in any of the above categories and refer to items such as routine tasks or other forms of internal/external communication.

### 2.6.3 Recommended Guidelines

These guidelines are based on the findings of our literature review, together with expert opinion. Any calculation methodology used must reflect the requirements for safe and accurate practice and the evolving roles and responsibilities that RTTs will be expected to take in the future. The varied expert roles of Radiation Therapists within individual radiation therapy departments must be recognised in workforce planning, together with the dominant gender balance towards those who identify as female (90%), considerable administrative duties up to and including unit and department management, research Radiation Therapists for the incorporation of the most up to date evidence base into practice and Advanced and Consultant Practitioners. It is our recommendation that **workforce planning can no longer be simplified into recommended number of Radiation Therapists per linear accelerator or Computed Tomography unit or per patient number**, reflecting the paradigm shift in the work performed within the profession as well as the increase in treatment complexity and advanced planning techniques. This antiquated method of workforce planning also ignores specialist Radiation Therapist roles such as Radiation Therapist clinician-scientists and specialist Radiation Therapists in areas including Image Guided Radiation Therapy (IGRT) and Adaptive Radiation Therapy (ART), Quality Improvement and Risk Management, Education and Treatment Planning.

**We therefore recommend that an activity-based model be utilised**, that is flexible enough to encompass the activity of individual departments in Europe and recognises the need to include periods of leave such as maternity, paternity, and parental leave, holidays as well as sick leave. Similar to the domains of practice identified in our literature review utilised by Radiation Therapists in Ontario, Canada, we propose the following areas of practice be considered when planning the Radiation Therapist workforce:

1. **Clinical Practice:** This includes Radiation Therapists working specifically in clinical roles on treatment units, simulation suites (CT, MRI, PET), treatment planning and brachytherapy as well as those working in advanced or consultant advanced practice roles. Consideration must be given to the ongoing development of staff with new technology such as Surface Guided Radiation Therapy (SGRT) as well as opportunities for release continuing professional development/education, a statutory body requirement in many jurisdictions and required for lifelong learning.
2. **Research and Innovation:** This includes Radiation Therapists in specific research or clinician-scientist roles, as well as those advanced and consultant Radiation Therapists where research is one of their pillars of practice.
3. **Quality and Risk Management:** Radiation Therapists can be specialists in these roles, and Radiation Therapists engaged in clinical practice play a vital role in quality management and quality improvement processes within radiation oncology departments. Accurate preparation and treatment delivery is central to quality and safety in ensuring the prescribed dose is delivered to the tumour with minimum dose to the surrounding tissues and organs at risk.  This is inherently quality and risk management as integral part of practice with the specialist role acting at a higher departmental practice level. Practicing accurately and safety is also key in order to adhere to accreditation standards. Radiation Therapists play a significant part of internal audit processes and in updating standard operating procedures.
4. **Education:** Every Radiation Therapist is engaged in the education of student Radiation Therapists, and many are also engaged in the education of trainee Radiation Oncologists and other allied health professionals. In the majority of accredited training and education centres, there is typically at least one Radiation Therapist student per work area at any given time. Therefore, education constitutes a significant workload for Radiation Therapists every day. Radiation Therapists are also involved in educating patients and carers about the procedures and processes involved in the practice of radiation therapy daily. Calculating staffing requirements will also inform the student recruitment requirement to ensure continuity of service delivery.
5. **Management:** While there are dedicated managerial roles within each department, all Radiation Therapists have managerial duties within their own context, encompassing time and resource management as well as human resource management, be these more junior or student Radiation Therapists. Patient side effect management and supportive care provision, which is a mainstay of the profession of radiation therapy is often overlooked in workforce planning and patient throughput.

6. Leadership: Every Radiation Therapist has the capacity as a leader, within their own context. Leadership and Management should be separated as not all leaders are managers and not all managers are leaders. Radiation Therapists have the ability to act as role models for students, advocate for patients and the profession of radiation therapy and this is an important area within the profession that should be acknowledged.

Every department is unique in its size, workflow, and practices. To determine the workforce necessary for any individual department, the percentage time per area of practice above must be quantified along with specification of the working day in that department (e.g. 8 hour or 10 hour). Those calculating workforce numbers must be cognisant that Radiation Therapists never work alone in clinical duties for safety reasons. As per the literature, we recommend that an additional 20% FTE of the total calculated above is required to cover all Radiation Therapist leave.

### 2.6.4 Recommendations

- Workforce planning can no longer be simplified into recommended number of Radiation Therapists per linear accelerator or Computed Tomography unit, per patient number or working hours. On any treatment unit, the range of techniques used daily is highly variable and patient dependent. In most radiation therapy centres the patient population covers the entire age and patient status spectrum. This again influences time allocation for both preparation and treatment. For example, paediatric patients may require anaesthesia but even without this require additional time allocated. Older patients, who will constitute a significant percentage of the workload, will also often require additional time and assistance. Patients may be at an advanced stage of disease, in pain or with additional comorbidities. All these factors combine to make time-based assessment impractical and impossible.
- Radiation Therapy technology and techniques are highly variable across Europe, within individual countries and indeed, even cities. Examples include in the treatment of breast cancer, where some institutions may use a technique called deep inspiration breath hold (DIBH). This is considerably more time consuming and staff resource intensive than a technique that does not use DIBH. Another issue is the use of magnetic resonance guided radiation therapy (MR-RT). This is utilised in some centres, particularly for the treatment of intra-abdominal tumours, such as pancreatic cancer. This is a highly resource intensive technique that requires specialist training. Another example is the use of imaging protocols from one department to another. Some centres use online image protocols where images are taken every day prior to treatment and interpreted before treatment. Others use offline imaging protocols

where decisions are not taken in real time. Again, this has staffing resource implications. These are just some examples to illustrate the myriad of techniques and technologies in use in radiation therapy currently. Therefore, we do not think it prudent or correct to apply a formula for staffing levels of radiation therapists. As we have stated, each department needs to assess their own needs.

### Staffing requirement calculation

In the context of the issues raised and discussed it is still necessary for radiation therapy departments to make as accurate an estimation of their current and future staffing requirements as possible and the following elements must be included.

As a starting point to ensure accurate and safe practice staffing levels can be calculated based on the following criteria:

- A radiation therapist must never work alone.
- The overall staffing requirement will be influenced by national legislation on working hours, maternity, paternity and parental leave, career breaks etc. which will be country specific.
- The number of full time, part time and locum/cover staff currently working
- Whether the department runs on single or multiple shifts which must include a time calculation to cover for staff breaks and shift crossover discussion.
- Scheduled maintenance, downtime and replacement need to be included as they will impact on treatment delivery and will require temporary introduction of additional working slots.

In estimating staffing requirements at a local level two approaches are necessary; firstly, what is the optimal number of radiation therapists necessary for accurate and safe practice and secondly a detailed analysis of the current staff cohort. This will provide a baseline on which additional roles can be added as appropriate to practice.
Forward planning
For consistency of service in the future and to inform education institutes of the potential future student intake the centre must also consider

- Equipment and any planned expansion
- Evolving staff roles and responsibilities as described previously.
- Attrition and retirements

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# 3. Education and Training Guidelines

It is appreciated that there is a common core of knowledge with respect to radiation safety that is required for all professionals, which should be based on the requirements of the BSSD.

Article 18: "Member States shall ensure that practitioners and the individuals involved in the practical aspects of medical radiological procedures have adequate education, information and theoretical and practical training for the purpose of medical radiological practices, as well as relevant competence in radiation protection." Also stated is the requirement for recognition of qualification and the need for continuing education.

Article 14: "Member States shall establish an adequate legislative and administrative framework ensuring the provision of appropriate radiation protection education, training and information to all individuals whose tasks require specific competences in radiation protection."

Based on the findings of the data collected the current status of education and training in radiology, radiotherapy, nuclear medicine and medical physics, and the professionals involved in each discipline will be determined. In preparing the guideline a brief summary of the methodology and findings will be provided. It is appreciated that there is a common core of knowledge with respect to radiation safety that is required for all professionals, and this should be based on the requirements of the BSSD. The guideline will provide a proposed content to meet this basic requirement. It will then be necessary to consider the specific education and training requirements for radiology, radiotherapy, nuclear medicine and medical physics, and the professional groups involved in their delivery. Again, in each discipline there will be an additional core of knowledge that can be defined followed by the specific requirements of each professional group to enable them to practice optimally and safely. There is also the need to consider the impact of new technologies and techniques, increasing workload, the combination of new treatment approaches and innovations and their impact on current and future practice; this will need to be reflected in any guidelines produced.

Training requirements are not limited to radiation protection but also consider the general training for each profession.

Despite the diversity of professions, certain similarities can be noted.

Criteria to enter the training:

- An EQF Level 4 or Level 5 qualification is the most common.

Structure of the training:

- 3 years minimum requirement equivalent to 180 ECTS going up to 4 or 5 years for some subspecialisations.
- The core curriculum differs among professions depending on the specialty, but with competency-based curricula being common.
- Funding is recommended during training to ensure equity of access.

Content of the training with a focus on radiation protection, quality management and safety:

- Core components of the curriculum providing the content necessary to understand the effect of radiation on tissue in order to ensure safe clinical practice should be included in all education and training programmes as per professional society (and other) recommendations and monitored at European level.
- To always maintain a safety culture possibly monitored at European level to ensure radiation protection for patients, staff, and the general public.
- Apply the general principles of BSS legislation for radiation protection.
- Research, quality and safety management should be integrated into all education and training programmes following professional society (and other) recommendations and ideally be monitored at European level.
- Harmonisation of CPD education within the professions.
- New technologies and techniques including AI should be included as part of education and training programmes for all professions.

Certification:

- National professional bodies hold responsibility, usually benchmarked against professional societies' recommendations by Higher Education Institutions which offer the curriculum for education and training. Harmonisation within professions across European countries is recommended.

Training centre:

- Formal accreditation, assessment and auditing of training centres should be mandatory across Europe and assessments and audits be carried out to ensure compliance with current legislation and practice.

## 3.1 Radiologists

Authors: A. Brady, B. Brkljačić, C. Loewe (European Society of Radiology – ESR)

### 3.1.1 Introduction

These guidelines have been developed based on the recommendations as defined in the European Training Curriculum (ETC) Levels 1-3 as defined by the European Society of Radiology (ESR) and supported by 38 national societies and numerous subspecialty societies. Additionally, these guidelines are also based on the long-lasting experience in national and international leadership positions of the authors of these guidelines (mentioned below).

The main goal of these guidelines is to establish harmonised training requirements regarding duration and content for radiology residency programmes within Europe in order to increase mobility and comparability. The approach to the calculation of workforce need as introduced above will be applied to the specific needs and requirements of the teaching situation. This rather simplified but practical approach for the quantification of time units per service needed and consequently, for the estimation of workforce calculation, will allow the estimation of the impact of education and teaching on the staffing calculation.

These guidelines will be summarised by a number of recommendations, including the endorsement of the European Diploma in Radiology by national authorities, the call for a harmonised duration of the residency of 5 years, the support of continuous medical education, and many more.

### 3.1.2 Recommendations for the education and training of Radiologists

#### 1. Harmonisation of duration and content of training within the EU member countries

In order to facilitate free mobility between Member States of the European Union and to enhance the quality of radiological care for patients, harmonisation of education and training of Radiologists is desirable. Based on the data described previously, obtained from the survey performed as part of the EU-REST study, and on existing guidelines, there is still some variation in the length of radiology specialty training among EU Member States. The specific training in Radiation Protection should be organised following the recently published guidelines (EC RP 175 [1]).

A specialty training programme lasting 5 years, however, has already become a generally accepted European standard, and should be established in all countries. The EU Professional Qualifications Directive [2], which still recommends a minimum training period of 4 years, should be adapted accordingly.

The European Society of Radiology (ESR) as the key transnational provider of radiological education within Europe, has defined the content, structure, and duration of the specialty training programme in radiology. Initially introduced as the European Training Charter in Radiology, the European Training Curriculum (ETC) provides a clear recommendation for a modern, structured training programme in Radiology. The content was defined in close cooperation with the relevant radiology sub-specialty societies (Breast, Cardiovascular, Interventional, Musculoskeletal, Chest, Neuroradiology, Head-Neck, Paediatric, Gastrointestinal, Urogenital, Gynaecological, Emergency), and it is structured according to required knowledge, skills, competences, and attitudes. This ETC is continuously updated and represents an ideal blueprint for harmonised radiology education in Europe.

This ETC is supported by 38 National Radiology Societies, but not all these countries have yet implemented this ETC as the basis for their training programmes.

**The clear recommendation is to establish the ETC (in its continuously updated form) as a European-wide standard for radiology education and training.**

## 2. Harmonisation of training structure within the EU member countries

The ETC differentiates between levels I (first three years of training), II (year 4 – 5) and III (Fellowship – subspecialisation). This structure differentiates between basic general education and training in years 1-3, and more advanced training, usually in selected subspecialty fields in years 4-5. After these 5 years, training to become a “General Radiologist” is finished.

This basic five-year structure is applied in many countries. Further harmonisation is desirable.

However, regarding Level III education, universally accepted European standards are missing. Structured Fellowship programmes are established in few countries, and their duration varies between 1 to 2 years. In some countries, dedicated subspecialty training is provided in selected fields (neuroradiology, interventional radiology, paediatric radiology), but even in these fields a common European standard is not accepted. Establishing formal subspecialty training requires political decisions and funding in most countries. Most European subspecialty radiology societies have produced training curricula for training in their respective subspecialties; as with the ETC-based standardisation recommended above, these (combined with ETC Level III curricula) could and should be adopted as standard bases for formal radiology subspecialty training.

**The recommendation is to establish coordinated and standardised Fellowship programmes after the end of the regular residency training. Such Fellowships should generally last 1 year. Curricula for training in radiology subspecialties should be based on a combination of ETC Level III and specific subspecialty society sponsored curricula.**

Training and education in radiology require a mix of knowledge and competences; volume-based competency is one factor in supporting quality. Currently, the ETC does not define hours of teaching (ECTS) / education per field, numbers of cases to be reported or numbers of procedures to be performed. Training programme outlines in many countries do include such numerical recommendations. A definition based on case numbers is an insufficient parameter on its own to determine competence, and the useful threshold between granular measurement (to ensure a realistic and beneficial case mix) and applicability is difficult to establish. Nonetheless, it seems self-evident that it would be helpful to define a minimum number of cases / procedures to be reported / performed in each subspecialty.

Additionally, a minimum of required ECTS in each subspecialty should be defined.

**The recommendation is to establish a minimum requirement for a combination of ECTS and case/procedure numbers for each subspecialty, based on the ETC, and to use this in all EU member countries.**

Consequently, education in radiation protection, patient safety and quality control should be standardised following the same principles as above. Each fully trained radiologist should be qualified and well educated in these essential fields. In most countries, radiation protection, safety, and quality management are established in the training programme, but the number of hours of teaching (ECTS) and the extent of practical training is not specified.

**The recommendation is to establish a minimum requirement for a combination of ECTS and practical training in radiation protection, safety and quality management within the ETC and to use this in all EU member countries.**

## 3. Harmonisation of certification of completion of training within EU member countries

In many, but not all, EU member countries, completion of specialty training is marked by formal certification. In many countries, this is based on a structured formal examination. In other countries, completion of training is determined as a dialogue among colleagues, and in some countries training completion is determined by spending a period of defined time in training (3 – 5 years).

The European Board of Radiology (EBR) has established the European Diploma in Radiology (EDiR), achieved by success in a formal standardised examination, taken after completion of formal time-based training; this diploma is fully endorsed by the UEMS and ESR.

As indicated on the website of the EDiR, "the EDiR is recognized as equivalent to: the exit training examination in Poland and in the Netherlands, the first part of the Turkish board examination and the image interpretation part of the Finnish national examination, and also to the Croatian National Board examination".

Moreover, the EDiR has significant value in many other countries, such as France, Italy, Belgium, Sweden, Russia, Bosnia and Herzegovina, Slovakia, Malta, Estonia, and Georgia, where EDiR holders can use the certificate for professional credentialing and classification purposes. This is also the case of most countries in the Middle East and Asia, especially in India and Pakistan, where the EBR has special agreements with the corresponding national radiology associations [3].

**The recommendations would be:**

1. **to formally complete training in radiology by a harmonised and standardised examination in all European countries.**
2. **to promote acceptance of the EDiR as equivalent to the national or specialty examination in radiology or – in countries without such specialty examination – to establish the EDiR as a requirement for certification of completion of training.**
3. **In those countries which already have established examinations which must be passed to complete training, local evaluation of equivalence with the EDiR may be helpful to ensure harmonisation of standards.**

## 4. Clear acknowledgement of trainees in workforce calculation

As described above, education in Radiology is mainly a combination of practical and clinical education. Acquiring volume-based competency is a central part of

Radiology training. There is a clear correlation between case load and experience. With increasing time within training, independent work of the trainees becomes more valuable to patient care and represents a central part of training at Level II (years 4-5).

As elaborated in greater detail in the guidelines for staffing as part of the EU-REST study (see section 2.1 of the present document), trainees must be taken into account while calculating workforce needs. Teaching is time-consuming (on the part of the teacher); conversely, trainees can deal with some parts of routine work and can contribute positively to department outputs. With increasing trainee experience, less time investment by the teacher is required. In the interventional setting, however, continuous presence of the fully qualified radiologist (teacher) is needed.

As a consequence, we proposed in the Guidelines for Radiologist Workforce modality-depended modifications of the staffing calculation in the educational/teaching setting.

As an example, we proposed the following calculation for MR:

**One hour MR ($HR_{MR}$) requires 1.5 working hours of a board-certified radiologist who is capable and licensed to work independently.**

If an MR service is running 5 days a week with 12 hours' patient room time a day, the total need would be to cover 3,000 hours per year. Doctors working 40 hours per week, for 40 weeks a year (following the assumption of The Gishen Ready reckoner [22] to reserve 12 weeks for leave, study leave, illness, meetings, machine breakdown or non-function) are working 1,600 hours per year. Based on the estimation above, an equivalent of 4,500 hours should be covered.

Following this calculation, for an MR service being busy 5 days a week for 12 hours, 3 radiologists being able to work independently and unsupervised are required.

In the teaching setting, this demand on staff needs to be modified based on the need for continuous teaching and instruction.

**One hour MR ($HR_{MR}$) in the teaching situation requires 1.5 working hours of a Resident plus 1 hour of a board-certified radiologist who is capable and licensed to work independently.**

These estimations and assumptions are dedicated to routine in-hour service. For on-call and/or out-of-hour services different calculations are needed.

## 5. Harmonisation of training centre evaluation within EU member countries

In order to provide harmonised quality assessment of training programmes, and to ensure common high standards, the European Training Assessment Programme (ETAP) has been introduced some years ago and was updated by the ETAP 2.0 programme.

ETAP is a joint initiative of the EBR and the European Union of Medical Specialists (UEMS) Section of Radiology.

This programme represents a formal quality assessment for radiology training programmes. It is in line with the ESR European Training Curriculum (ESR ETC) [3].

According to the ETAP description, this certification "allows to check the level of competence, attitude and development of new skills that trainees acquire during the training period." Furthermore, it provides objective assessment of training departments and serves as an indicator and benchmark for training departments among trainees.

**The recommendation would be to establish the ETAP certificate as a prerequisite for training centre accreditation in Europe.**

## 6. Harmonisation of continuing professional development

The Accreditation Council in Imaging (ACI), together with the UEMS, has established criteria for accreditation of educational events. Different rules and regulations apply for live education events (LEE), e-learning material, and for blended learning and webinars. For certain amounts of educational activities, Continuing Medical Education (CME) credits can be claimed. This concept provides a very high level of standardisation. As a consequence of a very fruitful collaboration between the UEMS and ACI, the roles are clearly defined: ACI is responsible for assessing the content of educational events, and UEMS defines the rules and provides the credits.

However, in some countries, local CME credits are provided following different rules and regulations, and direct exchange and acceptance of UEMS CME credits (EACCME) is not possible among all countries.

### The recommendations are:

1. **to establish the EACCME as the European currency for CME credits, and to accept these credits in all countries as proof for continuous medical education.**

2. **to establish a minimum number of CME credits which need to be obtained in a defined period of time to prove continuous medical education, and to use this number in all European countries.**

### 3.1.3 Recommendations

- To advocate for an increase of the minimum training period from 4 to 5 years in the EU Professional Qualifications Directive
- To establish the ETC (in its continuously updated form) as a European-wide standard for radiology education and training
- To establish coordinated and standardised Fellowship programmes after the end of the regular residency training. Such Fellowships should generally last at least 1 year. Curricula for training in radiology subspecialties should be based on a combination of ETC Level III and specific subspecialty society sponsored curricula.
- To establish a minimum requirement for a combination of ECTS and case/procedure numbers for each subspecialty, based on the ETC, and to use this in all EU member countries.
- To establish a minimum requirement for a combination of ECTS and practical training in radiation protection, safety, and quality management within the ETC and to use this in all EU member countries.
- To formally complete training in radiology by a harmonised and standardised examination in all European countries.
- To accept the EDiR as equivalent to the national specialty examination in radiology or – in countries without such specialty examination – to establish the EDiR as a requirement for certification of completion of training.
- To emphasise the importance of mandatory continuing professional development (CPD) and life-long learning.
- One hour MR (HRMR) requires 1.5 working hours of a board-certified radiologist who is capable and licensed to work independently
- One hour MR (HRMR) in the teaching situation requires 1.5 working hours of a Resident plus 1 hour of a board-certified radiologist who is capable and licensed to work independently.
- To establish the ETAP certificate as a prerequisite for training centre accreditation in Europe.

- To establish the EACCME as the European currency for CME credits, and to accept these credits in all countries as proof for continuous medical education.
- To establish a minimum number of CME credits which need to be obtained in a defined period of time to prove continuous medical education, and to use this number in all European countries.

### 3.1.4 References


1. European Commission (2014) Radiation Protection no 175, Guidelines On Radiation Protection Education And Training Of Medical Professionals In The European Union.
2. DIRECTIVE 2005/36/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 7 September 2005, on the recognition of professional qualifications (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02005L0036-20211210)
3. About EDiR - European Board of Radiology (myebr.org)
4. About ETAP - European Board of Radiology (myebr.org)


## 3.2 Nuclear Medicine Physicians

Author: F. Jamar (European Association of Nuclear Medicine – EANM)

### 3.2.1 Introduction

The survey as reported in EU-REST D6 (Report on the Identification and Collection of Existing Guidelines) revealed considerable differences in the way Nuclear Medicine (NM) physicians are educated, trained and qualified across the EU-27. These variations do not mean that levels of qualification differ between countries. Nevertheless, considering the European Directive 2005/36/EC that established a mechanism of automatic mutual recognition of medical doctors across Europe, the length of the training, requirements and qualification should be harmonised across the EU-27. This is currently far from being the case. The aim of the present guideline proposal is not to offer a rigid and constraining framework for the training and education pathways for all countries but to give the European Commission an idea of what could be improved and enforced to harmonise the current situation. For instance, it does not seem logical that a qualified NM physician, trained for three years in country X, gets automatic recognition in country Y, where the duration of training is five years. In addition, the requirements for education and training in radiation protection have been established by the Council Directive 2013/59/Euratom (BSS Directive), but not in detail, so Member States have translated them in different quantitative and qualitative legal terms. HERCA may help in the effort towards more uniformity amongst their members, which currently gather all EU-27 Member States.

