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Since 1999 the ETRAP conferences intend to bring together training providers, academics, policy makers, radiation protection experts, regulators and authorities, and end-users. It offers the opportunity for learning, discussing and networking about the latest findings and developments in education and training in radiation protection.

This conference is organized by the Belgian Nuclear Research Centre SCK CEN and the University of Groningen in cooperation with IAEA, EUTERP and IRPA, and with support of EFOMP, HERCA, IRPA-YG, BVS-ABR, NVS, FANR, Technical University Madrid and Leibniz University Hannover.

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UK RPA CERTIFICATION SCHEME CHANGES

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[1]*RPA 2000*

In 2021, the Health and Safety Executive (HSE) updated its Radiation Protection Adviser (RPA) statement. RPA 2000, the company set up for certifying competence in radiation protection practice in the UK, was required to amend its RPA certification and re-certification schemes to accommodate the revised statement. The major changes to the schemes were considered necessary by the regulator as it felt there were weaknesses regarding either the understanding of the regulations by individual RPAs or the ability of RPAs to communicate the appropriate advice. This paper looks at the reason for RPA competency, the changes to the scheme, implementation, and a review of the impact of the changes following the first 18 months.

1 Introduction

1.1 RPA 2000 and the radiation protection adviser (RPA) scheme

RPA 2000 was set up as a non-profit making company, limited by guarantee, for certifying competence in radiation protection practice and gained a Certificate of Recognition from the UK's Health and Safety Executive (HSE) as a Radiation Protection Adviser (RPA) Assessing Body. This was prompted by the introduction into UK legislation of the Ionising Radiations Regulations 1999 [1] (based on the Council Directive 96/29 from Euratom [2]) which included the following definition:

Qualified experts: Persons having the knowledge and training needed to carry out physical, technical or radiochemical tests enabling doses to be assessed, and to give advice in order to ensure effective protection of individuals and the correct operation of protective equipment, whose capacity to act as a qualified expert is recognized by the competent authorities. A qualified expert may be assigned the technical responsibility for the tasks of radiation protection of workers and members of the public.

In the UK – such experts were the radiation protection advisers. Hence, for the first time, there was the requirement for 'a system for explicit recognition of radiation protection advisers (RPAs)' [3]. In practical terms, from 2000, RPAs have been required to hold a *Certificate of Competence* (all certificates were to be in place by the end of 2004) which would be valid for 5 years and awarded on successful application to the RPA 2000 RPA certification scheme.

The HSE is the government agency responsible for workplace health, safety and welfare in Great Britain. An *RPA Statement* was published detailing the criteria for competence and the arrangements to be met by the assessing body. The RPA 2000 scheme was built around the syllabus detailed in the original statement. In 2021, HSE updated its RPA statement [4] due to legislation uplift and concerns on regulatory non-compliance.

1.2 HSE change of statement

The HSE had concerns regarding a small minority of cases that indicated poor compliance with the current legislation [5]. HSE concluded that the poor compliance resulted from one or more of the following three weakness:

i. inadequate understanding of the regulations and therefore poor advice from individual RPAs,
ii. inadequate ability of the individual RPAs to communicate the appropriate advice,
iii. inadequacy of the employer (customer) to follow the appropriate advice.

HSE considered that there was little that could be done about weakness three – so just the first two weaknesses would be addressed. Consequently, the HSE's revised *Statement on RPAs* was published on 1st September 2021. The RPA 2000 assessing body revised its RPA certification schemes to match. The revision went live on 1st January 2022.

2 Changes to the RPA Certification Schemes

2.1 Weakness (i) inadequate understanding of the regulations

The HSE syllabus had been modified to address the possible weakness of lack of understanding of the regulations. The RPA Initial Certification scheme requires the applicant to demonstrate adequate knowledge of the science and concepts of radiation protection. These are spilt across three different levels - General Awareness (GA), Basic Understanding (BU) and Detailed Understanding (DU). This requirement is in addition to the demonstration of adequate application of radiation protection advice.

The number of DU topics was increased from 5 to 17. This was originally perceived as an additional burden for applicants but reflects the importance of the need for thorough understanding all the main regulations within the Ionising Radiations Regulations 2017. It has been shown, that as expected, a few pieces of evidence can between them cover many of the DU topics – such as radiation risk assessment, local rules, the classification of workers, personal dosimetry etc.

Furthermore, the RPA Initial scheme has been amended to include an exemption route from providing evidence of knowledge of GA and BU topics. The HSE wished to introduce some efficiency for those practitioners who were already experienced in the subject matter. The routes for exemption were agreed with the regulator and are varied. Exemption is available for those who already hold a certificate of competence for similar schemes such as the Medical Physics Expert and the Radioactive Waste Adviser (both schemes assessed by RPA 2000), which demonstrate that the candidate had already proven satisfactory knowledge of such topics as basic atomic and nuclear physics, biological effects of radiation, ICRP principles of justification, optimisation and dose limitation etc. Further exemption routes were through the holding of membership or professional registration status gained 'as a result of work with radiation protection'. These levels exclude entry level status, and as before, the applicant would have already proven evidence of a satisfactory level of knowledge of such topics to gain the membership/registration. A caveat has been placed to ensure that the radiation protection experience covers ionising radiation. Finally, an exemption route was available to those who have satisfactorily completed certain training courses which have been recognised by RPA 2000 and whose syllabi require the correct knowledge of the science and the regulations, again making the evidence of knowledge unnecessary.

2.2 Weakness (ii) inadequate ability of the RPA to communicate the appropriate advice

For initial applications, when applicants submit evidence of their knowledge and competence for the 17 DU topics, they are now also required to demonstrate how that evidence would lead to them providing appropriate advice to the employer on compliance with the Ionising Radiations Regulations.

The updated HSE statement also affects the RPA Renewal Scheme which is utilised by those who are applying for a renewal of their certificate. The applicant is requested to submit information and evidence for two categories; Category 1 demonstrates that the candidate has maintained their knowledge and training in the subject. The number of Continuous Professional Development (CPD) points required have remained at 25. Category 2 is where the candidate submits evidence of their RPA work in addition to additional similar pieces of work which demonstrate their practical application of radiation protection. Due to the updated statement, the scheme has been changed to require a minimum of 25 points for Category 2, to address the perceived weakness (ii) – inadequate ability of the RPA to communicate effectively. This means that candidates are no longer able to recertificate without supplying some evidence of their RPA work.

3 Impact of the changes – so far

Since the changes to the schemes were introduced in January 2022, 24 Initial RPA applications have been received, of which 16 (67%) have successfully applied to utilise the exemption from demonstrating knowledge of GA and BU topics. In addition, the additional burden of the 17 DU topics would not appear to have negatively impacted the success of the applications.

The additional requirement in the RPA Renewal scheme to provide evidence of communication of advice has been adopted with some renewal portfolios being significantly larger than before.

4 Stakeholder Engagement

The HSE held several meetings with the RPA 2000 Board before publication of the revised statement on 1st September 2021. This enabled RPA 2000 to have the updated schemes ready for the New Year start date. During that period, RPA 2000 Board took opportunities to engage with stakeholders - assessors and applicants to explain the changes to the scheme. Special consideration needed to be given to those RPAs whose certificates had imminent expiry dates. Several training sessions were delivered on-line to the assessors. An email group was also set up. A detailed brief was delivered to The Society for Radiological Protection (SRP) Heads of Profession meeting to ensure that future applicants were aware of the changes, in addition to the workshop delivered at the start of the SRP annual meeting in 2022.

5 Conclusions

The uplifted schemes accurately reflect the new criteria required in the September 2021 HSE Statement on RPAs. The schemes have been adopted confidently by applicants and assessors. Early indications show that the exemption route has been widely and successfully adopted and the increase in DU topics has not negatively affected the success of Initial scheme applications. The request to provide examples of advice has been taken on board. It will be a while yet before it can be judged whether the HSE consider that the changes to the schemes have satisfactorily addressed the two perceived weaknesses of RPAs.

Acknowledgement

Thanks are due to the RPA 2000 scheme administration secretary and the assessment secretary who between them have gathered the data. In addition, the author would like to thank the RPA 2000 Board directors for their support with this presentation.

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[3] Work with ionising radiation, Ionising Radiations Regulations 1999, Approved Code of Practice and guidance
[4] HSE statement on radiation protection advisers (1st September 2021)
[5] The Ionising Radiations Regulations 2017, UK Statutory Instrument no. 1075

RADIATION PROTECTION EDUCATION AND TRAINING IN BELGIUM: CHALLENGES AND OPPORTUNITIES

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As a scientific society with the aim of spreading knowledge and supporting the scientific, ethical and organisational framework in radiation protection, the Belgian Society for Radiation Protection BVS-ABR organises various activities for professionals in radiological and nuclear domains. It offers a networking platform for different key-profiles such as the radiation protection expert, the radiation protection officer and occupational health physicians and strives to liaise with professionals working with numerous applications of ionising radiation, such as the nuclear industry, medical sector, research and development, emergency preparedness, non-destructive testing, space industry, etc.

Since education and training (E&T) is at the foundation of competence building in radiation protection, BVS-ABR devoted two of its meetings (October 21, 2022 and May 5, 2023) to discuss the status of education and training in radiation protection in Belgium. Current and near-future regulatory requirements were featured, and specific educational paths to meet the demand of qualifications in radiation protection by the applications in today's society. Particular emphasis was put on initiatives in continuous professional development, including issues such as sustainability in the organisation of E&T, quality assurance, diffusion, efficiency and efficacy of training.

This presentation will provide an overview of the current status of radiation protection E&T in Belgium, including the discussions of the latest meetings by BVS-ABR. It will highlight challenges and opportunities in the scattered landscape of radiation protection education and training in Belgium and a way forward to strengthen competence building in the future.

1 Methodology

Since education and training is an evolving topic, which is crucial to ensure a good understanding and application of radiation protection principles, BVS-ABR devoted two of its meetings (October 21, 2022 and May 5, 2023) to discuss the status in Belgium. In both meetings, the regulatory framework was introduced by the Competent Authority, followed by practical implementation of the training and re-training requirements by training providers and professionals in various domains, ranging from the nuclear and non-nuclear industry, first responders, medical professionals and expert profiles in radiation protection (such as the radiation protection expert RPE, the occupational health physician, the medical physics expert MPE). The programmes of the meetings (full day October 21, 2022, afternoon May 5, 2023) allowed for ample discussions between the speakers and the audience. The details of the programmes can be found on the website of BVS-ABR, and the presentations and recorded lectures are published online for the members of BVS-ABR [1].

2 Results and discussion

In both meetings, a general introduction to the attendees was provided, highlighting the importance of education and training as one of the cornerstones in radiation protection. Initiatives from BVS-ABR were highlighted, such as the scientific meetings and E&T meetings organized for the members to enable their continuous professional development, a webpage dedicated to all education and training requirements imposed by Belgian regulation, complemented by information on the majority of known training providers in Belgium offering academic and professional E&T.

On October 21, 2022, the focus was set on education and training for professionals in radiation protection, the nuclear industry and first responders. The (Belgian) Federal Agency for Nuclear Control (FANC) provided an overview of regulatory requirements for each of these target groups. Although the regulation was recently updated for most of the radiation protection professionals, the legislation and associated regulatory decrees still detail their requirements in a minimum number of hours in combination with training topics. A graded approach is used according to the risk present in the installations where the professionals work, for example, the training and continuous professional development (CPD) requirements for a Class I RPE are much more extensive than those for a Class II RPE[1]. For radiation protection experts, it is also remarkable that, next to obligations in radiation protection training, separate training requirements exist in topics of technology and nuclear safety.

The available training programmes for radiation protection experts were illustrated, complemented by a Master-after-Master in nuclear engineering to become a RPE for Class I installations. For occupational health physicians, a personal testimony described the educational pathway to obtain all required degrees and certificates. It was perceived to be very challenging to meet all requirements, especially in finding a suitable offer for the practical internship as well as suitable CPD initiatives to retain the certificate as an occupational health physician. A general request was made to start a uniform approach aligning all stakeholders in Belgium, allowing for a more coherent offer dedicated for this target audience.

A major update of the Belgian legislation in 2018, transposing the EU BSSD [2], introduced the framework of the radiation protection officer (RPO) and led to the development and implementation of various training programmes for RPOs. Four major training providers shared their experience in offering RPO training, and although all were compliant with the regulatory requirements, differences were observed in the approach. It is for example possible to follow the basic (theoretical) training via e-learning, via online webinar or in-person, leading to different dynamics between trainers and trainees. Although e-learning allows larger groups to be trained in a self-paced timeframe, it was perceived to be not optimal to fully cover the necessary competences for the job as RPO if this was the only training. There are also differences in targeting the audience, where some training providers have developed dedicated training courses matched to the domain (e.g. medical vs industrial vs transport), whereas others merely make a distinction based on the use of radioactive sources vs devices emitting ionizing radiation. The latter might result in a generalization of training content and reduction of relevance for the participant. Critical reflections were also made regarding the efficiency and effectivity of the training. It was agreed upon in the discussion that, being a gatekeeper in radiation protection on the work floor, RPOs should be trained according to the practical needs related to their tasks, meaning a sound theoretical basis, complemented by practical on-the-job training and preferably supported by an RPE associated to the facility.

[1] In the Belgian nuclear regulation ‘Class I’ facilities are those with the highest intrinsic risk (NPPs, research reactors, laboratories with fissile materials). ‘Class II’ facilities are accelerators, laboratories with high and medium active sources, etc. In ‘Class III’ most of the X-ray devices and lower activity sources are classified.

CPD opportunities for RPOs are currently not commonly available, and are a point of attention for the future where training providers and the Belgian Society for Radiation Protection BVS-ABR can work together.
It is also important to observe that, in contrast to the available regulation for RPOs who work in Class II and III installations, regulatory requirements for RPOs in Class I installations, working with the highest risks, are currently non-existent.

Since quality and quality assurance is an important step in ensuring efficient and effective education and training, BVS-ABR invited a guest speaker to present the system which is currently being implemented in the Netherlands. Independent of the regulatory authority and with support of the Dutch Society for Radiation protection (NVS) a quality commission was founded to review the quality of training providers, as well as training programmes in radiation protection. [3] The current methodology includes a self-assessment based on a harmonized survey, followed by an on-site review of the commission. This approach currently led to evaluations, of which all with a positive result. It is important to remark that e-learning is not (yet) taken into consideration, only full training programmes for RPEs.

For first responders presentations were provided of an academic programme for dangerous goods advisors (in support of fire and rescue incident commanders), training initiatives for fire brigades surrounding nuclear power plants and the activities of the CBRNe centre of excellence operating within the National Crisis Centre. The academic training programme for dangerous goods advisors is organized with several stakeholders from regulators to industrial partners, and contains two dedicated modules on radioactivity and ionizing radiation. Although the content in these modules contain theory, practical exercises and technical visits, a request to integrate more practical work reflected in the overall feedback of the training participants. Due to the extensive programme, which is mostly followed by professionals from fire brigades and civil protection, the success rate seems rather low.
In the southern part of Belgium, a graded approach in training initiatives for fire brigades surrounding nuclear sites was implemented in the latest years. These initiatives started with basic training for fire fighters up to advanced training for functions in the commanding structure. In addition, training modules were developed in a customized format depending on the locally used applications of ionizing radiation. Challenges identified were listed as the lack of a CPD framework, the lack of (national) harmonized intervention procedures and incomplete specific local information about the risk and locations. The CBRNe expert centre supports the National Crisis Centre with an integrated approach to chemical, biological, radiological and nuclear risks, of whatever origin. In this way support to education and training is also provided by the CBRNe expert centre in the form of multidisciplinary training to first responders and local authorities. Content for a CBRNe awareness training is provided on the related risks, first actions and tasks, as well as the psychological impact. In the framework of the (Belgian) nuclear emergency plan, train-the-trainers are organized on radiological risks and the use of dose measurement devices aimed for training schools in the various disciplines of first responders. The discussion highlighted the issue of identification of the target audience: which first responder units must be envisaged for radiation protection training, and to which extent should they be trained? It was also clear that not all initiatives taken on a high level were reaching the local levels of first responders. The lack of a systematic approach to continuous training was also discussed as a mayor challenge, in combination with the legal obligation that information on risks and protection actions should be repeated at time when incidents occur. A general request was expressed to use more existing incident scenarios in this respect.

The last topic of the meeting on October 21, 2022 dealt with education and training for occupational exposed persons and external workers in the nuclear industry.

Experiences were share by the license holder of the Belgian nuclear power plants, as well as a technical support organization. For larger companies, involving a large staff potentially exposed to ionizing radiation, information, education and training brings a large effort within the organization. Although advances have been made towards online learning for this target audience, partially boosted by the COVID-19 pandemic, it remains a challenge to balance effectivity and efficiency in refresher training: how to avoid systematic repetition and keep the relevance with respect to the practical needs of the work floor? It was agreed upon the participants that a yearly frequency of information and training was offering a good approach. Incidents from publicly available databases could be very valuable to serve as case studies in the refresher training.
The experience of the license holder showed an extensive framework including theoretical training, practical simulator training and on-the-job training in the controlled area. The yearly refresher encompasses a repetition of basic concepts, but also information about changed procedures and points of attention of the past period. It was also complemented by a periodic training programme in a mock-up environment with focus on the safety behavior. A similar, but slimmed down programme was offered to external workers. A regular and systematic review of the training framework was performed. The technical support organization also shared their training programme for their own staff, partially based on the regulatory requirements imposed by FANC but also using the SARCoN tool of the IAEA. [4] The benefit of using the latter system was the link between staff competences and the associated need for education and training.

On May 5, 2023, the focus was set on education and training in radiation protection for a medical target audience. After the general introduction, FANC presented the regulatory requirements in education and training for medical professionals. The framework is complex since it encompasses a broad variety of stakeholders (e.g. practitioners, nurses, physicists etc.) in various clinical domains, and these stakeholders can exercise different roles in the framework of radiation protection, such as an occupational exposed person, a radiation protection officer, and a person using ionizing radiation for medical exposure. The majority of requirements warrant a graded approach of initial and continuous training and was quite recently updated (in 2020). The FANC tries to collect and communicate all information on initiatives of continuous professional development on their website. [5] The legislation and associated regulatory decrees are available on the juridical database of the FANC (Jurion). [6] A new proposal was also presented to change the current legislation for medical professionals (including the E&T requirements), with particular focus to simplify overlapping requirements and to upgrade the E&T requirements for the nurses and paramedical staff who use ionizing radiation for medical exposure. The latter seemed very challenging for the attending audience of the meeting, with identified open issues regarding the clinical internship, the modular approach of training and associated lack of training providers, and overall study load for a target audience (nurses) which are already under pressure.

The practical implementation was illustrated by a higher education institute providing training courses for technologists in medical imaging and radiotherapy on a Bachelor level. This presentation emphasized the need for practical training and their unique offer via the use of a dedicated skills lab. The same facility was also offered for continuous training in medical imaging and radiation safety targeting nurses and even animal caretakers.
Even though this institute already provides an extensive training programme, the duration of clinical internship would not seem to be sufficient taken into account the future regulatory requirements. Back-to-back, a complementary presentation was provided by a large hospital sharing their experiences in the management of radiation protection training for hospital staff. The speaker demonstrated the challenge of keeping track of all staff that needs radiation protection training and re-training, a view which was broadly shared by the audience, since responsibilities are not clearly defined nor agreed upon between the radiation protection department, the human resources department, the respective clinical departments and the individual end-user.

