Safety Reports Series
No. 93

A Methodology for Establishing a National Strategy for Education and Training in Radiation, Transport and Waste Safety

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A METHODOLOGY FOR ESTABLISHING A NATIONAL STRATEGY FOR EDUCATION AND TRAINING IN RADIATION, TRANSPORT AND WASTE SAFETY

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SAFETY REPORTS SERIES No. 93

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FOREWORD

The IAEA assigns high priority to education and training in nuclear, radiation, transport and waste safety, considering them key mechanisms in facilitating the application of safety standards in its Member States and strengthening radiation protection around the world. At the end of 2000, an internal evaluation of the IAEA's education and training programme was undertaken. On the basis of this evaluation, a Strategic Approach to Education and Training in Radiation and Waste Safety, 2001–2010 was developed outlining the objectives and outcomes to be achieved over the ten year period. A Steering Committee on Education and Training in Radiation Protection and Waste Safety, comprising representatives of the IAEA, its regional and collaborating centres, and other international organizations, was established in 2002 to advise on the implementation of the strategy and make recommendations. The name was later changed to the Steering Committee on Education and Training in Radiation, Transport and Waste Safety.

Subsequent General Conference resolutions every year since 2003 have underlined the importance of sustainable programmes for education and training in nuclear, radiation, transport and waste safety, and have welcomed the continuing commitment of the Secretariat and Member States to the implementation of this strategy.

In 2009, the Steering Committee analysed the achievements of the strategy and recommended that a revised and updated version be continued for the period 2011–2020. The updated Strategic Approach to Education and Training in Radiation, Transport and Waste Safety, 2011–2020, including a summary of the key achievements under the 2001–2010 strategy, was noted by the Board of Governors.

One of the main elements of the strategic approach is to encourage and support the development and implementation of national strategies for building competence through education and training, the importance of which has also been emphasized by General Conference resolutions every year since 2010. Within this framework, the Steering Committee recommended that the IAEA give high priority to the development of the tools and guidance necessary to support Member States in establishing and implementing national strategies for building competence in radiation, transport and waste safety through education and training. This publication has been prepared in response to this recommendation.

The IAEA is grateful to all those who assisted in the drafting and review of this publication. The IAEA officer responsible for this publication was A. Luciani of the Division of Radiation, Transport and Waste Safety.

EDITORIAL NOTE

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CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

The IAEA has a statutory function to establish standards of safety for the protection of health, life and property against ionizing radiation and to provide for the application of these standards through, inter alia, education and training.

IAEA Safety Standards Series No. GSR Part 1 (Rev. 1), Governmental, Legal and Regulatory Framework for Safety [1], states that: "As an essential element of the national policy and strategy for safety, the necessary professional training for maintaining the competence of a sufficient number of suitably qualified and experienced staff shall be made available." GRS Part 1 (Rev. 1) also requires governments to "make provision for building and maintaining the competence of all parties having responsibilities in relation to the safety of facilities and activities." Furthermore, IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [2], requires governments to ensure that requirements are established for "Education, training, qualification and competence in protection and safety of all persons engaged in activities relevant to protection and safety".

Resolutions adopted by successive General Conferences (GC(46)/RES/9, GC(47)/RES/7, GC(48)/RES/10, GC(49)/RES/9, GC(50)/RES/10, GC(51)/RES/11, GC(52)/RES/9, GC(53)/RES/10, GC(54)/RES/7, GC(55)/RES/9, GC(56)/RES/9, GC(57)/RES/9, GC(58)/RES/10 and GC(59)/RES/9) have underlined the importance of sustainable programmes for education and training in nuclear, radiation, transport and waste safety.

Guidance on how to meet requirements for education and training in radiation protection and safety is provided in IAEA Safety Standards Series No. RS-G-1.4, Building Competence in Radiation Protection and the Safe Use of Radiation Sources [3]. RS-G-1.4 introduces the concept of a national strategy for building competence in protection and safety in Member States in order to address education and training needs in the field of radiation protection and the safety of radiation sources, in line with several General Conference resolutions (GC(54)/RES/7, GC(55)/RES/9, GC(56)/RES/9, GC(57)/RES/9, GC(58)/RES/10 and GC(59)/RES/9). The IAEA Strategic Approach to Education and Training in Radiation, Transport and Waste Safety, 2011–2020 [4] therefore proposes the development and implementation of national strategies for building competence.

1.2. OBJECTIVE

The objective of this Safety Report is to support the implementation of the IAEA Strategic Approach [4] by providing a methodology to assist Member States seeking to set up a national strategy for education and training in radiation, transport and waste safety. This in turn will contribute to strengthening radiation safety through the development of sustainable national expertise considering existing and foreseeable needs, and taking into account national and international capabilities and resources.

Guidance provided here, describing good practices, represents expert opinion but does not constitute recommendations made on the basis of a consensus of Member States.

1.3. SCOPE

This Safety Report describes the main steps for establishing a national strategy for education and training in radiation, transport and waste safety, based on four interlinked phases where the outcome of each phase is the starting point for the next.

It is primarily aimed at national authorities (e.g. regulatory bodies) and decision makers, although it will also be of interest to technical support organizations, education and training institutions, professional organizations and other relevant stakeholders.

This publication does not address the content of education and training courses nor the most appropriate training methods; these are dealt with in the IAEA publications on training programmes in radiation protection and the safe use of radiation sources [5] and the syllabus for the postgraduate educational courses in radiation protection [6].

1.4. STRUCTURE

The publication is organized as follows. Section 2 outlines the concept of a national strategy for education and training in radiation, transport and waste safety. Section 3 describes the first phase in the establishment of a national strategy, presenting the essential elements to be considered when assessing the education and training needs. Sections 4 and 5, respectively, describe how to design and then how to develop and implement an education and training programme based on the assessed needs. Section 6 describes the concepts and methodologies for evaluating the national education and training programme.

Appendix I provides a practical example of how to apply the methodology described in Sections 3, 4 and 5. Finally, Appendix II provides an example of the actions to be taken to establish a national strategy for education and training in radiation, transport and waste safety.

2. THE CONCEPT OF A NATIONAL STRATEGY FOR EDUCATION AND TRAINING IN RADIATION, TRANSPORT AND WASTE SAFETY

2.1. THE STRATEGIC APPROACH

The overall aim of education and training in radiation, transport and waste safety is to build and maintain an appropriate level of competence that is commensurate with the range of facilities and activities within the country. In this context, the education and training needs will be largely determined by:

— The range of facilities and activities, current or foreseen;
— The legal and regulatory framework, particularly in relation to the relevant education and training requirements.

The building of such competence in a sustainable manner will be helped by the adoption of a strategic approach that is based on national needs and considers national resources and capabilities for education and training. This will result in a national education and training programme that is designed to meet those needs in an effective and timely manner. Periodic evaluation of the efficacy of the programme will help keep it updated and in line with the expectations of national stakeholders.

It is important to recognize that the national education and training programme will be not only shaped by existing and foreseen facilities and activities and the evolution of the legal and regulatory framework, but will also be greatly influenced by the available national infrastructure and human resources.

2.2. THE PROCESS

RS-G-1.4 [3] provides guidance on the application of the requirements for education and training, as well as outlining the four phases (Fig.1) in establishing a national strategy for building competence in radiation, transport and waste

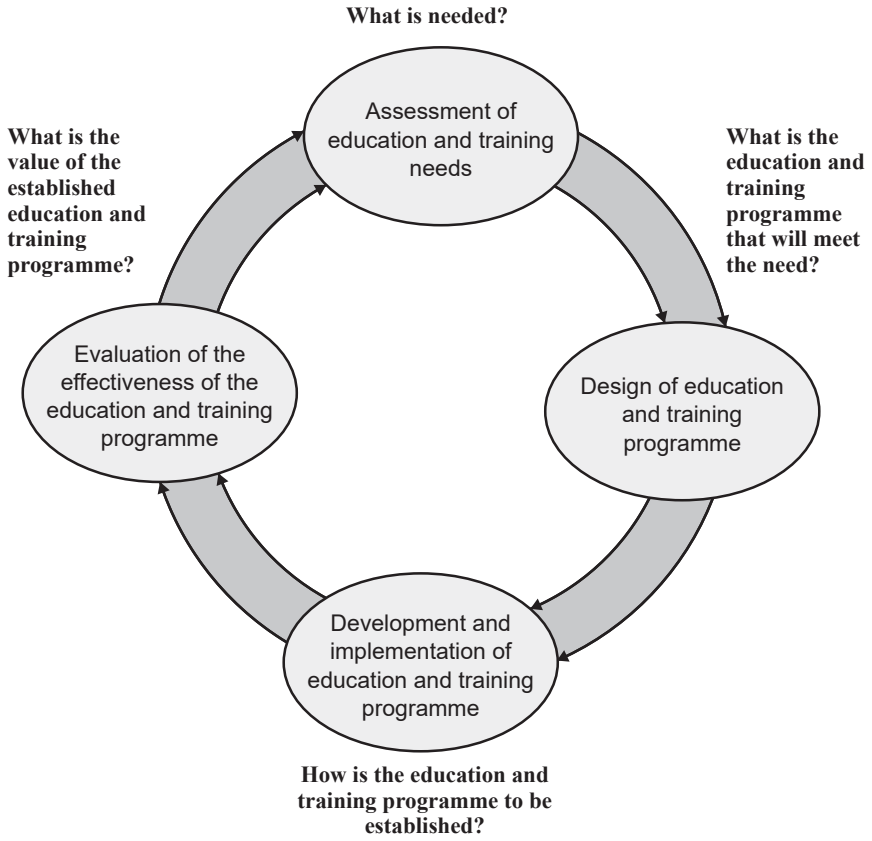

FIG. 1. Process for building competence in radiation, transport and waste safety through education and training.

safety. A brief description of the process is given below. Additional details are provided in Sections 3–6, with practical examples in Appendix I.

2.2.1. Assessment of education and training needs

The first phase in the process is to evaluate the national education and training needs. There are three components within this phase:

(1) Collection of information about facilities and activities;
(2) Analysis of education and training requirements specified in the legal and regulatory framework, plus any requirements associated with professional qualifications;

(3) Evaluation of the number of personnel within identified professional categories that will require education and/or training, including consideration of any ongoing needs for refresher training.

2.2.2. Design of an education and training programme

Based on the output of the first phase, the focus of the second phase is to design a national education and training programme that will meet all identified needs.

In simple terms, a national education and training programme can be defined as the schedule of activities to be delivered over a specified time frame in order to meet the identified education and training needs. Analysis of the identified education and training needs will lead to the development of options to meet these needs, depending on a number of parameters, including:

— Number of persons to be trained for relevant job functions in any facility and activity;
— Type of education and training required (e.g. academic at the undergraduate or graduate level, basic or specialized training, scientific or technical competence);
— Existing national capability (e.g. human resources, facilities, financial circumstances);
— International context (e.g. resources available and accessible in other countries, support provided by international organizations).

Once the most effective options have been identified and agreed, the detailed programme of work for a given time frame can be specified.

2.2.3. Development and implementation of the education and training programme

The establishment of the national education and training programme requires mechanisms for the development and implementation of the education and training activities to be in place.