Currently, at supranational level, there are two main sources of guidance. The first one is the document entitled “Training requirements for the specialty of Nuclear Medicine” [1] produced by the UEMS (in which all EU-27 Member States are represented) in 2017, a revised version of which was, at the time of writing the current draft guidelines, to be presented during the General Assembly of UEMS in October 2023. The second document was issued by the IAEA in 2019 in the TECDOC series (no 1883) [2] and is entitled “Training curriculum for Nuclear Medicine Physicians”. It is targeted to NM physicians not only in Europe, but in all countries including emerging ones with low or very low Internal Growth Product (IGP). For this reason, it is less stringent than the UEMS document, especially by limiting the duration of the education and training programme to three years. Both documents however converge in terms of a similar qualitative content that will serve as the basis for the following proposal.

Besides differences between countries in the content of the curriculum, three major challenges should be tackled in the years to come:

- Even if NM has been recognised as an independent specialty in 1988 by a European Directive, the qualification of doctors to practice this specialty varies considerably across the EU-27. In some countries there are pure NM physicians with a specific and dedicated training, in other countries they may combine the specialty with another one, such as internal medicine or paediatrics, or qualify for both radiology and NM. In the UK and the USA, there is also the legal qualification of nuclear radiologist.
- The qualification as NM physician is granted by different bodies in the EU-27, such as Ministries of Health, medical chambers or regulatory bodies (mainly competent for radiation protection issues).
- The recognition of NM physicians for their competence in radiation protection is also highly heterogeneous amongst EU-27 Member States.

This heterogeneity will also be dealt with in the current document.

### 3.2.2 Proposal

#### Duration of the training/education programme

The period of training should be a minimum of four but preferably five calendar years.

The curriculum as detailed below must include clinical training, theoretical education as well as qualification in radiation protection that will guarantee the safe use of radioactive materials for both the patient and staff.

This includes clinical training in specialties where NM is essential, such as, e.g., Internal Medicine, Cardiology, Neurology or Clinical Oncology. At least one year of the full training should be spent in this clinical in-depth training unless previous MD qualification has provided this at a sufficient level. This is unlikely to be the case for undergraduate students whose responsibilities remain limited. In addition, some training in cross-sectional Radiology practice would be essential, as NM has definitely moved to hybrid imaging (i.e. combined PET or SPECT with CT or MRI). Ideally, at least six months should be dedicated to Radiology, mainly for CT scans and MRI. One should keep in mind that the future qualified NM physician will not only have to perform hybrid imaging and be able to interpret it but also be able to integrate the NM imaging with other imaging procedures performed in the same patient. Accordingly, radiology training should not extend to radiologists' specific competences, such as dedicated US, breast imaging or standard radiological imaging, e.g. digestive or urinary tract imaging. Some time should also be dedicated to paediatric imaging in the fields where NM is relevant, for instance, bone imaging or procedures in oncology such as neuroblastoma or children/adolescent malignancies. This training in Radiology may be considered as little productive for the trainer, because the trainee will mainly be in assistance, but it will be essential for the full education of the NM trainee. Conversely, Radiology trainees may also spend some time in NM for the purpose of co-interpreting hybrid imaging. It is not the intention here to establish a strict modus operandi that can be applied in all countries from scratch, but essentially to give guidance for the years to come.

In our opinion, the minimum three-year programme proposed by the IAEA is too short when both theoretical and practical aspects are to be considered.

#### Content of the training

a) Theory

All trainees in NM should receive a basic theoretical curriculum that should account for 20-30 ECTS. This education is divided into two sections, i.e. scientific principles and clinical applications.

Scientific principles must include (unless recently covered by the undergraduate teaching):

- Physics, especially nuclear physics,
- Instrumentation, data acquisition and processing, including semi-quantitative and quantitative assessment and standardisation and tracer kinetic modelling. This should cover the available technologies in a particular country, such as gamma camera imaging, ex vivo procedures, SPECT, PET with or without CT, PET/MRI, dual energy X-Ray absorption (DEXA),
- Principle of artificial intelligence
- Radiobiology and radiotoxicology,
- Radiochemistry and radiopharmacy, including radiopharmacological aspects and practical applications of radiopharmaceuticals for diagnostic and therapeutic purposes,
- Internal dosimetry for therapeutic applications,
- Informatics, statistics and basic mathematics applied to NM,
- Radiation protection, encompassing the BSS, applied measures (justification, optimisation and dose limits), national legislation. This should not limit to radionuclides but also to the use of X-rays,
- Quality control and quality assurance,
- Transversal knowledge about patient care and communication.

The extent of knowledge provided by this education should be adapted to the national situation and availability of techniques. However, when considering transnational migration according to the free mobility of medical doctors across the EU, additional teaching modules may be required for national recognition depending on the level of initial training. For instance, if a doctor has been qualified in a country where radioligand therapy is not available and hence has no experience with it, it would be wise to establish a programme of training for this particular purpose before granting the full licence in the country of arrival. This can be proposed jointly by the medical and radiation protection authorities.

#### b) Clinical applications

The training should cover as many disciplines as possible, to the extent of what is available in the relevant country. If appropriate, fellowships abroad may help to cover topics that are not available yet but emerging in a particular country.

National funding, Erasmus programmes or other EU initiatives may help finance these fellowships to improve inter-European mobility. Participation in the ESMIT (EANM) level 1 and 2 programmes can also provide the trainee with additional knowledge and experience.

The content of the training is detailed in the IAEA and UEMS documents and can be summarised as follows:

- Patterns of radiopharmaceutical uptake, normal variants, artifacts.
- Cross-sectional anatomy, correlative imaging and knowledge of advantages and limitations of each modality.
- Special diagnostic investigations in all clinical specialties, see further.
- Radioguided surgery, e.g. sentinel node imaging and perioperative detection.
- Radiotherapy planning on the basis of functional imaging, especially PET-based.
- Therapeutic applications for benign and malignant disorders.
- Combined diagnostic and therapeutic applications, referred to as thera(g)nostics.

The current, not exhaustive, proposal aims to have postgraduate trainees be able to plan, perform, process and report *in vivo* procedures in the following areas:

- Central nervous system (200 procedures).
- Bone and joints (600 procedures).
- Cardiovascular and respiratory systems (500 procedures).
- Gastrointestinal and genitourinary systems (100 procedures).
- Endocrine, haematologic and lymphatic systems (400 procedures).
- General oncology (800 procedures).
- Infectious and inflammatory disorders (300 procedures).
- Miscellaneous, including paediatrics (150 procedures).

The above numbers in parentheses are adapted from the current UEMS syllabus and close to the IAEA proposal and represent the number of practical applications that a trainee should reach at the end of their programme. *In toto*, this represents an average of 3,000 documented procedures. Rather than reporting this in a paper document at the end of the training, it is advised that **the performed procedures be registered on a continuous basis, in an electronic format (training log), so that the supervisor and the trainee can**

**regularly**, e.g. on a 6-month basis, **monitor progression and the way objectives will be reached.** This can also be shared with a representative of the accreditation body, for online continuous evaluation.

Details of the procedures to cover can be found in Prigent et al. During the clinical training, the candidate should also actively take part in oncological multidisciplinary consultations. Junior residents are encouraged to participate as observers whereas senior residents should participate more actively, and, if deemed appropriate, represent their department, under supervision.

As far as therapeutic applications are concerned, it is the opinion that at least 100 procedures should be performed during the entire curriculum and should be as diverse as possible. Again, if a particular application is not available in the training centre(s), fellowships should be available to reach the necessary diversity. The main therapeutic applications are radioiodine for benign and malignant disorders, bone palliation, intra-arterial liver tumour therapy (SIRS), radiation synovectomy (where performed), and radioligand therapy.

Training for therapeutic applications should cover the following:

- Patient selection and setting of the indication, with full knowledge of the benefits, potential contraindications and alternative treatments.
- Administration of the therapeutic radionuclide and patient care for the appropriate duration (varies between hours and weeks depending on the type of therapy).
- Determination of absorbed dose to the target organ/tumour and the organs at risk.
- Dealing with potential side effects, together with the referring physician, e.g., medical oncologist.
- Taking care of radiation protection issues for the patient, his/her relatives and the general public. Specifically, take care of the issue of contraception in patients of childbearing age (both females and males). Also consider unexpected events such as resuscitation, premature death and cremation, or urgent hospitalization as part of risk management.

Finally, it is advised that the trainee be engaged in some research activity, including a presentation at a national or international conference or a publication in a peer-reviewed journal. Some countries may also require a thesis at the end of the training, based on literature analysis, methodological issues and personal research.

## Assessment of the training and education programme

Currently, there is no uniform manner to evaluate the achievements of a trainee. This document does not intend to propose a top-down solution. Nevertheless, some criteria have to be enforced to qualify a medical doctor as an NM specialist. The main competences are:

- Basic knowledge of theoretical background, including radiation protection issues.
- Advanced knowledge of clinical in vivo imaging procedures, such as described in the UEMS and IAEA documentation.
- Advanced knowledge of therapeutic applications, at least those available in a particular EU-27 country.

At the end of the training, there are many ways to assess the capability of a physician to independently undertake NM activities. This can be at local evaluation (academic or other), national or sub-national, or international level. All options seem acceptable, provided they ensure a similar level of knowledge and competence. The best and simplest option is nationally based evaluation, ideally through a commission of the ministry of health that will eventually grant the accreditation. Options for final evaluation are:

- MCQ exam
- Interview
- Continuous evaluation
- Live – real world – evaluation
- A combination of the above

Besides, accreditation for Radiation Protection (RP) should be issued by the competent authority. It is the opinion of the EU-REST study consortium that both should be given at the same time, by the use of a common commission, dealing with competencies in the specialty but also the relevant competencies in RP. This would facilitate the access to the specialty.

### Body for accreditation

The body for accreditation should be centralized within all EU-27 countries. Ideally, this responsibility should belong to any organ of the ministry of health in each country. Where this is not possible, a centralised certification can be sought, such as through the EANM/UEMS/EBNM training end exam (https://uems.eanm.org/fellowship-examination/).

#### Accreditation of training centre and responsibilities

The accreditation centre shall be chosen amongst those that are able to offer the widest operating workforce and range of activities. This does not mean that all activities may be available there but partnerships may exist or be established with other centres for additional training. The accreditation of training centres and those responsible shall be validated by a centralised body.

### 3.2.3 Recommendations

- The period of training should be a minimum of four but preferably five calendar years.
- The curriculum must include clinical training, theoretical education as well as qualification in radiation protection that will guarantee the safe use of radioactive materials for both the patient and staff.
- NM trainees should receive a basic theoretical curriculum that should account for 20-30 ECTS. This education is divided into two sections, i.e. scientific principles and clinical applications.
- Continuous documentation of the trainee's performed procedures, in an electronic format (training log), so that the supervisor and the trainee can regularly, e.g. on a 6-month basis, monitor progression and the way objectives will be reached.
- The importance of mandatory continuing professional development (CPD) and life-long learning should be emphasised.

#### **Perspectives and role of the European Institutions**

The main recommendations are:

- Nuclear medicine societies (EANM in coordination with national societies) to establish a knowledgeable status of the current curriculum for the specialty of NM.
- UEMS, national societies and national regulators to collaboration to harmonise the curriculum amongst the EU27, taking into consideration differences in equipment and IGP between the Member States.
- Professional societies to support clinical centres in organising practical cross-country mobility in order to give all medical doctors in the EU27 equal access to the specialty of NM.

### 3.2.4 References

1. Training requirements for the Specialty of Nuclear Medicine. Union Européenne des Médecins Spécialistes. Brussels, 2017 (https://www.iaea.org/publications/13579/training-curriculum-for-nuclear-medicine-physicians)
2. Training curriculum for Nuclear Medicine physicians. IAEA TECDOC series 1883. International Atomic Energy Agency, Vienna, 2019 (https://www.iaea.org/publications/13579/training-curriculum-for-nuclear-medicine-physicians)
3. A. Prigent, R. Hustinx and D.C. Costa. Nuclear medicine training in the European Union: 2015 update. Eur J Nucl Med Mol Imaging. 2016; 43:583-596. DOI 10.1007/s00259-015-3244-x.

## 3.3 Radiation Oncologists

Authors: Y. Anacak, P. Lara (European Society for Radiotherapy and Oncology – ESTRO)

### 3.3.1 Introduction

A radiation oncologist is a medical specialist that uses ionising radiation, either alone or in combination with other therapeutic modalities, for the treatment of patients with malignant or benign diseases. Radiation oncology technology and methods are evolving rapidly, and the work of a radiation oncologist becomes more complex, which requires competencies in several areas.

A radiation oncologist has responsibility for the prevention, diagnosis, treatment, follow up and supportive care of the cancer patient with a responsibility to manage care pathways across multiple disciplines and by multidisciplinary management.

### 3.3.2 Recommendations for the education and training of Radiation Oncologists

The European Society for Therapeutic Radiology and Oncology (ESTRO) is the leading international organisation for radiation oncology in Europe and has defined the content, structure, and duration of the specialty training programme of radiation oncology in the ESTRO Core Curriculum for Radiation Oncologists/Radiotherapists.

The first curriculum was published in 1991 and played a pivotal role in the establishment of comparable standards for training across Europe. In the 2nd edition issued in 2004 the evolution of radiation oncology techniques was included. It was endorsed by 35 national societies and integrated into the law or national guidelines in several European countries. It provided a significant step towards harmonisation across Europe. In 2011 the 3rd version was released where there was a change in focus from theoretical knowledge and skills to competency-based education. The curriculum was based on the CanMEDS model drawn up by the Royal College of Physicians and Surgeons of Canada and was endorsed by the European Union of Medical Specialists (UEMS).

The 4th edition of the curriculum [1] was released in 2019 which identifies 14 Entrustable Professional Activities (EPAs), key tasks of a discipline that can be entrusted to an individual who possesses the appropriate level of competence. Competences and enabling competencies are set out for each EPA. Levels of proficiency expected at the end of training are described as levels of EPAs achieved for the different tumour sites. The characteristics of training programmes that will enable trainees to develop these competencies and the characteristics of assessment systems that will provide assurance that they have developed them to the required levels are also described.

The 4th edition of the Curriculum has received wide support from the clinical oncology as well as the radiation oncology community. It has been endorsed by 29 National Societies and adopted as the European Training Requirement (ETR) for Radiation Oncology/Radiotherapy by the UEMS.

In this document, our recommendations for the education and training of radiation oncologists are drawn from the 4th edition of the Core Curriculum for Radiation Oncologists/Radiotherapists.

## ESTRO Core Curriculum for Radiation Oncologists/Radiotherapists, 4th Edition

### Entrustable Professional Activities (EPAs), Competences and Enabling Competencies

The ESTRO core curriculum is based on the CanMEDS 2015 framework which defines seven main roles (Medical expert, Collaborator, Communicator, Leader, Advocate, Scholar and Professional) for physicians required to effectively serve health care, and identifies 14 EPAs and the competencies required to perform these:

1. Medical Expert
    - Develop a management plan for patients with a cancer diagnosis.

- Implement a treatment strategy.
- Develop and implement a management plan for survivorship.

2. Communicator
   - Communicate appropriately and effectively with patients and their relatives.
3. Collaborator
   - Work effectively with other health care professionals to provide safe care and to optimise the quality of treatment.
4. Leader
   - Discuss the context in which they work and apply the principles of management including quality improvement methodology in this context.
   - Use resources appropriately.
   - Demonstrate the ability to work in, build and lead teams.
5. Advocate
   - Advocates for cancer patients.
6. Scholar
   - Plan personal learning experiences and use them to enhance patient care.
   - Educate others to enhance patient care.
   - Contribute to the knowledge base that underpins patient care.
7. Professional
   - Demonstrate that the care of their patients is their first concern.
   - Manage their work life balance to maintain their own wellbeing.

**Objective of the training programme**

The objective of the training programme is to educate and train physicians in the medical specialty of Radiation Oncology/Radiotherapy to the level of competency allowing them to practise as an independent specialist.

**Duration of the training**

5 years full time or an equivalent period of training for radiation oncologists is required, where at least 80% of the time needs to be spent in a clinical environment.

### Licencing

There is no standardisation across Europe for licensing doctors to practise in Radiation Oncology. Licensing should be based on objective assessment of completion of a training programme that fulfils the national guidelines.

### Training programmes

The training programme should correspond to the requirements outlined in the European core curriculum and to specific national requirements.

During the training the trainee should become gradually more responsible for patient care, with increasing autonomy and less dependent on supervision. A record clearly documenting the clinical competencies and activities of the trainee is advised as a tool to define the clinical responsibilities the trainee is authorised to undertake during different phases of their training.

### Training institutions

Education, training, and certification of radiation oncologists should be performed by training institutions which are accredited in accordance with their national regulations, and adequately equipped to support both the workload and range of radiation oncology/radiation services required for training including new technologies and novel techniques. Infrastructure of a training institute should include:

- Mega voltage machines, at least one with high-energy electrons, equipped with IGRT and able to deliver IMRT.
- Access to a dedicated CT scanner.
- Computerised treatment planning and technical support. This should include appropriate dosimetry.
- Radiotherapy protection equipment.
- Appropriate patient treatment aids.
- The opportunity to become at least familiar with brachytherapy and stereotactic RT. This can be organised by collaboration with institutions in which these treatments are concentrated.
- Beds for inpatients or at least sufficient access to them in another department.
- Facilities for systemic therapies.
- Facilities for supportive and palliative care.
- Quality control programmes for patient care, treatment decisions, follow-up, and outcome in a range of cancer sites.

- Access to regular Multidisciplinary Tumour Boards (MDTs).
- Adequate number of patients and a varied case-mix, a minimum of 500 oncology patients should be irradiated annually in the parent institution or the integrated programme.
- The recommended number of full case equivalents seen by each trainee should be at least 450 during the entire clinical radiation oncology training. A trainee should not treat more than 250 full case equivalents per year to ensure a good equilibrium between work experience and the time for more formal training.

**Faculty in training institutions:**

**Programme director**

Each training institution or integrated programme should appoint a single programme director responsible for trainee education.

The programme director:

- is responsible for the general administration, the structure and the content of the programme.
- must be a highly qualified radiation oncologist with considerable experience in trainee education and in organisational activities.
- ensures that the programme fulfils the criteria in the core curriculum and the national requirements.

**Medical teaching staff**

Adequate number of radiation oncologists with responsibility for training and dedicated professional time to the teaching programme are essential for training programme. ESTRO recommends that the number of trainees does not exceed the number of full-time equivalent staff radiation oncologists.

**Physics teaching staff**

Full time medical physics support must be available in teaching institutions with medical physics staff members responsible for teaching.

**Radiobiology teaching staff**

Teaching institutions or integrated programmes should aim to have guaranteed access to a cancer biology laboratory and a chance to interact with its scientific staff.

**Other facilities**

Access should be available to:

- Adequate medical services in oncology-related specialties.
- Current imaging techniques.
- Pathology.
- Clinical genetics relevant to oncology.
- Online resources and library.

**Components of the educational programme:**

The training programme must provide the trainee with in-depth knowledge in the basic and clinical sciences in the field of radiation oncology and must train the trainee to be proficient in the clinical practice of radiation oncology.

Training programmes should provide:

- teaching rounds.
- case presentations.
- scheduled lectures.
- journal clubs.
- research conferences.
- tumour boards.
- participation in the teaching courses and scientific meetings.
- clinical activities.
- engagement in a research project or quality improvement project.
- exchange programmes for trainees with other institutions.

**Audit of teaching programmes**

Regular external audit of the training programme is recommended.

**Basic Sciences**

The practice of radiation oncology is underpinned by basic sciences. In order to achieve these learning outcomes, trainees require formal teaching. This will often be provided in national or international courses such as the ESTRO courses.

- Cancer Biology
    - Molecular and Cell Biology.
    - Biological basis of systemic treatments.
    - Translational research.
- Radiobiology

- Basic radiation physics
- Radiation physics applied in radiation therapy
- Radioprotection
- Clinical research and measurement of treatment outcomes
- Statistics

**Proficiency in Treating Cancers at Different Sites**

The incidence of tumour types and organisation of Cancer Treatment Services vary across Europe. In many countries there is increasing sub-specialisation for some tumour sites or radiotherapy applications, while in other countries all trainees may be expected to become proficient.

The degree of proficiency has been expressed as the level of the EPAs, that trainees will be expected to achieve in relation to each tumour site. This includes the management of the primary tumour and metastases arising from it.

**Assessment**

The assessment system is designed by National Societies in accordance with the legal requirements of each country. These vary for example some countries are required to set high stakes, summative assessments such as formal examinations while in others this is not allowed. The guiding principles should be:

- Assessment of competences and performance require workplace-based assessments.
- Workplace based assessments should use validated tools where these are available.
- The trainee is primarily responsible for organising workplace-based assessments.
- Evaluation of the trainee’s progress using trainers’ reports and the results of workplace-based assessments, if available, should occur at regular intervals at least annually.
- High stakes, summative assessments should be focused on the assessment of competences and should include a practical component including assessment of radiotherapy planning competences.
- Trainers in the workplace and examiners for national high stakes examinations should receive appropriate training,.

**Documentation of Training and Assessments**

The trainee should maintain a learning portfolio, either in hard copy or an e-portfolio, for the duration of the training. This can be used to monitor the progress of training by recording attainment of competences and should be shared with trainers as well as used for personal reflection.

### Clinical Oncology Module

In 2020 ESTRO developed a Clinical Oncology module that could be combined with the ESTRO CC to enable clinical oncology trainees to follow a single curriculum.

- The Clinical Oncology Curriculum includes all the EPAs, competences and enabling competences of the ESTRO Curriculum.
- Proficiency in treating cancer at different sites is in line with the ESTRO Curriculum.
- Assessment should be as recommended in the ESTRO Curriculum.

### Other Guidelines for the education and training of radiation Oncologists

- **IAEA:** The International Atomic Energy Agency (IAEA) published a Syllabus for the Training of Radiation Oncologists in 2009 which defines the minimum requirements for radiation oncology training across the world [2]. The document was endorsed by ASTRO and ESTRO. The syllabus seeks to address the training requirements in developing countries to establish a common and consistent framework. The curriculum is competency based and recommends a minimum of 3 years of training.
- **CEEAO:** A core curriculum for Central-Eastern European Academy of Oncology (CEEAO) countries was developed with the aim of to build on and harmonise the postdoctoral curriculum and requirements of surgical-, radio and medical oncology and to provide a foundational scaffolding for essential and common requirements for training of oncology professionals [3]. It is hoped that the curricula of essential requirements will be used as a framework upon which to make modifications to suit the needs of the specific country in the future.
- **Australia and New Zealand:** The Royal Australian and New Zealand College of Radiologists (RANZCR) developed a comprehensive training programme for radiation oncology training in Australia and New Zealand [4]. The curriculum is competency based and recommends 5 years of training.
- **USA:** An educational curriculum for the United States is under development by the Radiation Oncology Education Collaborative Study Group (ROECSG) [5].