A suggestion was made to track down medical doctors requiring E&T in radiation protection via the health insurance codes used in the hospital related to the use of ionizing radiation. The hospital also implemented an in-house offer of continuous professional development in radiation protection training for different target audiences. Critical reflections were made regarding the follow-up of new incoming staff and staff which shifts function and location within the hospital. A list of authorized medical doctors made publicly accessible by the Federal Agency for Nuclear Control was suggested to facilitate this process.

The difficulties discussed by these speakers were not shared by the various medical doctors who presented the practical implementation of radiation protection training in their respective disciplines in nuclear medicine and radiotherapy. The requirements for medical doctors were perceived as being easy to achieve, since the initial training was well integrated into the academic curriculum of the clinical specialty. For them, radiation protection training was already perceived to be incorporated in their daily practice. For the continuous professional development, ample offer existed with local initiatives organized by the professional societies, as well as dedicated topics in radiation protection at international conferences. However, both speakers in nuclear medicine and radiotherapy demonstrated a tremendous advance in used technologies in the latest decades for imaging and therapy using ionizing radiation, resulting in an increase in complexity for the end-users and an absolute necessity for frequent training and education. The need for radiation protection training integrated into the basic curriculum of all medical doctors was also emphasized, since this is not the reality in Belgium. It was also stated that regulation on education and training in radiation protection is absolutely necessary, but should be balanced against the risks of the applications using ionizing radiation.

For radiology, the situation was presented by a professor which is involved in radiation protection training in multiple disciplines. It was made clear that the initial radiation protection training is mainly integrated into the academic curriculum for specialized medicine, and offered within the Master structure, a Master-after-Master or as post-academic training. However, as the regulation only stipulates a minimum required (total) hours within certain topics related to radiation protection, large differences exist between the offer of various higher education institutes. A general request was expressed to make an inventory on a national level which topics are provided in which phase of the academic education, to which extent, and how practical training was implemented. For clinical sub-specialties using ionizing radiation for medical intervention or diagnosis (usually via the use of fluoroscopy), no dedicated offer exists; this target audience can follow the general radiation protection courses as designed for medical diagnosis, but a modular approach would be beneficial to meet their specific demands in clinical relevance. The same remark was given for continuous professional development, where numerous opportunities exist such as linking radiation protection training with other accredited clinical training, interuniversity collaboration to optimize the use of resources (such as trainers and specialized topics), and the integration of radiation protection topics in (inter)national medical conferences to maximize the clinical relevance for each target audience. For medical doctors who received radiation protection training abroad, ad-hoc educational programmes are sometimes organized leading to a non-uniform approach within the academic level.

For medical physics experts (MPE), a private company was invited to share their experience in how new medical physicists are trained, and how CPD was organized for their staff. For the latter, details of the current regulation were explained, since the MPE has one of the most extensive E&T requirements in radiation protection. Possibilities of CPD initiatives exist either as a participant, or as an actor in other activities, such as lecturing, publications, training etc. Although the responsibility of participating in CPD activities was put with the individual MPE, ample resources were provided from the company. The registration and follow-up of all activities was done with a quality management (SharePoint) system, in combination with a regular review from the management.

A personal experience of the educational pathway was shared by a recently hired MPE, following each step as required by the legislation. The educational pathway involved different universities, and the required clinical internship was also spread across multiple academic hospitals. This combination allowed for a very broad buildup of experience, but at the same time demonstrated some limitations, such as absence of close involvement of in-house decisions as an intern. The overall guidance of the educational path was very well perceived, and room for improvement was expressed to have more information about the various sub disciplines in medical physics to allow a (more) informed decision on further specialization.

In dentomaxillofacial radiology, the floor was given to one of the very few dentomaxillofacial radiologists in Belgium. Also in this domain, it became clear that significant technological advances were made in the latest decades, requiring the dental practitioner to keep knowledge, skills and competences up to date. Following a recent survey in the domain, general knowledge on radiation doses and risks were still inadequate for modern 2D and 3D imaging techniques. The regulatory requirements, strictly followed up by the regulator and health insurance agency, were however perceived as sufficient and even at the high-end compared with other European countries. Practical issues which were identified were the lack of a dedicated clinical specialty in Belgium for dentomaxillofacial radiology and the lack of dental assistants thoroughly trained in imaging techniques. As there is a general shortage of dentomaxillofacial practitioners in Belgium, there is a large influx in foreign dentists, which do not always have the necessary qualifications in radiation protection. Mutual recognition of radiation protection competences did not seem optimized so far. Also, the lack of traceability and access to radiological images, in combination with a health insurance nomenclature perceived as not fit for purpose, allows for misuse by dentists and medical doctors putting healthcare economics above an approach which is justified and aligned with the ALARA principle. So although the framework of education and training in radiation protection, as well as the offer of training seems suitable, still aspects of improvement could be identified.

Lastly, a large manufacturer of medical devices was invited to share its experience in radiation protection training for their customers. In Belgium, relatively recent legislation obliges the license holder to ensure suitable information and training for every new purchase of a medical-radiological device, with focus on radiological risks, risk assessment for the patient, the clinical relevant functionalities, the correct use of the device and procedures for quality assurance and maintenance. This should be organized in close collaboration between the manufacturer/distributor of the device, the MPE and the RPE, where appropriate. The speaker demonstrated a personalized educational approach where the end users were able to train in a blended mode: online with virtual simulators, as well as on-site hands-on training on the device. Some complementary resources were offered for RP education and training, including an online library of video's, online presentation recordings, manuals and guides. Virtual simulations could be used to train clinical application protocols without exposure to patients or staff. Refresher training was also foreseen in the educational pathway. It was not clear to which extent which training components in the overall offer were optional or included in the purchase process, and how the MPE and RPE were involved in the hospital environment.

During both meetings, reference was also made to international initiatives, such as the recent ICRP Vancouver Call for Action [7], the financial support for international mobility offered by European funded projects PIANOFORTE [8] and ENEN2plus [9] and the ETRAP conference [10]. The ICRP Vancouver Call for Action to strengthen expertise in radiation protection worldwide highlights the concerns that a shortage of investment in training, education, research, and infrastructure will compromise society's ability to manage radiation risks. In its' 5-point call for action, it is explicitly calling towards universities to develop undergraduate and graduate university programmes and to make students aware of job opportunities in radiation-related fields.

Furthermore, it calls upon fostering general awareness of proper uses of radiation and radiological protection through education and training of information multipliers. The PIANOFORTE project [3], the European Partnership for Radiation Protection Research is offering financial support for cross-border mobility for early career researchers and professionals, as well as for related networking activities and training courses in radiation protection research. The ENEN2plus project [4] is a large education and training project in the nuclear field (including radiation protection) and offers numerous actions to build and maintain competences in various radiation-related domains. Besides significant funding for cross-border mobility and training courses, also activities are organized to attract new talent, such as career events, science competitions, awarding outstanding work etc. The funding mechanisms of the two projects mentioned above are crucial to enable cross-border CPD by experts and professionals in radiation protection by attending conferences, training courses or performing exchange visits.

3 Conclusion

Although the two meetings did not allow discussing education and training in radiation protection in all domains where professionals are exposed to ionising radiation, it allowed a sound basis for discussion in which the regulatory requirements regarding E&T, as well as the practical implementation were critically questioned. By sharing insights between training providers, the regulatory authority, and various disciplines using ionising radiation, requirements and methodologies can be further optimized by all stakeholders to match the needs of the work floor.

Acknowledgement

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DEVELOPMENT OF RP WORKFORCE KNOWLEDGE BASE THROUGH SHARING OF IDEAS AND PRACTICES

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Education and Training in Radiation Protection is essential for all the related professionals and researchers, for developing their competences within knowledge, skills and related technologies.
Support is required to allow the professionals to focus on current and future aspects of Radiation Protection inherent in their fields of application. They need to look ahead and be ready to provide training and support for young generation future experts with an adequate competence and to be open to future needs in Education and Training.
The opening of surveys, within IRPA Task Groups (TGs) involving professionals on issues that create challenges in the field of Radiation Protection, allows individual professionals to consider the trends in Radiation Protection, to look towards the issues that are evolving, and to open a broad communication that will lead to the sharing of points of view creating a wider spectrum of ideas.

1 Introduction

The creation of Educational Networks is well known for the related advantages through the sharing of information and points of view, and this is a basis, not only for younger students but also professionals, towards a best practice in their pertinent areas. Moreover, it is also a support towards creating awareness about possible critical situations, thus helping to be ready in taking decisions about evaluated choices within a decision process. IRPA recognizes the importance of establishing and promoting a sound radiation protection culture at the level of the workplace, to help practitioners in their specific field[1)].

A Young Generation Network across the field of Radiation Protection was created in IRPA to promote communication, collaboration and professional development of students and young professionals, and with the mission to motivate, stimulate and develop the next generation of radiation protection experts[2)].

The active involvement of young professionals and experienced professionals in IRPA Task Groups contributes to the enhancement of radiation protection. While experienced professionals bring their mentorship and their expertise to the table, younger colleagues bring their perspective, doubts, suggestions and innovative viewpoints, enriching the overall process. The feedback and comments from these discussions are instrumental in preparation of the final IRPA view/documents. This approach requires time and efforts in relation to the analysis of all the received comments, but the participation in the process creates clear advantages derived from a real involvement, from sharing of opinions, suggestions, related opening perspective, and from discussing the different points of view, in particular in relation to emerging and evolving aspects in Radiation Protection (RP). The consultations about documents in the pre-publication stage, see the contribution of members of the Associated Societies across different geographical areas before they are published, ensuring a comprehensive review process.

In the context of IRPA, a number of the 58 national and regional associations, covering 68 countries, are active in promoting enhancement of professional competence and networking, recognizing the ethical and societal dimension of RP, and encouraging high standards of professional conduct, skills and knowledge for the benefit of individuals and society. By embedding RP at a cultural level, IRPA, within a broad program of activities including Task Groups with international participation, creates networks and encourages the highest standards of professionalism, and contributes to the development of professionals prepared for the challenges facing the community in the development of the Radiation Protection System.

2 Examples of IRPA Task Groups

The preparation of educational material with up-to-date information is essential when there are significant changes in Radiation Protection practice. It is important to ensure the participation and awareness of the professionals within the workforce in the steps taken, and progressing and adapting to scientific and technological advances, while also considering the societal and ethical aspects. In this way a competent workforce can be maintained, and members are actively involved and participate in the development of ideas on the evolution of RP implementation.

IRPA, promotes excellence in Radiation Protection by providing benchmarks of good practice, raising awareness about radiation risks in different exposure situations, and preserving the Radiation Protection heritage. IRPA contributes to ensuring that professionals are prepared for future needs, based on education, and are invited to participate in dedicated IRPA Task Groups, for the discussions generated in preparing responses to survey questionaries.

IRPA Task Groups play an important role, through various national and regional associations, in promoting international cooperation among the professionals involved in radiation protection. Each group is actively involved in increasing awareness, disseminating information and collecting feedback on topics of interest for the radiation protection community. Within the term of reference 2021-2024 a number of IRPA Task Groups are active with focus on significant themes: Higher Education, Research and Training; Non-Ionising Radiation; Naturally Occurring Radioactive Materials (NORM); Public Understanding; Radiation Safety Culture in Healthcare; Review of the System of Radiological Protection; Tissue Reactions; Women in Radiation[3)].

2.1 The System of Radiation Protection

The TG on the review of the System of RP is closely related to the embarkation of ICRP on a review of the System [4)]. IRPA has initiated a TG to inform the ASs about this initiative and encourage them to reflect and give the views of the professionals. The input of IRPA ASs through three successive surveys has been invaluable, covering a wide range of viewpoints, and overarching considerations. In particular within the 1st survey, and in the 2nd survey emerged key issues related to the system's optimization and reasonableness. The feedback has underlined the need to simplify and clarify the system, highlighting the importance of communication, and stakeholder involvement. Although the majority of initial feedback was relatively broad, the collective responses provide a comprehensive overview of the main issues, and an indication of direction for the ICRP in addressing these issues, including priorities for review [5,6)].

2.2 The implementation of the revised eye dose limit

Within IRPA three TGs were launched, starting in 2012, 2015, and 2018, [7,8,9] with the aim of promoting a wide exchange of experiences at the international level, on the impact of the change in the dose limit for the lens of the eye and its implementation with regard to protection of the worker in occupational exposure and bringing attention to the proposed or chosen approaches. The TGs conducted questionnaire surveys and the answers received covered the views of 16 countries and 40 countries respectively in the 1st and 2nd survey, while the results of the 3rd survey, published in 2020, reported the points of view of 44 countries from Africa, Asia/Australia, North and South America, and Europe.
The participants' responses provided a comprehensive picture of various aspects related to doses to the eye lens, health effects, and decisions about defining appropriate protection and dosimetry practices.

Compared to the first two surveys, the last survey reflected the significant amount of work carried out in different countries, concerning practical implementation. It revealed that national and international guidelines were available and in place for half of the participating countries surveyed [10,11,12,13] underlining the crucial role of training and education in ensuring the proper use of protections and increasing awareness, also emphasized the need for continuous monitoring of these developments to facilitate the sharing of experiences and assist authorities in determining the appropriate route for implementation in their countries. Moreover, the training will need to be ongoing in view of the turnover of workers and require periodic auditing of compliance to ensure application of the ALARA principle. About half of the countries reported training initiatives at a local or national level, through seminars and conferences by professional societies, dosimetry companies, and local experts.

2.3 Implications of recent studies on tissue reactions

A new IRPA TG dedicated to Tissue Reactions, with a version of Term of Reference updated in 2023, and based on 12 members representing ten IRPA ASs, is now open [14]. The objective is to foster awareness about early and late effects of radiation in tissues and organs, with particular attention on the heart, cerebrovascular system, and diseases of the arteries and veins. This group is also considering the implications of the fact that a dose as low as 0.5 Gy, which can be reached in complex practice, such as fluoroscopy guided interventional and radiotherapy procedures, could potentially affect the circulatory system. The latest studies are acknowledging that the dose related to tissue injury varies with the tissue type, and different tissues have different responses to ionizing radiation. For example, in children some organs and tissues such as brain, and lens of the eye are more sensitive to radiation than in adults, and inversely some tissues such as the ovaries are seen as less sensitive than in adults[15].

The TG is addressing contributions to the promotion of a wide exchange of knowledge, experience and points of view, at an international level and among the IRPA ASs on progress updates, regarding the TG subject. There is ongoing continuous dedicated research, to obtain a better understanding of the impact of radiation on the disease processes involved. There are also developments towards the use of absorbed dose in place to equivalent dose, for setting limits on doses to tissues and organs for prevention of tissue reactions, as introduced in ICRP Publ. 147 [16]. Absorbed dose to organs and tissues is the fundamental scientific quantity and starting point for calculation of the other risk-adjusted quantities.
The Commission now considers absorbed dose to be the most appropriate quantity to be used when limiting doses to organs and tissues, and to avoid harmful tissue reactions. This draws a clear distinction between limits applying to tissue reactions, set in absorbed dose (Gy), and those applying to stochastic effects, set in effective dose (Sv).) This should be considered an important input into the next fundamental recommendations of the Commission and a change from the use of equivalent dose

to set limits on organ/tissue doses is expected at the time that new general recommendations will be prepared.

It is significant to see the important work by ICRP including focus on tissue reactions. The objectives of the ICRP TG 119 [17)], dedicated to Effects of Ionising Radiation on Diseases of the Circulatory System(DCS) and their Consideration in the System of Radiological Protection, includes: -to provide advice on the dose-rate dependence and radiation quality dependence of DCS risk; -to provide advice on how to reflect current knowledge of radiogenic DCS in the System of RP. It is remembered that ICRP Pub 118 [18)] already classifies the DCS, as tissue reactions, with a suggested threshold due to acute and fractionated/prolonged exposure to absorbed dose of 0.5 Gy to the brain and blood vessels. However, uncertainties are related to the shape of dose-response, and contribution of different risk factors.

The potential for radiation-related harmful effects in offspring is a recurrent issue for the public and a major concern for parents exposed to ionising radiation from occupational, medical or environmental sources. The ICRP TG 121 [19)], about the effects of Ionising Radiation Exposure in Offspring and Next Generations, will attempt to address questions such as e.g.: approaches to estimate effects and risks of radiation in offspring and the next generation; pre-conceptional effects due to exposure of parents, and to exposure of the embryo and the fetus.

The evolution towards a future level of limits on organ/tissue doses expressed in absorbed dose for tissues can be foreseen, replacing the use of equivalent dose, and this is a point of interest and discussion within the IRPA TG.

Regarding the IRPA TG on Tissue Reactions, the IRPA ASs will be asked to provide their views about the updated considerations that are introduced in the effects of radiation in tissues and organs and related aspects, based on a questionnaire developed by the TG. A TG report will try to capture the statements and suggested approaches of various countries to summarize the professional views, taking into consideration the different sectors of RP. Moreover, the ASs will be invited to offer documents they have produced directly or in cooperation with other organizations, related to the theme of the TG to create a wide exchange of views through the IRPA website. Even if it is not recommended as an immediate change to the System of RP, this could be considered a significant point for discussion. The TG key tasks are to collate the view of the IRPA Associations in considering the use of absorbed dose for the limits of tissues and organs, and on the justification of different limits for workers and members of the public, as for skin and lens of the eye.

3 Conclusions

IRPA TGs together with the IRPA Young Generation Network play a crucial role in fostering the enhancement of radiation protection among professionals across diverse countries and in particular in new generations. These initiatives establish robust connections among professionals, fostering a more collegial and engaging relationship that goes beyond the traditional trainer-trainee dynamic. This unique environment encourages sharing knowledge, emphasizing problem-solving, decision-making, and the development of practical solutions. Consequently, this strengthens the organization as a whole and enhances the dissemination of best practices from one country to another, emphasizing the significant impact of training on the evolution of radiation protection standards and practices worldwide.

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DEVELOPMENTS IN RADIATION PROTECTION EDUCATION,TRAINING AND QUALIFICATIONS IN THE UAE

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Since the establishment of the Working Group on the "National Strategy on Education, Training and Qualification in Radiation Protection in the UAE", as a follow-up to the 2017 IAEA EduTA to the UAE, various developments took place in the United Arab Emirates to enhance and further develop the infrastructure for the competency of Radiation Protection Professionals.
This paper will review the main elements of the first UAE National Strategy's implementation cycle, and present its characteristics and unique approach.

1 Introduction

An effective system for protection from ionizing radiation exposure situations in a country, frequently referred to as "Radiation Safety Infrastructure", can be fully achieved if several coordinated elements coexist [9].