Aspects to be addressed include consideration of appropriate implementation methods. For example, every identified education and training need should be matched with an appropriate methodology, such as attendance at a structured course, on the job training or distance learning. Likewise, requirements for training facilities are expected to be established when appropriate, prerequisite experience and/or qualifications for trainers specified and guidance provided on content, format and preparation of training materials.

2.2.4. Evaluation of the education and training programme

Monitoring and evaluation of the national education and training programme helps to ensure that:

— The options adopted to meet the needs continue to be effective;
— The overall programme is kept up to date and is continually improved.

Realistically, any national education and training programme would be expected to evolve over time in order to meet the changing needs as a result of, for example, improved national competence, new technologies, evolution of the legal and regulatory framework, or further development of the radiation protection infrastructure. The evaluation methodology needs to be able to capture the effectiveness and efficiency of the national education and training programme under these changing circumstances.

The IAEA's Education and Training Appraisal (EduTA) [7] methodology, when used as a self-assessment tool or as an external peer review service, can assist in the implementation of the above process.

2.3. POLICY FRAMEWORK

GSR Part 1 (Rev. 1) states that education and training in radiation, transport and waste safety is expected to be part of the national policy and strategy for safety [1]. The development and implementation of a national strategy for education and training will require government support and the long term commitment of all relevant stakeholders (e.g. regulatory body, governmental and other authorities and organizations in the field of radiation protection and safety, education and training providers, professional organizations). They are expected to carry out, in a synergistic and timely manner, the activities related to their specific functions in order to develop and implement the strategy. For this purpose, it is essential that Member States take ownership of the process, with a strong commitment at a high level, by establishing a formal framework with a clear identification of roles and responsibilities for the development and implementation of the national strategy.

In this respect, the establishment of a high level steering committee of stakeholders will greatly facilitate the development of a policy document that outlines the rationales for the national strategy for education and training in radiation, transport and waste safety. The same committee could also oversee the development and implementation of the national strategy.

The terms of reference for such a committee could include:

— Developing a policy document providing the general framework for the establishment of the national strategy for education and training in radiation, transport and waste safety.
— Providing advice to the government on any issue to support or facilitate the implementation of the national strategy, for example adequacy of national legislation and regulations for education and training in radiation, transport and waste safety; attribution of further responsibilities to certain stakeholders to allow them to contribute more effectively to the establishment of the national strategy.

Key factors to consider in the policy include:

(a) Background information on:
  (i) The range of techniques using ionizing radiation in the national context, considering the present status and future developments;
  (ii) The national legal and regulatory framework for education and training, and its compliance with international standards.
(b) A vision that communicates the values inspiring the Member State, giving directions about how national stakeholders are expected to behave and shaping the understanding of international organizations of why they are expected to collaborate and support the Member State in these endeavours. This vision would also need to address concepts and subjects such as sustainable infrastructure for education and training, national needs, maintaining competence, national legislation and regulations, and international safety standards.
(c) An outline of the main elements of the process underpinning the national strategy, in line with the concepts and methodology described in Section 2.2 and detailed in Sections 3–6.
(d) Identification of the national stakeholders for establishing and implementing the national strategy, stating their role, responsibilities and expected contributions.
(e) Provisions for mechanisms to monitor the implementation of the national strategy. For this purpose, a technical working group[1] could be established. In this case, the policy or other subsequent provisions would specify:

[1] The membership of the technical working group might overlap with that of the high level steering committee that developed the general policy document.

(i) The composition of the working group (representatives of the regulatory body, or other national stakeholders as identified in the previous step).
(ii) The terms of reference for the working group, which might include:
— Developing the performance indicators required to monitor progress on the implementation of the national strategy;
— Completing specific tasks necessary for the implementation of the national strategy (e.g. analysis of the education and training needs);
— Reviewing the progress of and providing advice with respect to the implementation of the national strategy.
(iii) Work procedures (appointment of a chairperson, frequency of meetings, reporting mechanisms).

To be effective, the policy document will need to be formally endorsed by the government and/or the body(ies)[2] empowered to take the actions required for the implementation of the national strategy, e.g. according to the advice provided by the high level steering committee, or to formally request that the competent institutions or organizations take such actions.

An example of the sequence of actions that might be taken to launch a national strategy, including establishing the policy framework and outlining the role of the different stakeholders is provided in Appendix II.

3. ASSESSMENT OF EDUCATION AND TRAINING NEEDS

3.1. LEGAL AND REGULATORY FRAMEWORK FOR EDUCATION AND TRAINING

A legal and regulatory framework, in line with the IAEA safety standards [1], is expected to be in place specifying a system for control of radiation sources and restriction of exposure to personnel. An important component of such a framework will be national requirements to ensure that all persons engaged in activities related to radiation protection and the safety of

[2] For example: authorities regulating the safe use of ionizing radiation, governmental institutions or organizations with responsibility for education and training in radiation protection and safety and/or more generally those responsible for the development of human resources at the national level.

radiation sources have the appropriate competence [2].[3] Specific requirements for education, training, qualification and competence need to be clearly laid out in regulations or guidance with the implementation of these requirements being enforced by the regulatory body. Qualification requirements are likely to include minimum education level, training, work experience and on the job training. A formal system of recognition of the qualifications will need to be in place for some specific personnel, including:

— Personnel with specific responsibilities or functions in radiation protection:
  - Qualified experts (QEs);
  - Radiation protection officers (RPOs).
— Workers that have recognized rights and duties in relation to occupational exposure, including those workers who have the responsibility for the day-to-day use of radiation sources (e.g. industrial radiographers, operators in waste management facilities, persons involved in the transport of radioactive material).
— Health professionals [2], such as:
  - Medical physicists;
  - Radiological medical practitioners (e.g. radiologists, nuclear medicine physicians, radiation oncologists, cardiologists, other specialist physicians, dentists);
  - Medical radiation technologists (e.g. radiographers, radiological technologists, nuclear medicine technologists, radiation oncologists);
  - Radiopharmacists;
  - Referring medical practitioners;
  - Other health professionals involved in the medical uses of ionizing radiation (such as biomedical or clinical engineers).
— Other personnel who may be involved or associated with activities involving radiation but not considered to be directly working with radiation, for example:
  - Staff of the regulatory body;
  - Emergency preparedness and response personnel.

This list of personnel is not exhaustive; care should be taken to ensure that all roles and functions relevant at the national level have been identified.

[3] When the regulatory framework is still under development, a Member State can seek support from the IAEA, but this should not stop the process of developing a national strategy for building competence through education and training.

For some of the above personnel, a different terminology has often been adopted in some Member State legislation and regulations (e.g. the 'radiation protection officer' is sometimes called 'radiation safety officer' or 'radiation protection supervisor' with different duties and responsibilities, often covering the QE's role as defined in the IAEA safety standards [2]). Therefore, instead of merely referring to the terminology, it is important to have a clear understanding of and focus on the definitions, functions, competence, duties and responsibilities of these personnel as given in the national legislation and regulations with regard to the IAEA safety standards [2, 3].

3.2. FACILITIES AND ACTIVITIES

Information should be gathered about the range and number of existing facilities and activities [2], or new ones that can be realistically foreseen. The information should be sufficiently detailed to ensure that all major applications within a practice[4] are considered.

Facilities include:

> "nuclear facilities; irradiation installations; some mining and raw material processing facilities such as uranium mines; radioactive waste management facilities; and any other places where radioactive material is produced, processed, used, handled, stored or disposed of — or where radiation generators are installed…" [2].

Activities include:

> "the production, use, import and export of radiation sources for industrial, research and medical purposes; the transport of radioactive material; the decommissioning of facilities; radioactive waste management activities such as the discharge of effluents; and some aspects of the remediation of sites affected by residues from past activities" [2].

It is important, when collating the information, that the number of organizations undertaking the activities also be identified as far as practicable. An estimate of the number/type of sources within the facilities is also useful information when it comes to determining the education and training needs.

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[4] A practice may involve many different facilities and/or activities [2].

In order to identify the facilities and activities in the country, the main sources of information are likely to be:

— Data on notifications to and authorizations made by the regulatory body on the intention to carry out a specific practice involving the use of radiation;
— Data from a national register or an inventory of radioactive sources, for example based on the IAEA's Regulatory Authority Information System (RAIS) [8] or any other equivalent system available within the country.

Other sources of information might include, for example:

— Manufacturers/equipment suppliers;
— Professional societies;
— Records of inspections;
— Import/export records;
— Personnel monitoring services;
— Accident and incident reporting.

3.3. NUMBER OF PERSONNEL TO BE EDUCATED AND TRAINED

Having acquired knowledge of the roles and responsibilities of personnel and their required competence, and a good understanding of the facilities and activities undertaken, the next phase is to determine the number of persons in each of the various categories of personnel for which education and training needs must be addressed. Consideration should be given to the projected number of educated and trained persons needed in the future; a time frame of five years might be reasonable. The likely turnover of staff in posts is another consideration when estimating the number of persons requiring education and training. The EduTA methodology [7] may be particularly helpful in this process.

It is worth noting that an analysis of this type is expected to identify any potential skills shortage in the future. For example, if a Member State is going to start a programme of isotope production, then it will require an appropriately educated and trained workforce, which would include graduates in scientific and technical disciplines, to support the programme. For this purpose, a programme of education and training in radiation protection would be an important component to be considered. Identifying this need at an early stage allows time to put the appropriate measures in place to ensure that any shortage of essential skills in the future is avoided.

There are a number of options as to how the collated information can be recorded and documented, but the resulting output from the assessment phase would be expected to include the following:

— Facilities/activities: A list of all current facilities and activities and those foreseen along with estimates of the number of sources.
— Functions/responsibilities: A list of all identified functions and responsibilities (ideally, cross-referenced to facilities/activities).
— Required education/training: Details of the education and training requirements for each combination of function/responsibility and facility/activity.
— Number of persons to be educated and trained: An estimate of the number of individuals for each function/responsibility and facility/activity combination likely to require education and training within a certain time frame (e.g. five years).

It should be ensured that any identified needs are based on the actual information on the education and training requirements and on existing and foreseen facilities and activities. Unfounded 'wish-lists' or the formulation of programmes to elaborate on existing satisfactory capabilities could end up diluting the real needs.

It is worth noting that training providers are expected to have established mechanisms to evaluate the training needs (particularly if accredited to a quality standard such as the one described in Ref. [9]). The analysis carried out by these training providers for their field of activity can provide a useful input to the overall analysis at a national level.

Once the education and training needs have been clearly identified, a national education and training programme can be designed to meet these needs.

4. DESIGN OF THE NATIONAL EDUCATION AND TRAINING PROGRAMME

4.1. ELEMENTS OF THE NATIONAL EDUCATION AND TRAINING PROGRAMME

As defined in Section 2.2, the national education and training programme is the schedule of activities to be delivered over a specified time frame in order to meet the identified education and training needs. At a minimum, the programme is expected to detail all education and training events to be delivered using

national capability and, when necessary, to be sourced outside the country, with information on the type of education or training, target audience, frequency of events and duration.

Where appropriate, the specified education and training programme may also be complemented by other activities such as:

— Train-the-trainer (TTT) activities (see Section 5.3.3) aimed at building training capability;
— Strengthening programmes relevant to radiation protection and safety provided by educational providers (e.g. universities);
— Establishing training centres.