### 3.3.3 Recommendations (summarised)

- The objective of the training programme should be to educate and train physicians to the level of competency allowing them to practise as independent Radiation Oncology/Radiotherapy specialists.
- The duration of the training should be at least 5 years full time or an equivalent period, where at least 80% of the time needs to be spent in a clinical environment.
- Licensing as a radiation oncologist/radiotherapist should be based on objective assessment of completion of a training programme that fulfils the national guidelines.
- The training programme should correspond to the requirements outlined in the European core curriculum and to specific national requirements.
- Training institutions should be accredited in accordance with national regulations, and adequately equipped to support both the workload and range of radiation oncology/radiation services required for training.
- Training institutions should appoint a programme director and should have an adequate number of radiation oncologists with responsibility for training and dedicated professional time.
- Full time medical physics support must be available in teaching institutions with medical physics staff members responsible for teaching.
- Teaching institutions or integrated programmes should have access to a cancer biology laboratory and interact with its scientific staff.
- The training programme must provide the trainee with in-depth knowledge in the basic and clinical sciences in the field of radiation oncology and must train the trainee to be proficient in the clinical practice of radiation oncology.
- Regular external audit of the training programme is recommended.
- Formal teaching in basic sciences, e.g., through national or international courses such as the ESTRO courses is recommended.
- Proficiency in treating cancers at different sites (degree of proficiency expressed as the level of the EPAs – Entrustable Professional Activities) is required.
- The assessment system should follow certain guiding principles for assessment.
- The trainee should maintain a learning portfolio for the documentation and assessment of training.

- The importance of mandatory continuing professional development (CPD) and life-long learning should be emphasised.

### 3.3.4 References

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## 3.4 Medical Physics Experts

Authors: R. Sanchez, N. Jornet*, C. Garibaldi*, D. Visvikis, C. Pesznyak, I. Polycarpou (European Federation of Organisations for Medical Physics – EFOMP / *European Society for Radiotherapy and Oncology – ESTRO)

### 3.4.1 Introduction

**Existing practice in medical physics experts' education and training**

From the analysis of European and international guidelines made by the EU-REST study consortium, it was found that EFOMP has published the core curriculum (CC) for the medical physics expert (MPE) in radiotherapy (2021) together with ESTRO, for the MPE in nuclear medicine together with EANM (2013) and for the MPE in diagnostic and interventional radiology with ESR (2011) [1]. All of them are based on the document RP 174 from the European Commission "Guidelines on Medical Physics Experts" published in 2014 [5] and international recommendations from the IAEA and the International Organization for Medical Physics (IOMP). The CC for the MPE in nuclear medicine is currently under revision and about to be published, while the CC for MPE in diagnostic and interventional radiology will be revised immediately afterwards. In the case of CC for MPE in radiotherapy, updated in 2021, the minimum education level to enter an MPE training programme should be a BSc degree, predominantly in physics, followed by an MSc degree in Physics or Medical Physics (BSc and MSc including in total at least 180 ECTS focused on fundamental physics and mathematics). The MPE training should have a duration of at least 4 years and the trainee must be appointed as a paid resident. MPE training can be in one or more subspecialties of Medical Physics. After completing the training, the professionals should be certified and registered by the competent authority to practise independently as MPE (one or more subspecialties). Continuing education after registration is mandatory. EFOMP's core curricula are based on the guidelines outlined in the European Commission's document RP174 [5] but are updated to reflect current scientific knowledge. They focus on developing the Medical Physics Expert (MPE) as the sole profession with EQF 8 level, preventing the proliferation of other unqualified professions or experts. This aligns with the 2013/59/EURATOM directive, which specifies that the MPE with EQF 8 level is the profession with competences in radiation physics for medical applications. The homogeneous training of MPEs through Europe would support the harmonisation of training and cross-border mobility of MPEs in Europe.

Apart from the survey performed during the EU-REST study [2], other valuable information sources are the surveys published by EFOMP and ESTRO in 2021 [3, 4], showing there are still some countries without training schemes for MPEs (6 out of 26). This collides with the 2013/59/Euratom directive that established in its article 14 that "*Member States shall ensure that arrangements are made for the establishment of education, training and retraining to allow the recognition of radiation protection experts and medical physics experts, as well as occupational health services and dosimetry services, in relation to the type of practice*", and requires a prompt solution. The current practice in Europe follows some of EFOMP's recommendations with most EU Member States requiring a bachelor's degree (with high content in physics and mathematics) and a Master's in Medical Physics or Physics Sciences to access training in a hospital/healthcare facility (65% of respondents) [4]. The training duration in the hospital is different depending on the Member State, ranging from 1 to 5 years with an average of 3.2 years [2, 4]. Such differences in educational programme durations cannot be observed for other professions. For example, the educational programme for radiologists takes between 4 and 6 years and for nuclear medicine physicians it ranges from 4 to 5 years. In the case of MPEs, for those Member States with training programmes, the duration of the educational programme ranges from 1 to 5 years. This anomaly contributes to enhancing the differences in quality and safety standards in the use of ionising radiation in medicine and requires an immediate solution to harmonise medical physics practice across Europe.

In most countries, the training period is dedicated to the three disciplines of medical physics (radiotherapy, nuclear medicine and radiology) [4]. However, there is no core curriculum for the profession of the MPE yet, compiling the common aspects from the three subspecialties. The three disciplines share basic topics such as radiobiology, ionising radiation dosimetry, radiation protection, quality management and other. Developing a unique core curriculum for the MPE is an urgent need for those Member States that have training schemes including the three disciplines. This requirement is in line with the guidelines on medical physics experts RP174 [5] and will also facilitate the harmonisation of the profession across Europe.

In 17 out of 20 Member States the students are paid during the residency. Non-paid residency programmes are more likely to result in lower training periods. For example, the 1-year programmes registered in the survey correspond to non-paid residency programmes, perhaps this is a symptom of not giving the required importance to the medical physics profession. In most of the Member States who answered the survey, registration after completing the training is compulsory to practise independently and continuous professional development is recommended in the majority of them, being compulsory in 6 Member States. It has been reported that in some cases, the title of medical physics was granted after completion of the Master level, sometimes halfway through the practical training and not all countries recognize the title of MP but restrict themselves to the title of MPE only. This situation was further complicated by the use of alternative titles such as medical scientist, qualified medical physicist, clinical physicist, radiological physicist, or biomedical engineer. These results have brought the conclusion that "*six years after the publication of the RP174 guidelines for the training of MPE [5], these have not yet been (fully) implemented in most European countries*", and in light of the current survey results this problem still remains ten years after the publication of RP174. In the survey published by EFOMP in 2021 it was concluded that "*The goal of a universal (registered) MPE accepted by all European countries is still far away despite the progress being made*" [3], and this problem must be addressed.

Since its founding, EFOMP has pursued a policy to improve and ensure high standards of training and performance of medical physicists across all its participating European countries [7]. In 2016, it established a procedure to assess how many Member States had a National Registration Scheme (NRS) dedicated to MPEs [8], combining education and the profession, in compliance with the 2013/59/Euratom directive, EC RP174 guidelines [5] and EFOMP Core-Curricula [1]. National Member Organisations (NMOs) that have formulated NRS which they believed to be in accordance with the above guidelines, were invited to submit details to the EFOMP Professional Matters Committee, to get formal approval of the NRS from the Federation. After eight years, 11 national NRSs have been approved by the EFOMP, indicating that the profession is regulated in these Member States, with a good level of harmonisation of the training frameworks. Another application for the NRS approval is currently being processed.

### 3.4.2 Recommendations

Based on the current practice obtained from the EU-REST survey results and the European and international guidelines about the education and training for MPE, and to progress in the harmonisation of the profession across Europe, the following recommendations for the Member States and the national and European organisations are proposed below:

1. In accordance with the Directive 2013/59/Euratom, in the medical physics field, to practice independently in Europe, the MPE accredited level (EQF8) should be achieved. All Member States shall provide education and training programmes and registration schemes for this goal.
2. There are still important differences across Member States in their educational and training programmes for MPE. Member states should converge in their education and training programmes seeking the standardisation of the safety and quality standards in the medical practices involving ionising radiation at European level. The updated core curricula and qualification framework for the MPE in Europe proposed by EFOMP together with other scientific organisations such as ESTRO, EANM, and ESR (based on the EC RP174 guidelines) [1] shall be the reference guideline for the education and training programmes for the Member States, that could be summarised as:

- Minimum requirements to access the education and training for MPEs: a BSc degree predominantly in Physics plus an MSc degree in Physics or Medical Physics (BSc + MSc 300 ECTS, including in total at least 180 ECTS in Fundamental Physics and Mathematics).
- Education and training for MPEs: duration of at least 4 years to obtain the competences (CanMEDS roles) to become an independent specialist. Training in one or more subspecialties of Medical Physics should exist. The training must be conducted in a hospital/healthcare facility accredited by the competent authority. Training facility and quality of the MPE training should be regularly audited by the competent authority.
- The MPE trainee must be appointed as a paid resident, with assigned duties under the supervision of a qualified MPE.
- Continuing professional development (CPD) shall be compulsory as recommended by EFOMP [6].
- Professionals should be registered before independent practice. National registration schemes for MPE will be based on EC RP174 guidelines [5] and EFOMP [8] recommendations.

3. A common core curriculum and career pathway for the profession of MPE encompassing all subspecialities of medical physics is instrumental in harmonising MPE education and training standards across Europe. This approach ensures consistency in the competences required to become an MPE, thereby standardising quality and safety for the medical applications involving ionising radiation. Furthermore, this initiative streamlines the recognition of the MPE profession in those EU Member States where it has yet to be formalised.

### 3.4.3 References


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## 3.5 Radiographers

Authors: F. Zarb, J. McNulty (European Federation of Radiographer Societies – EFRS)

### 3.5.1 Introduction

Developments in technology of medical imaging, nuclear medicine, and radiotherapy devices have altered and impacted delivery of patient care. These developments, across the three recognised branches of the radiographer profession, opened a wide variety of procedures and examinations, increasing the efficiency in healthcare services, by offering more effective and less invasive procedures.

Bearing this in mind, it is important that radiographers (medical imaging, nuclear medicine, and radiotherapy) update and maintain their knowledge and skills throughout their professional life to keep abreast with the changes taking place such as the advent of AI, changes in population demographics (e.g., an increase in the elderly population) and alterations in disease patterns. Developing an international strategic research agenda for radiography, to progress the profession and predict the influence of new technological developments in the radiographers' field of knowledge, is crucial.

Patient safety (beyond radiation safety) and effective communication skills are the main pillars of the profession. These requirements are achieved through research as an integral part of radiography education to generate highly qualified radiographers acting as the intermediary between the patient and technology. Radiographer education institutions must adapt the education model to the technological (r)evolution taking place.

Newly qualified radiographers must be professionals prepared to continue learning and to act as campaigners and leaders of change, aiding patients, and others by demonstrating effective person-centred care, and by their contribution to the development of society through research. The only way to develop the Radiography profession's field of knowledge and to rebuild, revolutionise and reinvent radiography is by including research in the educational curriculum for radiographers [1].

It is important that education and training programmes include diverse approaches to teaching and learning, to suit different learning topics as well as different learning styles / needs, along with diverse methods to assess competencies which are practice-based or 'real-world' clinical scenario-based assessments. Care should be given to avoid assessment overload, which is common in many health profession programmes. The involvement of patients and the public in radiographer education and training is also essential [2]

In keeping with access routes to education and training programmes, consideration should also be given to the provision of part-time pathways towards qualifications in medical imaging, nuclear medicine, and radiotherapy.

There can be different national considerations about the payment of trainees during their clinical training or indeed over the course of their programme, however, it would be important that medical imaging, nuclear medicine, and radiotherapy students are considered alongside all other allied health, nursing, and medicine students in this context.

### 3.5.2 Existing education and training practices based on D7: Report on the analysis of existing guidelines, education and training and staffing [3]

**Criteria to enter Radiography education and training programmes.**

Currently the minimum entry requirement for radiography education and training is normally EQF Level 4 or Level 5, with some institutions also considering other levels of qualification, professional, and clinical experience as being equivalent to meeting entry requirements.

**Structure of the training**

The education and training of radiographers, which incorporates medical imaging (MI), nuclear medicine (NM), and radiotherapy (RT) in most European countries, is delivered as a combined course programme. The United Kingdom (UK) and Ireland are the only European countries offering separate course programmes for MI and RT.

The total course duration incorporates between 180 ECTS to 240 ECTs over a period ranging between 2 to 4 years depending on whether the qualification is single (medical imaging, nuclear medicine, and radiotherapy only) or combined.

The minimum clinical placement required is 25% of the course content (ranging between 51 to 60 ECTS) but variations are great when considering the use of simulation, skills lab, and clinical training).

Payment during training was not referred to in any of the literature evaluated.

#### Content of the training with a focus on radiation protection, quality management and safety

Specific hours related to radiation protection and patient safety are not specified but are embedded in the curriculum.

#### Certification

Programmes lead to a bachelor's degree (EQF Level 6) qualification which is recognised as entry qualification to the profession in the disciplinary areas of medical imaging, nuclear medicine, and radiotherapy.

### 3.5.3 Recommendations

#### Recommendation 1: Entry routes and criteria to enter Radiographer education and training programmes.

To cater for the future workforce demands across European Union (EU) Member States it is essential that the diversification of entry routes to education and training programmes for Radiographers (medical imaging, nuclear medicine, and radiotherapy) is a priority action. While traditional entry requirements can be preserved, new 'non-standard' pathways to facilitate: second level school leavers who do not achieve the standard entry requirements; recognition of prior learning for graduates of other third level programmes with a desire to become radiographers, and individuals with significant relevant experiential learning, both healthcare professionals / workers with and without third level professional qualifications. All pathways should aim to ensure diversity in entry to education and training programmes with due consideration of social disadvantage, physical needs, and learning needs.

While European Qualifications Framework (EQF) Level 4 remains the recommended minimum entry level for radiographer education and training programmes, opportunities should also exist through appropriate access to higher education programmes for those who may not have a successful completed second level school leaving examinations at EQF Level 4.

**The recommendations would be:**

- **To implement diverse pathways into education and training programmes for radiographers in all EU Member States, and,**

- **To ensure that opportunities exist for all aiming to train as radiographers to do so through the implementation of appropriate access programmes.**

## Recommendation 2: Towards harmonisation of the structure of training

The European Federation of Radiographer Societies (EFRS) recommendation for education and training programmes to be offered at a minimum of EQF Level 6 (Bachelors) for entry into all branches of the profession (medical imaging, nuclear medicine, and radiotherapy) stands.

Additionally, the EFRS recommendation for education and training programmes to comprise a minimum of 180 ECTS also stands.

For dedicated programmes for any of the three branches of the profession (medical imaging, nuclear medicine, and radiotherapy), consideration must be given to ensure the curriculum encompasses all core content and core clinical experiences for the branch in question. For ‘combined’ programmes i.e., programmes which comprise medical imaging, nuclear medicine, and radiotherapy, additional consideration must also be given to the scope of the overall curriculum to ensure core content and core clinical experiences across the included branches of the profession.

Clinical training must be a compulsory component of all education and training programmes. It is recognised that there is much variability in the proportion, as a percentage, of clinical training within programmes, however, it is recommended that clinical placements should constitute a minimum of 25% of the overall programme ECTS, with the emphasis of this being of high quality, comprehensive, and varied clinical activities. Clinical training should take place in recognised / formally approved training centres, as per the EQF requirements, and should also be audited.

**The recommendations would be:**

- **To recognise EQF Level 6 (Bachelors) programmes of 180 ECTS as the minimum standard for entry to the profession in EU Member States, and,**
- **To ensure that both dedicated programmes in medical imaging, nuclear medicine, or radiotherapy, together with programmes combining two or three of these branches of the profession, encompass all core theoretical content and clinical experiences for each branch with clinical activities making up a minimum of 25% of the programme ECTS within recognised / approved training centres which are subject to regular audit, and,**

- **To establish diverse approaches to teaching, learning, and assessment which are practice-based and focused on true clinical scenarios, and,**
- **To create programme structures which also facilitate completion on a part-time basis, and,**
- **To ensure student radiographers receive equal treatment as other healthcare students in terms of consideration for payments linked to their clinical training.**

### Recommendation 3: Towards harmonisation of the content of the training (with a focus on radiation protection, quality management, leadership skills and safety)

The effective management of radiation protection and other risks to patients, carers, self, staff, and the public, together with the maintenance of a positive safety culture at all times, must be at the core of all programmes. This is critical to the delivery of safe and efficient medical imaging, nuclear medicine, and radiotherapy services, as is clinical governance.

Research, like education, is fundamental to the development of the professional field of knowledge of radiographers and to their effective practice, as well as to the patients and communities they serve. All education and training programmes must ensure that the development of evidence-based practitioners is a focus and is embedded throughout curricula [1, 4].

Similarly, emphasising the importance of mandatory continuing professional development (CPD) and fostering life-long learning, is essential for all radiographers [5].

New technologies and techniques, including automation, artificial and augmented intelligence, and robotics will also be a feature of the profession's practice and research, with radiographers utilising such technologies on a daily basis to support and enhance their work as well as undertaking research to critically examine the impact of these on the safety and quality of care of patients and the value they offer to the public [1].
The curriculum should also focus on the fundamental importance of the radiographers' role as the human interface between patients and technology, on the care and safety of patients, including radiation safety and protection, and on the need for effective interprofessional team working to properly support patients [2].
The important skills of effective communication, critical thinking, teamwork, leadership skills and ethical standards of practice must be included to enable individual radiographers to perform to the highest standards, from the professional, ethical, and societal perspectives, at all times.

The topics dedicated to radiation protection should align with the latest recommendations arising from projects such as EURAMED rocc-n-roll [6]. Quality management, quality improvement and safety, beyond radiation protection measures, are important, and it is thus essential for radiographers to have a very strong understanding to engage with and apply these principles. National regulatory or professional bodies should hold responsibility for defining the core curriculum, with the education and training delivered by higher education institutions (HEI) with due consideration of the EFRS EQF Benchmarking Documents for Radiographers [7-9] along with other consensus frameworks can be used to develop the curriculum.

**The recommendations would be:**

- **Necessary to establish minimum required curricular content at European level related to radiation protection, quality management, safety, and related professional topics, for programmes across all Member States**
- **To clearly identify the development of evidence-based practice and research skills throughout curricula, and,**
- **To ensure that mandatory CPD and the importance of life-long learning are recognised within programmes and that opportunities exist for all radiographers to engage in such activity, and,**
- **To establish core curricula, which are evidence-based and aligned with recognised frameworks, fit for purpose, consider the future of the profession, and are reviewed regularly, at a national level.**

### Recommendation 4: Towards national certification / registration

Programmes lead to an accredited bachelor's degree (EQF Level 6) qualification which is recognised as entry qualification to the profession in the disciplinary areas of medical imaging, nuclear medicine, and radiotherapy, with graduates registered and licensed to practice independently with HEIs and programmes subject to appropriate accreditation processes and professionals subject to appropriate registration / licensing requirements.
Undergraduate programmes providing entry to the profession should lead to radiographers possessing a high level of professional knowledge, skills, and competencies required to ensure associated high quality professional practice. Additional postgraduate opportunities, to further develop knowledge, skills, and competencies e.g., in radiation protection to facilitate the role of the radiographers as a radiation protection officer (RPO) and radiation protection expert (RPE) [9] or linked to magnetic resonance imaging safety, and the role of a magnetic resonance safety officer (MRSO) [10] as two examples.

It is being strongly recommended that radiographers training should not stop with certification, but that continuing professional development/education be mandatory for all and aligned with EFRS recommendations [5].

**The recommendations would be:**

- **To implement national programme accreditation systems, and,**
- **To establish national certification / licensing requirements and systems for individuals completing accredited programmes with ongoing licensing requirements for professionals, and,**
- **To recognise the need for additional postgraduate education and training for radiographers undertaking specialist / expert roles.**

### 3.5.4 Recommendations (summarised)

- To implement diverse pathways into education and training programmes for radiographers in all EU Member States, and,
- To ensure that opportunities exist for all aiming to train as radiographers to do so through the implementation of appropriate access programmes.
- To recognise EQF Level 6 (Bachelors) programmes of 180 ECTS as the minimum standard for entry to the profession in EU Member States, and,
- To ensure that both dedicated programmes in medical imaging, nuclear medicine, or radiotherapy, together with programmes combining two or three of these branches of the profession, encompass all core theoretical content and clinical experiences for each branch with clinical activities making up a minimum of 25% of the programme ECTS within recognised / approved training centres which are subject to regular audit, and,
- To establish diverse approaches to teaching, learning, and assessment which are practice-based and focused on true clinical scenarios, and,
- To create programme structures which also facilitate completion on a part-time basis, and,
- To ensure student radiographers receive equal treatment as other healthcare students in terms of consideration for payments linked to their clinical training.
- Necessary to establish minimum required curricular content at European level related to radiation protection, quality management, safety, and related professional topics, for programmes across all Member States
- To clearly identify the development of evidence-based practice and research skills throughout curricula, and,

- To ensure that mandatory CPD and the importance of life-long learning is recognised within programmes and that opportunities exist for all radiographers to engage in such activity, and,
- To establish core curricula, which are evidence-based and aligned with recognised frameworks, fit for purpose, consider the future of the profession, and are reviewed regularly, at a national level.
- To implement national programme accreditation systems, and,
- To establish national certification / licensing requirements and systems for individuals completing accredited programmes with ongoing licensing requirements for professionals, and,
- To recognise the need for additional postgraduate education and training for radiographers undertaking specialist / expert roles.

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## 3.6 Radiation Therapists (RTTs)

Authors: M. Coffey, M. Leech (European Society for Radiotherapy and Oncology – ESTRO)

### 3.6.1 Introduction

These guidelines have been developed based on the results of the EU-REST survey circulated as part of Work Package 1 (Data collection and analysis), the literature review completed as part of Work Package 2 (Drafting guidelines for staffing and education/training), the requirements relating to education and training in radiation protection as defined in European legislation and from additional resources identified through local, national, and international experience and professional recommendations.

Following recognition by the European Skills, Competences, Qualifications and Occupations (ESCO) framework it was decided that radiation therapist education and training requirements would be considered independent of diagnostic radiography and nuclear medicine. This was reflected in the survey where radiographers were asked to indicate if they completed the survey also on behalf of radiation therapists and there was no indication of this noted. The literature review also focussed specifically on radiation therapists.

### 3.6.2 European legislation

Appropriate education and training in radiation protection in medical radiological procedures is enshrined in European legislation.

Article 18: "Member States shall ensure that practitioners and the individuals involved in the practical aspects of medical radiological procedures have adequate education, information and theoretical and practical training for the purpose of medical radiological practices, as well as relevant competence in radiation protection." Also stated is the requirement for recognition of qualification and the need for continuing education.

Article 14: "Member States shall establish an adequate legislative and administrative framework ensuring the provision of appropriate radiation protection education, training and information to all individuals whose tasks require specific competences in radiation protection."

### 3.6.3 Survey results

#### 1. General commonalities identified

As part of Work Package 1 a set of commonalities among the professions was described. These commonalities are at a high level and for radiation therapists do not reflect the reality in many countries. For radiation therapists the minimum entry level is commonly completed second level education consistent with the commonalities of the survey with the duration of training a minimum of 3 years. The findings of 70-80% academic content for radiation therapists reflects the programme offered but the problem for radiation therapists is the lack of specific education and occurs in a majority of education and training programmes where the radiotherapy content is frequently minimal. There was wide diversity identified in methods of assessment of knowledge, skills, and competences. Payment during training is not common. Certification level varies across countries and educational institutions offering the programme and there was general agreement that education and training centres should be formally accredited and that all aspects of radiation protection should be integrated into the education and training programmes.