These include:

- An appropriate network of regulations and guides, designed on the actual use cases of sources of radiation in the country
- A system for regulatory authorization/licensing processes of the use of sources of radiation, and a corresponding system for regulatory inspection and enforcement on users of sources of radiation
- A system for the management of emergency exposure situations, both radiological and nuclear
- A system to ensure competence in the workforce, in relation to Radiation Protection, which can be subdivided into a number of elements:
    - **Education:** a formal curriculum of studies, normally administered in schools, colleges, universities, etc., and approved by a Government Authority (Ministry of Education or similar)
    - **Training:** vocational courses that may be formally recognized (or not) by the Government, by an academic institution, a Professional Association, etc., and may be delivered by a Training Provider that has been authorized by a central Government Authority (or not)
    - **Qualification:** a process by virtue of which competence in a specific profession or domain is recognized by a Governmental Authority[2]

[2] the term "qualification" is often used in its connotation of "competence" (as in "workers properly qualified", i.e., competent). The definition of "Qualification" that will be used in this paper refers to the formal process of demonstrating competence, as defined by the UAE National Qualification Center: "Full Qualification provides formal recognition at a given level for learners who achieve a set of cohesive learning outcomes covering all domains of knowledge, skills, and attributes. A coherent and cohesive set of learning outcomes obtained in the form of a certificate, diploma, or degree, only when an awarding/regulatory body determines, following established standards, that an individual has achieved such learning outcomes related to a complete qualification." [5] This definition appropriately mentions the role of a Regulator in regards to achieving the learning outcomes in a given field.

The UAE started a Nuclear Programme, in 2018-2019, pledging to adhere to the best international practices, and to follow the IAEA standard and guidance, partnering with responsible nations around the world [2]. As a result, the UAE and its Nuclear Regulator, the Federal Authority for Nuclear Regulation, (FANR), have welcomed several IAEA review and follow-up Missions and advisory services, since the start of the Nuclear Programme. Various IAEA Missions (IRRS, ORPAS, EPREV, INIR, IPPAS, etc.) covered numerous topics and fields related to regulatory infrastructure, nuclear safety, nuclear security, safeguards, and radiation safety, throughout the years.

In February 2017, FANR and several UAE Stakeholders welcomed the EduTA Appraisal Mission, which focuses on Education and Training, and provides [3]:

- *A detailed appraisal of the status of the provisions for education and training in radiation protection and the safety of radiation sources, including the identification of national education and training needs;*
- *Identification of areas in education and training where provisions should be improved to cope with national education and training needs and to comply with the IAEA Safety Standards; and*
- *Recommended actions to be taken to strengthen education and training in line with in the respective IAEA Safety Guide and Safety Report.*

The outcome of the EduTA Mission are reported in [4], and indicate a number of improvements -of various levels of urgency- to be implemented in the Country to improve its system for Education and Training in Radiation Protection, to bring it in line with the IAEA safety standards.

This article will present the status of the Education, Training and Qualification (ETQ, from now onwards) system in Radiation Protection Professionals in the UAE, as reviewed during the 2017 EduTA Mission, and will discuss the improvements that the UAE have put in place to effectively respond to the Experts' Recommendations and comply to the IAEA Guidance.

2 Review of the EDUTA recommendations and suggestions

The Recommendations and Suggestions from the EduTA Mission fall into three broad categories:

1. Definition of requirements related to the QE (R1, R3, S2, S3, S4) and the RPO (R2, S2, S3), and their roles, responsibilities and interface (S1)
2. Development of ETQ requirements for Occupationally Exposed Workers (S5), Emergency Workers (S6), and Workers employed in existing exposure situations (R4)
3. Development of a National Strategy for ETQ in RP (R5, S7)

FANR considered the development of the "UAE National Strategy for Education, Training and Qualification in Radiation Protection", (NS), as the main container for all the subsequent actions related to ETQ of QEs and RPOs, and to establish clear interfaces between RP Professionals.

A few fundamental decisions on the way forward were made, in 2017, as follow-up to the EduTA Mission, and they will be presented in the next chapters:

ESTABLISHMENT OF THE NATIONAL STRATEGY STEERING COMMITTEE

The Steering Committee leading the development of the NS (as in [6]) was established in the form of a Working Group (WG) in the frame of the "Radiation Protection Committee in the State" (the RPC), which is an authoritative consultative body, established by the UAE Nuclear Law [1] and chaired by FANR.

POLICY AND STRATEGY

A decision was made NOT to develop the National Policy [6], but to directly draft the National Strategy, with the aim of submitting it to the UAE Prime Minister's Office Cabinet for endorsement and implementation.

The WG submitted the NS to the RPC for prior approval in 2019, and the NS was approved by the RPC on 01-JUL-2019.

NATIONAL QUALIFICATIONS

Since the creation of the WG, the strategic role of the UAE National Qualifications Authority (now NQC, National Qualifications Center) was recognized, and FANR partnered with NQA to develop the ETQ framework for the RP Professionals[3].

The FANR-NQA Partnership evolved throughout the years, culminating in a Memorandum of Understanding that was signed in FEB-2023 [7].

FIVE RP OCCUPATIONS

An initial decision was made to develop the full qualification framework for five RP professional profiles: Qualified Experts (QE), Radiation Protection Officers (RPO), Medical Physicists (MP), Occupationally Exposed Workers (EW) and Emergency Workers (EmW).

The inclusion of QE and RPO was intended to directly respond to the outcomes of the EduTA Mission, with the objective of clarifying the requirements for Education, Training, Qualification, recognition/appointment, and the interfaces between the two Professionals in charge of the Radiation Protection of Workers and of the Public.

The inclusion of the "Medical Physicist" profession, in charge of the Radiation Protection of Patients, and originally not included in the EduTA Mission's scope of work[4], was intended to fill the gap in the Education and Training of MPs in the UAE, and to clarify roles, responsibilities and interfaces among QEs, RPOs and MPs in the medical practice.

Finally, the decision to also develop full qualification frameworks for "Occupationally Exposed Workers" and for all workers exposed in an emergency, "Emergency Workers", was also made. This was mainly motivated by the need to ensure a harmonized training framework for a large number of Workers in the UAE who are trained under the responsibility of their Employers, and with a large variety in topics and levels of learning outcomes[5].

[3] "The government, through the regulatory body or other competent organization, should identify the need for formal accreditation of the education and training provided. As an example, and depending on the government structure, this accreditation may be under the authority of a national accreditation body, the regulatory body, higher education authorities or other professional bodies or associations." para 4.239 in [9].

[4] the Authors consider that Protection of the Patient should also be included in EduTA Missions, as the operational arrangements in a medical workplace would benefit from a coordinated review of the functions of QEs, RPOs, MPs and other Exposed Workers operating in medical exposure (radiologists, radiographers, nurses, radiopharmacists, etc.)

[5] in many Countries, training of EW and EmW is not subject to National Qualifications. The decision of the UAE Regulator, to create a national framework also for EWs and EmWs, could be considered as an effective and useful innovation for Newcomer Countries.

3 The work of the steering committee

FANR recognized the importance of the development of the NS, as a main repository for all the actions related to ETQ in RP in the UAE, and the established the corresponding WG, with the aim of developing the NS document, to be submitted to the RPC for initial endorsement and subsequent submission to the UAE Prime Minister's Cabinet.

The Steering Committee leading the development of the NS (as in [6]) was established in the form of a Working Group (WG) in the frame of the "Radiation Protection Committee in the State" (the RPC), which is an authoritative consultative body, established by the UAE Nuclear Law [1] and chaired by FANR.

The RPC, by its nature, regroups all the UAE Stakeholders in the RP sector, including Ministries, Authorities, Universities, and other major Companies, across the medical, industrial, academic and nuclear fields. FANR chairs and coordinates the work of the RPC, providing also its Secretariat.

The WG, consequently, also reflected the RPC's variety of representation, and was composed, at its creation, of around 20 governmental Stakeholders, including Medical Authorities (Ministry of Health and Prevention, Dubai Health Authority, Abu Dhabi Health Authority, etc.), Universities related to the nuclear or radiological field (Khalifa University, Abu Dhabi Polytechnic, University of Sharjah, UAE University, Higher College of Technology, etc.), Ministries (Ministry of Environment and Climate Change, Ministry of Interior, etc.), the Nuclear Operator (Emirates Nuclear Energy Corporation, Nawah Energy Company), the Abu Dhabi National Oil Company, various enforcement and emergency-related Agencies (Armed Forces, Abu Dhabi Police, National Emergency Crisis and Disasters Management Authority, Federal Authority for Identity, Citizenship, Customs and Ports Security, etc.), Environment protection Agencies, and education-related Institutions (Ministry of Education, Abu Dhabi Department of Education and Knowledge, National Qualifications Authority, etc.).

It must be stressed that, in a newcomer Country with a fast-paced nuclear programme developing, and a growing number of medical and industrial applications of sources of radiation, the large and diverse variety in the representation within the Steering Committee is not only useful, but a key to NS' understanding, adoption, and effective implementation. Indeed, while it is important that the NS is supported in its implementation by the Government, all the discussions, clarifications and Stakeholders' engagement during the works of the WG ensure that its practical enactment is well understood and embraced, and that collaboration among Entities is facilitated. This is a result of hundreds of hours of meetings and consultations, which is not necessarily reflected in the final NS document.

The initial mandate of the WG also included other actions related to the EduTA Mission outcome, namely the creation of a pool of temporary Qualified Experts to be consulted while the full ETQ framework for QEs is established, and the organization of workshops to engage Professionals in shaping roles, responsibilities and interfaces of various RP Professionals.

The WG had its kick-off meeting on the 04-MAY-2017, and held on the 30-MAY-2023 its 47th meeting.

WG decisions are taken after extensive consultation and discussions, and involved formal voting only in rare and justified occasions.

Members of the WG changed over time, and new individual nominations were requested and submitted by various Entities: participation in the works of the WG requires clearance from UAE National Security, and the process was finely optimized along the years.

After the NS approval in 2019 from the RPC, new WG's Terms of Reference were submitted and approved to the RPC, which indicated a mandate to already start the implementation of the NS. A number of corresponding actions was started in 2019, just before the pandemic brought some of them to a halt.

In 2020 and in 2021, during times of lockdown, restriction of movement and, consequently, in-person meetings, a successful line of "virtual" activities was developed in the WG, which included shifting from in-person monthly WG meetings to online meetings over various platforms, and the successful deployment of the Temporary List of UAE Qualified Experts [8], which has been published for the first time in SEP-2020, and is now at its revision 11.

Since the pandemic receded, the WG kept meeting virtually, with a positive benefit in the overall attendance and ease of Members' participation.

4 Development of the UAE national strategy

According to the IAEA guidance, [6] and [9], the NS cycle is composed of four phases: the identification and collection of E&T needs, the development of an E&T programme, its implementation, and a review of its effectiveness.

The first step in the development of the NS was the assessment of the Country's needs, in the medium and in the longer term, which took a significant portion of the initial WG works.
Guidance is provided by the IAEA on how to perform the assessment of needs, an evaluation done adjusting the instruments offered in the EduTA Questionnaire and in [6] to the specific UAE circumstances.

The analytical approach that the IAEA favors is not always easy to implement in the practice, especially in situations in which developments happen simultaneously in various fields, and a clear trend in both the evolution of facilities (their number, nature, radiological risks), and the Personnel involved (practitioners and RP Professionals) is not established yet. Moreover, for some professional profiles, regulatory requirements on the number of Professionals (e.g. the number of minimum MPs in hospitals and medical cabinets and their time involvement) were not fixed yet.
A simplified approach than the one proposed by the IAEA's tables was therefore followed, which reflected the actual organization of data in the UAE. For example, the categories in Facilities, as suggested by the IAEA, was not entirely reflected in the UAE's licensing system, at that time, hence a few adjustments were needed, and tables used in [6] and [9] were simplified and adjusted to the UAE requirements.
Some calculations' assumptions were made, assuming for example a time trend where not available, an increase in the number of new facilities of a certain percentage (normally around 10% per year), and a number of workers being retrained every year (equal to the workforce divided two).
An assessment of the needs in 2017, in terms of QEs', RPOs' and EWs' workforce numbers, together with an inference of the needs for 2022 and 2027, was included in the NS document, and helped to define a reasonable number of training and re-training courses each year.
Data for MPs and for EmWs in the UAE were not included in the NS document.

Information on the Regulator's Staff training and retraining needs was also included, and was based on the workforce plan developed at FANR. In the following years, the number, competence and variety of professional profiles that joined FANR (reaching in 2023 more that 250 Members) continuously evolved: FANR, along the years, fully adopted the IAEA approach for Regulatory Bodies' Competence [14], including the Nuclear Knowledge Management approach [10], the Systematic Approach to Training, SAT [11], a Competency Framework structure, the Quadrant model for Competence and Competence mapping [12], Knowledge loss risk management [13], and succession planning [15], and has widely increased the opportunities for internal and external training, and Employees' growth.

Based on the assessment of a Country's needs, the IAEA [06] recommends to develop a corresponding National Training Programme, which will allow to fulfill training and retraining needs over the years, while also maintaining the target of competence growth for Professionals in the whole Country. In some Member States, in order to control the frequency and variety of training courses, the Regulatory Body takes responsibility for organizing national training courses, which are automatically certified and approved. In the UAE, since some time, a number of commercial training providers already operate and offer training opportunities in Radiation Protection, for various professional profiles. Moreover, national Government Entities also frequently offer training courses that cater to a larger Governmental audience (e.g., medical practitioners in public hospitals, first responders, etc.). It was therefore deemed appropriate, in 2017-2018, NOT to develop a National Training Plan within the NS, and to let commercial and governmental Training Providers offer courses to the market instead, and to focus on the definition of the training needs, with the development of UAE National Qualifications, and with a better specification of roles/responsibilities/interfaces of various professional profiles, in a FANR regulatory document.
For Training Providers (who require registration/licensing with the MoE's NQC) to provide UAE National Qualifications, though, an accreditation/authorization is needed: this topic was touched in a specific Chapter of the NS, to stress the need for Training Providers to become Authorized. Moreover, the strategy for training and delivery of the National Qualification of various profiles was indicated, also in accordance with the IAEA guidance in GSR Part 3 [16] and GSG-7 [17]: specifically, both the highest Qualifications for QE and MP would require completion of a path including education at a Master of Science level, and appropriate training, but the Qualification would be delivered by a Governmental panel. The Qualification as RPO would be delivered directly by the Accredited Training Provider (ATP), and those as EW and EmW could be delivered by the ATP or by the Employer, with the support of the appointed QE.

The NS describes in detail the strategy for the Qualification of the five professional profiles.
It is worth mentioning that the three Occupations QE, RPO and EW would develop over the same structure of three tiers (related to the radiological risk associated with the work activity) and three sectors (related to the type of activity, medical, industrial or nuclear): Tier 1 would be required in facilities characterised by lowest radiological risks, encompassing all sectors (industrial, research, medical, etc.); Tier 2 would be required in facilities characterised by intermediate radiological risks, with a further specialisation as 2A for the Medical sector and 2B for all the other Sectors: Tier 3 would be required in facilities characterised by highest radiological risks, with a further specialisation as 3A for the Medical sector, 3B for the nuclear power sector, and 3C for all the remaining Sectors.
Education requirements for QE is a Msc, with the possible exception of Tier 1, where a BSc could also be accepted, if the number of years of experience is sufficient.
Education requirements for RPO is a Bsc, with the possible exception of Tier 1, where a lower level could also be accepted, if the number of years of experience is sufficient.

A high-school degree has been fixed as educational requirement for EW, leaving the possibility to the industry sector or to Employers to fix additional requirements: it is worth to mention that EW is not generating a profession *per se*, and the level of knowledge, skills, abilities and experience requested to an EW depends on the specific work activity and sector of employment, and is not be entirely covered by the National Qualification.

MPs are subdivided into four tiers: DR for diagnostic radiology, NM for nuclear medicine, RT for radiotherapy, and ASST for Assistant MP.
In all cases, clinically qualifying residency programmes would cover the compulsory training after obtaining the MSc, while the ASST tier would be reserved to the MPs who did not receive the qualifying training yet. This latter tier would also comprehend all those BSc MPs graduated within previous programmes in the UAE, and who would require the completion of educational and training cycles.

EmW, finally, would be subdivided into two tiers only: Tier 1 for first responders directly involved in the initial activities on site, during the accident, across all sectors (industrial, nuclear, research, medical, etc.); and Tier 2 involved in subsequent activities of assessment and decontamination during latter phases of an emergency. This National Qualification intends to build a basic common level of competence for all Emergency Workers in the UAE, and again will not generate a Profession per se (as in the case of the QE and of the RPO). The appropriate level of knowledge, skills, abilities and experience requested to an EmW depends on the specific work activity and sector, and is not going to be entirely defined in the National Qualification.

Additional Professions are mentioned in the NS, whose National Qualifications could be developed at a later stage.
Those include Approved Medical Practitioners, Radiopharmacists, Operators of High Activity Sealed Sources, Transport Operators, radioactive waste management or NORMs activities' skilled Technicians, radioanalytical radiation measurements' laboratories' Technicians, calibration laboratories Technicians, whole-body counter or radiotoxicology analyses operators, environmental radiation operators, etc.
One of the EduTA findings was related to the Personnel involved in existing exposure situations, and qualifications of contamination remediation technicians, radon remediation technicians, or NORM operators could be envisaged in the future.

From the educational perspective, the academic environment has undergone a significant change in the last five years, and this has had an impact also in the was courses are structured in many UAE Universities, and the importance of some topics which have recently emerged and dominated the interest of potential students: space exploration, artificial intelligence, deep learning and big data. The NS advocated the creation of new MSc which could cater students able to start a career in the QE or MP profession.
In 2018, approval from MoE was granted to Khalifa University in Abu Dhabi for a new MEng in EHS, with a concentration in "Radiological Protection": that route had been identified to generate a new line of Qualified Experts in the UAE.
In 2019, approval was granted to Khalifa University in Abu Dhabi for a new MSc in MP, which would constitute the main professional line for the qualification of new MPs in the UAE, since the closure of the BSc programme in UAEU, years ago. Medical Authorities and Khalifa University have been in contact to develop a new Residency Programme for the three MP Tiers indicated above, and chances are that the Residency Programme could see the light soon.

It must be stressed that the pandemic was a disruptive element also for the growth of those new MSc courses: the MEng in RP is not fully started yet, and the MSc in MP is running while Residency Programme has not been fully established yet.

5 Creation of the UAE temporary list of qualified experts in radiation protection

As follow-up of the action related to S4 in the EduTA Mission, the WG established criteria for the temporary Qualification of Qualified Experts in Radiation Protection in the UAE.
Selection criteria for Candidates were defined and published [18], and a website page was prepared [19] to guide Candidates through the application [21].

Selection criteria, widely discussed upon and agreed in the WG, and shared and endorsed by the RPC, are essentially three: education, certification, residency.

Ideally, only Candidates having received the qualification of QE abroad would be identified as suitable and accepted in the list. In reality, the number of those Candidates would not suffice to cater for the UAE needs[6], and a more flexible approach was chosen, to also include Candidates who did receive appropriate education, and did mature experience in QE's tasks, all without previous formal qualification or appointment.
Educational requirements have been spelled out as "Master of Science (MSc) degree in Engineering, Physics, Chemistry, Biology (or other scientific subjects with a significant proportion of courses in radiation physics and radiation protection) or equivalent AND a minimum of five years of work experience in the Radiation Protection field, of which at least three years' direct work experience as "Qualified Expert" (or equivalent title)".
Alternatively, Candidates with a BSc would also be accepted , if they "possess a Bachelor of Science (BSc) degree in Engineering, Physics, Chemistry, Biology (or other scientific subjects with a significant proportion of courses in radiation physics and radiation protection) or equivalent AND a minimum of eight years of work experience in the Radiation Protection field, of which at least three years' direct work experience as "Qualified Expert" (or equivalent title)" [18].