4.2. ASSESSMENT OF NATIONAL RESOURCES AND CAPABILITIES

Having identified the education and training needs, the first step in the design of a national education and training programme is to assess existing capabilities, both in terms of the resources available and the appropriateness of those resources.

There are a number of methodologies that can be applied in order to ensure that all relevant information is included. Self-assessment has the advantage that it can be done on a practice by practice basis and could usefully be undertaken, for example, by the relevant professional bodies where they exist. The outcome will be a complete picture of the existing national education and training capabilities.

Information on national resources and capabilities can be collected via two complementary approaches. The first approach is based on ‘institutions’. In this approach, information is collected about, inter alia: institutions offering academic programmes related to physics or applied sciences with subjects dealing with ionizing radiation; medical schools that build the competence of health professionals who are responsible for protecting patients (e.g. medical physicists; doctors with specialization in relevant fields such as nuclear medicine, radiotherapy, diagnostic radiology); institutions providing training courses to operators dealing with nuclear applications (e.g. non-destructive test operators); and institutions providing training courses for personnel with responsibilities in radiation protection (RPOs, QEs).

The second complementary approach focuses on qualifications and requirements. In this case, the approach would involve collecting information based on:

— Identifying the primary qualification routes for those working (at all levels) within the practice. (This will identify any prescribed educational requirements as well as any discipline specific training schemes.) For example, in the case of a radiologist, the primary qualification route is medical doctor, with further training in the specific discipline of radiology.
— Determining whether there is any radiation protection component embedded within the primary qualification route and, if so, ascertaining the details, particularly existing national resources and capabilities supporting the provision of the related education and training. In the example of a radiologist cited previously, a component of radiation protection is expected to be built into the identified education and training programme, including topics such as dose to patient, factors that affect dose, techniques and methodologies to reduce dose using the 'as low as reasonably achievable' principle, and quality assurance. Whenever a gap is identified, the training programme needs to be adjusted accordingly.
— Determining whether radiation protection training is required and provided after the qualification and, if so, ascertaining the details. For example, refresher training is expected to be required to maintain professional competence with respect to radiation protection.

This process can be followed for each identified practice. Such a systematic approach is expected to identify all known capability in the field.

As an alternative, or in addition to the above approaches, external peer reviews may be used to identify the national education and training capability. The IAEA's EduTA methodology [7] can be used to assist this process. Where both internal self-assessment and external appraisal are undertaken, an overlap with respect to the resulting information can be expected. The combination of the two assessments will provide a comprehensive picture of what is available.

4.3. MATCHING THE NEEDS TO AVAILABLE RESOURCES AND CAPABILITIES

The next phase is to match the identified needs (Section 3.3) with the national capability for the provision of education and training (Section 4.2). The outcome of this matching exercise will be twofold; it will identify:

(a) The education and training needs that may be addressed using available national resources and capabilities.

(b) The residual education and training needs that can be addressed by:
   (i) Building capability (over time) within the country;
   (ii) Using available resources outside the country.

The matching exercise will need to consider the following points:

— The suitability of existing education and training capabilities needs to be verified by the relevant stakeholders. For example, training programmes, courses or providers (depending on the national requirements) might need to be recognized by specific authorities (e.g. the regulatory body) to cope with the training needs for some facilities and activities and/or some specific personnel.
— The matching process will indicate whether available resources are being optimized (e.g. it may be that existing capabilities and resources can be better deployed). If this is the case, then the issue needs to be identified and remediation built into the planned national education and training programme.
— Where a lack of capability at the national level has been identified, the reasons must be made clear, for example:
  • Shortage of relevant expertise;
  • Lack of appropriate facilities;
  • Lack of specific practical resources (e.g. simulators);
  • Emerging practice;
  • Lack of opportunity for on the job training.

Consideration of exactly where and why there is a shortfall in the capability at the national level may be a useful input in determining how best to meet that need (for example, it might not be cost effective to address the shortfall at the national level, depending on the number of persons to be educated or trained).

4.4. DESIGNING THE NATIONAL EDUCATION AND TRAINING PROGRAMME

Completion of the previous step of this phase structures the profile of the national education and training programme, identifying what needs to be done, where and when. This provides the input for the next step: formulating the details of the programme to meet the education and training needs by scheduling a programme of work over a specified time frame that makes use of all appropriate resources. Obviously, the schedule will reflect the volume of education and training required, but it also should reflect any prioritization identified when

assessing the needs. The programme of work may not need to be fixed in terms of the dates of events, or even who, or what organization, is expected to deliver the training, but in the latter case it is advisable that, at a minimum, appropriate targets and milestones (e.g. competence built in a certain timeframe through TTT activities) be incorporated into the programme.

5. DEVELOPMENT AND IMPLEMENTATION OF THE NATIONAL EDUCATION AND TRAINING PROGRAMME

5.1. INTRODUCTION

The third phase of the overall strategy is putting into practice the national education and training programme. There are two components to this phase:

(1) The development of the appropriate tools and mechanisms, where necessary, for the implementation of the activities outlined in the national education and training programme;
(2) The actual delivery (implementation) of the activities within the national education and training programme.

A detailed explanation of the aspects to be considered in the development and implementation of training courses is provided in section 5 of Safety Reports Series No. 20, Training in Radiation Protection and the Safe Use of Radiation Sources [5].

It is worth noting that education is provided by tertiary level institutions (e.g. universities), issuing certificates and diplomas often based on international mutual recognition mechanisms. On the other hand, training might be supplied by a large variety of providers (e.g. private companies, professional organizations, training centres), for which standards might not always have been clearly established, particularly for training in the field of radiation protection and safety.

The following sections present some considerations about the provision of training within a national education and training programme.

5.2. DEVELOPMENT

The focus in the development stage is on ensuring that the content and format of any training to be delivered will be such that the training needs will be adequately addressed. For this purpose, it can be helpful to consider any training event as a 'product' that must satisfy certain criteria.

5.2.1. Criteria for content and format

Within the national education and training programme, the following points need to be specified for every training event:

— Intended target audience;
— Aims and learning objectives;
— Preferred delivery format (e.g. classroom, distance learning, practical demonstrations, on the job training);
— Syllabus to be covered;
— Duration;
— Nature and format of student material to be provided (e.g. lecturer's notes, slides);
— Prerequisites for training providers (e.g. recognition of training centre and/or courses [3]);
— Prerequisites for trainers (e.g. qualification and/or competence in terms of technical capabilities and teaching ability).

5.2.2. Criteria for training providers

It is likely that within any country there will be a number of training providers, some capable of delivering a wide range of training events identified in the training programme, and others with more limited or specialized capability. In order to ensure consistency in the approach, basic criteria need to be established with respect to how training providers deliver training events. Specifically:

— Providers are expected to adhere to the criteria for content and format of training events (as specified in Section 5.2.1).
— Providers are expected to produce their own course material for students. Such an approach allows for a degree of flexibility (which can be beneficial), but minimum standards/criteria would be expected to be specified with respect to content and presentation.
— Format and standards for assessment tools (e.g. examination procedures) are expected to be specified (as further considered in Section 5.2.3).

It would be beneficial if these criteria/standards were to be generally available (e.g. on the web, or in a published document).

5.2.3. Examination procedures

At the end of each course (or module for longer events), the assessment of trainees can be used to evaluate the achievement of the learning objectives and to test the efficacy of the course delivery and the performance of the trainers. Examination procedures will need special consideration if the successful completion of the training confers a qualification or special status (for example, as QE or RPO).

If the examination at the end of the course does not confer such a qualification or special status, and a further examination conducted by national authorities is needed, the outcomes of such an examination could provide the training providers with important independent feedback to evaluate the effectiveness of their courses.

5.3. IMPLEMENTATION

The activities within the national education and training programme are expected to be assigned priorities for implementation based on their importance. In some cases it may take some time to develop certain activities, but this should not hinder the implementation of other activities that need little additional work or are ready to be implemented.

Although the issue of accessibility of education and training will have been considered when designing the national education and training programme, care should be taken to ensure that the education and training activities are made available where they are needed. In some cases this may mean that the training providers have to travel to where the need is, or that some larger facilities/organizations develop the training capability themselves in order to cope with their own training needs, subject to the criteria described in Section 5.2.

5.3.1. Meeting education and training needs using regional or international resources

When the necessary competence and facilities are not available nationally and persons go abroad for their education or training, the national stakeholders need to ensure that the contents and duration of the programmes are in line with national requirements. Consideration should also be given to the timing to ensure it meets the education and training needs as identified in the design phase.

Furthermore, limitations in the number of participants that can attend courses organized outside the country (e.g. limitations in the availability of funding to support the country's participants) also need careful consideration.

5.3.2. Recognition of training centres/providers/courses

While formal education is provided by tertiary institutions that are normally regulated within the national system, there might be a large diversity of training providers, in terms of type, capabilities, training programmes offered, etc. It may therefore be advantageous to establish an accreditation process for the recognition of training centres, providers and courses for the training of personnel for whom legislation and regulations have established requirements (e.g. the QE and RPO) in compliance with safety standards [2]. The regulatory body is likely to play a key role in formally conferring such recognition [3].

The criteria for accreditation of training centres, providers and courses need to be defined, for example in national standards that also establish requirements for training facilities, teaching staff, content, material and methods for training, examination procedures and training records [5]. Both requirements and criteria are expected to be reviewed periodically to ensure that they are effective and up to date.

5.3.3. Activities to build national training capability

One of the most important and effective means of optimizing resources and transferring the skills necessary for building competence is the TTT approach. This is aimed at training those who will become trainers, with a cascading effect that will make available a large number of trained personnel in a reasonable time frame. The desired end point is a pool of trainers with technical competence, practical experience, and teaching and communication skills in order to allow the establishment of a sustainable and self-supporting training programme in the country.

A country could consider adopting mechanisms for training the trainers with short and long term approaches.

In the first case, the country could make use of resources available abroad, for example inviting international experts to train local trainers, or organizing scientific visits for local trainers to well established foreign institutions to enable them to gain the necessary experience. Potential local trainers could also be sent as observers or participants to specifically designed training courses organized by international organizations (e.g. the IAEA has been regularly organizing workshops for training the trainers of RPOs).

In the long term, teaching modules for the TTT approach would be expected to be firmly implemented in the syllabi of courses provided at the national level in the field of radiation protection and the safety of radiation sources (e.g. as in the IAEA syllabus in Ref. [6]).

6. EVALUATION OF THE NATIONAL EDUCATION AND TRAINING PROGRAMME

It is important that the national education and training programme be in line with the relevant safety standards and that its effectiveness be monitored to ensure that it continues to meet changing needs (e.g. due to the introduction of new practices, the development of new techniques or the establishment of new regulations). Mechanisms for regular evaluation include self-assessment or an external appraisal [7].

Two approaches to evaluation can be adopted:

(1) Evaluation of the national education and training programme as soon as its implementation starts in order to review the status of completion of each phase (*continuous evaluation*);
(2) Evaluation of the overall efficiency and effectiveness of the programme in building competence according to the identified needs, after all the phases have been completed (*long term evaluation*).

In relation to continuous evaluation, performance indicators addressing the successful implementation of the individual phases of the national education and training programme might consider:

— The number of people educated at the academic level in the relevant areas;
— The number of people trained after having achieved the appropriate academic level;
— The pass rate on the examination for the formal recognition of the qualification for certain categories of personnel, after having achieved the appropriate levels of education and training;
— The number of people undergoing initial and refresher training;
— Feedback from attendees about the quality and effectiveness of education and training programmes;
— Feedback from employers on the basis of a formal and documented appraisal of the performance of trainees after training.