#### 2. Radiation Therapist specific responses

The survey responses from radiation therapists were a mix of current practice and recommendations to improve the current status.

##### Current status

The duration of education and training ranged from 0 - 4 years with the 4-year programmes offering dedicated radiation therapist degrees and the majority of courses joint with other disciplines who dominate in terms of numbers and with minimum radiotherapy specific topics. The ESTRO core curriculum and the IAEA handbook for the education of radiation therapists remain the only professional organisation radiation therapy-specific core curricula available. A wide variation in the structure of training was noted again with a range of 0-30% clinical experience required. Clinical training specifically in radiotherapy was not a requirement in all programmes offered. In some countries mentorship is a requirement following graduation as the radiotherapy specific content delivered is considered inadequate for practice.

### Recommendations for improvement

A dedicated education programme meeting the specific requirements of radiation therapists is essential for safe and accurate practice and formal certification is essential. Clinical practice in radiotherapy should be compulsory with 20-30% of the programme dedicated to as wide a range of clinical experience as possible. Both academic and clinical assessment should be in place and education institutes should be audited. Radiation protection should be a core component of education and training programmes and should include knowledge of the existing legislation as it applies to patients, staff, and the general public. Continuous education and dedicated postgraduate courses should be offered to ensure continuing professional development for the future workforce. Continuing professional development (CPD) RTT-relevant courses must be supported both at national and local levels through time and resources. RTTs should be supported with time off locally to prepare and attend short courses. At a national level, CPD courses can be supported financially by Ministries of Health and Education to permit RTTs to attend and to facilitate national and international teachers of CPD programmes.

## 3.6.4 Literature Review

After a careful analysis of the papers identified based on the criteria defined in the survey the following outcomes are reported:

- Thirteen papers were identified that related to education and training for Radiation Therapists in Europe.
- Four papers addressed specific aspects of radiation therapy practice and were considered in this context. One paper addressed the barriers to Radiation Therapist education in Belgium and one compared curricula in radiation therapy in selected European countries.
- Two of the papers benchmarked Radiation Therapist competencies at the time of graduation and for the development of advanced practice.
- CC for Radiation Therapists have been produced by the European Society for Radiotherapy and Oncology (ESTRO) and the International Atomic Energy Agency (IAEA).
- CC for Radiation Therapists are recommended by the professional societies in Australia, Canada and the United States of America and were included in the review.
    - Education and training for Radiation Therapists across Europe is very varied with minimal content related to radiotherapy in many countries. The minimum entry level varies across countries but in the majority completion of second level education is a requirement

for entry into a radiation therapy programme of study. The duration of education programmes varied from a few weeks to four years with little consistency of content.

- Education and training for Radiation Therapists across Europe is very varied with minimal content related to radiotherapy in many countries. The minimum entry level varies across countries but in the majority completion of second level education is a requirement for entry into a radiation therapy programme of study. The duration of education programmes varied from a few weeks to four years with little consistency of content.

- Curricula were competency based in countries with a strong education and training programme. The percentage of time dedicated to clinical practice specific to radiotherapy varied from none to 35%, clinical education and training was not compulsory in many programmes and there was limited evidence of assessment of competences generally.
- In some countries, where the basic education programme was limited, specific certification in radiation protection was required.
- In most instances the qualifications gained were not mapped against international qualification standards and training centres were not formally certified, audited or assessed.

ESTRO has produced two benchmarking documents for Radiation Therapist practice. EQF Level 6 relates to competences desired of a graduate from an initial programme and EQF Levels 7 and 8 for advanced practice. Defining competences in this way provides a template for the development of core curricula aimed to achieve these competences. The benchmarking documents are detailed giving the skills and knowledge necessary to develop the specific competences identified for best practice. The ESTRO Core Curriculum for Radiation Therapists reflects the competences identified in the EQF Level 6 benchmarking document.

- Both the ESTRO CC and the IAEA Handbook for the Education of Radiation TherapisTs (RTTs) recommend completion of second level education prior to commencing a programme of study for radiation therapy, with the IAEA further recommending content in mathematics, life sciences and physical sciences. ESTRO recommends a minimum radiation therapy programme duration of 3 years with the IAEA recommending a minimum of 2 years with a recommendation of 3 and 4 where possible. This reflects the international context of the IAEA where resources are low, staffing is a significant problem and education and training in Radiation Therapy is not formally established in many low to middle income countries (LMICs). Both curricula are competency based.

- The ESTRO CC recommends 20-30% of the programme be dedicated to radiotherapy specific clinical education with clinical educators in place to oversee the placements. The IAEA acknowledges that in some LMIC countries this is challenging where resources are limited and a series of detailed charts document academic and clinical breakdown depending on resources and the duration of the programme.
- Methods to assess competencies are described in both CC. Degree, diploma and certification are given depending on the content and duration of the programme but degree level is recommended. The IAEA CC is currently under revision and will recommend degree level only.
- The issue of trainee payment is not addressed in any of the papers or CC reviewed. The core components of the curricula provide the necessary content to understand the effect of radiation on tissue to ensure safe clinical practice and include radiation protection, quality and safety management and research.
- The number of hours dedicated to radiation protection are not stated but are integral to the academic content reflecting the wider context of radiation protection in radiotherapy. The CC is defined generally by the College or University where the programme is delivered but recommendations by the professional bodies and regulatory authorities are taken into account when designing the programme.
- In both documents it is recommended that education is delivered in an academic setting with associated clinical departments offering a wide range of experience and clinical training is compulsory in both documents. Graduates from programmes reflecting the core curricula are licensed to practice independently but this is country specific and related to its regulatory practice. Certification in radiation protection is required in centres where this has not been integrated into the academic programme but that this is inconsistent with the recommendations of the CC. It is recommended that education/training centres are formally certified, assessed and audited with the ESTRO CC providing such guidelines. Recommendations for minimum standards are given and detail on what additional content should be included.
- Core curricula recommendations have been developed in Canada, Australia, and the USA. In Canada and Australia, the recommendations are reflected in the academic programmes offered, in the USA the curricula vary from state to state and CC recommendations are not necessarily incorporated into programmes. Certification in the USA is also state-based and there is a wide variation of standards and requirements.
- Completion of second level education is a requirement to enter radiation therapy programmes of all three countries with the USA also

recommending post-secondary education college credits in defined topics – mathematics and reasoning, communication, humanities, information systems, social sciences, and natural sciences.

- A course duration of 3-4 years is recommended by all, and the CC are competency based. In Canada and Australia clinical training is stated as 30%+ of the overall programme but no value is given in the American CC.
- Clinical competencies are assessed in Canada and Australia but not the USA. It is not stated in any of the CC that trainees should be paid. In all three countries the professional society is responsible for defining the CC. Clinical training is compulsory in all three CC and in Canada and Australia the graduates are licensed to practice independently but, in the USA, it is state dependent.
- Radiation protection is integrated into all three CC and no additional certification is required. The radiation protection component is again defined by the professional bodies with certification integrated into the education programme.
- In Canada and Australia, the qualifications are mapped to the core curriculum and CanMEDs and largely leading international standards, the American CC is not mapped against international qualification standards but is consistent with them. Continuing education is mandatory in all three CC. In Canada and Australia training centres are formally certified but this is not stated in the American CC. Canada and Australia (and New Zealand although the CC was not available to review) have well established degree programmes in radiation therapy that are competency based and at a high level.

The following guidelines have been identified:

Some papers addressed specific aspects of radiation therapy practice [1-2]. One paper identified the barriers to radiation therapist education (Belgium) [3] and two ESTRO benchmarking documents defined radiation therapist competencies at the time of graduation [4] and for the development of advanced practice [5]. Two radiation therapist-specific core curricula have been produced by ESTRO [6] and the IAEA [7] and core curricula for radiation therapists have also been recommended by professional societies in Australia [8], Canada [9] and the United States of America [10]. In countries with well-developed education programmes for radiation therapists the move is towards competency-based education reflecting the complexities of clinical practice and preparing graduates to deliver quality and safe practice and to enable them to adapt to evolving changes in the future. Defining competences provides a template for the development of core curricula reflecting the knowledge and skills necessary to underpin the required competence for best practice.

### 3.6.5 Existing practice

This section is evidenced by a survey carried out in 2021 the results of which were published in 2022 [1] on personal knowledge of existing education programmes. The survey was circulated across Europe, Australia, New Zealand, USA, and South Korea. 101 responses were received of which 58 were complete representing 30 countries, 26 European and 4 outside Europe. No response was received from the United Kingdom, Germany, Spain or Portugal but there is personal knowledge of education in these countries, with the United Kingdom offering 3 year degrees specifically in radiation therapy. Portugal did have a 4 year degree dedicated to radiation therapy and which was highly regarded but was closed down in favour of joint programmes with work ongoing to try to restore it. Germany has a joint programme as does Spain. Ireland, Scotland, Australia and New Zealand all offer 4-year degree programmes specific to radiation therapy. Countries other than Scotland within the United Kingdom offer 3-year specific degree programmes. Cyprus send their students to the UK for education. In Armenia, Belgium, Denmark, and the Russian Federation, the legal qualification to work as radiation therapist is nursing with no requirement for any radiation therapy-specific education. In Belgium radiographers are also entitled to work in radiotherapy. In some of these countries additional education in radiation protection is a requirement to practice but the content of such education is general radiation protection and not specific to the protection focus of radiation therapy as detailed in the indicative competences given below. In two countries there is no defined professional qualification required to work as a radiation therapist. 17 countries offer combined programmes of duration 2-4 years, or a hospital-based training programme in one instance. Radiotherapy specific content of combined programmes varied from 10-50% with a significant level of inconsistency in the responses. Radiation Therapists were directly involved in the education programme in only 14 countries and the subject taught varied considerably both within and across countries with the majority focussing on practical aspects such as positioning and immobilisation, treatment techniques and communication skills. Education in the radiotherapy content was covered by radiation oncologists, medical physicists, nurses with 20% of countries also stating that radiation therapists had no input into the clinical component of the education programme or the assessment of competences achieved. In the majority of cases the programme leader was from another discipline which potentially explains the lack of radiation therapy specific content. Postgraduate programmes have been established in some countries largely with a focus on radiation therapy, however some programmes have still depended on content from other disciplines in their programme design thereby still limiting the radiation therapy specific content. Formal assessment of the clinical component was reported by only 5 responding countries. 9 countries responded that CPD was compulsory with 14 countries stating that CPD opportunities were available in their country with Belgium responding that this was only available for nurses working in radiation therapy. The level of understanding of the European Credit Transfer System (ECTS) was very varied and often limited and it is important to address a standardised approach consistent with the Bologna Process.

### 3.6.6 Recommendations

It is acknowledged that 50%-60% of cancer patients will benefit from radiotherapy as part of the management of their disease. The incidence of cancer is increasing with an ageing population so it is likely that demand for radiotherapy services will continue to increase in the future. It is therefore more important than ever to ensure that the radiation therapists who are ultimately responsible for the direct delivery of treatment are educated sufficiently to enable to delivery of a safe and accurate treatment to all patients irrespective of location and/or resources.

**1. From the EU-REST survey**

These are recommendations given by one or more respondents. The aim is to enable new graduates to start working immediately in a radiotherapy setting without the requirement of additional education or extended mentorship periods. Education and training programmes should be sufficiently robust to ensure that graduates from these programmes are competent to be licenced to practice. Duration of training of 3 years dedicated to radiation therapy specific topics with a minimum of 20-30% clinical training in a range of clinical settings with radiation therapists acting as clinical educators and formal assessment of competencies achieved. Mandatory accreditation of training centres should be introduced with regular audit to ensure continued relevance to clinical practice. CPD and postgraduate options should be available. Radiation protection and quality and safety management should be integral to any education and training programme in order for graduates to be able to practice accurately and safely. Research and AI and its impact on practice should be included in an education and training programme. The leader of programmes should be a radiation therapist and both academic and clinical content should be radiation therapist led.

### 3.6.7 Recommended guidelines

In preparing this guideline it is important to consider what radiation protection in radiotherapy encompasses as this determines how clinical practice is integrated into specialist education and training programmes. Radiation energies used in the preparation and delivery of radiotherapy range from diagnostic to megavoltage treatment units including protons and brachytherapy and education and training must reflect this spectrum. The safety of staff, the general public, and patients must therefore be considered in this context.

**These recommendations for education and training incorporate improvements that need to be made to ensure that all programmes contain sufficient knowledge, skills, and competences to enable graduate radiation therapists to work accurately and safely in a radiotherapy department without the need for extensive additional education or extended mentorship programmes which are currently common practice.**

**Where a competency-based approach to education is the optimal we are also giving an indication of the type of topics that should be included to underpin the knowledge component. The key competences relating to radiation protection and safety and consistent with the CanMEDs Competency Framework, are Radiation Therapist Expert and Professional. It should be reiterated that these are components of an education programme and not sufficient of themselves.**

### Professional / Quality Care Provider (competency)

As members of the radiotherapy team radiation therapists are responsible for the radiation protection and health and safety of staff, patient and the public while they are present in the radiotherapy department.

### Indicative components to be covered:

#### 1. Staff and the general public

- European legislation and national implementation.
- Safety procedures in the department – e.g. signs, warning lights and verbal warnings, door interlocks, area designation, shielding, workplace monitoring when appropriate.
- Local rules and procedures.
- Occupational and public exposure – dose limits and monitoring, investigation, reporting and corrective measure where necessary, protective equipment if required.
- Room design and construction.
- Safety and emergency systems in place – ‘last person out button’.
- Source safety for brachytherapy including storage, preparation, transport and shielding.

### 2. Patients (general)

- Protocols, procedures and local rules in place.
- Patient identification.
- ALARA principle.
- Benefits and risks.
- QA and QC procedures.
- Incident reporting and learning.

The aim of radiotherapy is to deliver a high dose to the tumour within the overall prescribed time with minimum damage to normal tissue and related organs at risk. In order to achieve this, radiotherapy departments employ a wide range of technology and techniques and understanding the associated risks from the perspective of radiation protection is essential. The equipment type and technique in common use, the role of imaging and imaging dose, and radiation protection principles and underpinning legislation all contribute to the definition of academic content of education and training programmes for radiation therapists.

## Radiation Therapist Expert

The Radiation Therapist is able to understand and interpret the treatment prescription in order to accurately prepare and deliver a course of treatment to an individual patient.

## Indicative components to be covered:

### 3. Patient treatment general

- Limited access control area.
- Accessory equipment including setup systems (alignment lasers or surface guided) and immobilisation devices necessary for accurate positioning and reproducibility.
- Preparatory imaging procedures
    - Justification including potential alternatives.
        - Appropriate information for treatment decision making and planning.
        - Avoiding repeat imaging where possible.

  - Optimisation
    - Volume of interest defined.
    - Scout views and slice thickness for CT etc.
    - Patient position.
    - Use of diagnostic reference levels (DRLs) and dose recording.
- Image guided radiotherapy – how frequently should imaging be carried out during treatment.
  - Purpose of imaging.
  - Action taken following imaging.
- Maintaining clear and detailed medical records and comprehensive datasets including dose delivered from all sources of exposure.

## 4. Individual patient

To meet the aim of radiotherapy it is necessary to understand the interaction of radiation and tissue and how it varies for different tissues/organs, tolerance doses, dose and fractionation schemes, the underpinning science and selection for treatment, the position/relationships of organs within the body. Radiation protection is based on delivering the correct dose to the correct volume and positioning and immobilisation is key to achieving this and requires an understanding and awareness of the potential for harm when treatment is delivered incorrectly.

- Positioning and immobilisation
- Cross sectional anatomy and organ relationships.
- Blood supply and lymphatic drainage.
- Radiobiology/molecular oncology and the dose tolerances of different organs and tissues.
- Physiological changes.
- ICRU recommendations.
- In-vivo dosimetry.
- Motion management.
- Interaction with other modalities – chemotherapy / immunotherapy.
- Principles of fractionation and overall time.
- Patient monitoring for movement, weight gain or loss etc.

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11. Technical Innovations and Patient Support in Radiation Oncology (24 (2022) 59-62)

# Annex 6: Report on project conclusions and recommendations

# Report on project conclusions and recommendations (Project Deliverable 14)

Service contract HADEA/2022/OP/0003

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# Disclaimer

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# List of Abbreviations

| | |
|---|---|
| **AB** | Advisory Board |
| **CPD** | Continuing Professional Development |
| **DRL** | Diagnostic Reference Level |
| **EACCME** | European Accreditation Council for Continuing Medical Education |
| **EANM** | European Association of Nuclear Medicine |
| **EBR** | European Board of Radiology |
| **EC** | European Commission |
| **ECTS** | European Credit Transfer System |
| **EDIR** | European Diploma in Radiology |
| **EFOMP** | European Federation of Organizations in Medical Physics |
| **EFRS** | European Federation of Radiographer Societies |
| **EQF** | European Qualifications Framework |
| **ESCO** | European Skills, Competences, Qualifications and Occupations |
| **ESMIT** | European School of Multimodality Imaging & Therapy |
| **ESR** | European Society of Radiology |
| **ESTRO** | European Society for Radiotherapy and Oncology |
| **ETAP** | European Training Assessment Programme |
| **ETC** | European Training Curriculum |
| **EU** | European Union |
| **FTE** | Full-time equivalent |
| **HERCA** | Heads of the European Radiological protection Competent Authorities |
| **HERO** | Health Economics in Radiation Oncology |
| **IAEA** | International Atomic Energy Agency |
| **ICRP** | International Commission on Radiological Protection |

| | |
|---|---|
| **IGP** | Internal Growth Product |
| **IR** | Interventional Radiology |
| **MCQ** | Multiple Choice Question |
| **MDT** | Multidisciplinary Team |
| **MPE** | Medical Physics Expert |
| **MR** | Magnetic Resonance |
| **NM** | Nuclear Medicine |
| **OECD** | Organisation for Economic Co-operation and Development |
| **PET** | Positron Emission Tomography |
| **PRG** | Peer Review Group |
| **QA** | Quality assurance |
| **QC** | Quality control |
| **RP** | Radiation protection |
| **RPE** | Radiation Protection Expert |
| **RT** | Radiotherapy |
| **RTT** | Radiation Therapist |
| **TIPSS** | Transjugular intrahepatic portosystemic shunt |
| **UEMS** | European Union of Medical Specialists |
| **WP** | Work Package |
| **WTE** | Whole-time equivalent |

# 1. Introduction

The service contract ‘EU-REST’ (European Union Radiation, Education, Staffing & Training) commenced on 1 September 2022 and will continue until 31 August 2024.

The study aims to provide an analysis of workforce availability, education, and training needs to ensure quality and safety aspects of medical applications involving ionising radiation in the European Union (EU) and foresees the development of staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications in the EU Member States.

The study aims to meet the following specific objectives:

- Collect and analyse data on workforce availability, education, and training needs to ensure quality and safety aspects of medical applications involving ionising radiation, as well as related stakeholder mapping;
- Draft guidelines for staffing and education/training for medical and other professionals involved in medical radiation applications in Member States and related stakeholder consultation;
- Develop conclusions and recommendations on EU workforce availability, education, and training needs for the quality and safety of medical applications involving ionising radiation and related stakeholder consultation.

This report provides an update on work conducted to date, specifically in relation to Work Package (WP) 3, Task 3.2. WP3 aims to provide the conclusions and recommendations on the EU workforce availability, education and training needs for the quality and safety of medical applications involving ionising radiation, for Medical Doctors, Radiographers, Radiation Therapists, Medical Physicists and other health professionals using ionising radiation, following the “step 3” stakeholder consultation process.
The following professional groups are covered:

- Radiologists
- Nuclear Medicine Physicians
- Radiation Oncologists
- Medical Physicists
- Radiographers
- Radiation Therapists (RTT)

The conclusions and recommendations are based on the deliverables from WP1 and WP2, a literature review and the outputs from the stakeholder consultation process step 2 made through an online survey.

Task 3.2 began in month 19 (March 2024) of the study and will conclude in month 22 (June 2024) after submission of the present draft conclusions and recommendations in month 20 (April). The task has been led by Prof. Adrian Brady with the contribution of all guideline writing group, i.e., consortium members.

## 1.1 Background and objective

The objective of this particular task (T3.2) of the EU-REST study was to formulate project recommendations with respect to: (i) further European staffing and education/training guidelines, and (ii) the needs for national and European support for education/training of medical professionals in quality and safety of medical radiation applications. This was preceded by a benchmarking exercise (Task 3.1) aimed at drawing EU-wide and Member State-specific conclusions with respect to: (i) the availability of the different categories of staff with responsibilities for quality and safety of medical applications, and (ii) the education/training of this staff in key quality and safety aspects.

The draft project conclusions and recommendations (v1) were subject to a stakeholder consultation, which informed the present revised, final Project Conclusions and Recommendations (v2).

## 1.2 Methodology for the conclusions and recommendations

Task 3.2 relied on D11.v2 (Staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications), a comprehensive set of guidelines for each of the professional groups listed above, which was prepared and finalised under Task 2.4, D12 (Benchmarking of workforce availability and training) as conducted by Task 3.1. as well as on D10 (Report on the ‘Step 2’ stakeholder consultation) as carried out by Task 2.6, which included questions on the need for further European staffing and education/training guidelines, and (ii) the needs for national and European support for education/training of medical professionals in quality and safety of medical radiation applications.

The present final version (D14.v2) of the Project Conclusions and Recommendations takes into account the feedback from stakeholders as well as on the report on the benchmarking of workforce availability and training

(D12), which was produced in parallel to the Draft Report on the project conclusions and recommendations (D14.v1).

## 1.3 Terminology and professions considered

In the tender application, the consortium preliminarily agreed on the professional groups below (listed in Task 1.1. of the Technical Offer):

a. Medical doctors
   iv. Radiologists
   v. Radiation Oncologists (including clinical oncologists – depending on local nomenclature) and, in some countries, Radiotherapists, distinct from b.iii below)
   vi. Nuclear Medicine physicians

b. Radiographers (known by a variety of terms, including radiology technologists etc.) and Radiation Therapists (known as RTT, radiotherapy technologist or therapeutic radiographer in some countries, distinct from a.ii above)
   iv. Diagnostic & Interventional Radiology
   v. Nuclear Medicine
   vi. Radiotherapy / Radiation Oncology

c. Medical Physicists (including Radiation Protection Advisors & Medical Physics Experts, depending on categorisation in each country)
   iv. Diagnostic & Interventional Radiology
   v. Radiation Therapy
   vi. Nuclear Medicine

d. Other professions using ionising radiation (focusing on high-dose procedures): Some other medical specialists and professions utilise ionising radiation in the performance of their work. Some of these confer relatively low radiation doses on patients (e.g. dentists). Examples of usage with the potential for high radiation dose include interventional cardiology, gastroenterology, endovascular intervention, and some surgical specialties (e.g. urology, orthopaedic and trauma surgery, neurosurgery).

The first step prior to collecting up-to-date data on staffing, education, and training of the relevant key professional groups in Member States was a pre-survey directed at professional societies and associations within each country, asking for information and contacts of those bodies which could provide the information required.

The pre-survey included the professions as specified in the Technical Offer.