In terms of previous certification or appointment, Candidates are required either to "possess a certification as "Qualified Expert" (or equivalent title) from an official national recognition/qualification body", or to have been "formally appointed in Expert RP role by an Employer" [18].

The last criterion is related to the residency of the candidate: it was indeed required, when the list was setup, that only Candidates permanently residing in the UAE, either UAE nationals or residents, should be allowed on the list.

The WG also agreed on the internal rules for the functioning of the Temporary List: how to screen Candidates, how to treat cases of Candidates belonging to the WG or to an Entity which is part of the WG, appeals.
With the criteria and internal rules approved by the RPC, the WG launcher an open call for Candidates to apply for the Temporary List in September 2020.

[6] the assessment in the NS indicated that a number of QE of around 100 would be required to satisfy the UAE-wide needs, supposing that a QE-staff is requested for any complex facility, and that a QE-consultant would be needed in the preparartion of regulatory documentation in each facility, and with the assumption that QEs would have an average of 10 clients

At present, 32 Temporary Qualified Experts are listed on FANR website [19], which is a significant improvement compared to beginning of 2021.

Each WG Member has access to Candidates' documentation, via a secured SharePoint website. Each Member has to undergo a special security clearance, both to access confidential documentation, and to handle private data.
FANR pre-screens the candidatures, ensuring that basic criteria are met, and anonymyzes all documents submitted. Then documents are uploaded on the SharePoint website.
Each WG Member has access to the redacted files and is requested to prepare their assessment of the Candidates, following a structured excel sheet.
During plenary meetings, each file is collectively reviewed and discussed, with the exception of those cases for which a minimum of 4 written assessments in agreement have previously been loaded on the Candidate's directory. Candidates can be accepted, rejected, or kept on hold, while collecting clarifications and additional information.

In the almost three years of review of Candidate files, several pattern emerged.

First, despite the publicity that has been given to the List, via official communication, social media and word of mouth, only a limited number of Candidates applied to the List. It must be considered that the driver to become "temporary qualified expert" is mainly a personal desire to see their competence somehow recognised, possibly with a potential improvement in working conditions/opportunities, more than the request from Licences, itself motivated by Regulatory pressure. Once FANR, which is currently reviewing its Regulation implementing the GSR Part 3, will introduce the much needed Regulatory clarifications in the obligations to hire QEs, their role, also in the licensing processes, and their interfaces with other RP Professionals, especially in the medical sector, an urge for more QEs in the Country will undoubtedly emerge.

Second, the largest majority of Candidates are related, directly or indirectly, to the Medical Sector. A large fraction is currently working- or has previous work experience - in that sector, and many Candidates have already the title of Medical Physicist, while some are currently operating as MP in a hospital or clinic.
Some Candidates are working as radiographers, and they requested to be inserted in the Temporary Qualified List.

This prompts two observations.
The first one is that the role and functions of the QE in the workplace is frequently not well known, and this is especially true for those Candidates who are from a Country of American RP tradition.
The role or QE as main reference Professional for RP of workers and the Public, as envisaged by the IAEA, and also as reflected in the Directive 59 of the European Union, is not entirely aligned with the RP practice in many Countries, in which QE roles and responsibilities are split over a variety of RP Professionals. In those Countries, moreover, years and years of stratification of habits and practices, and subsequent reorganisation of operational arrangements with other Professional and Services, would not favor a re-organisation of tasks towards a unique QE. However, this is possible in Newcomer Countries, and should be encouraged. Unfortunately, frequently, some Consultants and Experts supporting developments in Newcomer Countries have themselves little experience of different RP regimes than the one in the country (or countries) where they operated, and therefore tend to repeat and propagate that country's RP model over and over.

It would be useful if, in the future, the IAEA could add, to the already numerous training courses that it offers, a training course for overseas Consultants, in order to teach the major difference between Regulatory approaches, and enlarge views and understanding of the IAEA overarching guidance documents and their implementation. In the end, there are seldom uniquely right or wrong Regulatory approaches in RP: in most cases, it is the effectiveness of the practical arrangements that happen once a regulatory approach has been chosen and enforced by Regulation, that matters.

The second observation is that there is frequently a confusion in the roles, responsibilities, interface and mutual interaction between RPOs, QEs, and MPs in the medical workplace. As it will be discussed in detail in the next chapter, clarifying those uncertainties has been part of the work performed by the WG.

In the review and analysis of Candidates' files, it has been very frequent the case that MPs claim that they have been taking care of occupational dose assessments, for instance, or of setting up the RP System in the department. Frequently, too, roles equivalent to the QE have been taken over by RPOs, who lack appropriate education levels and formal training, and mostly learnt on-the-job by doing.

Clarifications, to both issues discussed, and other which arose in the review of the files, are the target of the WG's actions, together with regulatory actions addressing clarity and implementation.

6 UAE national workshops on the roles, responsibility and qualification of QE, RPO and MP

From a regulatory perspective, a clear and univocal definition of roles, responsibilities, duties and interfaces is beneficial to the operational practice and implementation, as it clearly indicates who is in charge and has the legal responsibility to perform a specific task/duty. This is very important for newcomer Countries, where, in those situations where a clear definition of roles and responsibilities is lacking, some Professionals tend to discharge duties which do not strictly pertain to their qualifications.
It is frequently the case with MPs, who are normally well trained and competent in areas also related to RP of workers and the public, and tend to discharge duties which are typical of the QE, like assessment of occupational doses or calculation of doses to the population. Sometimes, it also happens that RPOs take duties which are specific to the QE or to the MP, and frequently this is due to the absence of the corresponding Professionals in the work environment. Both situations pose potential safety issues. Moreover, those practices tend to become a *de-facto* standard, and in many instances, there are cases in which it becomes “normal” practice for the MP to take care of radioactive waste management in a Nuclear Medicine, or for the RPO to perform QC on a medical apparatus.
Differentiation of the RP roles between RPO, QE and MP is not clearly indicated in some IAEA Publications, and higher-level Publications suggest a different approach than other, lower-level, Guides and Technical Documents, a condition which may add confusion.
Moreover, some Professional Associations also increase confusion by stating duties for their Professionals which are not strictly related to their specialization.

Ideally, as univocal guidance for new Member States, it should be clearly specified that:
1. Radiation Protection of the Workers and of the General Public is a sole responsibility of the Qualified Expert in Radiation Protection, who is in charge of defining and supervising the local Radiation Protection System.
2. Radiation Protection of the Patient is a sole responsibility of the Qualified Expert in Medical Physics (which includes QC related to medical equipment, and finalized to ensure proper dose delivery to the patient).
3. The RPO should have an implementation role, and operate practical tasks related to the implementation of the Radiation Protection System which has been setup by the QEs. The RPO can work also under the directive of the MP, in medical environments.
4. Of course, a MP who is also competent and qualified as a QE, can operate as QE as well. And the same is true for a QE who is also competent and qualified as MP.

To help clarifying roles, responsibilities and interface between Professionals, FANR has organized three National Workshops, which took place in 2015, 2017 and 2019, with the fourth one being delayed by the pandemic.

National Stakeholders, WG Members and several members of the Professional groups operating in RP gathered and discussed topics related to the Qualification of personnel, training courses, and differentiation of professional roles. Support was also received by the IAEA in the deployment of the Workshops, with Experts discussing their experience in the field, and advising on actions to be implemented in the UAE.

7 Creation of new university degrees

As a part of the NS implementation, new routes for QE and MP education had to be created.
Agreement was found on the fact that both Professionals need education at MSc level, with a possibility to integrate practical RP work experience in the equivalence of MSc for QEs, who may also have a BSc, for lower tiers; and with the subsequent need to attend a clinically-qualifying residency programme for MPs, who would be clinically qualified in diagnostic radiology, nuclear medicine or radiotherapy only after two years of specialised studies and work under supervision in a medical setting.

No previous educational route for QEs was available in the UAE, with the exception of some MSc in Physics, in which topics related to radiation and RP were also taught. The freshly created and well-established MSc in Nuclear Engineering, which was designed mainly to cater for the nuclear programme, would possibly require some extension and adjustment in terms of accessibility for students and prior requirements (a scholarship was requested, for Emirati students who would access Nuclear Engineering studies).
A new application to the Ministry of Education was therefore submitted by Khalifa University in Abu Dhabi, to create a new concentration in "Radiological Protection" within an already existing MEng in "Health, Safety and the Environment". The syllabus prepared for the new degree, for which the WG also provided support and consultancy, contained topics as internal and external dosimetry, management of occupational, emergency and existing exposure, biological effects.

The list of courses in the new RP concentration would comprise:
- Radiations Science and Health Physics
- Radiation Measurement and Applications
- Principles of Radiological Protection
- Radiation Protection in planned exposure situations
- Radiation Protection in Existing and Emergency exposure situations

- Radiation dosimetry
- Occupational Radiation Protection
- Radiological Environmental Impact Assessment
- Biological effects of the exposure to ionizing radiation

The Concentration was approved in 2019, and was supposed to be operational in the fall of that year.

Regarding the MP route, a previous BSc in MP was indeed available in the UAE, but was discontinued years ago.
As a result, no route for MPs was available until 2019, when Khalifa University decided to start, within the Physics Department, a new MSc in MP. IAEA support was obtained, within the Technical Cooperation programme, to support the setup of the syllabus and the structure of the new course, faculty were hired and laboratories with instrumentation were set up in KU.
Since then, the programme is running and has received a lot of attention and a successful response from students. As everywhere else around the world, it is important to publicize the work of the Medical Physicist (probably not as well-known and attractive as an astronaut or a nuclear power plant Operator) within the general public, to spark even more interest in the students' population.

Importantly, clinical work in a hospital, and the full-extent corresponding residency programme, need to be completely set up and deployed, in order to close the circle and allow students to be fully qualified and operational in the job market. Actions are already ongoing in this regard.

8 Development of national qualifications

Since the inception of the WG's work, it appeared clear that, in order to ensure harmonisation of curricula across the Emirates, a wide approach for E&T should have been pursued.
FANR invited the National Qualifications Authority, NQA, to participate to the works of the WG, and started a strategic partnership with NQA.
In the first years, the collaboration between NQA and FANR went as far as allowing some NQC Staff support both the WG and the RNDC, to help get it started.

At the end of 2014, NQA authorized FANR to setup another working group, named "**Recognized National Development Committee**", RNCD, to develop National Qualifications for the five profession RP profiles that have already been mentioned: QE, RPO, MP, EW and EmW.
FANR setup and chairs the RNDC, and also invited representatives from the commercial Training Providers: the purpose of developing National Qualifications is indeed to generate standards that are accepted and supported by the industry, and by the corresponding Regulator.

The National Qualifications Approach that is supported and brought forward by NQC, as described in the "Qualifications Framework for the Emirates" [23] and in the corresponding "VETAC Guidelines for vocational training" [22], is based on National Qualification Unit Standards, a "formally approved set of learning outcomes developed to standards set by the developing industry bodies, which can be achieved by a learner". National Qualifications (NQs) may be represented by size (how long the take to complete) and level (how complex they are), and they take the form of ‘principal qualification’ or ‘award’.

The series of steps that bring to the definition of a NQ start with the preparation of the "Functional Analysis" and the "Occupational Profile" of the related occupation. The Functional Analysis is a minute description of the functions assigned to the occupation, with the definition of Functional Areas and sub-functional areas.

As an example, for the Occupation "Qualified Expert", five functional areas have been defined, based on the understanding that the main responsibilities of the QE cover setting up the RP Program and overseeing its implementation in the organization, assess doses to workers and the population, and interface with other services (QA, EHS, E&T, etc.) in the organization:

FA1 - Develop the organisation's Radiation Protection system
FA2 - Ensure the implementation of the organization's Radiation Protection system
FA3 - Evaluate and report the organization's dose measurements and assessments
FA4 - Provide consultation on Radiation Protection to organisational personnel
FA5 - Conduct Radiation Protection quality management assurance in the organisation

Each one of the Functional Areas is subdivided in Functions and Sub-Funtions.

For example, Functional Area 1 above is subdivided into four Functions:

F1.1 - Assume responsibility for Radiation Protection within the organisation
F1.2 - Develop the organisation's Radiation Protection system
F1.3 - Develop the organisation's Radiation Protection system's documentation
F1.4 - Verify compliance with UAE regulations

and Function 1.2 above is subdivided into five sub-Functions:

SF1.2.1 - Research international best practice for Radiation Protection
SF1.2.2 - Consult external and internal stakeholders on Radiation Protection policy
SF1.2.3 - Establish the organisation's Radiation Protection system
SF1.2.4 - Obtain the organisation's Radiation Protection system internal approval
SF1.2.5 - Integrate the organisation's Radiation Protection system with other policies in the organisation,

and so on, for all other Functional Areas, and for all five Occupations.

The systematic analysis of an Occupation in all its functions within an Organization helps pinning down the required knowledge, skills and attributes that are needed to a Candidate to fulfill all duties assigned to that occupation. In particular, this exercise allows to enucleate and identify the National Occupational Standards, also called Unit Standards (USs), that will represent the skeleton of the learning needed for that Occupation.

The second element was the definition of the "Occupational Profile", which specifies high-level requirements, as educational requirements, apprenticeship, indicative duration of the Qualification in terms of contact hours, and relationship of this Professional with others in the work environment, including potential career paths, potential Employers, expected salary, etc.
Importantly, it is in the Occupational Profile that the "fine structure" of the five Occupations, in Tiers and Sectors, was worded out.

Although simple in practice, the Tiers/Sectors structure eventually proved quite complex to be implemented in the Q+NOSS approach. After careful consideration, it was deemed necessary to define a different Occupation for each Tier, and to define an optional path, called "Stream" to differentiate Work Sectors (medical, nuclear, industrial). For each Tier/Sector, though, a full set of USs needs to be developed, which makes the development time longer and the overall Qualifications appear more complex at first sight.

This work was performed in 2017-2018, and reached consensus among the RNDC and the approval of NQC, with the invitation to the RNDC to develop the proposed Unit Standards for the five Occupations.
In 2019, work started on the preparation of the EWs and EmWs USs: in this phase, Learning Outcomes (LOs) are specified in terms of several Performance criteria (PCs) that candidates need to demonstrate, in order to reach appropriate competence. Assessment criteria are also specified, to ensure that the methodology to reach and demonstrate PCs is well understood by the Training Providers who have to develop training courses and assessments.

Various other elements are also introduced in the US, for example specific PCs related to a single LO, in case this is needed; references for the preparation of each topic in the training course; requirements, in term of education level, language fluency, previous qualifications; progression from the existing qualification into another job or qualification.

As an example, let us have a look how LOs and PCs for one US of EmW were developed[7].

EmW is subdivided into two tiers, the first one dealing with first response, and the second one with subsequent actions in later phases of an emergency situation.

EmW Tier 1 is composed of four USs:

Gain Knowledge on how to deal with radiation emergency situations – Radiation Emergency Worker Tier 1
Instigate protective measures to safeguard life – Radiation Emergency Worker Tier 1
Perform decontamination on people and facilities –Radiation Emergency Worker Tier 1
Conduct radiation measurements during emergency situations - Radiation Emergency Worker Tier 1

The first US, "Gain knowledge", hs a duration of 15 contact hours and has an aim to "provide Radiation Emergency Workers with the basic knowledge of radiation physics and radiation protection, and the basic skills to respond effectively, as Member of an Emergency Team, during the first phases of a nuclear or a radiological emergency situation".

The LO of that US is to:

1. Demonstrate knowledge in providing appropriate actions as a member of a radiation emergency response team in the UAE
2. Demonstrate knowledge of radiation hazard identification and control
3. Demonstrate knowledge in mitigation of potential damage to the environment from sources of radiation

The first LO is broken down in a number of PCs, which are:

PC1.01 Translate knowledge and understanding of basic radiation physics, namely the basic structure of an atom, including its three primary components
PC1.02 Explain the following:

• Alpha radiation
• Beta radiation
• Gamma radiation
• X-ray radiation
• Neutron radiation

[7] it must be noted that the development of NOSs is under the intellectual property rights of NQC, hence it is not possible to share the unfinalised USs before the occupation is endorsed and published.

• Radioactive decay
• Half-life
• Fission

PC1.03 State and explain the three Radiation Protection Principles (justification, optimization and limitation)
PC1.04 Describe the second principle: “As Low As Reasonably Achievable” (ALARA), in the context of a radiological/nuclear emergency
PC1.05 Describe the difference between irradiation and contamination
PC1.06 Describe the three main techniques for mitigating external exposure hazards
PC1.07 Describe techniques to avoiding or mitigating internal exposure hazards
PC1.08 Explain principles of Incident Command System (ICS) and the structure that allows for a cooperative response by multiple agencies in the UAE
PC1.09 Define Incident Command System
PC1.10 State the aims of the Incident Command System
PC1.11 Explain the importance of establishing, maintaining and completing legible incident reporting
PC1.12 Explain the importance of collaborating with the organisation’s management to implement emergency response arrangements

Specific evidence requirements are, related to these LOs:

"Candidate must demonstrate knowledge and understanding of the basic principles of radiation physics and protection plus basic emergency response procedures and the importance of implementing an effective Incident Command System and collaborating with the organisation’s management.

The following information is provided to aid the training provider in developing the course work:
PC1.05: irradiation (external exposure to radiation) and contamination (potential external and internal exposure to radiation)
PC1.06: Time-Distance-Shielding
PC1.07: confinement, Personal Protective Equipment, decontamination
PC1.11: provides chronological sequence of events; aids root cause analysis; provides feedback on lessons learned etc.
PC1.12: provides necessary foundation for development of site response plans and procurement of related equipment"

The guidance to help assessors to verify that LOs are met is indicated as:

"Assessment must be conducted in an environment where evidence gathered by Learners demonstrates consistent performance in conditions that are safe and replicate a potential accident workplace.

Assessment methods can include:
• Scenario setting
• Presentations
• Virtual simulations and modelling
• Written material and report
• Checklists and comparative charts
• Statements
• Topologies

• Evidence of written reports summarising results of candidate skills assessment
• Oral or written questioning

Evidence:
• Verbal or written questioning to assess candidate's knowledge
• Summative assessment to ensure consistency of performance in a range of contexts
• Formative evidence for this unit can be written, oral or diagrammatic
• Formative evidence ought to assist learners to learn and increase performance
• Summative assessment is based on real live work situations or simulated situations

Assessors and verifiers must satisfy NQC/VETAC requirements with subject matter expert related to radiation emergency assessment.
All evidence submitted by the learner must be verified and documented by the assessor for future evaluation purpose.
Summative assessment is based on real work situations or simulated situations.
Assessment judgements are based on evidence that is documented as valid, authentic, current, and sufficient, and are consistent with previous judgements made on similar evidence.
Re-submissions are permissible"

The same approach is followed for all the other LOs and PCs in every US.

This process is very detailed, and requires time and accurate reviews to ensure that all the significant learning elements are kept across sectors and tiers.

9 Conclusions

The UAE have started a number of actions as a follow-up of the EduTA Mission, which include the creation of a Working Group (Steering Committee) that prepared the National Strategy draft document, and started implementing it after endorsement.

Among the many activities that have been performed throughout the first implementation cycle, the creation of the temporary list for Qualified Experts, the National Workshops on roles and responsibilities of QEs, RPOs and MPs, and the preparation of National Occupational Standards have to be acknowledged.