In relation to long term evaluation, the impact of the entire national education and training programme needs to be considered, for example through improvements in safety in the operation of the facility. For that purpose, parameters could consider occupational and/or collective doses, or reduction in accident rates, and could be assessed by using performance indicators that compare:

— Inspection reports before and after training;
— Data on individual and collective doses before and after training;
— Accident reports before and after training.

The application of an appropriate quality management system [9] within the various phases for the establishment of the national education and training programme will be beneficial.

Appendix I

EXAMPLE ILLUSTRATING THE ESTABLISHMENT OF A NATIONAL STRATEGY

I.1. INTRODUCTION

This appendix illustrates the practical application of the methodology outlined in this publication for a hypothetical country. The example cited helps to visualize the implementation of the various steps of the process in a practical way.

The case study focuses on the first three phases of the process to establish a national strategy for education and training in radiation, transport and waste safety: assessment of education and training needs (Section 3), design of the national education and training programme (Section 4), and development and implementation of the programme (Section 5).

For simplicity, it is assumed that the hypothetical country has a sufficient number of personnel with adequate educational levels (academic), for each category of personnel, to meet the relevant educational requirements in the national legislation and regulations. Hence, in this example, Phase 1 only covers training needs. The availability of human resources at the national level with the appropriate educational achievements should be carefully considered when this guidance is applied to an actual case; if necessary, an assessment of educational needs could be carried out as well.

Furthermore, the theoretical case study has been limited to a restricted number of facilities and activities, and a restricted number of personnel (as outlined in Fig. 2). The training needs were assessed for facilities and activities in the industrial and research field, the medical field, other general practices, and regulatory activities. The personnel considered are QEs, RPOs, operators and health professionals (Fig. 2 (a)). On the basis of this assessment, the national education and training programme was then designed only for facilities and activities in the medical field and for three categories of personnel (QEs, RPOs and operators) (Fig. 2 (b)). Finally, an example of some actions to develop and implement the national education and training programme is provided for the training of RPOs in nuclear medicine (Fig. 2 (c)).

Explanatory notes at the end of this appendix provide information on how to use the example tables to collect and collate data for the assessment of education and training needs. Definitions, functions and responsibilities of the personnel considered in the example are also provided.

a)

		Personnel for whom requirements on education, training and competence are established							
		.....	.....	QE	RPO	Op	HP	.....	.....
Practices involving facilities and activities regulated by national legislation	.....								
	.....								
	Industrial and Research								
	Medical								
	Other Practices								
	Regulatory Activities								
	.....								
	.....								

b)

	QE	RPO	Op	HP
INDUSTRIAL and RESEARCH				
.....				
.....				
MEDICAL				
.....				
.....				
Dental radiology (alone)				
Diagnostic and interventional radiology				
Radiotherapy				
Nuclear medicine				
.....				
.....				
OTHER PRACTICES				
.....				
.....				
REGULATORY ACTIVITIES				
.....				
.....				

c)

	QE	RPO	Op
Dental radiology (alone)			
Diagnostic and interventional radiology			
Radiotherapy			
Nuclear medicine			

FIG. 2. Outline of the facilities and activities, and the personnel considered during: (a) assessment of the education and training needs (Section I.2); (b) design of a national education and training programme (Section I.3); and (c) development and implementation of the national education and training programme (Section I.4). QE: qualified expert; RPO: radiation protection officer; Op: operator; HP: health professional (includes all professionals in the medical field except those already considered in the previous categories).

In the case of a country establishing a national education and training programme, all the facilities and activities present in the country and regulated by national legislation and regulations, as well as all the categories of personnel for whom education and training requirements in radiation safety are established, need to be considered. QEs and RPOs will always be taken into consideration, owing to their central role and responsibilities in radiation safety. The entire four phase process (including the evaluation of the national education and training programme as presented in Section 6) needs to be applied.

I.2. ASSESSMENT OF EDUCATION AND TRAINING NEEDS

I.2.1. Legal and regulatory framework for education and training (Section 3.1)

At this stage, the government of the hypothetical country has established a regulatory body (Requirement 3 in Ref. [1]) and appropriate requirements for education, training, qualification and competence have been established for persons engaged in radiation protection and safety activities (para. 2.21 in Ref. [2]).

The regulatory body ensures the application of the requirements for education, training, qualification and competence in radiation protection and safety (para. 2.32 in Ref. [2]).

The registrants, licensees and employers ensure that all personnel engaged in activities relevant to protection and safety have appropriate education, training and qualification so that they understand their responsibilities and can perform their duties competently, with appropriate judgement and in accordance with the procedures (paras 2.41, 2.42 and 2.44 in Ref. [2]).

In particular:

— Requirements are established for the formal recognition of the QE (para. 2.21(b) in Ref. [2]). In the hypothetical country, the QE is recognized in the general field of radiation protection, but further requirements have been established with regard to the specific practices the QE could be asked to provide advice on. The number of QEs needed per practice is not specified. All facilities will need the advice of, and access to, a QE. In some complex facilities, the QE may be an employee of the facility, in other cases a consultant.
— Employers, registrants and licensees, in consultation with workers or through their representatives, designate an RPO, in accordance with the criteria established by the regulatory body (para. 3.94(e) in Ref. [2]). The

regulatory body specifies that RPOs are needed for all practices. However, one RPO may serve several departments (e.g. with regard to the diagnostic and interventional radiology practice in a hospital, an RPO may be designated for different radiology departments).

— Employers, registrants and licensees ensure that, for all workers engaged in activities in which they are or could be subject to occupational exposure, suitable training in protection and safety is provided, as well as periodic retraining (Requirement 21 and para. 3.76(h) in Ref. [2]). Registrants and licensees provide appropriate information, instruction and training for persons working in controlled areas (Requirement 24 and para. 3.90(i) in Ref. [2]). Employers, in cooperation with registrants and licensees: provide all workers with adequate instruction, training and periodic retraining in radiation protection and safety, and sufficient information on the significance of their actions; provide those workers who could be involved in or are affected by the response to an emergency with appropriate information, adequate instruction, training and periodic retraining, for protection and safety (Requirement 26 and paras 3.110(a) and (b) in Ref. [2]). Employers, in cooperation with registrants and licensees, maintain records of the training provided to individual workers (Requirement 26 and para. 3.110(c), Requirement 42 and para. 3.183(b) in Ref. [2]).
— The regulatory body identifies a category of personnel among the workers responsible for the day-to-day use of radiation sources (operators), trained in the operation of the equipment, and with a high level of expertise in their area of work [3]. Such workers are appointed by the employers and, in the hypothetical country, are authorized by the regulatory body. Examples of these workers are the personnel responsible for non-destructive testing (e.g. radiographers [10–12]), personnel in the industries handling naturally occurring radioactive material (NORM) [13], staff in the medical sector (e.g. diagnostic radiographers), research reactor operators [14], those involved in the transport of radioactive material [15] and workers in radioactive waste facilities [16]. The number of these workers depends on the needs of the facilities.
— The regulatory body requires that health professionals with responsibilities for medical exposure be specialized in the appropriate area (e.g. diagnostic radiology, image guided interventional procedures, radiotherapy and nuclear medicine), and they meet the requirements for education, training and competence in the relevant specializations (para. 3.150 in Ref. [2]). They need to receive adequate education and training in radiation protection and safety as part of the process of building their specific competence.
— A process has been established to develop and maintain the necessary competence and skills of staff of the regulatory body [17], as an element

of knowledge management. This process includes the development of a specific training programme based on an analysis of the necessary competence and skills. The training programme covers principles, concepts and technological aspects, as well as the procedures followed by the regulatory body for assessing applications for authorization, for inspecting facilities and activities, and for enforcing regulatory requirements (para. 4.13 of Ref. [1]).

— Some guidance is available specifying the minimum levels of education and training (including on the job training) that have to be demonstrated by specific categories of personnel, such as RPOs, QEs, operators, health professionals and the staff of the regulatory body. The government has established which persons need to have particular qualifications and the process to be employed for the recognition of such qualifications (for example for QEs).
— In the hypothetical country, there is a training centre[5] and relevant courses are recognized by the regulatory body [3].

I.2.2. Details on facilities and activities, and personnel to be educated and trained (Sections 3.2 and 3.3)

Tables 1 and 2 show the data collected for the facilities and activities, and categories of personnel to assess the training needs in the hypothetical country. For simplicity, it is assumed that personnel with appropriate and adequate education levels are already available in the hypothetical country (for more details see the introduction to this appendix).

[5] In the example, a national training centre (NTC) is in place. However, it may not be necessary to establish a dedicated radiation protection training centre. The relevant capabilities may be available in universities and other organizations (e.g. technical support organizations and professional organizations).

TABLE 1. ASSESSMENT OF TRAINING NEEDS

Type	Facilities and activities			Qualified experts (QEs)			Radiation protection officers (RPOs)			Operators			Health professionals (HPs)[a]		
	Existing	Foreseen (<5 years)	Total	Existing	Estimated QEs required	QEs to be trained	Existing	Estimated RPOs required	RPOs to be trained[b]	Existing	Estimated operators required	Operators to be trained	Existing	Estimated HPs required	HPs to be trained
INDUSTRIAL AND RESEARCH															
Industrial radiography	11	2	13	2	0[c]	0	3	13	10	88	104	16	n.a.[d]	n.a.[d]	n.a.[d]
Industrial irradiator facilities (industrial and research)	2	0	2	2	0	0	2	2	0	3	4	1	n.a.[d]	n.a.[d]	n.a.[d]
Industrial gauges and well logging	38	7	45	2	3[c]	1	38	45	7	152	180	28	n.a.[d]	n.a.[d]	n.a.[d]
Research activities: use of sealed and unsealed sources	12	3	15	0	7[c]	7	12	15	3	75	90	15	n.a.[d]	n.a.[d]	n.a.[d]
Research accelerators or reactors	2	0	2	0	2	2	2	2	0	10	13	3	n.a.[d]	n.a.[d]	n.a.[d]

TABLE 1. ASSESSMENT OF TRAINING NEEDS (cont.)

Type	Facilities and activities			Qualified experts (QEs)			Radiation protection officers (RPOs)			Operators			Health professionals (HPs)[a]		
	Existing	Foreseen (<5 years)	Total	Existing	Estimated QEs required	QEs to be trained	Existing	Estimated RPOs required	RPOs to be trained[b]	Existing	Estimated operators required	Operators to be trained	Existing	Estimated HPs required	HPs to be trained
Mineral extraction and processing companies (NORM)	10	2	12	0	6[c]	6	10	12	2	250	300	50	n.a.[d]	n.a.[d]	n.a.[d]
MEDICAL															
Dental radiology (alone)	500	200	700[e]	0	0	0	0	0	0	300	400	100	700	900	200
Diagnostic and interventional radiology	620	120	740[e]	0	37[c]	37	225	270	45	600	740	140	800	1100	300
Radiotherapy	3	1	4	1	4	3	3	4	1	20	28	8	10	14	4
Nuclear medicine	13	3	16	0	16	16	13	16	3	60	70	10	26	32	6

TABLE 1. ASSESSMENT OF TRAINING NEEDS (cont.)