Following further feedback on the Pre-Survey after the Inception Meeting, it was agreed that Radiographers and Radiation Therapists will be addressed separately in the Main Survey, where country-specific information suggests this is appropriate. The Main Survey collected data related to A) education and training, B) workforce numbers, demographics and availability, C) workforce planning and D) quality and safety.

The following professional groups are, therefore, covered by the EU-REST study:

- Radiologists
- Nuclear Medicine Physicians
- Radiation Oncologists
- Medical Physicists
- Radiographers
- Radiation Therapists (RTT) – for countries where this group of workers are independent from the category of Radiographers

The consortium recognises the different viewpoints related to “Radiation Therapist (RTT)” as a profession separate from Radiographer:

**ESTRO:**

ESTRO highlights the recognition of the radiation therapist profession by the ESCO framework. ESCO describes radiation therapists (code 3211.2, category “Technicians and associate professionals”) as follows: “Radiation therapists are responsible for the accurate delivery of radiotherapy to cancer patients and, as part of the multidisciplinary team, for elements of treatment preparation and patient care. This encompasses the safe and accurate delivery of the radiation dose prescribed and the clinical care and support of the patient throughout the treatment preparation, treatment delivery and immediate post treatment phases.” ESTRO points out that Radiation Therapists (distinct from Radiation Oncologists) are known across Europe by over 20 titles, including RTT, radiotherapy technologist, therapeutic radiographer, nurse working in radiotherapy etc., the key criteria being that they are directly involved in radiotherapy preparation and delivery. The full list of titles used across the EU for radiation therapist is available at:

https://esco.ec.europa.eu/en/classification/occupation?uri=http://data.europa.eu/esco/occupation/e139b0a3-3bc5-4c33-bfbf-51ac20ac12fa

### EFRS:

Radiographers in radiation therapy are included, along with medical imaging and nuclear medicine radiographers, in the professional group 'Radiographers' as defined by the EFRS.

According to ESCO (code: 2269.8, category "Professionals"), "Radiographers use a range of technologies to examine, treat and care for patients. They work in the fields of Medical Imaging, Radiotherapy and Nuclear Medicine and apply ionising radiation, ultrasound, magnetic resonance imaging and radioactive sources."

The list of titles used across the EU for radiographer is available at:

https://esco.ec.europa.eu/en/classification/occupation?uri=http://data.europa.eu/esco/occupation/7639a601-6db0-41ed-9fb0-813d9b8beb05

### WHO:

The World Health Organization's Radiation and Health Unit, which is represented on the EU-REST Advisory Board, pointed out the ambiguity of the term "Radiation Therapist (RTT)", mentioning that in many languages "therapist" is used for medical doctors performing the therapy rather than for radiation technologists or radiographers, and raised concerns about possible confusion resulting from treating RTTs as a separate profession in the EU-REST Conclusions and Recommendations.

### Stakeholder consultation:

3 out of the 73 stakeholders who provided feedback pointed out the overlap between the radiographer and the RTT sections and the unclarity resulting from it.

The EU-REST study leaders acknowledge these different standpoints and the resulting ambiguities. Resolving this issue is, however, beyond the scope of the EU-REST study.

# 2. General Recommendations

## 2.1 Introduction

Earlier phases of this project have revealed both many common elements affecting all professional groups involved in the study, and many elements which are specific and individual to each professional group. Section 3 of this document will outline the profession-specific recommendations for each group. This Section 2 will detail a set of general recommendations that are applicable to all professional groups.

## 2.2 National registries

The data collection and analysis (D4) as well as the literature review (D6: Report on the identification and collection of existing guidelines) performed in the course of the EU-REST study, in preparation of the development of the Staffing and Education/Training Guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications (D11) revealed a general lack of existing metrics about workforce availability for the professions, and an absence of any widely-applicable future-proofed standards for appropriate staffing levels (see also D12). Furthermore, available official data about equipment availability (EUROSTAT and OECD reports) were found to be inconsistent. Efforts by the EU-REST Consortium to develop staffing level guidelines will be outlined in Section 3 (and have been submitted in greater detail in Deliverable 11).

**Despite the diversity of professional groups, the guideline writing groups concur in recommending that each EU Member State should maintain a central registry for each professional group, and for equipment relevant to the performance of their work. Each Member State should ensure (ideally uniform) high quality of the data, including information on the**

- **Number of professionals (and, if possible, number of whole-time equivalents)**
- **Age and gender profile of professionals (to allow for planning of training positions for future staff, retirement replacements, etc.)**
- **Appropriate qualifications needed for inclusion in the registry, and for licensing for independent practice**

Such registries should, ideally, operate on common standards across all EU Member States, to ensure a meaningful cross-comparison of data. To provide for this, the definitions used to collate and verify the data contained within these registries should be common for all Member States. Data maintained in such registries should be shared through the EC, to facilitate the collation and maintenance of EU-wide data.

Establishment of EU-wide common definitions of each professional group lies beyond the scope of the EU-REST study, but is necessary to ensure that the registry data outlined above will be comparable among all Member States, and useful for EU-wide understanding of staffing availability and needs (see Section 2.7).

## 2.3 Continuing professional development (CPD)

Continuing professional development (CPD) is. essential for professionals involved in the medical use of ionising radiation to stay current throughout their careers. CPD ensures that these professionals provide the highest quality of care and maintain the utmost safety for the patients they serve, whether directly or indirectly.

CPD in radiation protection is already required under the Basic Safety Standards Directive (BSSD), which has been transposed into national law in each Member State.

**Mandated CPD should also include techniques and knowledge relevant to each professional group, beyond radiation protection issues.** The exact methodology and requirements for CPD for each group is a matter for each Member State, but adoption of the general principle of its being mandated should be accepted by each state.

We acknowledge that there may be barriers to adoption of CPD requirements (beyond the BSSD) in some Member States, and that resourcing may be required in some states to support the achievement of the necessary CPD credits. Nonetheless, the fact that difficulties may arise does not negate the need for this recommendation to be implemented by all.

## 2.4 Barriers, risks and potential alleviation of the barriers

### 2.4.1 General

As mentioned above in Section 2.2., the recommendation of mandatory CPD (beyond the BSSD) could be a barrier to implementation of the EU-REST guidelines for certain Member States.

The EU-REST consortium acknowledges that the role of the European Commission (EC) in enforcing the adoption of the staffing and education/training guidelines, including national registries of professionals and equipment, by the Member States, is limited due to the lack of relevant legislation. Nevertheless, the consortium believes that the guidelines proposed under the present EU-funded study will contribute to improving the situation in EU Member States, if supported as appropriate standards by the EC. The extent to which this will be done will depend on the individual countries' needs and possibilities for improvement, and also on the support provided for promulgation of these proposed standards by EC agencies.

On an early positive note, it is heartening to report that a concrete impact has already been achieved prior to finalisation of the EU-REST study. As a consequence of the stakeholder consultation on the draft guidelines, the long-deplored lack of a regulated status for Medical Physics Experts (MPEs) in Croatia was brought to the attention of that country's Ministry of Health, and final discussions are currently underway to formalise medical physics education.

### 2.4.2 Results of stakeholder consultation

The draft guidelines developed by the EU-REST consortium were submitted to a defined set of stakeholders in November 2023, with the request to provide feedback by answering a questionnaire, which included questions on either perceived or potential barriers to implementing the staffing and education/training guidelines.

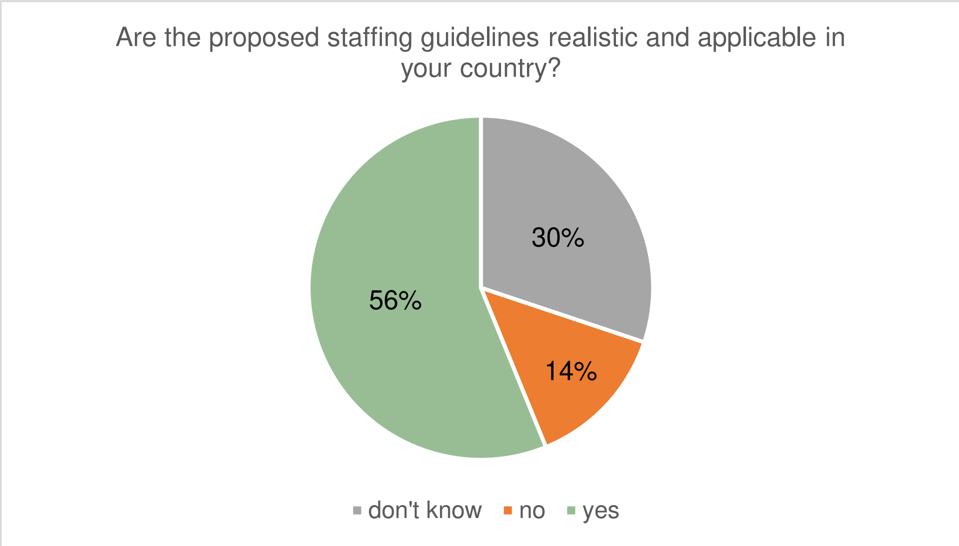
The questionnaire and analysis of the results is described in detail in D10: Report on the 'Step 2' stakeholder consultation. A summary of the responses to the questions related to barriers is provided below.

#### 2.4.2.1 Staffing guidelines

**Perceived and potential barriers to staffing guideline implementation**

It is worth noting that the majority of the respondents (56%) considered the proposed staffing guidelines realistic and applicable in their country (Figure 1).

**Figure 1 – Expected level of realism and applicability of proposed staffing guidelines**




38% of those who did not consider the guidelines realistic and applicable in their country saw financial issues and/or political framework/government-related issues as barriers to implementation (Figure 2). Among those who considered the proposed staffing guidelines realistic and applicable in their country or who did not know, 63% indicated these factors as possible barriers (Figure 3).

**Figure 2 – Barriers perceived by those not considering the proposed staffing guidelines realistic and applicable**

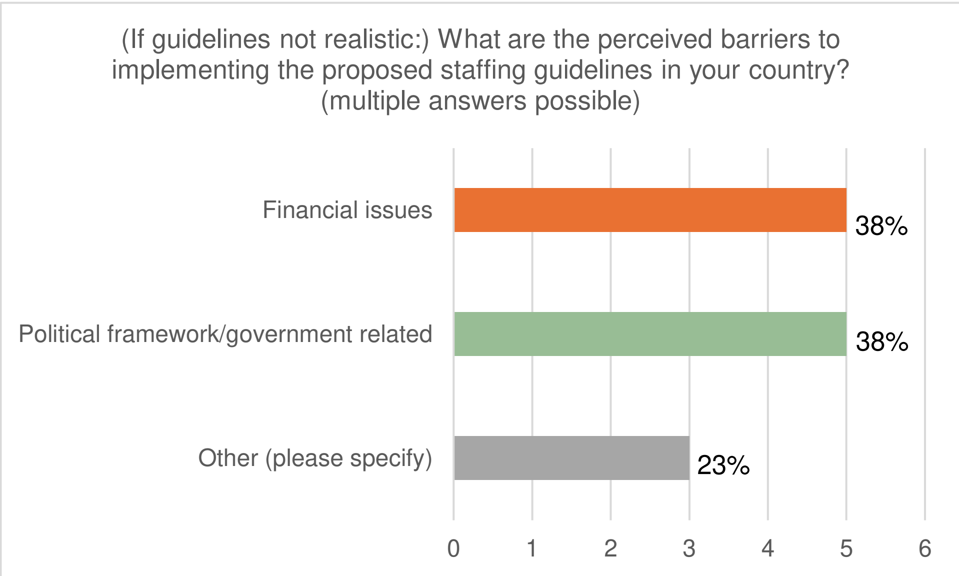
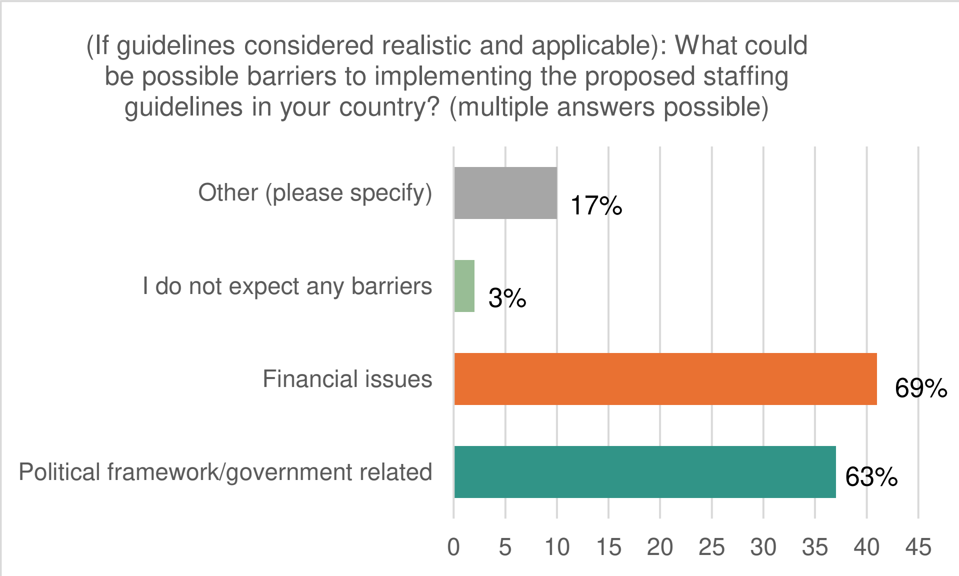


**Figure 3 – Possible barriers stated by those considering the proposed staffing guidelines realistic and applicable**




Other perceived and possible barriers indicated by respondents included a lack of (radiography/medical imaging/radiotherapy) students or (MPE) trainees, as well as (radiology/NM) physicians and training positions and capacities.

For MPEs, the lack of recognition as a healthcare profession was pointed out under this and/or other questions by respondents from Belgium, Croatia and Germany.

## Ways to overcome barriers to staffing guideline implementation

Suggestions on ways to overcome barriers to implement the proposed staffing guidelines can be summarised as follows:

Respondents from various countries and professions recommended engaging in dialogue with policy makers and/or implementing the guidelines through national authorities. Other suggestions provided by several countries and professions included raising awareness of the relevant professions, including among students, and collaboration with/among relevant professional societies. Financial considerations such as payment, reimbursement and funding of training were also mentioned.

## Ways to introduce the staffing guidelines

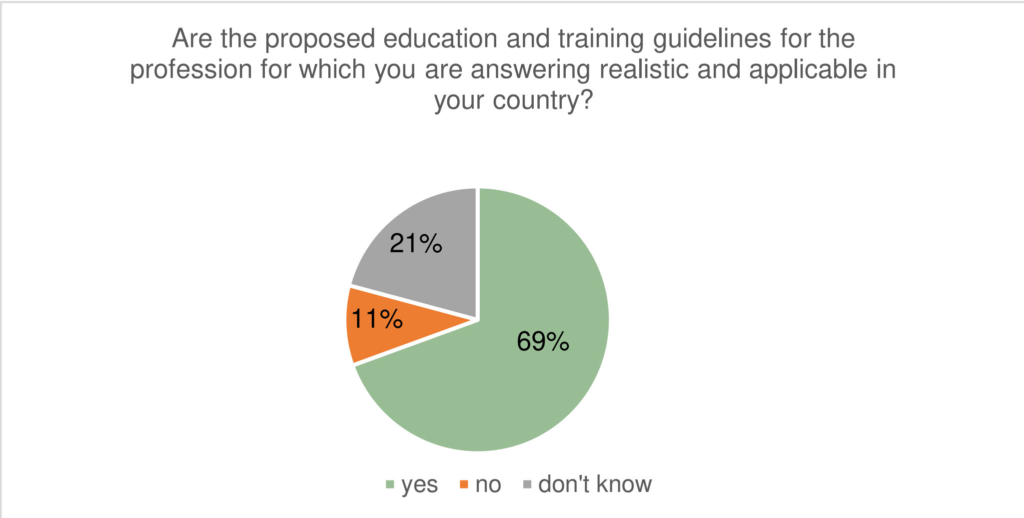
Various countries and professions suggested introducing the staffing guidelines through the Ministries of Health. Several countries and professions also suggested that this should happen through professional societies. Some countries and professions stated that the guidelines should be implemented by law. Another suggestion was to raise awareness of the guidelines via a short summary/video, webinars or publications in scientific journals.

#### 2.4.3.2 Education and training guidelines

**Perceived and potential barriers to education and training guideline implementation**

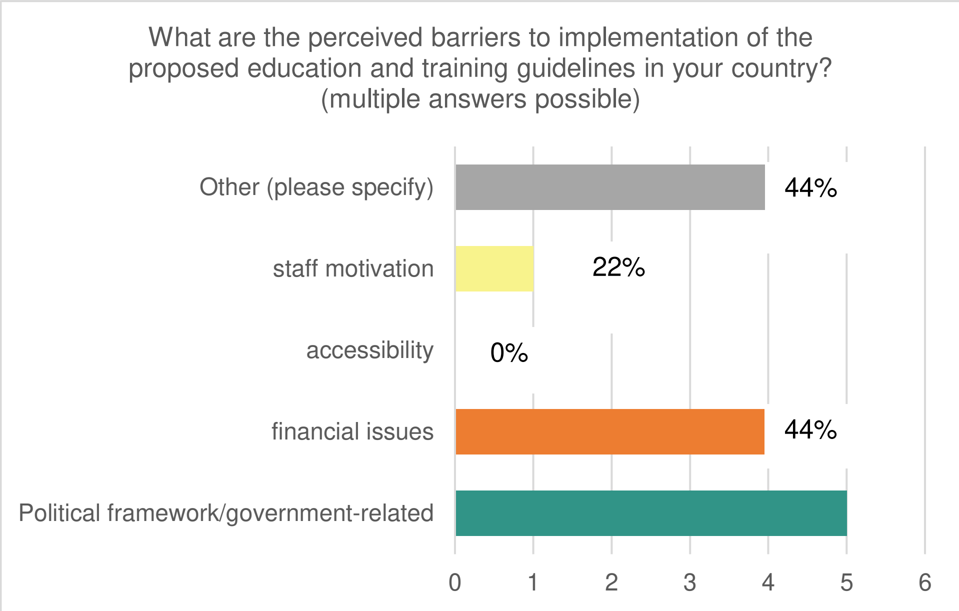
69% of the respondents considered the proposed education and training guidelines realistic and applicable in their country (see Figure 4).

**Figure 4 – Expected level of realism and applicability of proposed education/training guidelines**



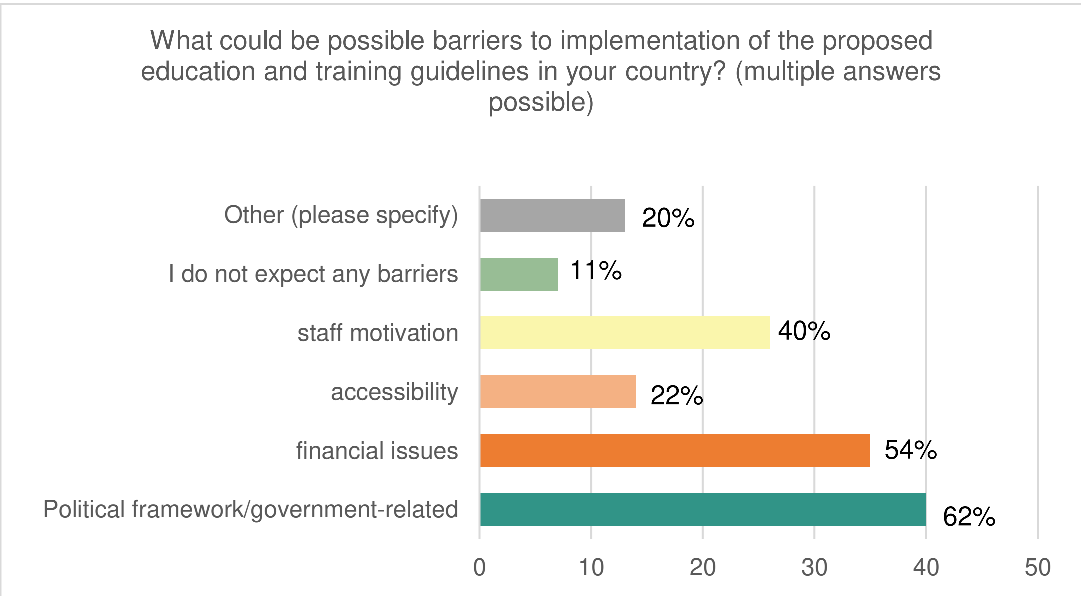

56% of the respondents who did not consider the proposed education and training guidelines for their profession realistic and applicable in their country stated political framework/government-related issues as reasons for this viewpoint. 44% saw financial or other issues as barriers to implementation (see Figure 5). 11% of the respondents did not expect any barriers (see Figure 6).

**Figure 5 – Barriers perceived by those not considering the proposed education/training guidelines realistic and applicable**




62% of those respondents who considered the proposed guidelines realistic and applicable in their country or those who could not judge saw political framework/government-related issues and 54% indicated financial issues as possible barriers (see Figure 6).

**Figure 6 – Possible barriers stated by those considering the proposed education/training guidelines realistic and applicable**




Lack of staff/training resources was mentioned by several respondents who provided additional comments on these questions.

### Ways to overcome barriers to education and training guideline implementation

Raising awareness of the importance of education and training among health authorities was suggested by some countries and professions. Incorporation (of the guidelines) into training curricula / university practice was also suggested. Some countries and professions suggested collaboration between stakeholders, including Ministries of Health, universities and professional organisations. Some respondents considered funding for (the harmonisation of) education necessary.

### Ways to introduce the education and training guidelines

Various countries and professions suggested introducing the education and training guidelines through the Ministries of Health. Some respondents also suggested this should take place through professional societies, the ministries of education or training coordinators, and national competent authorities. Two respondents considered European recommendations / endorsement by the EU helpful for implementation. Raising awareness via social media, webinars or workshops and scientific publications was also suggested.

Additional profession-specific answers as relevant are provided in Section 3 of the present report.

## 2.5. Adoption vs adaptation of guidelines

The clear recommendation from the EU-REST consortium is that each Member State should adopt the recommendations, which will encourage uniformity of standards and practice and, thereby, ultimately improve patient safety. If adoption of the guidelines is not possible in certain settings for justified reasons, relevant countries might adapt the proposed guidelines to make them applicable in their national context. The extent of such adaptation should, however, be limited.