In particular, the systematic and analytic approach for the definition of the National Qualifications has proved to be a long and complex task, and its completion will contribute to the definition of a coherent and harmonised framework for ETQ of RP Professionals in the UAE.

10 Annex 1: Recommendations and Suggestions from the 2017 EduTA Mission to the UAE

R.1 A formal system of recognition for the qualified expert should be established in line with the IAEA Safety Standards. This system should specify the required functions, duties and qualifications of a qualified expert.
R.2 Criteria for the designation/appointment of the radiation protection officer should be established, in line with the IAEA Safety Standards, with provisions for radiation protection officer's functions, duties, and qualifications.

R.3 Once the formal system of recognition of the qualified expert is established, the FANR licensing and inspection procedures should reflect the application of the related requirements.
R.4 Consideration should be given to establish requirements for training in radiation protection for personnel in existing exposure situations.
R.5 A national policy and strategy for education and training in radiation, transport and waste safety should be developed.

The EduTA team also identified how process and procedures can be improved and therefore suggest that:
S.1 In association with R.1 and R.2: When establishing the functions, duties and qualifications of the qualified expert (R1) and those of the radiation protection adviser (R2), care should be taken to differentiate between the advisory role of the qualitied expert and the supervisory role of the radiation protection officer.
S.2 In association with R.1 and R.2: Consideration should be given to using the national qualification framework for developing a system for the formal recognition of the qualified expert. If appropriate, the same approach should be used for the designation of the radiation protection officer.
S.3 In association with R.1 and R.2: Once the role, functions and qualification requirements of the qualified expert and radiation protection officer have been established, current provisions for the training (e.g. training programmes) should be revised and updated.
S.4 A survey should be carried out to identify existing potential qualified experts that could form a pool of expertise for a transition period until the recognition scheme is operational.
S.5 Consideration should be given to the development of further guidance on the content of radiation protection training courses for the workers in all practices. The existing guidance and any new guidance should be disseminated to training organisations.
S.6 In the process of developing the training programme for the emergency preparedness and response personnel, consideration should be given to providing training in radiation protection in accordance with the actual and predicted needs. This training should be focussed on the job functions.
S.7 In association with R.5: Consideration should be given to the draft white paper outlining the content of the policy and identifying the main steps and actions to establish the national strategy. While the policy is expected to be submitted to Government, the strategy could be endorsed by all the relevant national stakeholders concurring to its implementation (e.g. Radiation Protection Committee in the State).

11 Annex 2: Acronyms

ATP: Accredited Training Provider
ETQ: Education, Training and Qualification
EmW: Emergency Workers
EW: Occupationally Exposed Workers
FANR: Federal Authority for Nuclear Regulation
QE: Qualified Expert
LO: Learning Outcome
MoE: Ministry of Education
MP: Medical Physicist
NQ: National Qualification
NQA: see NQC
NQC: National Qualifications Center
PC: Performance Critwria
RP: Radiation Protection

RPC: Radiation Protection Committee in the State
RPO: Radiation Protection Officer

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THE ROLE OF EDUCATION AND TRAINING IN THE DEVELOPMENT OF A REGULATORY INFRASTRUCTURE IN RADIATION PROTECTION IN SURINAME

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In 2022, the Dutch Society for Radiation Protection (NVS) provided recommendations to the Suriname government regarding a possible system of Education and Training in radiation protection in Suriname as a follow up of more general recommendations on a regulatory infrastructure in radiation protection. The NVS Chapter Radiation Protection in Suriname and the Caribbean area started Education & Training activities in Suriname, in line with the recommended system of E&T from 2021 onwards. In this contribution we will present these recommendations and a status report on its adoption. We also summarize recent and planned E&T activities in Suriname.

1 Introduction

In November 2019, the Dutch Society for Radiation Protection (NVS) participated in a mission to Suriname, intended to provide recommendations to the Suriname government on establishing a regulatory infrastructure in radiation protection (Adhikari et al., 2021)[1]. During the NVS mission, a stakeholder meeting was held with representatives from the radiation field in Suriname. A survey sent out after the stakeholder meeting showed that there was a great need for knowledge and expertise in the field of radiation protection. As a consequence, the NVS established a special chapter in November 2020. With this new chapter, the NVS intends to promote organised radiation protection in Suriname and the Caribbean area. Membership is open to all professionals who have an affinity with or who work with ionizing radiation in Suriname and the Caribbean countries and municipalities that are part of the Kingdom of the Netherlands.

In its first meetings the members of the chapter decided to focus on raising awareness on radiation and radiation protection. For pragmatic reasons, a two-track approach was chosen. On one hand preparations were made to provide the Suriname government with more detailed recommendations on establishing a system of Education and Training in Radiation Protection. Simultaneously, the chapter started Education & Training activities in Suriname, in line with the recommended system of E&T.

In chapter 2 we present the essentials of the recommendations on E&T that were presented to the Suriname government in July 2022. We also give an update on the adoption of these recommendations. In chapter 3 we present an overview of the E&T activities since 2021 as well as our plans for future activities.

2 A possible system of Education & Training in Radiation Protection for Suriname

Before formulating recommendations on an E&T system, several meetings with professional organizations in Suriname were held to collect response to our ideas, and to identify priorities and missed items. The organizations are exclusively active in the medical field (Suriname Dentists

Association, The Association of Medical Imaging and Radiation Experts in Suriname, the Department of Radiology). Additionally, a meeting with the labour inspectorate was organized. Of course, earlier input from the stakeholder meeting in November 2019 was also taken into account.

2.1 Recommendations

The NVS recommends that the Surinamese government arrive at a training system in radiation protection that, at its core, consists of two different training programs for radiation protection officers, supplemented by a guideline for the content of two different basic radiation protection courses. The following sections describe these four courses in more detail.

The embedding of this training system in national regulations obviously also requires determining when the government requires an entrepreneur to have a radiation protection officer and what his or her duties and responsibilities are. These recommendations make no mention of this, other than a single concluding remark that relates to further training. The same applies to a lesser extent to basic radiation protection courses. It is recommended that the learning objectives of the basic courses not be laid down in regulations, but that the requirement be imposed on the entrepreneur that "employees working with ionizing radiation must be adequately instructed”. In our opinion, this instruction should consist of a general basic course as referred to here, supplemented by an application- and company-specific instruction, to be provided by someone who has been trained as a radiation protection officer (and appointed for this purpose by the company). We do recommend some guidelines for the topics to be covered in the case of the basic courses as these are not described elsewhere.

2.2 Radiation protection officers

For courses for a Radiation Protection Officer responsible for X-ray equipment, we recommend

- Nominal duration: approximately 4 days including practicals and exam
- Main target groups:
    - Employees who supervise the safe operation of ionizing radiation emitting devices within (inter)national regulations in a simple setting (i.e. with relatively low risk), which is mostly, but not exclusively of a medical nature;
    - Persons performing inspections on the above applications.
- Ancillary target group:
    - Employees who work under supervision with ionizing radiation emitting devices in a setting of relatively high risk.
- Learning objectives: it is recommended that these broadly correspond to the final learning outcomes as laid down in the Dutch Regulation Basic Safety Standards for Radiation Protection for the Radiation Protection Officer for Medical Applications, for Dentistry – basic level, and for Measuring and Control Applications - X-ray equipment, with the understanding that
    - All specific applications that are or may be relevant in Suriname are covered concisely, and
    - The legislative and regulatory section focuses on internationally accepted standards and on Surinamese regulations.

For courses for a Radiation Protection Officer responsible for sealed sources, we recommend

- Nominal duration: approximately 4 days including practicals and exam
- Main target groups:
    - Employees who supervise the safe operation of sealed radioactive sources, within the (inter)national regulations in a simple setting (i.e. with a relatively low risk);
    - Persons performing inspections on the above applications.
- Ancillary target group:
    - Employees who work under supervision with sealed radioactive sources in a setting of relatively high risk.
- Learning objectives: it is recommended that these broadly correspond to the final learning outcomes as laid down in the Dutch Regulation Basic Safety Standards for Radiation Protection for the Radiation Protection Officer for Measuring and Control Applications - Sealed Sources, with the understanding that
    - All specific applications that are or may be relevant in Suriname are covered concisely, and
    - The laws and regulations section focuses on internationally accepted standards and Surinamese regulations.

No recommendations are issued for Radiation Protection Officers responsible for radioactive material in dispersible form as these materials are not used in Suriname, neither in medical, nor in research or industrial applications. Naturally occurring radioactive material (NORM) has not been taken into consideration yet, as a consequence of the fact that our recommendations follow a graded approach. On the long term, adequate arrangements for NORM should be made.

2.3 Basic instruction in Radiation Protection

For a basic course in radiation protection around X-ray applications, we recommend the following:

- Nominal duration approximately 1 day
- Main target audience:
    - Employees who work with ionizing radiation emitting devices in a simple setting (i.e. with relatively low risk), which is mostly, but not exclusively medical in nature.
- Secondary target groups:
    - Persons performing inspections, but not necessarily charged with overseeing the above applications;
    - Persons interested in ionizing radiation emitting devices, their risks and how to protect themselves from them.
- Learning objective: the student has basic knowledge in the field of radiation protection and can safely perform operations with X-ray devices that are not or could not be intrinsically safe.
- Content: the following topics could serve as a guideline for the content of this basic course:
    - Properties and origin of X-rays.
    - X-ray applications
    - Detection of X-rays
    - Imaging - with a focus on medical practice
    - Quantities and units in radiation protection
    - Biological effects of ionizing radiation
    - Laws and regulations in radiation protection
    - Practical safety measures around X-ray equipment
    - Simple dose calculations

For a basic radiation protection course for working with sealed radioactive sources we recommend

- Nominal duration approximately 1 day
- Main target audience:
    - Employees who work with sealed radioactive sources in a simple setting (i.e., with relatively low risk).
- Secondary target groups:
    - Persons conducting inspections but not necessarily charged with overseeing the above applications;
    - Persons interested in ionizing radiation, its risks and how to protect themselves from them.
- Learning objective: the student has basic knowledge in the field of radiation protection and can safely perform operations with sealed radioactive sources for applications that are not or could not be intrinsically safe.
- Content: the following topics could serve as a guideline for the content of this basic course:
    - Properties of alpha, beta and gamma radiation
    - Applications of sealed radioactive sources
    - Detection of ionizing radiation
    - Quantities and units in radiation protection
    - Biological effects of ionizing radiation
    - Laws and regulations in radiation protection
    - Practical safety measures around sealed radioactive sources
    - Simple dose calculations

2.4 Continuous Professional Development & Recognition of foreign certificates

Persons who actively work with or supervise ionizing radiation should keep their knowledge up-to-date. Based on the discussion held in the NVS-SC Chapter, we recommend a frequency of once every 3 years for continuous professional development, specifically addressing the issues most relevant to radiation protection. For RPOs, the nominal duration of such refresher training will be roughly one day, for those who have taken a basic course, several hours.

The number of higher-risk applications in Suriname is limited. If the national government were to decide to require all operators to have a RPO, the training requirements for a RPO for high-risk applications should be similar to those of a Radiation Protection Expert, as referred to in the European Basic Safety Standards or Qualified Expert, as referred to in the IAEA Basic Safety Standards. It is not realistic to achieve such training in Suriname. The NVS therefore recommends recognizing persons who have completed training as Radiation Protection Experts at the level of Coordinating Expert (as referred to in the Dutch Regulation Basic Safety Standards for Radiation Protection). In addition, it is recommended that the Dutch training courses for 'Radiation Protection Officer' in Suriname be recognized as training courses for RPOs, insofar as these are substantially similar in content to the corresponding Surinamese training, on the understanding that at first opportunity the specifically Surinamese aspects should be retrained. Also - under the same conditions as mentioned above - it can be considered to accept those European training programs that are directly or indirectly recognized by the national government of countries of the European Union or another state party to the Agreement on the European Economic Area or Switzerland. An additional condition could, of course, be that the person concerned is able to express himself at an adequate level in Dutch or any other language commonly used in Suriname.

2.5 Status report

The recommendations were sent to the Surinamese government in July 2022. The formal handover of the recommendations followed in August 2022 (at the Ministry of Health and the Ministry of Labor). Also present at the handover and subsequent discussion were representatives of the Labor Inspectorate. The recommendations were also presented at a symposium of the NVS chapter in November 2022 in Paramaribo, Suriname.

At the invitation of the Minister of Labor, a presentation was held on May 3rd 2023 at the Government Council meeting, which is chaired by the President of the Republic of Suriname and includes the vice-president and all ministers. The presentation focused on the scope of radiation protection in Suriname, highlighting the work that had already been done in regard to strengthening the current capacity on radiation protection. Different stakeholders across the ministries were identified and their role in establishing a roadmap for establishing adequate radiation protection was emphasized. The major gaps with regard to radiation protection included the outdated legislation, the lack of competent human capacity, the lack of an infrastructure to perform monitoring and control activities on practices using ionising radiation and the disconnect with international organizations working on ionising radiation such as the International Atomic Energy Agency. The presentation concluded with a call for action to the Government Council to develop a plan to update the current legislation taking into account the report on the education and training system, as well as to decide on the Ministry that will take the lead in implementing the actions. Finally, the Government Council was prompted to also decide on applying for membership to the International Atomic Energy Agency. The presentation was well received; the president proposed to also include a plan to raise awareness amongst the public on the (safe) uses of ionising radiation.

3 Education & Training activities in Suriname

3.1 Recent courses

The newly established NVS chapter organized three introductory courses on radiation protection in 2021 and 2022 in collaboration with the Groningen Academy for Radiation Protection of the University of Groningen (GARP). The courses were based on introductory courses that are offered in The Netherlands by GARP and could easily be transferred into online courses. In fact, the restrictions due to the COVID-19 pandemic turned out to be advantageous for the development of basic courses on radiation protection in Suriname.

The first course focused on dentist assistants and consisted of two lectures and a concluding 'self test'. In the lectures, attention was paid to general aspects of radiation, radiation risk and practical radiation protection, as well as to specific aspects of dental radiology (positioning techniques and imaging). The (online) audience consisted of participants from both The Netherlands and Suriname.

The second course focused on basic knowledge of radiation protection around X-ray equipment and attracted primarily participants from the medical field and the labour inspectorate. The course duration was approximately 4 hours and treated all basic elements of X-rays and radiation protection. Thus, the course was fully in line with the recommendations. The participants ended the first session with an online test with 30 multiple-choice questions that had to be answered within about one hour. An additional Q&A session and short discussion on the results of the test concluded the course.

The third course focused on radiation protection for sealed radioactive sources and was intended as an addition to the basic radiation protection course around X-ray devices. Participants were primarily, but certainly not exclusively, from the labour inspectorate and the radiotherapy department of the Academic Hospital Paramaribo. As not all aspects of radiation protection had to be treated, the extra duration of this course was only approximately 2 hours. This course ended with an online test and a final Q&A and discussion session too.

In table 1, a summary of the participance of these courses is presented.

Table 1: Basic RP courses in Suriname in 2021 & 2022.

Course	Date	Participants	Passed test
Basic RP for Dentist assistants	5 March 2021	30	n.a.
Basic RP for X-ray applications	26 March & 9 April 2022	72	66
Basic RP for sealed radioactive sources	31 March & 9 April 2022	39	36

3.2 Future plans

Although a formal system of Education & Training in Radiation Protection has not been incorporated in national legislation in Suriname yet, we have nevertheless developed plans for organizing a course for RPOs responsible for X-ray devices. A fully online course will not be possible as we consider it undesirable to refrain from practicals and a written exam. At the same time, face-to-face training is highly appreciated in general. Therefore, we are developing a program that starts with some online lectures, and will be continued (and partially repeated) face-to-face. The learning outcomes of the course will be (almost) identical to the Dutch RPO courses for low risk X-ray devices. It is our intention to organize the first course in 2024.

A RPO course for measurement and control applications of sealed radioactive sources will be considered consecutively. We also note that there is already a commercial party, the NRG Academy, offering a similar RPO course on request – they provided a course to employees of gold mining company and the national oil company in April 2023. According to our information, this course was – apart from the practicals – largely in line with the recommendations. Collaboration with this party will be discussed.

Finally, the NVS chapter is currently in preparation of a second basic course for dentist assistants. This course will be organized along with a short symposium and in close collaboration with the Suriname foundation of Oral Health Therapists. The course is scheduled for the end of 2023.

4 Conclusion

In this paper we presented a possible system of Education and Training in radiation protection in a developing country with a limited range of applications, in line with the graded approach that the NVS already recommended in 2019 to the Surinamese government. We conclude this contribution with a few observations.

- The pragmatic approach to start organizing courses in Suriname without a formal system being in place, has so far worked out well given the number as well as the reactions of the participants. At the same time, the realization of this system within the national regulation of Suriname, faces serious delay – a phenomenon common to almost all countries. However, we consider the fact that the presentation of the scope of radiation protection in Suriname in general, and the recommendations on E&T in particular was well received, as an encouraging sign.

- In 2019, the NVS recommended to have adequately trained staff at the authorities and – specifically – the inspectorate as well. We observed a significant number of participants from the labour inspectorate among the audience.
- Developing countries might be supported by professional RP protection organizations like the NVS in establishing a RP community in their country. The realization of the NVS chapter Radiation Protection in Suriname and the Dutch Caribbean has enabled stakeholders in Suriname to stay informed regarding radiation protection. The limited number of RP professionals really active in the chapter may however threaten the long-term continuity of the work of the chapter and thus the E&T activities in Suriname.

Acknowledgement

The authors would like to thank the Dutch Society for Radiation Protection for their support in establishing education and training activities in Suriname.

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EURADOS EDUCATION AND TRAINING VISION AND STRATEGY: FROM TRAINING EVENTS AND SCIENTISTS SUPPORT TO WEBINARS ON RADIATION DOSIMETRY

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17 European Organization for Nuclear Research (CERN), Geneva, Switzerland

18 Belgian Nuclear Research Centre (SCK CEN), Mol, Belgium

The EURADOS Strategic Research Agenda includes education and training activities for the maintenance of expertise in radiation protection and dosimetry field. Such activities mostly take place within the EURADOS Working Groups, which carry out research work, organize training courses, intercomparisons, perform simulations and measurement campaigns and publish reports and guidelines on best practices in radiation dosimetry. As latest initiative, EURADOS started a series of webinars with the aim of wider dissemination of research results and knowledge: such webinars have become a regular appointment for both early career researchers and senior scientists.

1 EURADOS Education and Training Vision and Strategy

European Radiation Dosimetry Group, EURADOS, has for decades been active in education and dissemination activities and in supporting early career scientists. A review of EURADOS activities and aims for education and training (E&T) were reported in a recent paper [1]. The EURADOS Strategic Research Agenda [2] includes E&T activities for the maintenance of expertise in the radiation protection and dosimetry field.
EURADOS E&T actions are focused, on one hand, on organising regularly scientific and training events like *schools*, *scientific workshops* and *training courses* and, on the other hand, on supporting early career scientists in their research activities in radiation dosimetry by attending conferences *(EURADOS Young Scientist Conference Support*), recognizing the scientific value of their research work *(EURADOS Award)* and on funding research stays (*EURADOS Grant)*.