Type	Facilities and activities			Qualified experts (QEs)			Radiation protection officers (RPOs)			Operators			Health professionals (HPs)[a]		
	Existing	Foreseen (<5 years)	Total	Existing	Estimated QEs required	QEs to be trained	Existing	Estimated RPOs required	RPOs to be trained[b]	Existing	Estimated operators required	Operators to be trained	Existing	Estimated HPs required	HPs to be trained
OTHER PRACTICES															
Waste management facility	1	0	1	1	1	0	1	1	0	1	4	3	n.a.[d]	n.a.[d]	n.a.[d]
Veterinary radiology	3	1	4	0	0	0	1	3	2	3	6	3	n.a.[d]	n.a.[d]	n.a.[d]
Security equipment (e.g. baggage X rays, container inspection, etc.)	5	2	7	0	0	0	5	7	2	65	95	30	n.a.[d]	n.a.[d]	n.a.[d]
Isotope production operations and source manufacturing	1	0	1	0	1	1	1	1	0	5	7	2	n.a.[d]	n.a.[d]	n.a.[d]
Uranium mines	0	0	0	0	0	0	0	0	0	0	0	0	n.a.[d]	n.a.[d]	n.a.[d]

[a] This category of personnel includes all professionals in the medical field except those already considered in the previous categories.
[b] The number of RPOs to be trained reflects the fact that some of the existing facilities do not yet have RPOs as required by the regulations.
[c] Not all practices need full time QEs.
[d] n.a.: not applicable.
[e] Number of devices.

TABLE 2. ASSESSMENT OF TRAINING NEEDS, REGULATORY STAFF

	Existing	Estimated regulatory staff required	Regulatory staff to be trained
Authorization	7	7	0
Inspection	5	15	10
Assessment	3	6	3
Enforcement	3	6	3

I.3. DESIGN OF A NATIONAL EDUCATION AND TRAINING PROGRAMME

I.3.1. National resources and capabilities for training of the relevant personnel (Sections 4.1 and 4.2)

Based on the information about the personnel to be trained (Tables 1 and 2), competent authorities and education and training institutions have provided information about relevant existing training programmes at the national level.

Table 3 shows the data collected in the hypothetical country about training programmes in radiation protection and safety in the medical field. The professional association of dentists regularly organizes basic courses in the field of radiation protection; the courses comply with the requirements provided by the regulatory body for the minimum training levels for operators in the field. There is a national training centre (NTC) that has developed a comprehensive training portfolio in the field of diagnostic and interventional radiology for QEs (in collaboration with the Faculty of Physics at the national university and hospitals), RPOs and operators. In the fields of radiotherapy and nuclear medicine, courses are available only for operators.

TABLE 3. NATIONAL RESOURCES IN THE HYPOTHETICAL COUNTRY FOR TRAINING IN RADIATION PROTECTION AND SAFETY IN THE MEDICAL FIELD

Facilities and activities	Personnel	Training programme			Remarks
		Provider	Title	Purpose	
Dental radiology	Operator	Professional association	Radiation protection in the use of X ray generators in dental radiology	Training of operators in radiation protection in dental radiology	n.a.[a]
Diagnostic and interventional radiology	QEs	NTC with: national university Faculty of Physics, hospitals	Advanced course in radiation protection in diagnostic and interventional radiology	Building QEs' competence in radiation protection in diagnostic and interventional radiology	Course established by the NTC using, inter alia, the material developed by the IAEA,[b,c] complementary courses and on the job training (in collaboration with the university and hospitals) to comply with national requirements for the recognition of QEs
	RPO	NTC	Training course in radiation protection in diagnostic and interventional radiology	Training of RPOs in radiation protection in diagnostic and interventional radiology	Course established by the NTC using, inter alia, material developed by the IAEA[d]

TABLE 3. NATIONAL RESOURCES IN THE HYPOTHETICAL COUNTRY FOR TRAINING IN RADIATION PROTECTION AND SAFETY IN THE MEDICAL FIELD (cont.)

Facilities and activities	Personnel	Training programme			Remarks
		Provider	Title	Purpose	
	Operator	NTC	Radiation protection in the use of ionizing radiation in diagnostic and interventional radiology	Training of operators in radiation protection in diagnostic and interventional radiology	n.a.[a]
Radiotherapy	Operator	NTC	Radiation protection in the use of ionizing radiation in radiotherapy	Training of operators in radiation protection in radiotherapy	n.a.[a]
Nuclear medicine	Operator	NTC	Radiation protection in the use of unsealed radiation sources in nuclear medicine	Training of operators in radiation protection in nuclear medicine	n.a.[a]

[a] n.a.: not applicable.
[b] IAEA training material on radiation protection in radiotherapy [18].
[c] Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources: Standard Syllabus [6] (a revised version of this publication is in preparation).
[d] A syllabus for the training of RPOs at industrial and medical radiation facilities is in preparation.

I.3.2. Matching the needs to available resources and capabilities (Section 4.3)

Once the training needs are clearly identified (Tables 1 and 2), the national education and training programme is designed in order to fulfil such needs using

domestic and foreign capabilities. Existing capabilities to match some of the training needs were identified in Table 3 for the medical field.

Table 4 shows an example of the training courses and other activities in the medical field that are required to address the needs in the hypothetical country as identified in Tables 1 and 2. The national education and training programme needs to address the training needs for QEs and RPOs in radiotherapy and nuclear medicine. For these practices, only the training of operators is available at the NTC (Table 3). The country might adopt the following approach:

(a) For radiotherapy, the number of personnel to be trained in the next five years might not justify the development of a national course. Therefore, personnel to be recognized or designated as QEs or RPOs will be trained making use of external resources, such as the IAEA Regional Training Centres (RTCs), located in specific IAEA Member States [19]. However, the country needs to carefully consider that the time needed to train personnel depends on the number of training vacancies in the RTC courses available to international participants:
    (i) With regard to the training of QEs, since the country has a formal system of recognition for QEs based on general competence in radiation protection and safety complemented by additional knowledge on a specific practice, the regulatory body will endorse the postgraduate educational course in radiation protection and the safety of radiation sources [6], integrated with the practice specific course delivered by the RTC. Seminars and on the job training will also be required by the regulatory body to comply with national requirements for the recognition of QEs. These training activities will be organized by the Faculty of Physics in collaboration with hospitals (as in the case of QEs in diagnostic and interventional radiology).
    (ii) For the training of RPOs, the regulatory body will endorse the training course delivered by the IAEA RTC and based on IAEA training material.
(b) For nuclear medicine, the number of personnel to be trained might justify the development of some national capabilities, making use of the available resources when possible and appropriate. In fact, the country is considering whether the development of some expertise at a national level in nuclear medicine could be important even for other practices and technological applications using unsealed sources.
    (i) In order to address the need for QEs in a sustainable way, there will be a need to build the competence of the future trainers in the course to be established (Phase 1 in Table 4). The trainers will be trained on the technical aspects through a course in radiation protection provided by

TABLE 4. MATCHING THE TRAINING NEEDS WITH NATIONAL AND INTERNATIONAL RESOURCES AND CAPABILITIES IN THE MEDICAL FIELD

Facilities and activities	Personnel	Provider	Course	Attendees	Remarks
Dental radiology	Operator	Professional association	Radiation protection in the use of X ray generators in dental radiology	100	n.a.[a]
Diagnostic and interventional radiology	QE	NTC with: national university Faculty of Physics, hospitals	Advanced course in radiation protection in diagnostic and interventional radiology	37	n.a.[a]
	RPO	NTC	Training course in radiation protection in diagnostic and interventional radiology	45	n.a.[a]
	Operator	NTC	Radiation protection in the use of ionizing radiation in diagnostic and interventional radiology	140	n.a.[a]

TABLE 4. MATCHING THE TRAINING NEEDS WITH NATIONAL AND INTERNATIONAL RESOURCES AND CAPABILITIES IN THE MEDICAL FIELD (cont.)

Facilities and activities	Personnel	Provider	Course	Attendees	Remarks
Radiotherapy	QE	RTC	Postgraduate educational course in radiation protection and the safety of radiation sources[b]	3	The number of personnel to be trained does not justify the development of a national course
			Specialized training course in radiation protection in radiotherapy[c]		The regulatory body endorses the course[b] provided at the RTC as part of the framework for the recognition of QEs, but further practice specific courses (including the specialized training course[c] delivered at the RTC), seminars and on the job training are added to comply with national requirements for recognition of QEs
		National university Faculty of Physics, hospitals	Practice specific seminars and on the job training		

TABLE 4. MATCHING THE TRAINING NEEDS WITH NATIONAL AND INTERNATIONAL RESOURCES AND CAPABILITIES IN THE MEDICAL FIELD (cont.)

Facilities and activities	Personnel	Provider	Course	Attendees	Remarks
Radiotherapy (cont.)	RPO	RTC	Training course for RPOs in radiotherapy[d]	1	The number of personnel to be trained does not justify development of a national course The regulatory body endorses the course[d] provided at the RTC
	Operator	NTC	Radiation protection in the use of ionizing radiation in radiotherapy	8	n.a.[a]
Nuclear medicine		RTC NTC (Phase 1)	Training course in radiation protection in nuclear medicine, and TTT course: how to be a lecturer	4[e]	The TTT course is organized by the NTC hiring as lecturers the attendees of the postgraduate educational course (which includes a module on TTT)
	QE	NTC with: national university, Faculty of Physics, hospitals (Phase 2)	Advanced course in radiation protection in nuclear medicine	16	The course makes use of the lecturers trained in Phase 1

TABLE 4. MATCHING THE TRAINING NEEDS WITH NATIONAL AND INTERNATIONAL RESOURCES AND CAPABILITIES IN THE MEDICAL FIELD (cont.)

Facilities and activities	Personnel	Provider	Course	Attendees	Remarks
Nuclear medicine (cont.)	RPO	NTC with the RTC	Training course for RPOs in nuclear medicine[d]	3	Basic module[d] delivered at the NTC and practical module delivered at the RTC The regulatory body endorses[d] the part of the course delivered at the RTC
	medicine	NTC	Radiation protection in the use of unsealed sources in nuclear medicine	10	n.a.[a]

[a] n.a.: not applicable.
[b] Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources: Standard Syllabus [6] (a revised version of this publication is in preparation).
[c] IAEA training material on radiation protection in radiotherapy [18].
[d] A syllabus for the training of RPOs at industrial and medical radiation facilities is in preparation.
[e] Estimation of the number of trainers that must be trained (not the number of final trainees to be trained, as derived from Tables 1 and 2 in the other cases).

foreign organizations (e.g. the RTC) and on the soft (teaching) skills through a TTT course. The lecturers of the TTT course, organized by the NTC, will be selected from among those who attended the postgraduate educational course in radiation protection and the safety of radiation sources [6] (which includes a TTT module) to become QEs in radiation protection. Once the trainers have been trained, the NTC will establish an advanced training course for QEs in radiation protection in nuclear medicine in collaboration with the Faculty of Physics and hospitals, as already performed in the case of diagnostic and interventional radiology (Phase 2 in Table 4).