Fundamentally, consortium members believe that **adoption of recommendations by all Member States in a uniform manner would likely be more beneficial than adaptation of the recommendations. Adoption should be the goal of the study and the EC.**

## 2.6 Recommendations on further European staffing and education/training guidelines

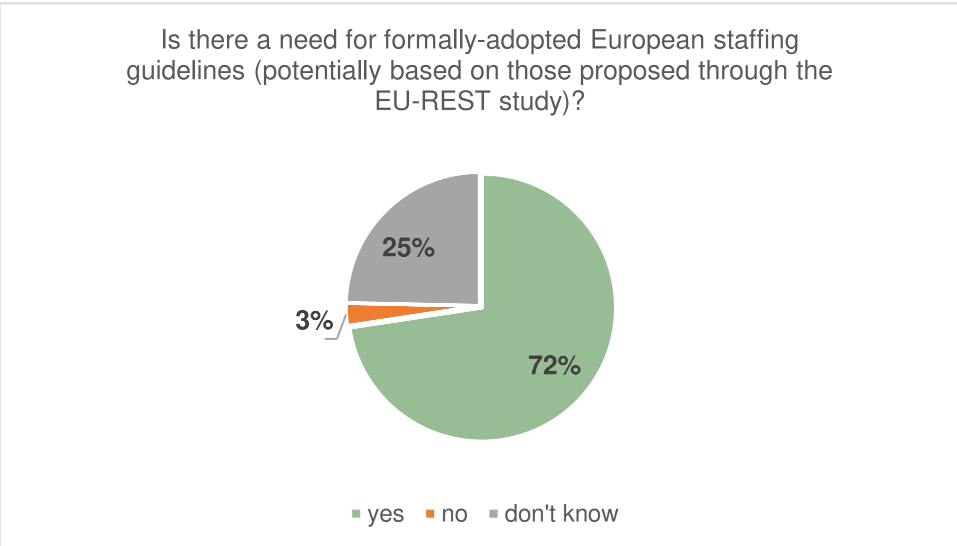
This section provides an outline of the responses obtained from the stakeholder consultation mentioned under 2.3.2 on the following questions for the relevant professional groups:

- 17. Is there a need for formally-adopted European staffing guidelines (potentially based on those proposed through the EU-REST study)?
- 18. In which areas would formally-adopted European staffing guidelines (potentially based on those proposed through the EU-REST study) be needed?
- 31. Is there a need for formally-adopted European education and training guidelines (potentially based on those proposed through the EU-REST study)?
- 32. In what areas would formally adopted European education and training guidelines (potentially based on those proposed through the EU-REST study) be needed

### 2.6.1 Staffing guidelines

Almost three quarters (72%) of the respondents saw a need for formally-adopted European staffing guidelines (potentially based on those proposed through the EU-REST study), 3% did not see any need and 25% indicated they were not able to answer this question (Figure 7).

**Figure 7 – Need for formally-adopted European staffing guidelines**



33% of those who answered the question about areas in which formally-adopted European staffing guidelines are needed stated that such guidelines would be needed in all areas.

Specific answers from radiologists from several countries (about areas where staffing guidelines are needed) included the following: General/diagnostic radiology, CT, MRI, interventional radiology, NM, oncology, surgery, orthopaedics, dentistry, radiography.

Keywords and replies also related to organisational aspects such as the supervision of trainees, specialist referral centres, the difference between private practice and teaching hospitals, the suggestion to introduce a unified system for quality control of X-ray devices, and the aim to achieve standards and norms (for workload) for radiology on a national level, taking into consideration all aspects of radiology work rather than just ‘reporting time’.

One respondent mentioned that when calculating working hours for healthcare professionals, MDTs are only defined for oncology and rare diseases. Another respondent mentioned arguing for an increase in funding for training and hiring staff.

Answers from NM physicians in terms of guideline areas included radiation safety. Another respondent mentioned the need for guidelines for staffing of radio-chemists / -pharmacists and radiographers / technologists.

Medical Physics Experts’ replies included that for NM, emerging therapies warrant more MPEs, that for RT standardisation is needed, and that for radiology / radiography MPEs are lacking in hospitals. Another area where formally-adopted guidelines would be needed was non-ionising radiation.

A national competent authority in radiation protection (and national society of MPEs) representative stated that staffing guidelines are especially needed for radiologists and radiographers.

Two Radiographer respondents stated that staffing guidelines must adequately address all three branches of this overall professional group: diagnostic radiology, nuclear medicine and radiotherapy.

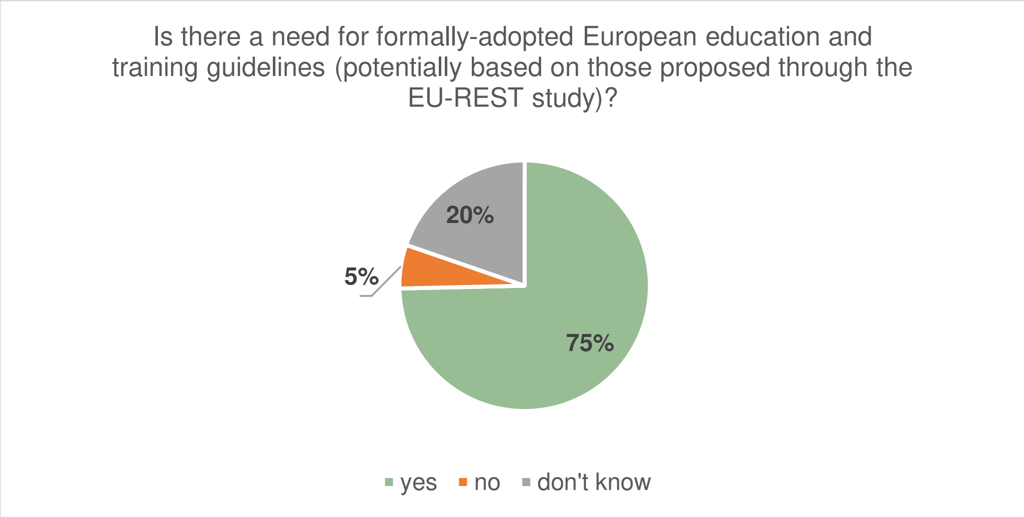
One Radiation Oncologist stated that guidelines are needed in clinical practice and education, and another respondent stated guidelines are needed for the discussion with public stakeholders.

Two radiation therapists stated that formally adopted guidelines are needed in all areas mentioned in the draft guidelines.

### 2.6.2 Education and training guidelines

75% of the stakeholders who answered the questionnaire saw a need for formally-adopted European education and training guidelines (potentially based on those proposed through the EU-REST study). 5% did not see any need for such guidelines, and 20% said they did not know (see Figure 8).

**Figure 8 – Need for formally-adopted European education/training guidelines**




26% of the respondents from all relevant professions and several countries saw the need for education/training guidelines in all areas.

Specific replies from those who answered the question about areas in which formally-adopted European education/training guidelines are needed included the following:

Radiologists: Radiologist training and exit examination, general/diagnostic radiology, interventional radiology.

Further aspects stated were: [the guidelines' role] to improve the quality of education, the recommendation to implement the guidelines via the local / national legal system so they reach all possible areas, achieving national standards and norms (workload) for radiologists taking into consideration all aspects of the work rather than just reporting time, as well as [guidelines for] hospitals and academic hospitals.

A nuclear medicine physician stated the area of radiation safety.

Areas stated by Medical Physics Experts included nuclear medicine, radiology, radiotherapy and non-ionising radiation.

One Medical Physics Expert replied that an MPE core curriculum exists for Radiotherapy, but not for Diagnostic Imaging or Radiation Protection. [Note: This is not correct: A core curriculum exists for all disciplines.]

Answers from Radiation Oncologists included the areas of oncology and radiotherapy, and one respondent suggested the guidelines to serve as a benchmark for national education programmes/ structures to enable international employment.

Areas mentioned by Radiographers included diagnostic radiography, nuclear medicine, radiation therapy, and, organisation-wise, national education and training harmonisation as well as guidelines in universities and hospitals.

One radiation therapist replied that all areas should be included.

One respondent considered the mobility of professions across European countries as essential.

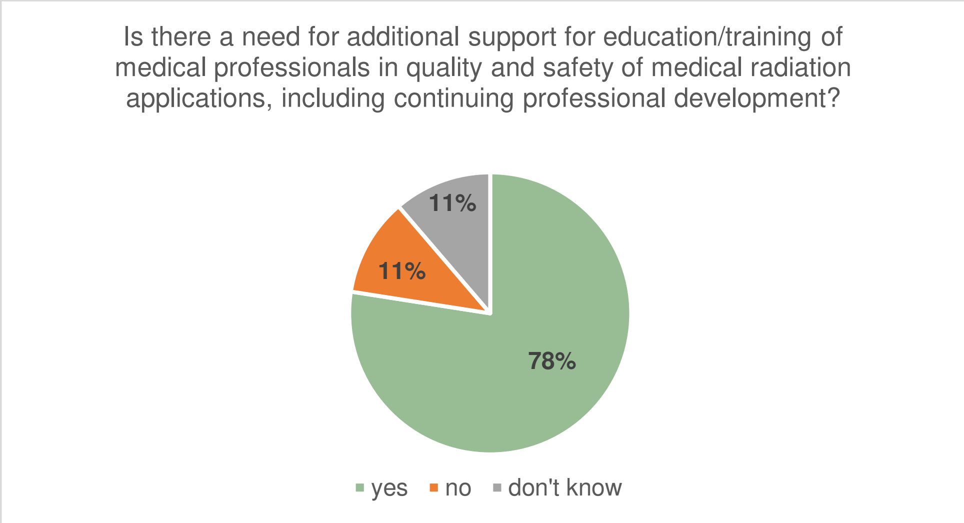
## 2.7 Needs for support for education/training of medical professionals

An outline of the stakeholders' responses to the question asking about the required further support for education/training of medical professionals in quality and safety of medical radiation applications is provided below, based on the following questions of the stakeholder consultation survey:

- 35. Is there a need for additional support for education/training of medical professionals in quality and safety of medical radiation applications, including continuing professional development?
- 36. What kind of additional support for education/training of medical professionals in quality and safety of medical radiation applications, including continuing professional development, would be useful?

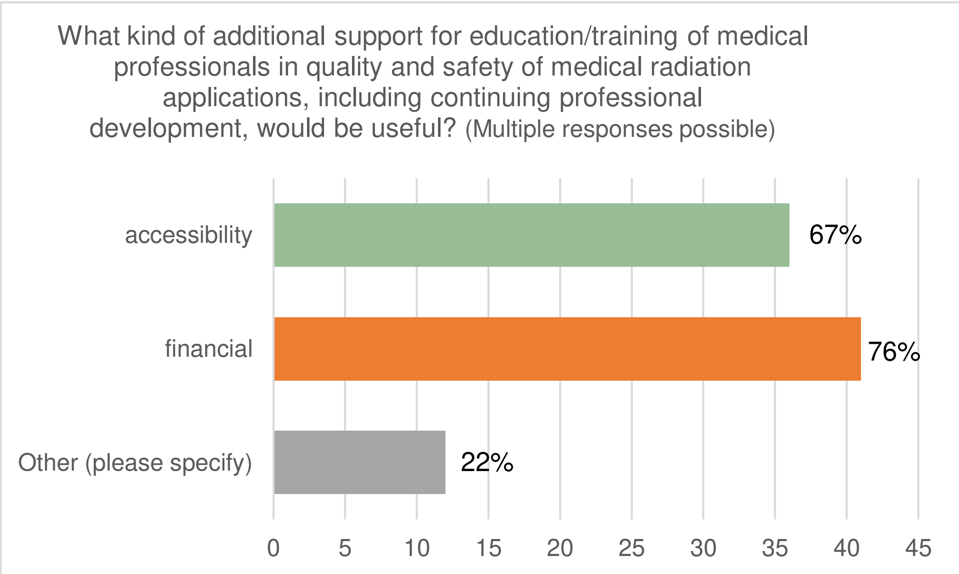
78% of the respondents to the questionnaire saw a need for additional support for education/training of medical professionals in quality and safety of medical radiation applications, including continuing professional development (see Figure 9).

**Figure 9 – Need for additional support for education/training**




76% of those who answered the question about what kind of support should be provided stated financial support. 67% recommended support in terms of accessibility (Figure 10). Other aspects stated included (free) access to training, resources for teaching, mentorship.

**Figure 10 – Type of additional support for education/training needed**




## 2.8 Suggestions for potential follow-up projects

Suggested actions that would exceed the scope of the EU-REST study and might, therefore, be considered to be dealt with by a separate follow-up project include the development of EU-wide common definitions of professions involved in medical radiation protection.

Further to the national registries recommended in section 2.2, the development of a common ontology of the types of data to be collected by Member States could also be considered.

## 2.9 Summary of general recommendations

1. **Despite the diversity of professional groups, the guideline writing groups concur in recommending that each EU Member State should maintain a central registry for each professional group, and for equipment relevant to the performance of their work. Each Member State should ensure (ideally uniform) high quality of the data, including information on the**

   (a) **Number of professionals (and, if possible, number of whole-time equivalents)**

   (b) **Age and gender profile of professionals (to allow for planning of training positions for future staff, retirement replacements, etc.)**

   (c) **Appropriate qualifications needed for inclusion in the registry, and for licensing for independent practice**

2. **Mandated CPD should include, in addition to radiation protection and safety issues already covered by the BSSD, techniques and knowledge relevant to each professional group, beyond radiation protection issues.**

3. **Adoption of the recommendations arising from the EU-REST study by all Member States in a uniform manner would likely be more beneficial than adaptation of the recommendations. Adoption should be the goal of the study and the EC (rather than adaptation of recommendations).**

4. **For each professional group, harmonisation of training across all 27 EU Member States (in terms of duration, curriculum, and certification of successful completion) is desirable, and should be supported. This would benefit interchangeability of qualifications across Member States, and facilitate mobility of relevant professionals**

The consortium recommends that the project's final report and conclusions and recommendations are widely disseminated to all interested parties, including patient representatives.

# 3. Profession-specific recommendations

Approaches to calculating staffing needs differ between the professional groups for many reasons. Among these are the diversity of the roles and responsibilities of the professions (in terms of current experience, complexity of tasks, expected pace of scientific and technological developments, and type and extent of collaboration with related professions), the differences among the professions in terms of how their specific workload is and should be measured, potential future developments in professional activities and variations in the amount, quality and applicability of existing data which could be used for benchmarking.

Where relevant, this section also provides important profession-related remarks provided by stakeholders who answered the questionnaire on the draft guidelines.

## 3.1 Radiologists

Authors: Adrian Brady, Boris Brkljačić, Christian Loewe (European Society of Radiology – ESR)

### 3.1.1 Introduction

The development of recommendations regarding staffing and education which are generally applicable Europe-wide is challenging due to lack of standardisation and harmonised data on different levels, detailed in brief in the following sections. The proposed approach to determine guidelines regarding staffing / workforce needs aims to introduce a simplified, thus easily applicable, method for calculation. Despite these simplifications, this approach provides the opportunity to be continuously modified and adopted as “living” guidelines. Facing the fast and continuous evaluation of Radiology as a profession, such continuously ongoing adaptation to changing needs and possibilities seems to be of additional attractiveness.

### 3.1.2 Summary of radiology staffing guidelines

Measuring how much work is done by a radiologist is a far-from-simple task. Many efforts have been made in the past to define reproducible, accurate and scalable methods, including definition of workforce needs related to the number of inhabitants, number of machines, number of beds and more. Additional attempts included different concepts of introducing and defining radiology value units to compare the workforce needs related to different radiological examinations. However, the lack of stable data / standards about the number of examinations needed per population, the number of pieces of equipment needed per population, and/or the appropriate per-radiologist reporting output as well as the huge variation regarding the number of Radiologists among European countries supported the idea of defining a new, rather simplified approach for staffing needs in Europe. These are explained in detail in the EU-REST Staffing and Education/Training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications (Deliverable 11), and are summarised in the following.

The selected concept aims to introduce a method which can be easily adapted in case of changed working times, changed case mix, and new methods/procedures, and can also reflect specific requirements in the teaching setting.

As part of the EU-REST study, a basic unit defined by hour of machine/system/activity which is multiplied by a specific conversion factor was defined for each Radiological modality (i.e. MR, CT, Interventional Radiology, etc.), which can be multiplied by the working hours of the respective machine. The calculations are based on 50 weeks of normal operation per year, excluding holiday periods. For better understanding, the approach to Interventional Radiological procedures is presented here as example:

*The basic unit as described above in Interventional Radiology refers to the room-time of the patients. One hour IR ($HR_{IR}$) as the basic unit to be used as the basis for staffing guidelines refers to one hour room-time of the patients. The conversion factor applied for Interventional Radiology was estimated to be 1.5. Consequently, one hour IR ($HR_{IR}$) requires 1.5 working hours of a board-certified interventional radiologist who is capable and licensed to work independently.*

<u>*Rationale:*</u> *The fact that the basic unit was defined by the room time of the patients (which is longer as the procedure time) and by applying the conversion factor, the time that the Interventional Radiologist is involved in patient preparation, case discussion, material selection, patient after care, and more, seems to be reflected realistically.*

Using this simplified approach, if service hours are increased (e.g. expanding an 8-hours-per-day service to one provided for 12 hours per day), or the number of machines/rooms used to deliver a service increases, the staffing requirement can be very simply recalculated. Even the different workforce needs depending on the respective case mix will be addressed by the calculation method proposed herein. The concept of using conversion / multiplying factors provides the opportunity for adoption and continuous changes in the fast-evolving current practice of Radiology. Possible shifts in workforce needs due to the possible implementation of AI tools could be easily incorporated in the calculation of staffing needs based on the method provided herein.

The following table should provide a simplified overview about the principle of the calculation proposed in these guidelines:

**Staffing calculation – radiologists:**

**Table 1 – Staffing calculation method: Radiologists**

| Teaching setting yes / no | Basic unit | Con-version factor | Radiology service | Practice examples |
|---|---|---|---|---|
| | one hour room-time of the patients | **1.5** | **Interventional Radiology** | For example TIPSS: procedure time = 60–120 min. Room time of the patient = 120–180 min. need for the interventionalist = 3–4.5 hours.<br><br>IR service = **5** days a week / **8** hours' patient room time = **2000** hours per year.<br>Based on our estimation **3000** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = 1600 hours = **2 IR specialists** being able to work independently and unsupervised are required to cover the 3000 hours. |
| yes | one hour room-time of the patients | **1.5 + 1.0** | **Interventional Radiology** | 1.5 hr board certified + 1.0 hr resident |
| | | | | |
| | one hour room time of the MR unit | **1.5** | **Magnetic Resonance** | MR service = **5** days a week / **12** hours' patient room time = **3000** hours per year. Based on our estimation **4500** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **3 Board certified Radiologists** being able to work independently and unsupervised are required to cover the 4500 hours. |
| yes | one hour room time of the MR unit | **1.0 + 1.5** | **Magnetic Resonance** | 1.0 hr board certified + 1.5 hr resident |
| | | | | |
| | one hour room time of the CT unit | **1.5** | **Computed Tomography** | CT service = **5** days a week / **12** hours' patient room time = **3000** hours per year. Based on our estimation **4500** hours should be covered.<br><br>Doctors working 40 hours per week, for 40 weeks a year = **3** Board certified Radiologists being able to work independently and unsupervised are required to cover the 4500 hours. |

| Teaching setting yes / no | Basic unit | Con-version factor | Radiology service | Practice examples |
|---|---|---|---|---|
| yes | one hour room time of the CT unit | **1.0 + 1.5** | **Computed Tomography** | 1.0 hr board certified + 1.5 hr resident |
| | | | | |
| | one hour room time of the patients | **1.5** | **Interventional CT** | Interventional CT service = **5** days a week / **4** hours' patient room time = **1000** hours per year.<br><br>Based on our estimation **1500** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **1** Board certified Radiologists being able to work independently and unsupervised are required to cover the 1500 hours. |
| yes | one hour room time of the patients | **1.5 + 1.5** | **Interventional CT** | 1.5 hr board certified + 1.5 hr resident |
| | | | | |
| | one hour room time of the PET unit | **1.5** | **PET CT*** | PET service = **5** days a week / **12** hours' patient room time = **3000** hours per year. Based on our estimation **4500** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **3** Board certified Radiologists being able to work independently and unsupervised are required to cover the 4500 hours. |
| yes | one hour room time of the PET unit | **1.0 + 1.5** | **PET CT*** | 1.0 hr board certified + 1.5 hr resident |
| | | | | |
| | one hour running time of the respective X-Ray unit. | **0.5** | **X-Ray** | X-Ray service = **5** days a week / **8** hours' patient room time = **2000** hours per year. Based on our estimation **1000** hours should be covered. Doctors working 40 hours per week, for 40 weeks a year = **less than 1** Board certified Radiologists being able to work independently and unsupervised are required to cover the 1000 hours. |
| yes | one hour running time of the respective X-Ray unit. | **0.5 + 0.5** | **X-Ray** | 0.5 hr board certified + 0.5 hr resident |
| | | | | |

| Teaching setting yes / no | Basic unit | Con-version factor | Radiology service | Practice examples |
|---|---|---|---|---|
| | one hour running time of the respective Fluoro unit | **1.0** | **Fluoro** | Fluoro service = **5** days a week / **4** hours' patient room time = **1000** hours per year. Based on our estimation **1000** hours should be covered Doctors working 40 hours per week, for 40 weeks a year = **0.625** Board certified Radiologists being able to work independently and unsupervised are required to cover the 1000 hours. |
| yes | one hour running time of the respective Fluoro unit | **1.0 + 1.0** | **Fluoro** | 1.0 hr board certified + 1.0 hr resident |
| | | | | |
| | one hour time of patient service | **1.0** | **Sono** | Sono service = **5** days a week / **8** hours' patient room time = **2000** hours per year. Based on our estimation **2000** hours should be covered Doctors working 40 hours per week, for 40 weeks a year = **1.25** Board certified Radiologists being able to work independently and unsupervised are required to cover the 2000 hours. |
| yes | one hour time of patient service | **1.0 + 1.0** | **Sono** | 1.0 hr board certified + 1.0 hr resident |
| | | | | |
| | one hour MDT-meeting time | **3.0** | **Multidisci-plinary team conference** | As example: **5 MDT** meetings per week = 2 hours each = 10 hours MDT per week = **500** hours per year.<br><br>Based on our estimation **1500** hours should be covered Doctors working 40 hours per week for 40 weeks a year = **1** board-certified radiologist being able to work independently and unsupervised is required to cover the 1500 hours. |

*Note: The EU-REST study has aimed to define education and training standards and appropriate workforce numbers for all relevant professional groups in all 27 EU Member States, trying to take account of the varying practices in different countries. As hybrid imaging practice varies across Europe, with PET/CT being performed/interpreted either by Nuclear Medicine Physicians or by Radiologists or by members of both specialties working collaboratively, staffing recommendations for PET/CT have been developed by both EANM and ESR experts as part of this study. Thus, depending on the practice in their specific setting, stakeholders can consult the recommendations of the respective specialty.

### 3.1.3 Results of stakeholder consultation

The lack of radiologists and the need to increase the capacity of existing training sites was mentioned by stakeholders replying to the questionnaire.

### 3.1.4 Summary of radiology education/training guidelines

The European Society of Radiology (ESR) as the scientific society and by far most important provider of Radiological education on a European level on the one hand, and the European Board of Radiology (EBR) as the accreditation body for Radiological education and continuous professional development as well as the body governing the European Diploma in Radiology (EDIR) on the other hand have set standards for radiology education and training. Training curricula for undergraduates, level 1 (specialty training years 1-3), level 2 (years 4 and 5), as well as level 3 (subspecialisation) have been defined, in close collaboration with the respective subspecialty societies.

The guidelines developed as part of the EU-REST study attempt the highest possible harmonisation regarding

- length of specialty training (5 years) and training structure (subdivision into levels I and II),
- board examination marking completion of training (approaching the European Diploma in Radiology as a standard and advocating cross-acceptance of EDIR and national board examinations wherever possible), as well as
- requirements for continuing professional development (CPD) including cross-acceptance of EACCMEs and national credits, as well as harmonisation of the minimum number of hours required
- assessment of accreditation of training centres following the concept of the European Training Assessment Programme (ETAP), a joint initiative of the EBR and UEMS.