Last but not least, within its Working Groups (WG), EURADOS offers the opportunity to senior and junior researchers to work together allowing for all participants a *continuous learning process* and updating of knowledge.

During EURADOS Annual Meetings, which gather together more and more researchers with an average attendance in recent years of about 300 people, the WG meetings are open to all interested scientists, with only specific exceptions (i.e. when confidentiality is needed as for the meetings for inter-comparison (IC) exercise management).

Additionally, EURADOS dedicates specific efforts to disseminate as wide as possible knowledge on radiation dosimetry either related to EURADOS research and harmonization activities or related to documents of relevance issued by international Commissions or Organizations.

In fact, EURADOS publishes its research results and achievements not only in scientific journals but also, since 2012, in the *EURADOS Report series*. These EURADOS reports are freely available on the EURADOS website.

Most recently, since 2020 *EURADOS has started to deliver webinars* regularly during the following years, making them a regular appointment for both early career researchers and senior scientists.

1.1 About EURADOS

The European Radiation Dosimetry e.V. was founded in 1982 [3] and registered in Germany as a non-profit organization since 2008. It promotes research and development and European cooperation in the field of the dosimetry of ionizing radiation as well as harmonization of the dosimetric procedures used within the EU and their conformance with international practices.

At present, EURADOS (http://www.eurados.org) is a network of 80 European institutions (Voting Members) from 32 countries and 785 scientists (Associate Members) from 51 countries.

The main activity is performed by the Working Groups (WGs), currently eight, each dedicated to a specific field of ionizing radiation dosimetry (see Table 1). Since 2021, a Pilot Group on *Dosimetry in nuclear medicine* has been launched with a 3-year term. WGs carry out research work, organize intercomparisons and surveys, perform simulations and measurement campaigns and, last but not least, publish reports and guidelines on best practices in radiation dosimetry. EURADOS WG2 and WG7, for example, contributed within dedicated EC Funded Projects to the development of the EC Technical Recommendations for individual monitoring of external and internal exposure to ionizing radiation, published by EC as Radiation Protection 160 (RP160) [4] and as Radiation Protection 188(RP188)[5].

Table 1 – EURADOS Working Groups (WG) and respective chairperson

WG	Title	WG Chairperson (Institution, country)
WG02	Harmonization of individual monitoring	M-A. Chevallier, IRSN, France
WG03	Environmental monitoring	A. Vargas, UPC, Spain
WG06	Computational dosimetry	H. Rabus, PTB, Germany
WG07	Internal dosimetry	D. Broggio, IRSN, France
WG09	Radiation dosimetry in radiotherapy	L. Stolarczyk, DCPT, Denmark
WG10	Retrospective dosimetry	E. A. Ainsbury, UKHSA, UK
WG11	High energy radiation fields	M. Caresana, PoliMi, Italy
WG12	Dosimetry in medical imaging	Ž. Knežević, RBI, Croatia
Pilot Group	Dosimetry in nuclear medicine	W. Li, BfS, Germany

Since 2012, EURADOS has developed a *Strategic Research Agenda* (SRA) to identify the future research needs in radiation dosimetry.

The SRA is used to direct the research of the EURADOS WGs. The SRA is also used in the priority setting of research calls of the European Commission. The 2020 version of *Visions for radiation dosimetry over the next two decades - Strategic Research Agenda of the European Radiation Dosimetry Group* has been published as EURADOS Report 2020-04 and shortly in a paper[2]. Figure 1 illustrates all the Visions and Challenges in the SRA current version. The SRA forms the basis of EURADOS roadmap, shown in Figure 1, and include a section on ***E&T*** common to all SRA Visions.
EURADOS has endorsed international conferences and promotes the continuation of the series of conferences of *Individual Monitoring Conference (IM)* and *Neutron and Ion Dosimetry Symposium (NEUDOS),* which are both relevant to radiation dosimetry research and new developments at international level.

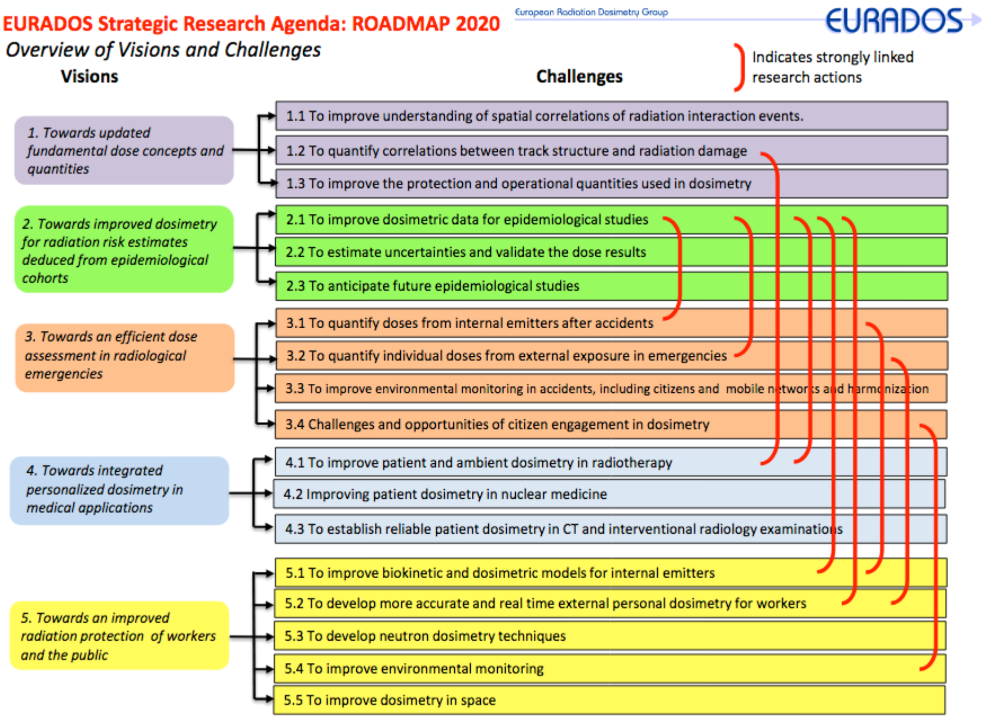

Figure 1. Visions and Challenges in the current version of EURADOS SRA [2, 3]

1.2 Schools and Workshops at EURADOS Annual Meeting

Since 2007 EURADOS *Winter Schools* and *Scientific Workshops* have taken place at EURADOS Annual meetings, held usually at the beginning of the year. The *Schools* last one full day or half a day and they provide "refresher courses" on topics relevant to radiation dosimetry intended for students and those new to the subject area. In contrast, *scientific workshops* used to be organized at EURADOS Annual Meetings (AM), related to research topics or results from EURADOS Working Groups. Winter Schools and Workshops were usually held alternately at AM, though occasionally held together at the same AM. Table 2 and Table 3 list the Schools and Scientific Workshops held since 2007 respectively. The last Scientific Workshop was held in 2012, whilst *Winter Schools* have been regularly held every year since 2007. Since 2020 *Winter Schools* have been called *EURADOS Schools*.
The presentations given at the Winter/EURADOS Schools are available for download from the EURADOS website since the 6th edition. For some Schools EURADOS Reports collecting contributions in a paper form have been also published; the lectures given at the Workshops were published in the open literature in peer-reviewed journals(i.e. Radiation Protection Dosimery or Radiation Measurements).

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Table 2 – Topics of the Schools held at EURADOS Annual Meetings

AM	#	Winter School topics
AM2023	16th	Contribution of Dosimetry in the Field of Nuclear Emergency Preparedness and Radiological Accident Management.
AM2022	15th	Computational Methods in Dosimetry – State of the Art and Emerging Developments
AM2021	14th	Fetal Radiation Risk: Dose Assessment in Occupational, Medical and Emergency Situations (online event)
AM2020	13th	Eye Lens Dosimetry
AM2019	12th	Radon: Dosimetry, Metrology and Regulation
AM2018	11th	Application of Physical and Computational Phantoms in Dose Assessment
AM2017	10th	Internal dosimetry for radiation protection and medicine
AM2016	9th	Dosimetry for Epidemiological Cohorts
AM2015	8th	The Fukushima Daiichi Nuclear Accident, the Role of Dosimetry in Assessing the Consequences
AM2014	7th	Relative Biological Effectiveness, Radiation Weighting Factor and Quality Factor: their Role in Quantifying Effectiveness of Ionizing Radiation
AM2013	6th	Status and Future Perspectives of Computational Micro- and Nanodosimetry
AM2011	5th	Radiation Protection for Medical Staff
AM2010	4th	Radiological Emergencies – Internal Exposures
AM2009	3rd	Low-Dose Radiation Effects
AM2008	2nd	Retrospective Dosimetry
AM2007	1st	Uncertainties in Radiation Dosimetry

Table 3 – Scientific Workshops held at Annual Meetings

AM	Workshop titles
AM2012	Dosimetry for Second Cancer Risk Estimation in Radiotherapy
AM2010	Accelerator Radiation Protection and Shielding
AM2009	Cosmic Radiation and Aircrew Exposure
AM2008	Dosimetric Issues in the Medical Use of Ionizing Radiation
AM2007	Characterization of Workplaces for the Assessment of the Doses to Individuals
AM2006	Uncertainties in Dosimetry - Principles Through to Practice
AM2005	Radiation Protection Dosimetry and Dosimetry for Medical Applications
AM2004	Biological and Physical Dosimetry for Radiation Protection

1.3 Events on Individual Monitoring at EURADOS Annual Meeting

In 2008, the European Radiation Dosimetry Group (EURADOS), as part of the agenda of WG2 'Harmonization of Individual Monitoring in Europe', initiated a successful self-sustained programme of regular intercomparisons (ICs) that qualify as inter-laboratory exercises for individual monitoring services (IMSs)that routinely provide personal dosemeters.

For each of the fourteen intercomparisons an ***IC Participant's meeting*** was held at EURADOS AM since 2009 (two exceptions in combination with IM and NEUDOS conferences) to discuss on results, needs for improvements and on the actual state of the art. IMSs in EURADOS IC exercises are on average almost or above 100 for photon personal dosemeters and about 30 for neutron dosemeters: IC Participants' meetings put together a large audience of IMS staff and experts and they promote exchange of knowledge, procedures and best practices. The average of participants in IC Participant's meetings is about 50 people.

Since 2017, a new format, the ***Learning Network*** (LN) on individual monitoring for external exposure, was launched by WG02 in combination with the EURADOS AM. The LN meetings are aimed at promoting harmonization, giving opportunities for discussion on a range of relevant topics on scientific or practical aspects of individual monitoring: from causes and management of "bad" results to traceability and validation of dosimetric methods, from quality procedures to achieve accreditation, to eye lens dosimetry. For each LN, usually 3-4 topics are selected in advance through open "calls" within the WG02 members and network in advance. In general, the selected topics are briefly introduced by a moderator, previously appointed within WG02, then *discussion groups* are formed on each topic, eventually the audience reconvene in a final plenary session, where a *rapporteur* from each of the *discussion groups* presents a summary of the discussion. The average of participants is about 50 people. The list of LNs and topics are reported in Table 4.

Table 4 – Topics of the WG02-Learning Network held at EURADOS AM

AM2023	– Calibration: how and how often – Reporting uncertainty and minimum dose – How to deal with type testing
AM2022	– Responses in emergency situations – Extremity/skin doses – Lost and non-returned dosemeters
AM2020	– Dosimetry and Information Technology – CR-39 supply problems – Verification and validation
AM2019	– Eye-lens dosimetry – Transit and background dose subtraction – ISO/IEC 17025:2017
AM2018	– Dosimetric aspects of QA/QC – Traceability - Validation of the method – Management aspects of QA – Causes of "bad" results – Dosimetric aspects of QA/QC
AM2017	– Privacy on personal data – Homemade type testing – Assuring the quality of test and calibration results – The use of customer feedback to improve a dosimetry service – How does YOUR dose report looks like?

1.4 EURADOS Training Courses

In order to respond to the need for training in the field of radiation dosimetry EURADOS develops and offers dedicated *training courses* (TCs), either on implementation of dosimetry techniques or on novel or improved dosimetric methods. These activities are dated back to the 90s, when TC were held with the support of the European Commission (EC) on various topics as *Methods in Radiation Measurement*, *Internal Dosimetry*, *Use of MCNP in Radiation Protection and Dosimetry*, *Voxel Phantom Development and Implementation for Radiation Physics Calculations*, *Dosimetry for Radiobiology*. Since 2006 TCs have been organized as self-substaining events by the WGs. They are usually delivered by EURADOS speakers or external experts and generally last 3 to 5 days, with participation limited to about 40 attendees. They may include practical sessions with exercises as well as visits of laboratories of the host institution.

Some of the TCs have had more editions, slightly updated according to the demand. For example, six editions of the TC on the implementation of EC RP160 - Technical recommendations for monitoring individuals occupationally exposed to external radiation [4], and three editions of EURADOS Voxel Phantom Schools in the period 2011-2018. In 2019, the first edition of the TC on the EC RP188-Technical Recommendations for Monitoring Individuals for Occupational Intakes of Radionuclides [5] was organized and further are planned. TCs provided in the period 2009-2022 are listed in Table 5.
Recently, in the framework of European Joint Project CONCERT, four TCs were organized and hosted at EURADOS Voting Members institutions (see Table 6): three by WG10-Retrospective dosimetry and one as a joint action of WG06-Computational dosimetry and WG07- Internal dosimetry. One of them was a joint action with European Network RENEB (Running the European Network for Biodosimetry and Physical Dosimetry). The next planned TCs are:

- TC (0,5 day as satellite event at EURADOS AM2023 - June) on *How to Measure and Analyze Luminescence Signals for Potential Applications in Radiation Dosimetry: Theory and Computational Procedures*
- TC (5-day, in September 2023 at EEAE in Athens – Greece) on *Dosimetry and Emergency Preparedness,* organized by WG2 together with EEAE– Greek Atomic Energy Commission (supported by the EURAMET project EMPIR 19NET03 supportBSS and the European Metrology Network for Radiation Protection with its partners, the Bundesamt für Strahlenschutz (BfS) and the United Kingdom Health and Safety Agency (UK HSA).
- TC (5-day) on *Biokinetic Modelling* planned for Autumn 2023 (not announced yet)

Table 5 – EURADOS Training Courses in the 2009-2022 period (Px = participants).

WG	Training Course (title, venue)	Year	Px
WG11	**EURADOS Training Course on Unfolding of Bonner Sphere Spectrometer Neutron Measurements** – Paul Scherrer Institute (PSI), Villigen, Switzerland, July	2022	23
WG06	**EURADOS Training Course – Application of Monte Carlo Methods for Individual Monitoring and Dosimetry of Ionizing Radiation**, IFJ, Krakow, Poland, April	2022	7
WG07	**EURADOS Training course on the Technical Recommendations for Monitoring Individuals for Occupational Intakes of Radionuclides** (Radiation Protection 188), IAEA, Vienna, Austria, March	2019	26
WG02	***EURADOS Training Course: European Technical Recommendations for Monitoring Individuals Occupationally Exposed to External Radiation (Radiation Protection 160)*** **– (2012-2022)**		
6th	New title for the 6th edition: EURADOS Training Course on Radiation Protection Dosimetry and Accreditation of IMS: Secrets & Solutions (based on Radiation Protection 160)- IST, Bobadela, Lisbon, Portugal, October	2022	40
5th	New title for the 5th edition: Radiation Protection Dosimetry and Accreditation of IMS: Secrets and Solutions, IRSN Fontenay-aux-Roses, France, May	2019	39
4th	AOU Careggi,UO Fisica Sanitaria, Firenze, Italy, April	2017	47
3rd	Instituto Superior Técnico, Bobadela, Portugal, May	2015	25
2nd	Ruđer Bošković Institute, Zagreb, Croatia, November	2013	32
1st	Institute of Nuclear Physics of the Polish Academy of Sciences, Krakow, Poland, November	2012	41

WG	Training Course (title, venue)	Year	Px
WG06 3rd 2nd 1st	**EURADOS Voxel Phantom School (2011-2018)** Karlsruhe Institute of Technology, Karlsruhe, Germany, March Helmholtz Zentrum München, Neuherberg, Germany, May IRSN, Fontenay-aux-Roses, France, October	 2018 2014 2011	 11 25 31
WG07	**Monte Carlo Methods for calibration of body counters**, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, November	2013	14
WG10	**School on Retrospective Dosimetry** (Practical exercise in solid state & cytogenetic dose reconstruction) - Helmholtz Zentrum München, Neuherberg, October	2012	12
WG07	**EURADOS/IAEA Regional Training Course on Advanced Methods for Internal Dose Assessment** (Application of IDEAS Guidelines and dissemination of CONRAD internal dosimetry results) - IAEA and Czech Technical University, Prague, Czech Republic, February	2009	34

Table 6 – EURADOS-CONCERT Training Courses in 2017-2019 period (Px = participants).

WG	Training Course (title, venue)	Year	Px
WG10	***EURADOS-CONCERT School on Uncertainty analysis processes for retrospective dosimetry and associated research,*** IRSN, Fontenay-aux-Roses, France, June	2017	20
WG06 +WG07	**EURADOS-CONCERT Short Training Course on Application of Monte Carlo methods for dosimetry of ionizing radiation**, Karlsruhe Institute of Technology, Karlsruhe, Germany, March	2018	11
WG10	**EURADOS-CONCERT School on Uncertainty in biological, physical, and internal dosimetry following a single exposure**, IRSN, Fontenay-aux-Roses, France, April	2019	23
WG10	**RENEB-EURADOS-CONCERT: ADORE Application of cytogenetic and EPR/OSL techniques for biological dosimetry and physical retrospective dosimetry,** Bundesamt für Strahlenschutz, Helmholtz Zentrum München, Germany, June-July	2019	12

1.5 Actions to encourage early career scientists in the field of radiation dosimetry: Award, Grant and Conference Support

Since 2014, EURADOS has started actions to support and encourage early career scientists. All details are available on the EURADOS website (https://eurados.org/eurados-events-opportunities).
At the beginning EURADOS *Award* and EURADOS *Grant* selections were aimed to, respectively, either recognise excellent research results or support a short research stay at EURADOS Voting Members. EURADOS Award and Grant, are offered annually during the EURADOS General Assembly and they both include an official certificate signed by the EURADOS Executive Board and an invitation to the next EURADOS Annual Meeting.
The research work carried out within EURADOS working groups is the frame of the Award and Grants. Priority is given to proposals directly linked with activities mentioned in the EURADOS Strategic Research Agenda (SRA). It is expected that the outcome of the research work has resulted in a peer reviewed publication and/or a presentation at an international conference or a workshop.

In 2019 the *Young Scientist Conference Support* selection was started with the aim of an economic contribution for participation in conferences, with different numbers of supports per year depending on the list conferences selected annually by EURADOS Council among the ones most related to ionizing radiation dosimetry.
Since 2014, EURADOS assigned a total of ten awards, ten grants and sixteen conference supports. In Table 7 the features of supports provided since 2014 are reported. For 2023, 1 Award and 1 Grant have been just announced and 12 *Young Scientist Conference Support* are available for 7 International Conferences, Symposia or Meetings. See details and announcements on EURADOS Website.