(ii) In the case of RPOs, the number of personnel to be trained might not justify the full development of a national training course. However, considering the objective of building national competence in this field, the country may consider adopting a training scheme with a basic module based on an IAEA syllabus for RPOs (which is under development), delivered by the NTC, and practical modules in nuclear medicine provided by a foreign organization (such as an RTC). For the basic module, the NTC could make use of the module included in the course for RPOs in diagnostic and interventional radiology which is delivered regularly in the country. This solution will enhance the use of national resources in a synergistic way. The regulatory body endorses the part of the course delivered at the RTC.

I.3.3. Outline of the national education and training programme (Section 4.4)

Matching the needs with the resources and capabilities provides the input for the national education and training programme that will identify which courses need to be organized in the next five years.

The maximum number of trainees that can be enrolled in each course will depend, inter alia, on the capacities of the organizations/institutions hosting the courses and the facilities required, particularly, for the practical exercises. The number of training courses that must be organized over the next five years in the medical field is presented in Table 5 (assessed on the basis of a maximum number of 20–25 participants per course).

In summary, the national courses needed, on average, in the next five years are:

(a) Two courses for QEs in the area of diagnostic and interventional radiology using national resources. Initiatives will also be taken by national stakeholders to train personnel at the RTC in order to build the competence

TABLE 5. OUTLINE OF THE NATIONAL EDUCATION AND TRAINING PROGRAMME IN THE MEDICAL FIELD FOR THE NEXT FIVE YEARS

Facilities and activities	Category of personnel	Provider	Course	Number of courses
Dental radiology	Operator	Professional association	Radiation protection in the use of X ray generators in dental radiology	5
Diagnostic and interventional radiology	QE	NTC with: national university Faculty of Physics, hospitals	Advanced course in radiation protection in diagnostic and interventional radiology	2
	RPO	NTC	Training course in radiation protection in diagnostic and interventional radiology	2
	Operator	NTC	Radiation protection in the use of ionizing radiation in diagnostic and interventional radiology	7
Radiotherapy	QE	RTC	Postgraduate educational course in radiation protection and the safety of radiation sources[a]	Based on schedule and availability[b]
			Specialized training course in radiation protection in radiotherapy[c]	Based on schedule and availability[b]

TABLE 5. OUTLINE OF THE NATIONAL EDUCATION AND TRAINING PROGRAMME IN THE MEDICAL FIELD FOR THE NEXT FIVE YEARS (cont.)

Facilities and activities	Category of personnel	Provider		Course	Number of courses
Radiotherapy (cont.)	QE (cont.)	National university: Faculty of Physics, hospitals		Practice specific seminars and on the job training	As needed[d]
	RPO	RTC		Training course for RPOs in radiotherapy[e]	Based on schedule and availability[b]
	Operator	NTC		Radiation protection in the use of ionizing radiation in radiotherapy	1
Nuclear medicine	QE	Phase 1	RTC	Training course in radiation protection in nuclear medicine[f]	Based on schedule and availability[b]
			NTC	TTT course: how to be a lecturer[f]	1
		Phase 2	NTC with: national university Faculty of Physics, hospitals	Advanced course in radiation protection in nuclear medicine	1

TABLE 5. OUTLINE OF THE NATIONAL EDUCATION AND TRAINING PROGRAMME IN THE MEDICAL FIELD FOR THE NEXT FIVE YEARS (cont.)

Facilities and activities	Category of personnel	Provider	Course	Number of courses
Nuclear medicine (cont.)	RPO	NTC	Training course for RPOs in diagnostic and interventional radiology: basic module[e]	1[g]
		RTC	Specialized course in radiation protection in nuclear medicine: practical module[e]	Based on schedule and availability[b]
	Operator	NTC	Radiation protection in the use of radioisotopes in nuclear medicine	1

[a] Postgraduate Educational Course in Radiation Protection and the Safe Use of Radiation Sources: Standard Syllabus [6] (a revised version of this publication is in preparation).
[b] Depends on the time schedule of courses at the RTC and on the number of seats available to foreign participants.
[c] IAEA training material on radiation protection in radiotherapy [18].
[d] Seminars and on the job training can be arranged by the Faculty of Physics of the national university, and by hospitals whenever the need arises.
[e] A syllabus for the training of RPOs at industrial and medical radiation facilities is in preparation.
[f] For building the competence necessary for establishing an advanced course in radiation protection in nuclear medicine for QEs (Phase 2 in Table 4).
[g] Making use of one of the courses regularly provided by the NTC for training the RPOs in diagnostic and interventional radiology.

necessary for QEs in radiotherapy and nuclear medicine (Phase 1); in the latter area, in the long term, there will be an additional course for QEs using national resources (Phase 2).

(b) Two courses for RPOs in the area of diagnostic and interventional radiology using national resources. The course for RPOs in nuclear medicine is organized by the NTC and the RTC. The stakeholders should contact the RTC to plan the attendance of trainees at the practical modules delivered at the RTC after they have attended the basic module at the NTC. The training course for RPOs in radiotherapy is provided by the RTC; the stakeholders need to contact the RTC to plan the attendance of trainees.

(c) Fourteen courses for operators using national resources.

(d) A TTT course using national resources (Phase 1) in preparation for the national course for QEs in nuclear medicine (Phase 2).

I.4. DEVELOPMENT AND IMPLEMENTATION OF THE NATIONAL EDUCATION AND TRAINING PROGRAMME

I.4.1. Development of training courses to meet needs (Section 5.2)

Once the national education and training programme is designed, its development and implementation begins. It is important to ensure that the requirements for the training infrastructure are met, and to keep records on the courses and personnel being trained as well as to be aware of substantive changes in the projections (over the next five years).

The example provided below shows the development of training for RPOs in nuclear medicine (I.4.1.1.–I.4.1.3.). Some information about the target audience, the aims of the course, the delivery format, the syllabus, the providers of the training, and the examination is provided as well.

According to Table 5, the training scheme is based on a basic module provided by the NTC (making use of the module included in the training course for RPOs in diagnostic and interventional radiology already implemented in the country) and a practical module provided by the RTC. This will optimize the use of national human and material resources and allow, at the same time, for the development of core competence in a field where the national capabilities are still limited.

I.4.1.1. Background information on the training course for RPOs in nuclear medicine in the hypothetical country

The target audience is personnel to be designated as RPOs by the registrant, licensee or employer in accordance with the criteria established by the regulatory body to oversee the application of relevant requirements in nuclear medicine.

The aims and learning objectives are to provide theoretical and practical training in radiation protection and the safety of radiation sources to comply with the duties of RPOs in nuclear medicine.

The objective of the training is to have a full understanding of:

— Radiation protection principles and source safety necessary to effectively act as an RPO;
— General requirements of GSR Part 3 [2] when overseeing their application as an RPO;
— The role and duties of the RPO.

The syllabus is based on a core module and a practice specific module. The course will be delivered through classroom sessions, practical demonstrations, visits and on the job training.

I.4.1.2. Syllabus for the training course for RPOs in nuclear medicine in the hypothetical country: Core module

The core module will be organized by the NTC. On completion of the foundation training based on the core syllabus, the participant will:

— Have a basic understanding of radiation protection principles and source safety;
— Have a basic understanding of the requirements of GSR Part 3 [2];
— Understand the role and duties of the RPO.

As a prerequisite for the module, the participant needs to have secondary or tertiary education with a technical or scientific background.

Examinations will be held at the end of the core module (at the NTC). The topics covered by the core syllabus are listed below.

The RPO

— Introduction to GSR Part 3 [2]: brief overview of its objectives, scope and structure. This includes:

- Terminology: facilities, activities, practices; exposure situations (planned, existing, emergency); categories of exposure (occupational, public, medical).

— The RPO: definition, role, duties.

Basic nuclear physics

— Atomic structure: protons, neutrons and electrons; periodic table; atomic mass; isotopes of an element; excitation, ionization; characteristic X rays, bremsstrahlung; radiation, energy.

— Radioactivity: nuclear stability; unstable nuclei; radionuclides; radioactive decay, alpha, beta, gamma, neutrons; table of radionuclides; activity; law of radioactive decay; half-life; decay chains and equilibrium.

— Interaction of radiation with matter: properties of alpha, beta, gamma, X rays, bremsstrahlung radiation, ionization.

— Practical demonstration: alpha, beta and gamma radiation — range in air and suitable shielding material.

Quantities and units

— Radiation quantities: activity, absorbed dose, equivalent dose, effective dose, dose rate, committed effective dose.

— Radiation units: becquerel, gray, sievert.

Sources of radiation exposure

— Natural radiation: terrestrial radionuclides, uranium and thorium decay chains, radon.

— Human-made radiation: production of radioisotopes, sealed sources, unsealed sources, radiation generators (X ray sets, accelerators), common uses of radiation (e.g. industrial radiography, industrial irradiators, process control gauges, radiotracers, well logging, diagnostic and interventional radiology, nuclear medicine, radiotherapy).

Biological effects of ionizing radiation

— Effects of radiation on cells: breakage of chemical bonds, ionization; interaction with DNA; chromosomes; cell damage; cell repair; cell sensitivity.

— Stochastic effects: cancer induction, hereditary effects; effects on embryo/fetus. Concept of risk and sources of data on radiation health effects (e.g. atomic bomb survivors, medical exposures, uranium miners), dose response relationship.

— Deterministic effects: threshold dose, acute radiation syndrome, erythema, cataracts, hair loss.

International and national framework for protection and safety

— International organizations directly involved in radiation protection: Food and Agriculture Organization of the United Nations, IAEA, International Commission on Radiological Protection, International Labour Organization, Pan American Health Organization, United Nations Scientific Committee on the Effects of Atomic Radiation, World Health Organization.
— IAEA safety standards, international undertakings (codes of conduct, conventions).
— Responsibilities of the government and regulatory body:
  • Justification, optimization of protection and safety, dose limits;
  • Application of the principles of radiation protection;
  • Establishment and elements of a legal and regulatory framework and a regulatory body;
  • Systems for notification and authorization, review and assessment, inspection and enforcement, exemption and clearance.

Planned exposure situations: General responsibilities of registrants and licensees

— Responsibility for protection and safety.
— Optimization and dose limits.
— Management for protection and safety.
— Management systems, safety culture, human factors.
— Graded approach.
— Notification, registration and licensing.
— Safety assessment.
— Monitoring for verification of compliance.
— Prevention and mitigation of accidents and investigations.
— Good engineering practice, defence in depth, accident prevention, emergency preparedness and response.
— Investigation and feedback of information on operating experience.
— Radiation generators and radioactive sources.
— Human imaging for purposes other than medical diagnosis, treatment or research.

Planned exposure situations: Occupational exposure

— Protection of workers.
— Compliance by workers.
— Cooperation between employers, registrants and licensees.
— Radiation protection programme: controlled and supervised areas, local rules, personal protective equipment; monitoring the workplace.
— Assessment of occupational exposure, health surveillance, records.

— Information, instruction and training.
— Conditions of service.
— Special arrangements for female workers and persons under 18 years.

Planned exposure situations: Public exposure
— Responsibilities of registrants and licensees, including the protection of visitors.
— Radioactive waste and discharges.
— Monitoring and reporting.
— Consumer products.
— Responsibilities.

Planned exposure situations: Medical exposure
— Justification.
— Optimization: design, operational considerations, calibration, dosimetry of patients, diagnostic reference levels, quality assurance, dose constraints.
— Pregnant women and breastfeeding.
— Release of patients.
— Unintended and accidental exposure.
— Reviews and records.