Another important recommendation of the guidelines developed herein is the reflection of the specific workforce requirements in educational and academic situations, as described above. The number of trainees should be directly related to the calculation of the required workforce, which is addressed by the changed conversion factor to be used in training centres.

### 3.1.5 Results of stakeholder consultation

One respondent stated that the EDIR may not meet national board exam level. Another reply was about financing and scarce teaching resources. It was also commented that in the Netherlands nuclear medicine is part of the radiology training.

## 3.2 Nuclear Medicine Physicians

Author: F. Jamar (European Association of Nuclear Medicine – EANM)

### 3.2.1 Introduction

Defining the workforce and needs for nuclear medicine (NM) physicians across the EU27 is a difficult if not impossible task. It is important to keep this in mind as a preamble to any guideline.

There are several reasons for this:

- Firstly, the status of NM is very diverse across Europe, depending on equipment availability, sustainable delivery of radiopharmaceuticals, quality assurance programmes, development of new technologies and treatments etc.
- Secondly, the Internal Growth Product (IGP) varies considerably across the EU27 and the proportion of it dedicated to healthcare as well. In addition, the part of healthcare provision dedicated to NM is highly variable.
- Thirdly, due to huge differences in training and education, expertise varies across countries although major efforts are made, in particular through the EANM and ESMIT (European School of Multimodality Imaging & Therapy) as well as through IAEA channels to provide countries the opportunity to access high-level training and professional efficiency.
- Fourthly, the definition of NM as a separate specialty also varies across the EU27, with specialists in some countries being either pure NM physicians, combined internists and NM physicians, nuclear radiologists or, in Scandinavia, even clinical physiologists with competence in NM.
- Finally, the issues of radiation protection, although based on the Council Directive 2013/59/Euratom (BSSD), were translated into national law in different ways, leading to differences, e.g., in the way recently implemented treatments are dealt with as far as radiation protection measures are concerned.

In addition, NM is rapidly evolving, and the staffing needs will undoubtedly change, with growing indications of hybrid imaging and the recent explosion of radionuclide therapy, especially using radioligands.

NM involves the use of radioactive drugs, called radiopharmaceuticals, for the diagnosis and treatment of numerous diseases (described in detail in the EU-REST Staffing and education/training guidelines for key professional groups involved in ensuring radiation safety and quality of medical radiation applications – D11).

The complexity of the tasks will guide the need for physician workforce. For example, a simple thyroid scan takes 5-10 minutes for the physician to check the indication with the patient, perform the clinical examination and write a report that will in most cases not exceed 5-10 lines. Conversely, radioligand therapy for an mCRPC patient using [$^{177}$Lu]Lu-PSMA ligands is very time-consuming for the physician: the total time will be in excess of 6 hours for the first course and 3 hours for the additional ones. Furthermore, it is a team effort that necessitates a close collaboration with other professionals such as radiopharmacists, MPEs, nurses/technologists, RPEs and administrative support.

Staffing needs should encompass not only performing NM procedures as such but also other tasks that are intrinsically part of the profession, i.e. teaching and training, in academic or non-academic centres, clinical research and development, as well as the expanding active participation in multidisciplinary consultations, especially in oncological care.

Finally, it should be kept in mind that the reimbursement (wages) of the physician may not be adequate to the time and effort spent for each of the NM procedures, leading to inequalities between physicians who perform simple, rapid, procedures and those who engage in more complicated ones.

### 3.2.2 Summary of nuclear medicine physician staffing guidelines

Staffing guidelines can be proposed at a country level or at the department level. Although it would be interesting to compile data at the EU27 level, the diversity of activities and the huge differences in the IGP amongst Member States makes it essentially an effort for statistical purposes.

The most relevant parameter seems to be the staffing needs at an institution/department level because they reflect the link between the activity (number of procedures and complexity) and the staff as a whole: performing NM procedures is a team effort, involving not only physicians, but also medical physics experts, nurses, technologists (usually referred to herein as radiographers), IT personnel, radiochemists and radiopharmacists and others.

At this stage, the best reference that can be used for benchmarking is the IAEA document “A model to assess staffing needs in NM”. This comprehensive document covers 5 objectives, i.e. i) *determining adequate staffing levels,* ii) *determining optimal staff deployment,* iii) *justifying needs,* iv) *assessing system risks and identifying quality improvements* and v) *improving personnel effectiveness*.

The IAEA provides a companion tool that allows online calculation of individual institution staffing needs on their International Research Integration System (IRIS) platform.

At an institution/department level, calculating the staffing needs can be performed using the IAEA table establishing *"Weights assigned to attending Nuclear Medicine physicians"*. This table presents the number of time units (each of 15 minutes) for various procedures in NM according to their complexity and involvement of the physician (for a particular procedure the workload on the nursing/technology staff may be much higher than for the physician, see example in EU-REST D11, 2.2.3, p. 41). This IAEA table takes already into account the most recent developments in the specialty, such as hybrid PET imaging (with CT or MRI) and radioligand therapy. Considering the rapid development of the latter, it is most likely that the workload for NM physicians will significantly increase in the coming years, requiring more FTEs and hence a call for more physicians to choose NM as a specialty after graduation as Medical Doctors.

At this stage, the first recommendation is to use the available sources (IAEA, OECD, EUROSTAT or UNSCEAR) as a basis for **building a robust EU27 Member State registry**, able to identify current and potential future shortages, as well as other interesting parameters. These include age, gender, European or extra-European mobility, issues related to mutual recognition of diplomas/titles in EU27 etc. The IAEA's IMAGINE database provides updated data since 2019 and serves as a good basis for future comparisons.

The EU-REST staffing guidelines mention the IAEA's IRIS tool as a basis for recommendations at EU level, despite its limitations, such as not being applicable to departments covering multiple work sites, not taking into account the details of available equipment, staffing dedicated to research or the specificity of some institutions, e.g., paediatric hospitals. It is recommended that the **IRIS tool be confronted with actual data** to evaluate its reliability in terms of resources, at local level, i.e., individual institutions, as a potential separate follow-up action upon completion of the EU-REST study. Besides, the aid of HERCA, as the association of national regulatory authorities, may be useful in harmonising data collection.

These efforts will help bridge the gaps between recommendations and the reality: the most accurate knowledge of the current situation can only help in drafting the future role(s) of NM physicians.

Notwithstanding, this document provides recommended guidelines to be followed and, if appropriate, endorsed by the European institutions, as well as a basis for possibly more precise specifications of staffing needs in the future.

### 3.2.3 Results of stakeholder consultation

To summarise the remarks and suggestions of the stakeholder consultation, the following were considered:

- It was pointed out that NM should be an **independent specialty**, working of course in close and appropriate collaboration with clinical and other partners (e.g., radiologists, interventional radiologists, cardiologists, anaesthesiologists).
- NM is a team effort: extending the staffing guidelines to other professions in a harmonious manner is essential for the future of the specialty. These include medical physics experts specialised in NM, nurses and radiographers (who are also referred to as **NM technologists**) by EANM [1].
- Other professions that have not been the object of attention in this study, because they are not directly involved in the exposure of patients to ionising radiation, are **radiochemists and radiopharmacists**. These professions will become increasingly crucial to the development of NM, considering the local production (in-house) of diagnostic or therapeutic radiopharmaceuticals. This field is currently the focus of several EU-funded projects. All common efforts should converge to make NM a coherent whole rather than the sum of parallel tasks and jobs.

### 3.2.4 Summary of nuclear medicine physician education/training guidelines

Two guidelines are the main sources of information which the EU-REST training and education guidelines for NM physicians are based on. First, the “Training Curriculum for Nuclear Medicine Physicians” published by the IAEA in the TECDOC series (no 1883) (2019), and secondly, the UEMS document entitled “Training requirements for the specialty of Nuclear Medicine” (2023).

Both documents are comprehensive but dedicated to different audiences. The IAEA source contains a methodological and philosophical approach and covers training and education needs that can be extended not only to EU27 (or high-income) countries but also to emerging and developing countries. It also sets a sophisticated evaluation process that can serve as a basis for national implementation but cannot be used as such by all certification bodies.

The document issued by the UEMS (in which all EU27 Member States are represented) is more practical and directly adapted to European countries. It contains guidance on the three levels cited in the introduction. The theoretical basis necessary for education is described in detail (albeit not mentioning any ECTS valorisation). Quantitative requirements for training are proposed as well and are quite similar to those proposed by IAEA. The 2023 revision of the UEMS document includes a scaling of competence levels from I (*theoretical knowledge*) to III (*Both practical skills and very good theoretical knowledge, so as the trainee is fully autonomous*). It also refers to a NM curriculum called “UEMS-EANM European Nuclear Medicine guide”, which is available as an app.

Both documents, though, converge in terms of similar qualitative contents that can serve as the basis for the following proposal. Interestingly, the UEMS Section of Nuclear Medicine has merged with the European Board of NM (EBNM). They propose the EBNM exam as an alternative to national certification. However, this is intended on a voluntary basis as there is no legal European setting to mutually accept this certification.

The UEMS 2023 curriculum revision, published during previous steps of the EU-REST study, brought the following most significant changes:

- Developing education and training in the most recent evolutions of radionuclide therapy, including more extensive knowledge of oncology care, appropriate indications for the various available therapies and management of complications and side effects.
- Integrating NM by active contribution to multidisciplinary tumour boards or other clinical boards whenever relevant.
- Establishing continued medical education/CPD in order to gain/maintain familiarity with new targets for molecular imaging and therapy.
- Besides competences, also develop “attitude” " (i.e. non-technical) skills to enable adequate communication with patients, staff and clinical partners.

Apart from differences between countries in the content of the curriculum, three major challenges should be tackled in the years to come:

- Even if NM was recognised as an independent specialty in 1988 by a European Directive, the qualification of doctors to practice this specialty varies considerably across the EU27. In some countries there are pure NM physicians with a specific and dedicated training, in other countries they may combine the specialty with another one, such as internal medicine or paediatrics, or qualify for both radiology and NM. In the UK and the USA, there is also the legal qualification of nuclear radiologist.
- The qualification as NM physician is granted by different bodies in the EU27, such as Ministries of Health, medical chambers or regulatory bodies (mainly competent for radiation protection issues).
- The recognition of NM physicians for their competence in radiation protection is also highly heterogeneous amongst EU27 Member States.

## Duration of the training/education programme

The period of training should be a minimum of four but **preferably five calendar years**. The minimum three-year programme proposed by the IAEA is too short when both theoretical and practical aspects are to be considered.

The curriculum as detailed below must include clinical training, theoretical education as well as qualification in radiation protection that will guarantee the safe use of radioactive materials for both the patient and staff. The details are presented in D11.

## Content of the training

### a) Theory

All NM trainees should undergo a basic theoretical curriculum that should account for 20-30 ECTS. This education is divided into two sections, i.e., scientific principles and clinical applications.

The extent of knowledge provided by this education should be adapted to the national situation and availability of techniques. However, when considering transnational migration according to the free mobility of medical doctors across the EU, additional teaching modules may be required for national recognition depending on the level of the initial training.

### b) Clinical applications

The training should cover as many disciplines as possible, to the extent of what is available in the relevant country. If appropriate, fellowships abroad may help to cover topics that are not available yet but emerging in a particular country. National funding, Erasmus programmes or other EU initiatives may help finance these fellowships to improve European mobility. Participation in the ESMIT (EANM) level 1 and 2 programmes can also provide the trainee with additional knowledge and experience.

The content of the training is detailed in the IAEA and UEMS documents (see EU-REST D11). The content is described both qualitatively (type of procedures) and quantitatively (number of procedures).

The referred numbers are adapted from the current UEMS syllabus and close to the IAEA proposal and represent the number of practical applications that a trainee should reach at the end of their programme. *In toto*, this represents an average of ~3,000 documented procedures. Rather than reporting this in a paper document at the end of the training, it is advised that **the performed**

**procedures be registered on a continuous basis, in an electronic format (training log), so that the supervisor and the trainee can regularly**, e.g., on a 6-month basis, **monitor progression and the way objectives are reached.** This can also be shared with a representative of the accreditation body, for online continuous evaluation.

During the clinical training, the candidate should also actively take part in oncological multidisciplinary consultations and develop communication skills.

**At least 100 therapeutic procedures**[14] should be performed during the entire curriculum and should be as diverse as possible, combining benign diseases as well as outpatient and inpatient cancer patients. Again, if a particular application is not available in the training centre(s), fellowships should be available to reach the necessary diversity.

Training for therapeutic applications should cover the following:

- Patient selection and setting of the indication, with full knowledge of the benefits, potential contraindications and alternative treatments.
- Administration of the therapeutic radionuclide and patient care for the appropriate duration (varies between hours and weeks depending on the type of therapy).
- Determination of absorbed dose to the target organ/tumour and the organs at risk together with physicists under MPE guidance.
- Dealing with potential side effects, together with the referring physician, e.g., medical oncologist.
- Taking care of radiation protection issues for the patient, his/her relatives and the general public. Specifically, taking care of the issue of contraception in patients of childbearing age (both females and males). Also consider unexpected events such as resuscitation, premature death and cremation, or urgent hospitalisation as part of risk management.

Finally, it is advised that the trainee be engaged in some research activity, including a presentation at a national or international conference or a publication in a peer-reviewed journal. Some countries may also require a thesis at the end of the training, based on literature analysis, methodological issues and personal research.

[14] Some countries may propose alternative numbers (higher or lower), according to their level of development.

### Assessment of the training and education programme

Currently, there is no uniform manner to evaluate the achievements of a trainee. This document does not intend to propose a top-down solution. Nevertheless, some criteria have to be enforced to qualify a medical doctor as an NM specialist. The main competences are:

- Basic knowledge of theoretical background, including radiation protection issues.
- Advanced knowledge of clinical in vivo imaging procedures, such as described in the UEMS and IAEA documentation.
- Advanced knowledge of therapeutic applications, at least those available in a particular EU27 country.

Assessing the capability of a physician to independently undertake NM activities at the end of the training can take place at local (academic or other), national or sub-national, or international level. All options seem acceptable provided they ensure a similar level of knowledge and competence. The best and simplest option is a nationally based evaluation, ideally through a commission of the Ministry of Health that will eventually grant the certification. Options for the final evaluation are:

- MCQ exam
- Interview
- Continuous evaluation
- Live – real world – evaluation
- A combination of the above

Besides, certification for Radiation Protection (RP) should be issued by the competent authority. The EU-REST study consortium recommends that both should be given at the same time, by a common commission dealing with competencies in the specialty but also the relevant competencies in RP. This would facilitate access to the specialty.

#### Body for certification

The body for certification should be centralised within each of the EU27 countries and ideally be the responsibility of the Member State’s Ministry of Health. Where this is not possible, a centralised certification can be sought, such as through the EANM/UEMS/EBNM training end exam (https://uems.eanm.org/fellowship-examination/).

#### Accreditation of trainers and training centres

The training centre shall be chosen amongst those that are able to offer the widest operating workforce and range of activities. This does not mean that all activities must be available there, but partnerships may exist or be established with other centres for additional training. The accreditation of training centres and those responsible shall be validated by a centralised body.

### 3.2.5 Summary and final notes

- The period of training should be a minimum of four but preferably five calendar years.
- The curriculum must include clinical training, theoretical education as well as qualification in radiation protection that will guarantee the safe use of radioactive materials for both the patient and staff, as well as for the public and the environment.
- NM trainees should undergo a basic theoretical curriculum that should account for ~20-30 ECTS. This education is divided into two sections, i.e. scientific principles and clinical applications.
- Continuous documentation of the trainee’s practical progress is recommended, in an electronic format (training log), enabling the supervisor and the trainee to regularly, e.g. on a 6-month basis, monitor progression and the way objectives will be reached.

### 3.2.6 Perspectives and potential role of the European Institutions

The main recommendations are:

- Nuclear medicine societies (EANM in coordination with national societies) to establish a knowledgeable status of the current curriculum for the specialty of NM.
- UEMS, national societies and national regulators to collaboration to harmonise the curriculum amongst the EU27, taking into consideration differences in equipment and IGP between the Member States.
- Professional societies to support clinical centres in organising practical cross-country mobility in order to give all medical doctors in the EU27 equal access to the specialty of NM.

### 3.2.7 References

1. EANM Technologists' Guide. Available at: https://www.eanm.org/publications/technologists-guide/ (accessed on 18 June 2024)

## 3.3 Radiation Oncologists

Authors: Y. Anacak, P. Lara (European Society for Radiotherapy and Oncology – ESTRO)

### 3.3.1 Introduction

Radiation oncology is a clinical discipline of medicine requiring an orchestrated team effort. The radiation oncologist is universally accepted as the leader of this team and has several tasks and responsibilities including evaluation of the patients before, during and after radiotherapy; decision making at several points of the treatment process (decision to treat, decision for treatment plan etc.); managing side effects and complications of the treatment; discussing treatment options with other physicians in a multidisciplinary approach and providing a high quality patient management at every step.

Since radiation oncology is fully dependent on radiotherapy machines, and more than 90% of those treated with radiotherapy are cancer patients, it is relatively straightforward to estimate the workload of the radiation oncologists, and the required number of radiation oncologists in a department and in a country.

Radiation Oncology and Radiotherapy form a separate specialist section of the European Union of Medical Specialists (UEMS) with an own training curriculum. However, in some EU countries clinical oncology is the recognised medical specialty which covers radiation oncology and medical oncology.

The ESTRO core curriculum is the most comprehensive document covering the education and training of radiation oncologists/radiotherapists in Europe, which was developed with the advice of representatives of 27 European countries and endorsed by 29 European national societies. A Clinical Oncology module that could be combined with the ESTRO core curriculum was developed as well.

### 3.3.2 Summary of radiation oncologist staffing guidelines

Staffing recommendations of many European countries range between 130–300 patients per radiation oncologist per year. The IAEA recommends 200-250 patients per radiation oncologist, with no more than 25–30 patients under treatment by a single radiation oncologist at any one time. It should be noted that radiotherapy applications evolved very fast in the last decade and most new radiotherapy techniques such as online adaptive radiotherapy or stereotactic radiotherapy demand more involvement of radiation oncologists in radiotherapy planning, set-up and delivery; on the other hand, emerging artificial intelligence technologies have the potential to reduce the time spent by a radiation oncologist for contouring, plan evaluation and other radiotherapy processes. Updated staffing guidelines including the recent developments are needed. The IAEA developed an activity-based staffing approach which addresses all daily activities of a radiation oncologist. Updated European staffing guidelines based on the IAEA activity-based staffing approach are needed.

The ESTRO-QUARTS study of 2005 reported an average of 205 patients per radiation oncologist, and a decade later the ESTRO-HERO paper of 2014 reported 208.9 patients per radiation oncologist in Europe. The present EU-REST study identified an average of 171 patients per radiation oncologist per year in Europe. It is evident that overall, the number of patients per radiation oncologist decreased in the last two decades, and the current numbers are within the recommendations of the IAEA and most European countries.

### 3.3.3 Summary of radiation oncologist education/training guidelines

ESTRO produced several editions of the Core Curriculum in Radiation Oncology. These Core Curricula were endorsed as European Training Requirements by the UEMS (latest in 2019). A core curriculum for clinical oncology was also produced to provide this harmonisation tool to countries where radiation oncology is practiced inside the broader specialty of clinical oncology. The ESTRO core curriculum recommends at least 5 years full time or an equivalent period of training for radiation oncologists, where at least 80% of the time needs to be spent in a clinical environment. However, although the current 4th version of the ESTRO core curriculum was endorsed by 29 countries, the duration of specialty training in radiation oncology (residency) varies from 2 to 5.25 years in the EU, with an average of 4.5 years.

We recommend the same duration as ESTRO: 5 years of training, 80% of which should be spent in a clinical environment.

The aim of radiation oncology is to deliver a high dose to the tumour within the overall prescribed time with minimal damage to normal tissue and related organs at risk. The equipment type and techniques in common use, the role of imaging and imaging dose, radiation protection principles and underpinning legislation contribute to the definition of academic content of education and training programmes for radiation oncologists just as for radiation therapists (see 3.6.4).

There is considerable heterogeneity regarding the training in radiation protection during residency: the training duration varies from less than 2 weeks to 24 weeks. The majority of countries require specific certification in Radiation Protection, however only 3 countries require mandatory continuous professional development for radiation protection.

Licensing should be based on an objective assessment of the completion of a training programme that complies with national guidelines.

## 3.4 Medical Physics Experts (MPEs)

Authors: R. Sanchez, N. Jornet*, C. Garibaldi*, D. Visvikis, C. Pesznyak, I. Polycarpou (European Federation of Organisations for Medical Physics – EFOMP / *European Society for Radiotherapy and Oncology – ESTRO)

### 3.4.1 Introduction

The present study identified several challenges related to Medical Physics Experts (MPEs). These include the lack of official recognition of the profession in some Member States, despite the provisions of the 2013/59 directive. Additionally, the number of MPEs per million inhabitants varies widely across the European Union [4-43 /M]. The training period also varies widely, ranging from 1 to 5 years, being among the widest ranges for all professions analysed in the study. The traditional use of different names for MPEs, such as medical physicist, medical scientist, and radiological physicist etc., hinders efforts to harmonise the profession across Europe. Consequently, achieving a universally recognised MPE role and profession across all European countries remains a distant goal.

The following guidelines, intended for health authorities and scientific societies of the Member States of the EU, provide a roadmap to address these challenges in the coming years. This initiative aims to ensure the highest quality and safety in medical practices using ionising radiation for all EU citizens.

### 3.4.2 Summary of medical physics expert staffing guidelines

1. The MPE, with level 8 in the European qualification framework, is the qualified professional to assume the competences in radiation physics applied to medical exposures, in accordance with the 2013/59/EURATOM directive [1] and the European Commission guidelines for medical physics experts, radiation protection no. 174 [2]. The concept of radiation physics includes both, ionising and non-ionising radiation. Member states should consider this profession in the assessment of the workforce.
2. The Medical Physics Expert (MPE) as defined in the directive 2013/59/EURATOM should be the healthcare professional to supervise and assume the responsibilities for radiation protection activities in hospital settings, including patients, working staff, members of the public and visitors. The Radiation Protection Expert (RPE) in hospital settings should be an MPE, since medical physicists have the highest level of radiation physics knowledge and training.
3. The latest published recommendation by EFOMP (currently the EFOMP policy statement 7.1) [3] in agreement with international recommendations should be adopted as the reference document for comparison of staffing levels for MPEs.
4. Medical physics departments may include other professionals such as dosimetrists or medical physics assistants and bioengineers working under the supervision of MPEs. If this is the case, the staffing guidelines should include these resources as a factor to be taken into account in the total time needed to develop the different activities.
5. Member states should have a registry of their active MPEs, managed by the competent authority and updated at least on a yearly basis, including information on age, gender, and the main field of practice (radiotherapy, diagnostic & interventional radiology, nuclear medicine), for proper planning of future workforce needs and for the promotion of gender equality in the profession. Coordination with national scientific societies is recommended to achieve this objective.
6. A common training and registration scheme for MPEs should be established to facilitate their mutual recognition across Europe, in order to foster professional mobility and knowledge sharing for new technologies between Member States.
7. The algorithms to calculate FTEs of MPEs included in the EFOMP recommendation [3][15] should be revised at least every five years depending on changes in technology and practice. In particular, the impact on workforce of aspects such as hadron radiotherapy, the emergence of

[15] EFOMP [3] uses the synonym WTE for FTE

dose management systems in diagnostic and interventional radiology and the increasing workload in advanced radionuclide therapy should be evaluated by scientific societies and updated if needed.