Table 7 – Awards, Grants and Conference Supports provided since 2014

Year	# of Awards	# of Grants	# of YSCS
2022	1	2	10
2021	1	1	1
2020	1	1	0 (COVID Pandemic)
2019	1	1	5
2018	0 (no applications)	1	--
2017	1	1	--
2016	2	0 (no applications)	--
2015	2	1	--
2014	1	2	--

2 Dissemination of knowledge actions

EURADOS regularly publish their achievements in open literature and reports which are made available on the EURADOS website. On the other hand, since 2020 and regularly during the following years, *EURADOS Webinars* have been held to briefly describe recent studies or relevant issues in radiation dosimetry.
As a key action for promoting harmonization and knowledge in radiation dosimetry, EURADOS organizes self-sustained intercomparison exercises on a regular basis where personal dosimeters in suitable fields are irradiated and compared as well as similar exercises where detector systems for environmental monitoring are compared. Recent intercomparison exercises included those for:

- personal dosemeters (e.g. for whole body, extremities, eye lens)
- on Monte Carlo-modeling for the in-vivo monitoring using phantoms
- early warning dosimetry network systems
- calibration method in assive area dosemeters

Analysis of the results of all EURADOS ICs are reported in publications or EURADOS reports which then become reference documents for state of the art on European dosimetry techniques and actual practices.

2.1 EURADOS Reports and publications

EURADOS Reports are either on research and studies of EURADOS WGs activities, or on results of ICs. They often provide comprehensive reviews on relevant topics and can be used as reference or best practice on the related topic. Since 2012, 33 EURADOS Reports were published, on average three per year. The entire list and links for download of all EURADOS Reports are available on the EURADOS website.
EURADOS WGs regularly publish results in scientific journals and develop also documents including guidelines on dosimetry and surveys on quality assurance.

2.2 EURADOS Webinars

The COVID pandemic has slowed down conferences but has given a boost to all kinds of online events. In December 2020, EURADOS started a Webinar series with the main aim of a better and wider dissemination of the scientific results of the EURADOS Working Groups.
The Webinars are usually announced one month in advance, they generally last one hour, with short lectures given by three or four speakers followed by a *Questions and Answers* session. For a better interaction with the audience, *polls* with questions related to the contents of the webinar are launched and evaluated during the presentations. Indeed, the results of the polls associated with the Webinars have been found useful and, in some cases, even directly led to the definition of the topics for new tasks for EURADOS Working Groups.
For each webinar a WG member is assigned as responsible together with the EURADOS Office and the officer in charge of the online tool which hosts EURADOS Webinars. A landing page of presentation is made available, an announcement is issued at least one month in advance, and registration is invited through EURADOS social media, newsletter and website.
Since December 2020, 21 Webinars took place with contributions from all EURADOS Working Groups (see the full list in Table 8). In some cases in collaboration with other international organizations (e.g., NERIS, EFOMP) or on behalf of the MEENAS, the Consortium of European Radiation Protection Research Platforms (MELODI, EURADOS, EURAMED, NERIS, ALLIANCE, SHARE).
The average attendance is 165 personsa significant number of which are not affiliated with EURADOS and even come from outside Europe.
The presentations of each webinar are available for download at the EURADOS website (www.eurados.org/webinars). Moreover, with single exceptions, all webinars have been recorded and are available on the EURADOS YouTube channel (www.youtube.com/eurados).
The topics are chosen to reflect the main needs or recent achievements of the dosimetry community, including research projects. Recently, early career scientists attending the EURADOS AM have called for educational Webinars on basic topics of radiation dosimetry. Such kind of educational webinars (e.g., on the practical aspects of TLD measurements) are currently planned.
Online events have clearly brought a new approach to educational and training activities and, in some cases, have made them more efficient, allowing to easily reach a wide audience. For this reason, even after the COVID pandemic, EURADOS webinars are continuously offered and have become a regular appointment for both early career researchers and senior scientists from all over the world. It is planned to be continued on a regular basis, approximately eight webinars per year.

Table 8 – EURADOS Webinars since December 2020 (Px = participants).

#/Year	#	Webinar titles	Px
4/2023	21st	Out-of-field doses for paediatric and pregnant patients in radiotherapy	119
3/2023	20th	Calculation of Radiation Exposure at Aviation Altitudes in Case of Solar Particle Events	122
2/2023	19th	Things to consider when your simulations are finished – teasers from "EURADOS WG6 Intercomparisons in Computational Dosimetry" (Special Issue of Radiation Measurements)	112
1/2023	18th	EURADOS report on New Operational Dose Quantities - Impact Evaluation & Recommendations for Implementation	288
7/2022	17th	Intercomparison IC2021 area of passive area dosimetry systems – a review by organizers and participants	149
6/2022	16th	PODIUM Project – Personal online dosimetry using computational methods	201
5/2022	15th	EURADOS comparison exercise on neutron spectra unfolding in Bonner spheres spectrometry (BSS)	61

4/2022	14th	Small photon field dosimetry: current status and challenges	214
3/2022	13th	In collaboration with MEENAS Consortium: Current situation in Ukrainian nuclear industry - in Chornobyl and Zaporizhzhia NPPs and Kharkiv neutron source facility	483
2/2022	12th	Research Center of Cosmic Rays and Radiation Events in the Atmosphere (CRREAT)	123
1/2022	11th	Challenges and developments in relation to the production of new radiopharmaceuticals	183
9/2021	10th	Accuracy and quality control of skin dose mapping software: results from the VERIDIC project	118
8/2021	9th	Correlating micro- and nano-dosimetry with initial biological damage	176
7/2021	8th	Inter-comparisons of personal dosemeters: Lessons Learnt	227
6/2021	7th	Joint EURADOS-NERIS webinar - The use of unmanned aerial systems ("drones") to characterize the radiological situation in the aftermath of nuclear or radiological accidents	212
5/2021	6th	ICRU Report 94: Methods for Initial-Phase Assessment of Individual Doses Following Acute Exposure to Ionizing Radiation	142
4/2021	5th	Dosimetry for workplace and environmental radiation monitoring	190
3/2021	4th	Retrospective dosimetry techniques or internal exposures to ionizing radiation and their applications	180
2/2021	3rd	Accreditation of Individual Monitoring Services (IMSs) – EURADOS report 2020-02	187
1/2021	2nd	The CERF and CSBF workplace exposure facilities at CERN	130
1/2020	1st	The EURADOS WG 10 and RENEB 2019 biological and physical retrospective dosimetry field test	147

3 Conclusions

EURADOS E&T activities have been organised to respond mainly to the need of the EURADOS community. They are well structured, provided on a regular basis and with established formats contributing to international Education and Training activities in the field of radiation protection and dosimetry.

By means of training courses, webinars, inter-comparisons and networking activities, EURADOS promotes the maintenance of expertise in radiation dosimetry. Additionally, with grants, awards and conference supports EURADOS encourages early career scientists to enter the radiation dosimetry and radiation protection community. The *EURADOS Webinar Series*, the latest action in dissemination of knowledge and research results achievements, is considered as an excellent, timely and concise way to disseminate EURADOS scientific results and EURADOS report contents and to inform on recent and relevant publications.

Acknowledgement

Thanks are due to past and present EURADOS Council members, past and present WG chairs together with all WG members for their efforts in setting up the various EURADOS E&T activities.

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RADIATION SAFETY E-LEARNING TRAINING FOR NON-RADIOLOGY DOCTORS AND OTHER STAFF: EXPERIENCES IN A MAJOR ACADEMIC TEACHING HOSPITAL IN IRELAND

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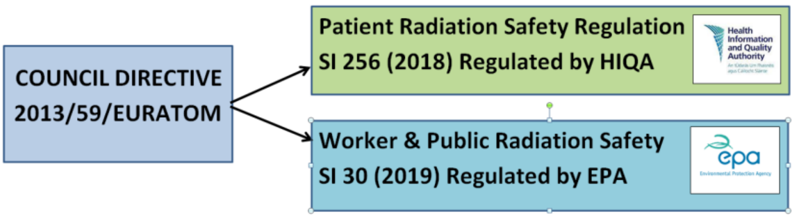
This study examines the implementation and effectiveness of an in-house e-learning program for radiation safety training in Beaumont Hospital, an academic teaching hospital in Ireland. The program aims to improve radiation safety knowledge amongst relevant staff in compliance with the requirements outlined in COUNCIL DIRECTIVE 2013/59/EURATOM and the related Irish legislation. The development, implementation, and completion rates are analysed, highlighting the program's ability to adapt to future regulatory changes and its potential for informing the development of a national online radiation safety program. The paper outlines strategies for increasing the completion rates through communication within the existing governance structures of the hospital.

1 Introduction

1.1 Background

Beaumont Hospital is an academic teaching hospital in Dublin, Ireland, with over 400 employees involved in work with ionising radiation, including a biennial intake of over 100 junior doctors every January and July [1]. The requirements for radiation protection education, training, and information for individuals working with ionising radiation are described in Chapter IV of COUNCIL DIRECTIVE 2013/59/EURATOM [2]. These requirements are articulated in two in two distinct Irish statutory instruments (SI), regulated by two different competent authorities:



- SI 256 (2018) European Union (Basic Safety Standards for Protection Against Dangers Arising from Medical Exposure to Ionising Radiation) Regulation 2018, regulated by the Health Information & Quality Authority (HIQA) [3]. Regulation 22 requires that the undertaking (e.g. hospital) ensures that practitioners, and individuals to whom the practical aspects of medical radiological procedures are delegated, have adequate radiation safety training. The training must be as prescribed by the relevant professional bodies, "having regard to" the Knowledge, Competence & Skills specified in EC RP 175 *Guidelines on Radiation Protection Education and Training of Medical Professionals In The European Union (2014)* [4].

- SI 30 (2019) Radiological Protection Act 1991 (Ionising Radiation) Regulations 2019, regulated by the Environmental Protection Agency (EPA) [5]. Regulation 35 requires that the undertaking ensures that appropriate training is provided to all exposed workers, for the protection of themselves and other workers and the public.

1.2 Material and Methods

The hospital Learning and Development (L&D) department oversees all corporate learning programmes in collaboration with the executive management team and department managers.
The Beaumont Online Resource for Interactive Study (BORIS) provides online access to the majority of learning programmes. BORIS is a Moodle® based online learning management system (LMS) that provides educational modules for different areas [6]. The LMS assists the L&D department in administering the learning content as well as tracking and recording user participation across all modules. It also allows workers to track their individual learning progress. Some learning modules are elective e.g., *Healthy Lifestyles*, others are mandatory for all staff e.g., *Fire Safety*, whilst other modules are mandatory for a subset of staff e.g., *Medication Safety*.

In a collaboration with the L&D department and the Human Resources department, the radiation protection team, including the radiation protection expert/adviser, medical physics experts, the radiation protection officer, and practitioners, began designing and building two mandatory online radiation safety modules, in accordance with local interpretations of regulatory requirements and having regard to the EC RP 175 "knowledge" components of radiation safety for different staff groups. The online e-learning modules were created using Adaptbuilder® on the Learning Pool platform that hosts BORIS [7]. The programme was created to be engaging and interactive, and to utilise multimedia resources, including video, to enhance the learning experience and aid in knowledge retention.

The first module was entitled "*Basic Radiation Safety Training for Allied Health Professionals Working in Controlled Areas" (Image 1)*. It is designed for people who work in the vicinity of fluoroscopy.

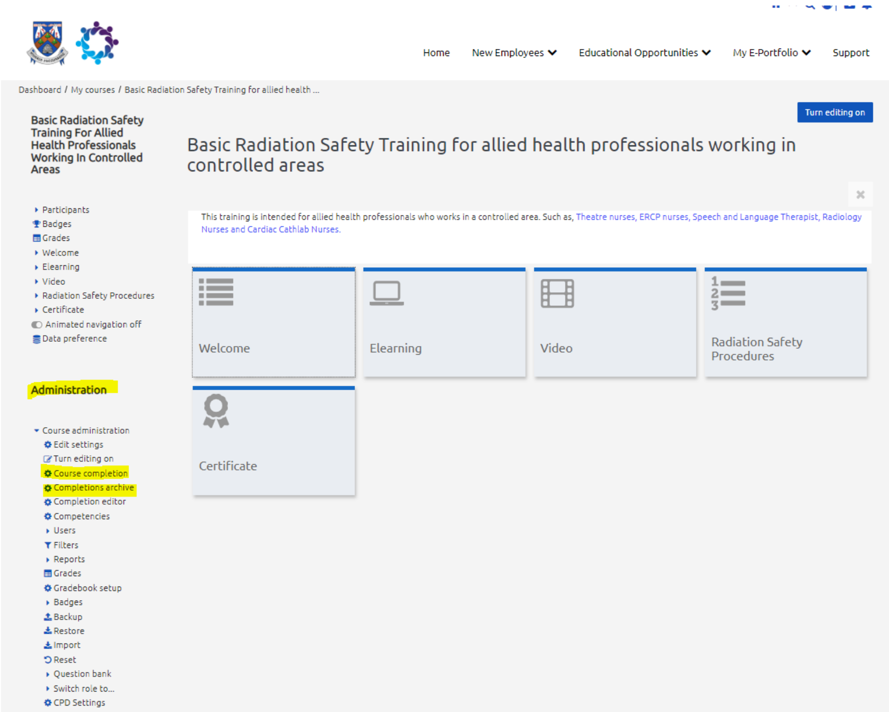


Image 1 An administrator view of BORIS showing tools which are used to provide an overview of completions etc.

The second module is called "*Basic Radiation Safety for Referrers and Practitioners*" (Image 2). It is designed for medical professionals who refer patients for radiological procedures and for practitioners who physically carry out medical exposures.

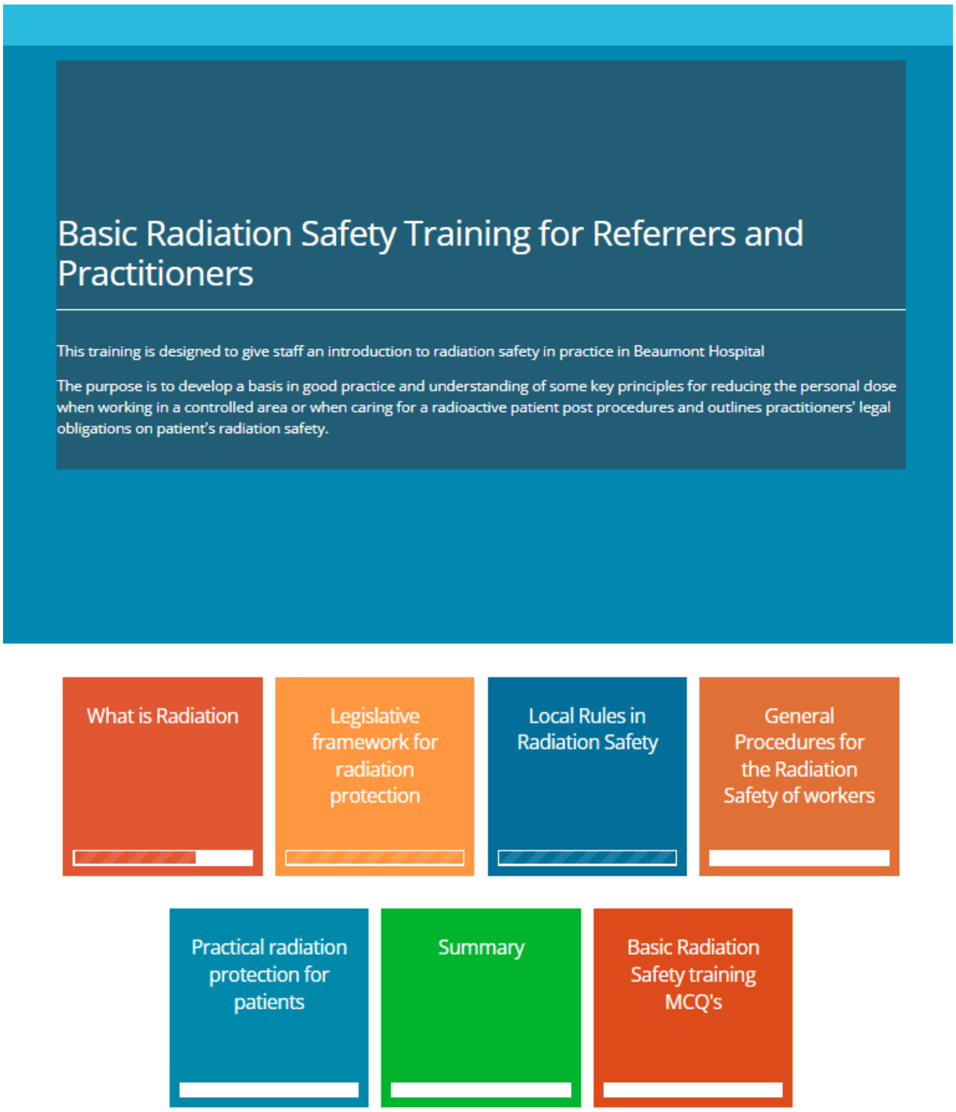


Image 2 A user view of the "Basic Radiation Safety for Referrers and Practitioners"

The learning content of both modules includes tailored information about:

- The general principles of radiation protection.
- A guide on how to use personal protective equipment, including how to wear and store lead aprons and how to request and use personal dosimeters and how to retrieve personal dose results.
- Hyperlinks to the specific radiation safety procedures and precautions in connection with the work with ionising radiation to which they may be assigned.
- An outline of the responsibility of the individual in maintaining a safe workplace.
- A description of the risk assessment in identifying necessary safety measures.
- The relevant parts of the emergency response plans and/ or procedures to be followed in the event of an incident.
- The importance of complying with medical, technical, and administrative requirements.
- Where relevant, the potential risks to the foetus.

Additionally, the referrer and practitioner module contain specific information about the hospital procedures for the Justification and Optimisation of medical exposures.
Verification of engagement with the training modules is achieved through a multiple choice questionnaire at the end of each module, with a minimum pass requirement of 80%, in line with other e-learning modules.

2 Results

The radiation safety e-learning program was formally implemented in 2020 and provided to relevant staff across nine clinical directorates including non-radiology doctors. The completion rates for different directorates within the hospital were captured on BORIS. The overall completion rates for all relevant staff are 63% for 2020, 69% for 2021, 73% for 2022, and 77% in Q1 2023 (Figure 1 and Table 1). Completion rates for some clinical directorates were lower on average but increased for all but two directorates year on year (Critical Care & Anaesthetics and Surgical).