Emergency exposure situations
— Generic requirements.
— Public exposure.
— Exposure of emergency workers.
— Transition from emergency exposure situation to existing exposure situation.
— Examples of radiation accidents.

Existing exposure situations
— Scope.
— Generic requirements.
— Public exposure: justification and optimization; responsibilities for remediation; radon, radionuclides in commodities.
— Occupational exposure: protection of workers, remediation, radon in workplaces, air/space crew exposure from cosmic radiation.

Transport safety
— Introduction to the IAEA transport regulations and guidance.
— Consignor’s and carrier’s responsibilities.
— Types of packages.

— Transport index.
— Labelling and placarding.

Operational radiation protection and safety of sources

— General principles of protection:
  • Time, distance, shielding;
  • Protection against unsealed sources and contamination control;
  • Protective clothing, respiratory protection, protective equipment;
  • Leak testing;
  • Storage of radioactive material and physical protection.
— Design of facilities:
  • Design features: primary and secondary barriers, maze entrances, air scatter;
  • Safety systems (interlocks, warning lights); physical barriers; changing areas.
— Operational workplace monitoring:
  • Dose rate monitors and contamination monitors (basic features and suitability);
  • Monitoring programmes;
  • Testing and calibration of radiation monitors.
— Individual monitoring:
  • External monitoring: film badge, thermoluminescent dosimetry, electronic personal dosimeters.
  • Internal monitoring: whole body counting, thyroid monitoring, biological samples, personal air samplers.
— Practical demonstration:
  • Types of dose rate and contamination meters;
  • Types of personal dosimeters: thermoluminescent dosimetry, film badge, electronic personal dosimeter, air samplers.

I.4.1.3. Syllabus for the training course for RPOs in nuclear medicine in the hypothetical country: Practice specific module

The practice specific module will be organized by the IAEA RTC. On completion of a training course based on this supplementary module, the participant will:

— Have a more detailed understanding of the radiation protection and source safety principles associated with the specific practice;
— Better understand the role and duties of the RPO for the specific practice.

As a prerequisite to attend the practice specific module, the participant needs to complete the foundation training for RPOs based on the core module, or be able to demonstrate that he/she has the equivalent knowledge in all subjects of the RPO foundation syllabus.

The participant will also preferably have prior experience working in a nuclear medicine facility.

Examinations will be held at the end of the practice specific module (at the RTC). The topics covered by the core syllabus are listed below.

Equipment and radionuclides used in nuclear medicine

- Overview of the types of equipment and radionuclides used in nuclear medicine.
- Diagnostic nuclear medicine: radionuclides, scanners, gamma camera, positron emission tomography.
- Therapeutic nuclear medicine: radionuclides.
- Isotope generators.

Duties and responsibilities

- Registrants/licensees and medical practitioners:
  - Management of radiation safety and safety culture;
  - Radiation protection programme;
  - Management system;
  - Facilities and resources;
  - Notification to the regulatory body;
  - Authorization from the regulatory body;
  - Clinical referral;
  - Justification of medical exposures.
- RPOs and QEs.

Safety assessment for nuclear medicine facilities

- Developing a safety assessment for nuclear medicine facilities.
- Outcome of the safety assessment.
- Review of the safety assessment:
  - Practical exercise: development of a safety assessment for a nuclear medicine facility.

Radiation protection programme

- Structure, scope and content of a radiation protection programme for a nuclear medicine facility:
  - Management structure and policies;
  - Assignment of responsibilities for radiation safety;

- Programme of education and training;
- Local rules and supervision;
- Designation of controlled and supervised areas;
- Programme of workplace monitoring;
- Arrangements for individual monitoring (workers);
- Health surveillance programme (workers);
- Protection of the patient, comforters and carers, the public;
- Emergency preparedness plan;
- Reviews and records;
- Quality assurance.

— Records of the safety assessment.
— Radiation safety committee/ethics committee.

Training and qualifications

— Training programme for employees.

Individual monitoring of medical staff

— Monitoring of radiation doses to workers at a nuclear medicine facility:
  - Individual dose assessment (whole body, extremity, lens of the eye, internal dose assessment, thyroid);
  - Record keeping;
  - Investigation of doses;
  - Health surveillance.

— Practical demonstration of types of dosimeters and monitoring for intakes of radionuclides.

Workplace monitoring

— Programme of radiation monitoring around a nuclear medicine facility: external dose rate, surface and airborne contamination measurements, fixed and removable contamination.
— Selection, maintenance and calibration of survey meters suitable for dose rate and contamination measurements.
— Practical demonstration: types of dose rate and contamination meters.

Safety of radioactive material

— IAEA Code of Conduct on the Safety and Security of Radioactive Sources (including import/export guidance);
— Storage and inventory of radioactive material;
— Radioactive waste management, discharges and disposal.

Optimization of protection and safety

— Design considerations.
— Operational considerations:
  • Appropriateness of equipment and techniques;
  • Protection of children, volunteers for biomedical research, pregnant women, embryo/fetus;
  • Protective equipment (thyroid, gonad shields, etc.);
  • Protection of comforters and carers;
  • Release of patients after administration of radionuclides.
— Calibration.
— Dosimetry of patients.
— Quality assurance for medical exposures.
— Protection of the public.

Facility design and safety features

— Facility design and safety features:
  • Design of nuclear medicine facilities, contamination control;
  • Fume cupboards, glove boxes;
  • Warning notices;
  • Decontamination procedures.
— Individual protection for medical staff:
  • Syringe shields, lead glass screens, face masks, local shielding, etc.
— Practical exercise: design the layout and contamination control measures for a nuclear medicine facility.

Transport of radioactive material

— Movement of radioactive material within the medical facility;
— Transport of radioactive material outside the medical facility;
— Practical exercise: prepare documents and labels for transporting radioactive material by road.

Radioactive waste

— Collection and storage of radioactive waste;
— Discharge and disposal.

Emergency preparedness and response to events

— Examples of events involving nuclear medicine radioisotopes: causes and lessons learned.
— Development of emergency plans.
— Types of emergencies.
— Content of an emergency plan.

— Emergency equipment.
— Emergency procedures.
— Training and exercises.
— Periodic review of plans.
— Reporting.

Additional activities

— Technical visits: to see various types of nuclear medicine facilities for diagnosis and treatment, to discuss designation of areas, and to carry out radiation monitoring.
— Practical exercises: on typical tasks to be carried out by the RPO according to the syllabus.

I.4.2. Implementation of training courses to meet the identified needs (Section 5.3)

The training course for RPOs in nuclear medicine makes use of national and foreign resources for the delivery of the core module (at the NTC) and the practice specific module (at the IAEA RTC). As the course is aimed at addressing the training needs for the RPO in compliance with national legislation and regulations, the regulatory body will need to consider the endorsement of the training course, for instance providing guidance on education and training requirements for the RPO that includes the syllabus. In this specific example, if the course is conducted by using resources from an institution located abroad, the recognition of the NTC responsible to conduct only the core module might not be sufficient to comply with national education and training requirements for an RPO in nuclear medicine. Further actions are expected to be taken by the regulatory body or other relevant/competent authorities to establish mechanisms of recognition of training and qualifications provided by institutions outside the country.

I.5. EXPLANATORY NOTES

I.5.1. Explanatory note 1: Data collected on facilities and activities for different practices and personnel to be trained

To identify the training needs, information on several factors should be collected, including:

— The number of existing facilities and activities and related equipment/sources.
— The number of additional facilities to be established and activities to be initiated, with the number of related pieces of equipment/sources, in the near future (e.g. five years);
— The availability of educated and trained personnel;
— The number of educated and trained personnel leaving the facilities/activities (e.g. retirement or turnover) in the near future (e.g. five years);
— Evolution in the national legislation and regulations providing requirements for education and training in radiation protection and safety;
— Evolution of technologies.

This information is most likely to be available from the regulatory body, the personnel monitoring services and, possibly, professional organizations.

To carry out the evaluation, a first approximation is made linking the number of qualified personnel to the number of facilities and activities. However, for some facilities and activities, the regulatory body may have specific requirements on the minimum number and qualification of personnel.

Tables 1 and 2 serve as a guidance tool to facilitate the assessment of training needs by collecting information on existing and projected facilities and activities as well as existing and projected personnel to be trained. For simplicity, the tables do not address education needs. However, as explained in the introduction to this appendix, a similar analysis also needs to be carried out to evaluate the needs in the area of education (at the tertiary level). In the tables, the general term 'facilities' is used, whereas in some cases it will be appropriate to use the term 'machines or devices'. For example in a diagnostic radiology facility there may be several X ray machines. However, considering the categories of personnel, there may be more than one RPO but not necessarily one for each X ray machine (i.e. one RPO might be designated for more than one X ray machine or even for the whole facility within the same practice). Again, specific requirements set by the national authorities on the staffing should be considered when available.

The tables are not intended to be exhaustive in terms of the facilities and activities and categories of personnel (see also Fig. 2). All the relevant applications of ionizing radiation in the country for which education and training programmes in radiation protection should be established need to be considered. Categories of personnel with specific responsibilities in the field of radiation protection, such as QEs and RPOs as defined in GSR Part 3 [2], should always be taken into consideration. The training of other individuals, such as occupationally exposed workers, can sometimes be addressed more easily and more effectively, for instance, at the facility level.

The following steps should be taken to complete the tables:

— Enter the number of ‘Facilities and Activities’ ‘Existing’, ‘Foreseen’ (e.g. within five years) and ‘Total’ (summing up the values entered for the previous two columns).
— For each category of personnel, specify the existing number of people for each facility or activity (in the column ‘Existing’).
— For each category of personnel, estimate the number of people (e.g. the column ‘Estimated QEs required’ for QEs) required to address the needs of existing and future facilities or activities (as reported in the column ‘Total’ in ‘Facilities and Activities’).
— Fill in the columns for the personnel to be trained (e.g. the column ‘QEs to be trained’ for QEs) for each type of facility or activity, which is the difference between the estimated number and the existing number of personnel.

After completion of Tables 1 and 2, an estimate of the number and qualification of individuals to be trained will be available.

I.5.2. Explanatory note 2: Categories of personnel

An overview on the main categories personnel is provided below:

— **QE**. A QE is defined in GSR Part 3 [2] as:

“An individual who, by virtue of certification by appropriate boards or societies, professional licence or academic qualifications and experience, is duly recognized as having expertise in a relevant field of specialization, e.g. medical physics, radiation protection, occupational health, fire safety, quality management or any relevant engineering or safety specialty.”

RS-G-1.4 [3] states that:

“Qualified experts should provide advice on and/or conduct activities in their field of specialization and should promote safety culture. Whenever necessary, users of radiation sources should seek advice from a qualified expert. Individual qualified experts are unlikely to have expertise in all areas but will probably be specialized in specific topics. A qualified expert should have a sound understanding of the specific applications to be dealt with.”

The same guide also provides examples of QEs in some applications of ionizing radiation, appropriate levels of education, training and work experience, and desirable personal attributes (including communication skills, leadership and analytical skills).