### 3.4.3 Results of stakeholder consultation

The need for the MPE to become a recognised medical professional was stated by respondents from Belgium, Croatia and Germany. One respondent mentioned that a universal (registered) MPE accepted by all European countries would be helpful, and another respondent mentioned the need for national authorities' awareness of the importance of the MPE in the healthcare system.

Further, the lack of MPEs and the need to substantially increase training was mentioned.

### 3.4.4 Summary of medical physics expert education/training guidelines

1. In accordance with the Directive 2013/59/Euratom [1], to practise independently in the field of medical physics in Europe, the MPE accredited level (EQF8) should be achieved. All Member States should provide education and training programmes and registration schemes for this goal.
2. There are still considerable differences across Member States in their educational and training programmes for MPEs. Member states should converge in their education and training programmes seeking the standardisation of the safety and quality standards in the medical practices involving ionising radiation at European level. The updated core curricula and qualification framework for the MPE in Europe proposed by EFOMP together with other scientific organisations such as ESTRO, EANM, and ESR (based on EC guidelines RP174)  [4] shall be the reference guidelines for the education and training programmes for the Member States, which could be summarised as follows:
    - Minimum requirements to access the education and training for MPEs: a BSc degree predominantly in Physics plus an MSc degree in Physics or Medical Physics (BSc + MSc 300 ECTS, including in total at least 180 ECTS in Fundamental Physics and Mathematics).
    - Education and training for MPEs: duration of at least 4 years to obtain the competences (CanMEDS roles) to become an independent specialist. Training in one or more subspecialties of Medical Physics should be available. The training must be

conducted in a hospital/healthcare facility accredited by the competent authority. Training facility and quality of the MPE training should be regularly audited by the competent authority.

- The MPE trainee must be appointed as a paid resident, with assigned duties under the supervision of a qualified MPE.
- Continuing professional development (CPD) shall be compulsory as recommended by EFOMP [5].
- Professionals should be registered before starting independent practice. National registration schemes for MPE will be based on EC RP174 guidelines [2] and EFOMP [6] recommendations.

3. A common core curriculum and career pathway for the profession of MPE encompassing all subspecialties is instrumental in harmonising MPE education and training standards across Europe. This approach ensures consistency in the competences required to become an MPE, thereby standardising quality and safety for the medical applications involving ionising radiation. Furthermore, this initiative streamlines the recognition of the MPE profession in EU Member States where it has yet to be formalised.

### 3.4.5 Results of stakeholder consultation

MPE specific replies from stakeholders included the following:

Low income and a long training duration could be a barrier, particularly as there is no status of medical physics students comparable to medical internship.

Health authorities still do not recognise the importance of establishing education and training programmes as well as accreditation for MPEs.

### 3.4.6 References


1. COUNCIL DIRECTIVE 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom
2. European Commission (2014). European guidelines for medical physics experts. Radiation protection 174. doi: 10.2833/18393.
3. Evans, Christofides and Brambilla. The European Federation of Organisations for Medical Physics. Policy Statement No. 7.1: The roles, responsibilities and status of the medical physicist including the criteria for the staffing levels in a Medical Physics Department approved by EFOMP

Council on 5th February 2016. Physica Medica 32 (2016): 533. http://dx.doi.org/10.1016/j.ejmp.2016.03.001

4. Core Curricula. European Federation of Organisation of Medical Physics https://www.efomp.org/index.php?r=fc&id=core-curricula

5. Christofides et al. The European Federation of Organisations for Medical Physics Policy Statement No. 10.1: Recommended Guidelines on National Schemes for Continuing Professional Development of Medical Physicists. Physica Medica 32 (2016): 7-11.

6. Christofides et al. The European Federation of Organisations for Medical Physics Policy Statement No. 6.1: Recommended Guidelines on National Registration Schemes for Medical Physicists. Physica Medica 32 (2016): 1-6. https://www.efomp.org/uploads/policy_statement_nr_6.1.pdf

## 3.5 Radiographers

Authors: F. Zarb, J. McNulty (European Federation of Radiographer Societies – EFRS)

### 3.5.1 Introduction

Radiographers, inclusive of the three branches of the profession recognised at the European level (Medical Imaging, Nuclear Medicine, and Radiation Therapy) are essential in the delivery of up-to-date healthcare. Estimation of staffing and education and training requirements of Radiographers needs to be considered in line with developments in imaging and treatment technologies, improvements in health care policies, and changes in population health needs, which have altered Radiographers' roles and work practices.

The proposed guidelines of the EU-REST study for Radiographers (Medical Imaging, Nuclear Medicine, and Radiation Therapy) are based on such considerations to meet the requirements of today and tomorrow, based on current experience and research evidence to ensure both radiation safety and quality of medical radiation applications.

### 3.5.2 Summary of radiographers staffing guidelines

The number of Radiographers varies significantly between EU Member States, even in countries having a similar population. Having an appropriate and effective allocation of Radiographers is paramount to ensure an efficient service delivery in terms of cost, quality, and quantity. The future workforce across medical imaging, nuclear medicine, and radiotherapy needs to cater for teleoperations and advanced practice to enhance services and patient care, provide career progression opportunities, increase job satisfaction for Radiographers and focus on the need for adequate skills mix and help support retention of a skilled workforce.

Just one of the literature sources reviewed specified the need for two radiographers to be working per CT or MRI scanner with just one at a time required per general X-ray room or ultrasound room; numbers for other areas are not specified. No method was specified as to how these numbers were achieved.

To address the main challenge of establishing a practical guideline for the calculation of a Radiographer workforce, a workload-based approach is being proposed to ensure having the right number of people, with the right skills, in the right place, at the right time, with the right attitude, doing the right work, at the right cost and with the right work output. The proposed methodology for the calculation of FTEs for Radiographers as part of the EU-REST study is workload-based and is more accurate than other metrics if the data is correctly reported. The guidelines provide a harmonised method of calculating staffing needs, both for current practice but also for a future expansion of services or new roles of the Radiographer workforce across EU Member States.

Teleoperations represent an alternative practice model that may offer some patients better access to imaging and alternative working models for Radiographers. However, any procedure should be carried out by both trained and qualified remote and onsite Radiographers in close contact and communication with each other. Current national legislation must be followed and authorised personnel must not be replaced by unqualified professionals [1].

It is recommended that all Radiography education programmes lead to a bachelor's degree (EQF Level 6) qualification which is recognised as entry qualification to the profession in the disciplinary areas of medical imaging, nuclear medicine, and radiotherapy.

Recommendations emanating from the development of the guidelines include publication of a more comprehensive evaluation of the EU Radiographer workforce through the implementation of national registries and implementation of national structures for the annual review of workforce data in collaboration with education and training providers to facilitate workforce planning and promotion to increase diversity in entry to the profession. Such data will allow for more accurate monitoring of retention within the Radiographer workforce and will allow health services, institutions, and professional bodies to implement strategic actions to improve retention.

**Recommendations**

1. To implement a workload-based approach to estimate staffing levels,
2. To implement a harmonised framework for the calculation of the Radiographer workforce across EU Member States, and,
3. To have this data published centrally by the EC, and additionally by relevant professional organisations, and widely publicised by interested parties, to facilitate a more comprehensive evaluation of the EU Radiographer workforce.
4. To implement comprehensive national registries for Radiographers across EU Member States, and,
5. To implement national structures for the annual review of workforce data in collaboration with education and training providers to facilitate planning, and,
6. To promote increased diversity in entry, through novel access routes / widening participation initiatives to train as a Radiographer and go on to the profession across EU Member States.
7. To recognise additional and emerging essential roles for Radiographers across EU Member States, inclusive of extended and advanced practice together with emerging specialisms, and,
8. To implement initiatives to facilitate the advancement and development of the Radiographer workforce, to establish these roles with appropriate education, training, and governance structures.

### 3.5.3 Summary of radiographers education/training guidelines

Radiographer education institutions must be proactive, adapting the education model to the technological (r)evolution taking place and with due consideration of evidence-based research, education, management, and with impactful, and clinically relevant approaches, including simulation.

Core curricula for Radiography should include topics dedicated to radiation protection aligned with recognised frameworks, such as Radiation Protection 175 and the latest recommendations arising from projects such as EURAMED rocc-n-roll [2] which are fit for purpose, consider the future of the profession, and are reviewed regularly, at a national level. The EFRS European Qualifications Framework (EQF) Level 6 Benchmarking Document: Radiographers [3] specifies radiation protection knowledge, skills, and competences for radiographers, across medical imaging, nuclear medicine, and radiotherapy, Additionally, the EFRS Radiation Protection Officer (RPO) Role Descriptor [4] for Radiographers describes more advanced knowledge, skills, and competences for radiographers, again across medical imaging, nuclear medicine, and radiotherapy who undertake this important radiation protection leadership role.

Recommendations emanating from the development of the guidelines include ensuring opportunities to access diverse pathways (including part-time) into education and training programmes for Radiographers in all EU Member States. EQF Level 6 (Bachelors) programmes of 180 ECTS should be recognised as the minimum standard for entry to the profession in EU Member States, with diverse approaches to teaching, learning, and assessment which are practice-based and focused on true clinical scenarios, inclusive of simulation. Ensuring at least 25% of the programme ECTS are clinical activities (with careful consideration of the inclusion of appropriate clinical simulation activities to support and enhance traditional clinical education) included within programmes in medical imaging, nuclear medicine, or radiotherapy, or programmes combining two or three of these branches of the profession. A minimum required curricular content at European level related to radiation protection, quality management, safety, evidence-based practice and research skills should be established across all Member States. Student Radiographers should receive equal treatment as other healthcare students in terms of consideration for payments linked to their clinical training.

Opportunities for all Radiographers to engage in CPD and life-long learning as per BSSD should be offered and the need for additional postgraduate education and training for Radiographers undertaking specialist / expert roles recognised.

Significant variability in the education and training of Radiographers for entry to the profession across Europe still exists. It is thus essential that data and metrics are regularly and uniformly collected at both the national / EU Member States and European levels to facilitate more accurate monitoring of the varying approaches to education and training; encourage the harmonisation of aspects of education and training where appropriate; and better facilitate and promote the free movement of the Radiographer workforce across Europe to better balance supply and demand.

### 3.5.4 Results of stakeholder consultation

Responses from stakeholders included the lack of Radiographer students, training capacities and awareness of the Radiographer profession. The authors, therefore, suggest that additional and emerging essential roles for Radiographers across EU Member States should be recognised and initiatives to facilitate the development of the Radiographer workforce, to establish these roles with appropriate education, training, and governance structures, should be facilitated.

### 3.5.5 References

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2. EURAMED rocc-n-roll. Deliverables. Available at: https://roccnroll.euramed.eu/deliverables/ (accessed on 17 June 2024)
3. EFRS (2018) EFRS Benchmark for EQF level 6 - 2nd Edition
4. EFRS (2020) EFRS Radiation Protection Officer (RPO) Role Descriptor for Radiographers

## 3.6 Radiation Therapists (RTTs)

Authors: M. Coffey, M. Leech (European Society for Radiotherapy and Oncology – ESTRO)

### 3.6.1 Introduction

Following recognition of the radiation therapist profession by the European Skills, Competences, Qualifications and Occupations (ESCO) framework, it was decided that radiation therapist education and training would be considered independent of diagnostic radiography and nuclear medicine in these guidelines, as ESCO is under the remit of the European Commission. The full list of titles used across the EU for radiation therapist are available at: https://esco.ec.europa.eu/en/classification/occupation?uri=http://data.europa.eu/esco/occupation/e139b0a3-3bc5-4c33-bfbf-51ac20ac12fa

This is also consistent with the dynamic changes that have taken place in radiotherapy over past decades, the associated evolution of the roles and responsibilities now integrated into current practice, and the changing future of practice.

In preparing the education and training guidelines, it is important to consider what radiation protection in radiotherapy encompasses as this determines how clinical practice is integrated into specialist education and training programmes. Radiation energies used in the preparation and delivery of radiotherapy range from kilovoltage to megavoltage. In addition, other particles such as electrons, protons and light ions are also used for treatment and education and training must reflect this spectrum. The ability to treat small volumes to higher doses creates potential for geographic miss, thus irradiation of normal tissue and failing to ‘protect’ the patient from unnecessary radiation. The safety of staff, the public, and patients must therefore be considered in this context of small volumes and high doses. Current staffing models based on activity have been proposed by the International Atomic Energy Agency (IAEA) and the European Society for Radiotherapy and Oncology (ESTRO-HERO). Several countries have adopted an activity-based approach, independent of these two models, reflecting the changing roles and responsibilities taken by radiation therapists in modern radiotherapy centres. To achieve the goal of quality and safe practice, our recommendations reflect an activity-based approach to staffing requirements.

### 3.6.2 Summary of radiation therapist staffing guidelines

As a starting point to ensure accurate and safe practice staffing levels can be calculated based on the following criteria:

- A radiation therapist must **never** work alone during treatment simulation and treatment delivery. A minimum of two radiation therapists is always required during these procedures.
- The overall staffing requirement will be influenced by national legislation on working hours, maternity, paternity and parental leave, career breaks etc. which will be country specific.
- The number of full time, part time and locum/cover staff currently working
- Whether the department runs on single or multiple shifts which must include a time calculation to cover for staff breaks and shift crossover discussion.
- Scheduled maintenance, downtime and replacement need to be included as they will impact on treatment delivery and will require temporary introduction of additional working slots.
- Additional time and support for continuous professional development activities for radiation therapists must be factored into staffing levels.
- Dedicated radiation therapist management roles must also be considered in overall staffing levels.

In estimating staffing requirements at a local level, two approaches are necessary; first, what is the optimal number of radiation therapists necessary for accurate and safe practice and second, a detailed analysis of the current staff cohort. This will provide a baseline on which additional roles can be added as appropriate to practice.

**Forward planning**

For consistency of service in the future and to inform education institutes of the potential future student intake the centre must also consider

- Equipment and any planned expansion
- Evolving staff roles and responsibilities as described previously.
- Attrition and retirements

### 3.6.3 Results of stakeholder consultation

One stakeholder who replied to the questionnaire stated that for radiation therapy, a survey amongst the departments carried out a few years ago, showed that the staffing levels proposed in RP174 would lead in most cases to an overshoot. However, we are currently in the midst of a global radiation therapist staffing crisis, so this opinion has not come to fruition. One respondent from Belgium stated that the student/general population should be further informed of the existence of the RTT profession and that the salary of the RTT profession should be increased.

### 3.6.4 Summary of radiation therapist education/training guidelines

These guidelines recommend improvements that need to be made to ensure that all programmes contain sufficient knowledge, skills, and competences to enable graduate radiation therapists to work accurately and safely in a radiotherapy department without the need for extensive additional education or extended mentorship programmes which are currently common practice.

While a competency-based approach to education is optimal, these guidelines also give an indication of the type of topics that should be included in a syllabus to underpin the knowledge component. The key competences relating to radiation protection and safety and consistent with the CanMEDs Competency Framework, are Radiation Therapist Expert and Professional. It should be reiterated that these are components of an education programme and not sufficient of themselves.

The following guidelines have been identified:

Some papers addressed specific aspects of radiation therapy practice [1-2]. One paper identified the barriers to radiation therapist education (Belgium) [3] and two ESTRO benchmarking documents defined radiation therapist competencies at the time of graduation [4] and for the development of advanced practice [5]. Two radiation therapist-specific core curricula have been produced by ESTRO [6] and the IAEA [7] and core curricula for radiation therapists have also been recommended by professional societies in Australia [8], Canada [9] and the United States of America [10]. In countries with well-developed education programmes for radiation therapists the move is towards competency-based education reflecting the complexities of clinical practice and preparing graduates to deliver quality and safe practice and to enable them to adapt to evolving changes in the future. Defining competences provides a template for the development of core curricula reflecting the knowledge and skills necessary to underpin the required competence for best practice.

## Professional / Quality Care Provider (competency)

Radiation therapists, with all members of the radiotherapy team, are responsible for the radiation protection and health and safety of staff, patients and the public while they are present in the radiotherapy department.

## Indicative syllabus:

### 1. Staff and the general public

- European legislation and national implementation.
- Safety procedures in the department – e.g. signs, warning lights and verbal warnings, door interlocks, area designation, shielding, workplace monitoring when appropriate.
- Local rules and procedures.
- Occupational and public exposure – dose limits and monitoring, investigation, reporting and corrective measure where necessary, protective equipment if required.
- Room design and construction.
- Safety and emergency systems in place – 'last person out button'.
- Source safety for brachytherapy including storage, preparation, transport and shielding.
- Emergency planning and procedures
- Emergency guidelines or protocols

### 2. Patients (general)

- Protocols, procedures and local rules in place.
- Patient identification.
- ALARA principle.
- Benefits and risks.
- QA and QC procedures.

- Incident reporting and learning.

The aim of radiotherapy is to deliver a high dose to the tumour within the overall prescribed time with minimal damage to normal tissue and related organs at risk. To achieve this, radiotherapy departments employ a wide range of technologies and techniques and understanding the associated risks from the perspective of radiation protection is essential. The equipment type and technique in common use, the role of imaging and imaging dose, and radiation protection principles and underpinning legislation all contribute to the definition of academic content of education and training programmes for radiation therapists.

### Radiation Therapist Expert

The Radiation Therapist can understand and interpret the treatment prescription to accurately prepare and deliver a course of treatment to an individual patient.

### Indicative syllabus:

#### 3. Patient treatment general

- Limited access control area.
- Accessory equipment including setup systems (alignment lasers or surface guided) and immobilisation devices necessary for accurate positioning and reproducibility.
- Preparatory imaging procedures
    - Justification including potential alternatives.
        - Appropriate information for treatment decision making and planning.
        - Avoiding repeat imaging where possible.
    - Optimisation
        - Volume of interest defined.
        - Imaging parameters
        - Scout views and slice thickness for CT etc.
        - Patient position.
        - Use of diagnostic reference levels (DRLs) and dose recording.

- Image guided radiotherapy – how frequently should imaging be carried out during treatment.
    - o Purpose of imaging.
    - o Action taken following imaging.
- Maintaining clear and detailed medical records and comprehensive datasets including dose delivered from all sources of exposure.

## 4. Individual patient

To meet the aim of radiotherapy it is necessary to understand the interaction of radiation with tissue and how it varies for different tissues/organs, tolerance doses, dose and fractionation schemes, the underpinning science and selection for treatment, and the position/relationships of organs within the body. Optimisation is based on delivering the correct dose to the correct volume and positioning and immobilisation is key to achieving this and requires an understanding and awareness of the potential for harm when treatment is delivered incorrectly.

- Positioning and immobilisation
- Cross sectional anatomy and organ relationships.
- Blood supply and lymphatic drainage.
- Radiobiology/molecular oncology and the dose tolerances of different organs and tissues.
- Physiological changes.
- ICRU recommendations
- ICRP Ethics of radiation protection
- In-vivo dosimetry.
- Motion management.
- Interaction with other modalities – chemotherapy / immunotherapy.
- Principles of fractionation and overall time.
- Patient monitoring for movement, weight gain or loss etc.
- Imaging modalities and application in acquisition for planning and treatment verification

### 3.6.5 References


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## 3.7 Summarised overview of training curricula / guidelines per professional group

**Table 2 – Overview of training curricula/guidelines per professional group**

| Considered guidelines / recommended training curricula | Recommended min. training duration | Other |
|---|---|---|
| **Radiologists** | | |
| ESR European Training Curriculum for Radiology | 5 years | Dedicated workforce calculation model for the teaching situation is proposed |
| **Nuclear Medicine Physicians** | | |
| • Training requirements for the specialty of Nuclear Medicine, UEMS (2023)<br>• Training Curriculum for Nuclear Medicine Physicians, IAEA (2019) | minimum of 4 years, preferably 5 calendar years | harmonised certification across the EU-27 |
| **Radiation Oncologists** | | |
| ESTRO Core Curriculum (CC) for Radiation Oncologists/ Radiotherapists, 4th edition, 2019 | 5 years full time or an equivalent period of training, at least 80% of the time to be spent in a clinical environment | Every EU country has its own official regulations for the training of radiation oncologists, however, these regulations comply with the standards set by UEMS. |
| **Medical Physics Experts** | | |
| Core curricula published by EFOMP (in collaboration with ESR/EANM/ESTRO)<br>• Core curriculum for Medical Physics Experts (MPE) in Radiotherapy (2022)<br>• Curriculum for education and training of Medical Physicists in Nuclear Medicine, Recommendations from the EANM Physics Committee, the EANM Dosimetry Committee and EFOMP (2013), update about to be published)<br>• Core Curriculum for Medical Physicists in Radiology (2011, update in progress) | Min. requirements to access MPE education and training: BSc degree predominantly in Physics + MSc degree in Physics or Medical Physics (BSc + MSc 300 ECTS, incl. in total at least 180 ECTS in Fundamental Physics and Mathematics).<br><br>MPE education and training: min. of 4 years to obtain competences (Can MEDS roles) to become an independent specialist | CC are endorsed by majority of EU countries' national medical physics professional organisations.<br><br>Registration by the competent authority for independent practice.<br><br>Compulsory and accredited continuing professional development. |

| Considered guidelines / recommended training curricula | Recommended min. training duration | Other |
|---|---|---|
| **Radiographers** | | |
| EFRS White Paper on the Future of the Profession Radiographer Education, Research, and Practice (RERP): 2021-2031<br><br>EFRS (2020) Radiation Protection Officer (RPO) role descriptor for Radiographers | EQF Level 6 (Bachelors) programmes of 180 ECTS as the minimum standard for entry to the profession in EU Member States.<br><br>The total course duration incorporates between 180 ECTS to 240 ECTs over a period ranging between 2 to 4 years depending on whether the qualification is single (medical imaging, nuclear medicine, and radiotherapy only) or combined. | |
| **Radiation Therapists (RTT)** | | |
| Recommended ESTRO Core Curriculum for RTTs (Radiation TherapisTs) – 3rd edition, 2011 – supplemented by:<br><br>• European Higher Education Area Level 6 Benchmarking document for Radiation TherapisTs | EQF Level 6 (Bachelors) programmes of 180 ECTS as the minimum standard for entry to the profession in EU Member States<br><br>3-4 years | |
| The European Society for Radiotherapy and Oncology (ESTRO) European Higher Education Area levels 7 and 8 postgraduate benchmarking document for Radiation TherapisTs (RTTs)<br><br>Mary Coffey, Michelle Leech, on behalf of the ESTRO Radiation TherapisT Committee<br><br>A handbook for the education of radiation therapists (RTTs). Training Course Series no. 58. International Atomic Energy Agency Vienna, 2014. | Postgraduate | |

# 4. Conclusions and next steps

The EU-REST consortium believes that the proposed staffing and education/training guidelines as well as the present conclusions and recommendations of the EU-REST study, which is part of the EU4Health 2021 Work Programme, will contribute to the implementation of Europe’s Beating Cancer Plan and tie in with the actions of the Strategic Agenda for Medical Ionising Radiation Applications (SAMIRA) Action Plan in the area of Quality and Safety of medical applications of ionising radiation.

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