— **RPO**. An RPO is defined in GSR Part 3 [2] as "A person technically competent in radiation protection matters relevant for a given type of practice who is designated by the registrant, licensee or employer to oversee the application of regulatory requirements."
RS-G-1.4 [3] states that:

"Radiation protection officers are employees who should be designated by the registrant or licensee to supervise radiation safety within a facility and to ensure that work is carried out safely and in accordance with the relevant national requirements. They should provide the links between the workplace, the registrant or licensee, the qualified expert and the regulatory body, and should ensure that operations involving radiation are in compliance with established regulations. They should be fully familiar with operations performed in a facility, its organizational infrastructure and working procedures, and should have an understanding of the relevant regulatory requirements. They should have sufficient authority to be able to perform these functions effectively. They should also be responsible for organizing training of workers. A radiation protection officer should be the central point of reference within a company for radiation protection matters, and may carry out or directly supervise contingency plans in the event of an accident or incident. They may also be assigned responsibilities concerning safety aspects of radioactive waste management as well as protection of the public in the vicinity of the facility."

The same guide also provides examples of specific functions of RPOs, the appropriate level of education, training and work experience and desirable personal attributes.

— **Workers**. A worker is defined in GSR Part 3 [2] as "Any person who works, whether full time, part time or temporarily, for an employer and who has recognized rights and duties in relation to occupational radiation protection."
These persons will need to be provided with the appropriate information, instruction and training on protection and safety as required by GSR Part 3 [2]. Specific provisions are also established for radiation protection when training female workers. Persons categorized as workers cover a wide range. Some workers are potentially exposed to radiation at high levels (such as in laboratories for radioisotope production). Other workers (such

as personnel working in the vicinity of a level gauge, industrial radiography assistants or maintenance personnel) may occasionally be exposed to low levels of radiation.

With regard to workers, RS-G-1.4 [3] also identifies those who use radiation sources daily. Such workers (operators) need to be trained in the operation of the equipment and will have a high level of expertise in their area of work (the term 'qualified operator' is used in the guide). The same guide also provides examples of typical working environments of such workers, consideration on desirable minimum educational requirements, training objectives, on the job training and assessment of qualifications.

— **Health professional**. A health professional is defined in GSR Part 3 [2] as:

"An individual who has been formally recognized through appropriate national procedures to practise a profession related to health (e.g. medicine, dentistry, chiropractic, podiatry, nursing, medical physics, medical radiation technology, radiopharmacy, occupational health)."

Radiological medical practitioners, medical physicists, medical radiation technologists, referring medical practitioners and other health professionals with specific duties in relation to protection and safety for patients in a given radiological procedure need to have the appropriate specialization [2]. These examples of health professionals are defined in the glossary of GSR Part 3 [2].

RS-G-1.4 [3] provides further examples of occupations of health professionals in different medical fields and general considerations on education and training minimum levels, and experience.

Appendix II

OVERVIEW OF ACTIONS FOR ESTABLISHING A NATIONAL STRATEGY FOR EDUCATION AND TRAINING IN RADIATION, TRANSPORT AND WASTE SAFETY

II.1. INTRODUCTION

This appendix provides a summary of the actions to be taken to establish a national strategy for education and training in radiation, transport and waste safety. It sets out the chronological sequence of actions, including the contribution from the different stakeholders and the role of the steering committee. It provides an example, particularly with respect to the initiation of the process, of the establishment of a national strategy and the role of the steering committee. The actual national context and the actual role of the relevant stakeholders (e.g. the regulatory body) in a specific country might require a different assignment of responsibilities, or different actions in another sequence.

II.2. DIAGRAM OF ACTIONS

The actions to establish a national strategy for education and training in radiation, transport and waste safety, together with the associated national education and training programme are given in Table 6. In the first column, the stakeholders expected to take the leadership for each action are listed. The other columns sequentially represent the phases in the process to establish the national strategy and the outputs at the end of each phase. The actions are generally expected to be completed within each phase; however, some actions need to be considered on a continuous basis (e.g. the provision of information to the steering committee in Actions 5 and 6). In particular, the technical working group and the steering committee are expected to continuously monitor, through each phase, the progress made in the implementation of the national strategy for education and training (Actions 18 and 20).

— **Action 1**. The government initiates a consultative process with the key stakeholders to address requirements in the IAEA safety standards, establishing a high level steering committee of representatives from all stakeholder organizations responsible for overseeing the development and implementation of the national strategy for education and training in

TABLE 6. ACTIONS TO ESTABLISH A NATIONAL STRATEGY FOR EDUCATION AND TRAINING IN RADIATION, TRANSPORT AND WASTE SAFETY

Stakeholders	Policy framework	Output 1: National policy and strategy in place	Assessment of education and training needs	Output 2: Education and training needs assessed	Design of the national education and training programme	Output 3: Schedule of activities to meet the education and training needs	Development and implementation of the national education and training programme	Output 4: Competence built in support of national radiation, transport and waste infrastructures	Evaluation of the national education and training programme	Output 5: National education and training programme continues to be effective and up to date
Government	Action 1 Action 4		Action 5				Action 16 Action 17			
Regulatory body	Action 1		Action 5 Action 7				Action 12 Action 13 Action 14			
Professional organizations	Action 1		Action 6 Action 7				Action 12 Action 13 Action 14			
Technical support organizations Service providers	Action 1		Action 6 Action 7							
Education and training providers	Action 1		Action 7		Action 9 Action 11		Action 12 Action 13 Action 14 Action 15 Action 17			
High level steering committee	Action 2		Action 20		Action 20		Action 20		Action 20	
Technical working group	Action 3		Action 8 Action 18		Action 10 Action 11 Action 18		Action 18		Action 18 Action 19	

radiation, transport and waste safety (paras 2.3(d), 2.5(15) and 2.34–2.38 in Ref. [1]).

— **Action 2**. The high level steering committee[6], with representatives nominated by the relevant key stakeholders, prepares a general policy document that provides the basis and outlines the strategy for education and training in radiation, transport and waste safety. The committee will also provide advice on the need to establish a technical working group to conduct operational tasks[7].
— **Action 3**. The technical working group develops criteria and performance indicators to monitor and evaluate the implementation of the national strategy.
— **Action 4**. The government endorses the national policy and strategy for education and training in radiation, transport and waste safety submitted by the high level steering committee.
— **Output 1. National policy and strategy for education and training in radiation, transport and waste are in place.**
— **Action 5**. The regulatory body and other governmental authorities provide the high level steering committee with information on:
  - Requirements and guidance for education, training, qualification and competence in protection and safety of all persons engaged in activities relevant to protection and safety and with responsibilities in relation to the safety of facilities and activities (para. 2.21(a) in Ref. [2]; para. 2.36(a) in Ref. [1]), including regulatory staff (para. 4.13 in Ref. [1]);
  - Requirements for the formal recognition of QEs (para. 2.21(b) in Ref. [2]);
  - Criteria for the designation of the RPO (para. 3.94(e) in Ref. [2]).
— **Action 6**. Professional organizations provide the steering committee with information on requirements and guidance for education, training, qualification and competence in protection and safety of all persons engaged in activities relevant to protection and safety and with responsibilities in relation to the safety of facilities and activities.
— **Action 7**. The regulatory body and other organizations (such as dosimetric service providers, professional organizations, education and training providers) provide the high level steering committee with information on:
  - The type and number of facilities and activities (existing and foreseen in the near future, e.g. five years);

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[6] This committee might include governmental authorities, the regulatory body, technical support organizations, professional associations, training providers and academic institutions.

[7] If no technical working group is established, its actions will be completed by the high level steering committee.

- The current number of RPOs, QEs (in radiation protection), health professionals (e.g. medical physicists, radiologists, etc.), regulators and workers.

— **Action 8**. The technical working group, based on the information collected by the high level steering committee (Actions 5–7), evaluates the education and training needs for each relevant category of personnel.

— **Output 2. Education and training needs are assessed covering all the relevant categories of personnel and facilities and activities in place and foreseen in the country.**

— **Action 9**. National education and training organizations and institutions provide the technical working group with the information on existing capabilities in radiation protection and safety, both in terms of the resources available (e.g. courses and programmes) and the appropriateness of those resources (e.g. to build the competence of the personnel, as addressed in Actions 5 and 6).

— **Action 10**. The technical working group matches the identified education and training needs (Action 8) with the existing national capability for the provision of education and training (Action 9), identifying:

(a) The education and training needs that can be addressed using currently available national resources and capabilities.

(b) The residual education and training needs, indicating how these can be addressed, for example:

(1) Using resources outside the country (e.g. bilateral/international resources);

(2) Building national competence over time (e.g. TTT).

— **Action 11**. The technical working group, together with the national education and training organizations and institutions, outlines the national education and training programme (defined in Section 4.4).

— **Output 3. All the education and training activities required to address the needs have been identified and scheduled.**

— **Action 12**. The regulatory body and other relevant organizations consider establishing criteria for the content and format of education and training events to be delivered within the national education and training programme designed in Action 11.

— **Action 13**. The regulatory body and other relevant organizations consider establishing criteria with respect to how examinations should be carried out, particularly when the successful completion of the training confers qualification or status (for example, as a QE or RPO) in accordance with national legislation and regulations.

— **Action 14**. The regulatory body and other relevant organizations consider establishing criteria for the recognition of education/training providers and/or specific courses they offer.
— **Action 15**. National education and training providers develop appropriate tools and material, when necessary, for the implementation of the activities outlined in the national education and training programme (Action 11). This may include the development of course material, provision of equipment for laboratory exercises or provision of other facilities necessary to support the delivery of the courses.
— **Action 16**. The government takes actions to meet education and training needs using regional or international resources (e.g. courses delivered in institutions outside the country) (Action 10 (b), (1)). The actions might include bilateral agreements with authorities of countries hosting the institutions, and requests to international organizations to support training through fellowships (e.g. in the framework of the IAEA technical cooperation programme).
— **Action 17**. Government and education and training providers take long term actions to build national competence over time (Action 10 (b), (2)). For example, when building sustainable competence through the TTT approach, the following initiatives are expected to be considered:
  - Inviting international experts to train local trainers, organizing scientific visits for local trainers to well established foreign institutions to enable them to gain the necessary experience, and sending observers/participants to specifically designed training courses organized by international organizations (e.g. the IAEA). The government might need to take specific actions at certain times (e.g. requesting support in the framework of the IAEA technical cooperation programme).
  - Implementing teaching modules for TTT in the syllabus of the training courses provided by national education and training providers.
— **Output 4. Competence is built in support of national radiation, transport and waste safety infrastructures.**
— **Action 18**. The technical working group monitors the progress made in the implementation of the national strategy for education and training (continuous evaluation in Section 6). It applies the performance indicators whenever appropriate at each phase to ensure that the education and training programme continues to meet the needs (e.g. due to the introduction of new practices, development of new techniques, establishment of new regulations). The technical working group reports back to the high level steering committee the results of the evaluation.
— **Action 19**. The technical working group evaluates the effectiveness and efficiency of the national education and training programme to build

competence according to the education and training needs in order to strengthen the radiation safety infrastructure (long term evaluation in Section 6). The technical working group reports back to the high level steering committee on the results of the evaluation.

— **Action 20**. The high level steering committee, on the basis of the evaluations conducted by the technical working group, modifies the national strategy accordingly, to keep it updated. It informs the government, regulatory body and any other relevant stakeholders about the actions necessary to keep the national strategy effective and efficient.

— **Output 5. The national education and training programme continues to be effective and up to date.**

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