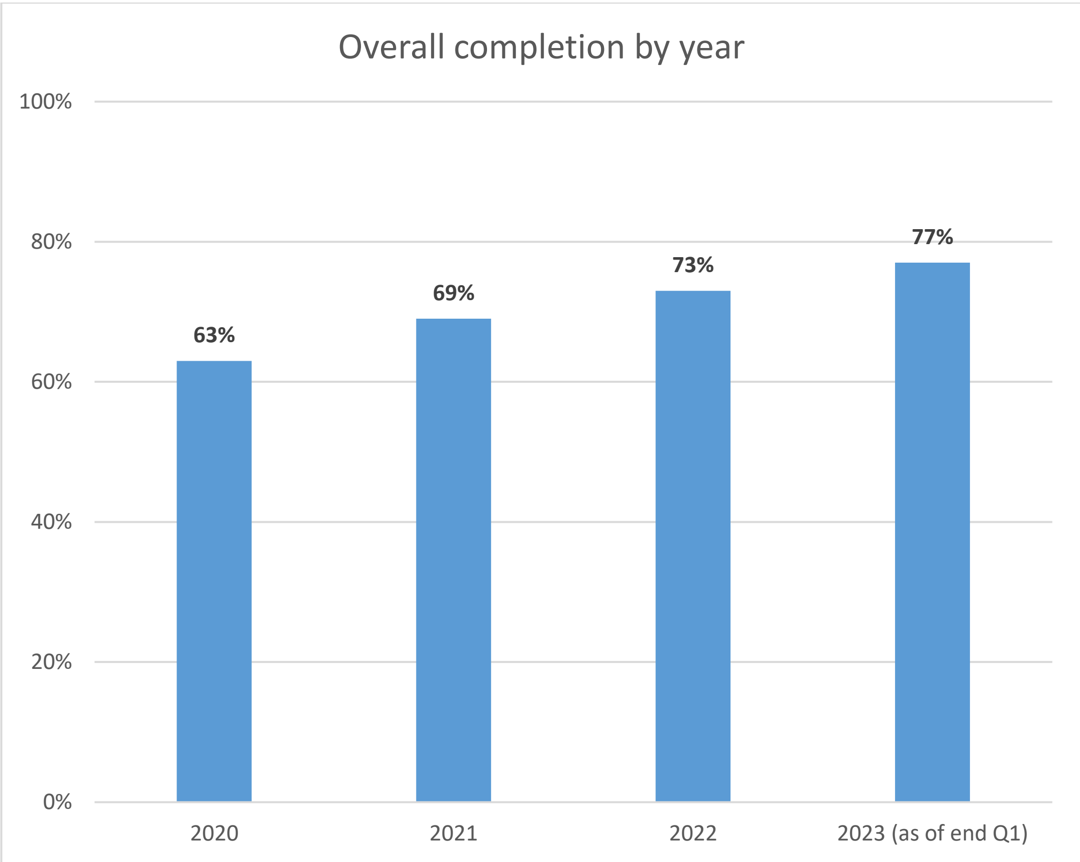


Figure 1 The coverall completion rate extracted from BORIS LMS

The directorates with the largest numbers of staff (i.e. Imaging & Interventional and Nursing) have the highest completion rates. Directorates based in the hospital's operating theatres (i.e. NeuroCent (Neurosurgery Centre) TUN (Transplant Urology & Nephrology, Critical Care & Anaesthetics), consistently have completion rates of less than 50%. The General Services directorate has only one person who occasionally works in a controlled area (Theatre) and has not completed training.

Tier 1 - BORIS Radiation Safety Training Completion per year (all staff)					
Tier 1	**2019**	**2020**	**2021**	**2022**	**Q1 2023**
Completions/year	104	602	560	509	93

Tier 1 - BORIS Radiation Safety Training: Compliance by Directorate (badged staff)				
Directorates:	**2020**	**2021**	**2022**	**Q1 2023**
Clinical Services	73%	90% (of 21 staff)	94% (of 22 staff)	96% (of 25 staff)
Critical Care & Anaesthetics	35%	56% (57)	44% (34)	50% (38)
General Services	0%	0% (1)	0% (1)	0% (1)
Imaging & Interventional (excl. radiologists)	92%	98% (65)	100% (74)	100% (75)
Medicine	59%	65% (31)	74% (35)	73% (33)
NeuroCent	25%	20% (5)	33% (6)	43% (7)
Nursing	57%	69% (150)	78% (156)	80% (162)
Surgical	48%	35% (20)	40% (25)	40% (25)
TUN	57%	40% (10)	64% (11)	67% (12)
	63%	**69%** (of 360 staff)	**76%** (of 364 staff)	**77%** (of 378 staff)

Table 1 The completion rate per directorate as extracted from the BORIS LMS

3 Discussion and Conclusion

In a busy teaching hospital with a large annual staff turnover, and during the COVID pandemic, the provision of e-learning has enhanced the provision of radiation safety training and facilitated greater visibility of radiation safety training compliance across the hospital.
Future work will focus on improving the completion rates of radiation safety training e-learning through regular communication with directorate heads and other stakeholders. To help with this, detailed information about training completion rates for all groups and individuals will be made available on the hospital intranet for review by each line manager and by the chair of the hospital radiation safety committee. This will also be used to verify that individuals who work with ionising radiation are correctly identified in each area.

A useful contribution to achieving engagement with mandatory radiation safety training is the agreement with the senior management of the hospital to:

1. Provide a hyperlink to the relevant online mandatory training upon employment acceptance. This means that new staff can access and complete their online training before starting work in the hospital.
2. Grant access to the hospital PACS/RIS only to individuals working in a controlled area that have completed the relevant radiation safety e-learning module. This has helped improve completion figures for medical doctors in the Medicine directorate who would refer patients for radiological procedures.

It is important to note that physicians and surgeons who carry out fluoroscopic procedures have to undergo additional radiation safety training in relation to the radiation protection of patients. This training, not in Table 1, is a combination of lectures, hands on practical training and clinical supervision. Evidence of completion of such training is captured when an individual physician or surgeon uploads a certificate to BORIS that indicates completion of approved training. Professional training bodies that prescribe such additional training to junior surgeons and physicians in Ireland have yet to formally incorporate references to SI 256 (2018) into their training curricula. Nevertheless, under the regulations, it is the undertaking (e.g. hospital) that must ensure that staff are adequately trained for the work they are employed to do, and to ensure that evidence of same is available.

One of the strengths of online knowledge-based training modules is that the content can be relatively quickly updated and/or tailored to meet any future requirements prescribed by the relevant professional bodies and/or regulators.

The Beaumont Hospital experience of using e-learning to provide basic radiation safety training has contributed to the current on-going development of providing a national basic radiation safety training e-learning programme for all hospitals within the Irish public health service.

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RADIATION PROTECTION UPDATE TRAINING FOR DENTAL PROFESSIONALS AND UNIVERSITY STAFF/STUDENTS – EXPERIENCES WITH ONLINE VS FACE-TO-FACE OPTIONS

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Dental practitioners and other registered dental care professionals in the UK undergo regular update training on radiation protection matters as part of their CPD requirement. Experience gained from delivering these courses has shown that if assessments are not made as part of the update training session, it is difficult to demonstrate that real learning has taken place. It is also difficult to know whether there are any areas within the lectures that prove difficult for participants to understand. The author examined whether this situation can be improved by the use of both pre- and post- training session testing with additional written feedback, and what, if any, differences occur when delivering courses face-to-face or online. Experiences with delivering basic radiation protection safety training for university staff and students in face-to-face and online is also discussed.

1 Introduction

Dental practitioners and other registered dental care professionals in the UK undergo regular update training on radiation protection matters as part of their CPD requirement to maintain registration with their professional body, the General Dental Council (GDC). There has not been a large amount of published work regarding the knowledge levels of dental staff on radiation protection (RP) issues. However, the work that has been published indicates knowledge that can be quite variable. A Belgian questionnaire study of postgraduate general dental practitioners showed 32% didn't know what kV they used; 75% didn't know what mA they used; and 47% didn't know what 'collimation' meant [1]. A Welsh study of postgraduate RP CPD testing of general dental practitioners showed very low test scores, with only 2.4% - 4.9% of GDPs reaching the pass mark for CPD courses in 2003-2007 [2].

Experience delivering RP CPD courses for dental staff has shown that it can be difficult to demonstrate that real learning has taken place, and to assess whether there are any areas within the lectures that have proved difficult for participants to understand. If mere attendance is required then there is no guarantee that any learning has taken place. All that may matter to the participant is receiving the CPD certificate, and increased radiation safety awareness or improved practice may not happen. In the UK, the GDC has published guidance for providers of 'enhanced CPD' to try and improve this situation [3].

Active participation and discussion are clearly important, but discussion used as the primary method for assessing participation has some problems, as it can be intimidating for those who are naturally shy or who are in the presence of a more senior colleague. Discussion may easily be dominated by a few individuals, often with their own agenda, and in extremis, this can derail course progression.

Written feedback is also important, but feedback used as the primary method for assessing participation also has some problems, as it can be dominated by issues over catering, parking, heating, etc., and it may be difficult to assess whether specific areas or issues have been adequately addressed. Nevertheless, anonymised feedback clearly does have a place to deal with concerns or necessary amendments to content.

2 Dental Training Methods

Each dental CPD training session was delivered by the author as a series of five consecutive 1-hour lectures (with breaks), designed to cover the topics in the defined syllabus. The topics were: Ionising radiation – risks & safety; relevant legislation; practice issues & quality assurance; the science behind dental X-rays; and dental radiography & radiographic technologies.
The courses were provided to mixed audiences of dentists, dental nurses and hygienists, and it was explained to the dental nurses and hygienists beforehand that some of the course content went beyond their training requirements.
Participants in both face-to-face and online courses were encouraged to actively participate by asking for clarification on any issue. Participants in the online sessions were required to keep video on throughout the lectures, to try and ensure continued participation.
Prior to the start of the training session, participants completed a short 10-question, largely multiple-choice questionnaire (MCQ). At the end of the session, participants then completed a longer 30-question MCQ. The questions on the pre-session test were a sub-set of the post-session test. Many questions on both tests were designed to have more than one correct answer, and participants were informed of this beforehand, both on the test sheets and by verbal reminder. No fixed time limit was given for the completion of the questionnaires and participants were allowed to use any notes they had taken for the post course test but were asked not to use internet-based research.
For the online courses, pre-course MCQs were emailed at the start of the Zoom session and were returned prior to commencement of the course. Post-course MCQs were emailed after the course and were returned before the end of the session.
The pre- and post-training session MCQs have been used at eight face-to-face training sessions with a total of 178 participants and three online sessions with a total of 44 participants.
For both face-to-face and online courses, all participants were provided with anonymised feedback sheets and asked to return these. The feedback sheets contained both closed questions and space for free text comments.

3 Dental Training Results

The results of the MCQ tests for face-to-face courses are presented in Table 1.

Table 1: Face-to-Face MCQ Results

	Pre-Course % MCQ sub-set	**Post-Course % MCQ sub-set only**	**Post-Course % All Questions**
Mean	51.1	76.5	67.0
Range	5-92	51-95	22-91
Mean % Improvement		18.7	15.9
Participant Improvement		93.0	88.0
n = 178			

The results demonstrate a notable improvement in test scores, and when post-course tests are compared against the pre-course tests, this is statistically significant at a level of $p<0.001$ using the Wilcoxon Rank-Sum Test. Although there remains a wide variation in test scores, 88-93% of participant improved their scores, with a mean improvement of 15.9-18.7%.

The results for each question were also reviewed, and the data used to see which particular topics gave the most incorrect answers. This resulted in changes to both lecture content/enhanced delivery and the overall ordering of the lectures.
At this point, courses moved online, principally due to the covid-19 pandemic. The MCQ data from the limited number of these courses was then analysed, with the results being presented in Table 2. It can be seen that although both the scores and the range have remained largely the same, the percentage improvement has increased, from 15.9-18.7% for the face-to-face courses, to 25.0-30.4% for the online courses due to the changes to content and ordering.

Table 2: Online MCQ Results

	Pre-Course % MCQ sub-set	**Post-Course % MCQ sub-set**	**Post-Course % All Questions**
Mean	39.6	72.0	66.8
Range	19-62	48-97	38-96
Mean % Improvement		30.4	25.0
Mean % Improvement		97.7	97.7
n = 44			

Results from the feedback sheets completed by participants were overwhelmingly positive, with the summary data shown in Table 3.

Table 3: Dental RP Training Feedback Summary Results

Was the speed of delivery of the session....?	*much too slow*	*little too slow*	*ok*	*little too fast*	*much too fast*
	1	10	215	12	1
Was the level of the information presented...?	*much too easy*	*little too easy*	*ok*	*little too hard*	*much too hard*
	0	0	206	32	3
Did the session cover the material expected...?	*a lot missing*	*a little missing*	*ok*	*exceeded expectations*	
	0	1	197	24	
Did the delivery of the session maintain your interest...?	*much too boring*	*little too boring*	*ok*	*quite interesting*	*very interesting*
	2	29	132	41	15
Do you feel that the content was relevant to you...?	*Yes*	*No – your explanation will help with future courses*			
	216	10 (no reasons given)			
Do you feel that this course has...	*Increased your knowledge base*	*Increased your understanding of your existing knowledge base*	*Left you with some areas of confusion*	*Had little overall effect*	
	121	99	16	1	

How did you find the assessment questions…?	*much too easy*	*a little too easy*	*ok*	*a little too hard*	*much too hard*
	1	1	104	109	14

What is your view on doing an assessment…	*somewhat useful*	*very useful*	*somewhat of a waste of time*
	119	92	21

There were not a large number of free-text comments, although the comments that were given provided useful feedback:
"Found that the quiz before useful to get me thinking about radiography and jog my memory about forgotten information";
"Pre- and post-course testing helped improve my self-awareness of my knowledge of the topic"; and
"Will undertake updated risk assessments".
Further comments were emailed to the presenter in the days following the course. These were particularly useful as they indicated that key learning had taken place and were being used in practice
"Have updated our local rules since attending course and have also ordered radon testing kit";
"I now move my patients to the nurse's chair to take intra-oral radiographs as before I would have had to walk through the X-ray beam to reach the main switch in an emergency shut off"; and
"I have now lowered the exposure time to our patients after the course".

4 University RP Training

All non-clinical staff and students at a university where I act as Radiation Protection Adviser (RPA) are required to attend a radiation safety awareness course if they intend to use any form of x-ray generator. The course duration is approximately 2 hours and covers basic radiation safety topics, including: Ionising radiation doses & effects; radiation protection principles; relevant legislation; and practical safety issues concerning the university's x-ray equipment and its use. There is no form of assessment, although active participation through questions and comments are encouraged throughout. The university provides their own feedback questionnaire for post-course feedback, with the questionnaire containing both closed and open questions. Table 4 contains the summary results from the last three face-to-face courses as an example.

Table 4: University RP Training Feedback Summary Results – Closed Questions

1. What was your overall assessment of the event?	Excellent	Very Good	Good	Average	Poor
	34	12	-	-	-
2. How effective were the facilitators / presenters?	Excellent	Very Good	Good	Average	Poor
	38	7	-	-	-
3. How well were the event objectives met?	Excellent	Very Good	Good	Average	Poor
	30	16	-	-	-
4. How useful were the materials / resources supporting this event?	Excellent	Very Good	Good	Average	Poor
	29	17	-	-	-
5. Opportunities to network and share knowledge / ideas	Excellent	Very Good	Good	Average	N/A
	20	7	4	3	6
6. Did the event meet your expectations?		Exceeded	Met	Partially Met	Barely Met

<table>
<tr><td colspan="2"></td><td>19</td><td>27</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">7. To what extent has your level of understanding of the event topic increased?
(4 being greater than 0)</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>-</td><td>2</td><td>1</td><td>18</td><td>25</td></tr>
<tr><td colspan="2" rowspan="2">8. If you notified us of any additional requirements, were these accommodated?
If 'NO', please provide details:</td><td rowspan="2"></td><td>YES</td><td>NO</td><td>N/A</td></tr>
<tr><td>10</td><td>-</td><td>30</td></tr>
<tr><td colspan="3" rowspan="2">9. Would you recommend this event to a colleague?
If 'NO', please state why:</td><td>YES</td><td>NO</td><td>N/A</td></tr>
<tr><td>34</td><td>-</td><td>7</td></tr>
</table>

80% of participants on the face-to-face courses also added comments in the feedback sheets where they were asked three open questions: which part(s) of the course they felt were most useful; which were least useful; and if they had any further comments to add. Multiple answers were allowed for each question. Comments were overwhelmingly positive, with the sections on radiation science (~20% of comments) and the practical safety steps (~40% of comments) stated as being the most useful. The section on legislation only received a small number of comments, equally divided between being useful and not. The author has a lecturing style the tries to make the courses as enjoyable as possible, and this was commented on positively several times, although two comments suggested that the 'digressions' (used to lighten the content) were not useful.

During the covid-19 pandemic, the RP safety courses were moved online. However, not everyone had a sufficient data or signal to permit video calling. Under these circumstances, it was therefore not possible to assess the level of participation in the course. Given that the RP safety course is not part of the core, examinable content for students, the use of direct face-to-face delivery enabled far better levels of active participation. As such, online delivery was not considered to be an optimal method for this type of training for this audience.

5 Conclusions

Pre- and post-course testing for the dental RP CPD training courses has confirmed that learning has taken place.

Anonymised feedback sheets with both closed and open questions provide additional pointers to areas that require change, and in some cases have shown the practical value of the training to change local RP practice.

Questions with many incorrect answers have been used as pointers to change the order and increased the explanation of the content of the lectures to aid greater understanding on those topics.

Moving the dental courses online did not result in any loss of course value.

Online RP training for university staff and students was not as successful as when carried out face-to-face.

Requiring active video for online courses to encourage participation appears to be important to ensure engagement.

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CONTINUING ONLINE RADIOLOGICAL PROTECTION EDUCATION FOR PROFESSIONALS

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A simple way to virtualize continuing education in radiation protection is presented. Four different courses, accredited by regional council, were created in order to comply with Spanish legislation, when face-to-face teaching was not possible. The education is aimed to Nuclear Medicine, Diagnostic Radiology, Oncological Radiotherapy and Haematology Departments, and other exposed professionals involved in radiological procedures. Contents include operational radiological protection, radiation protection of the patient, radioactive waste management, radioactive material transport and practical aspects of daily work in a radioactive facility. More attendance and satisfaction of the students is accomplished with online teaching, for more people can benefit from the course and contents are much longer. Material can also be downloaded and reviewed when needed. Accreditation of courses makes them more appealing for staff.

1 Introduction

Continuous education in radiation protection is mandatory in Spanish legislation for health professionals that work with ionizing radiations in different radioactive facilities. Royal Decree 35/2008 [1] establishes that all personnel performing tasks related somehow with nuclear safety or radiation protection, must receive the necessary training to properly perform their duties. A specific continuous training program, adapted to different risk levels and different kind of activities, must be developed, and these education programmes are assigned to the Medical Physics and Radiation Protection departments as ours.

Furthermore, Instruction 28 [2], proposed by the National Security Council (CSN), establishes the need to create a training program on radiation protection at a level appropriate to each workers' responsibility and the risk of exposure to ionizing radiation in each workplace. This programme will have biennial periodicity and is aimed at all exposed workers at a radioactive facility, including sessions relating to emergency plans, functioning regulations, their practical application and the development, where appropriate, of emergency drills.

Recently, royal Decree 601/2019 [3] gives additional importance to the specific education and training in radiation protection for all professionals involved in medical-radiological procedures, and establishes that continuous education should be accredited by a competent health authority.

At our hospital, many different departments make use of ionizing radiations, but the most relevant are Nuclear Medicine, Radiotherapy and Diagnostic Radiology. Also urology, traumatology, neurosurgery or other surgical departments use ionizing radiations in their daily practice, in fact about 400 professionals are considered exposed professionals at the hospital.

During COVID-19 pandemic, it was difficult to maintain traditional training, because meetings were forbidden at our country for some time as they were perceived as a risky activity. It was then decided to develop online courses for the different units involved with radiations, both for diagnostic and/or therapeutic procedures, to fulfil the need of continuous education for the different departments.

The aim of this study is to present a simple way to virtualize the continuing radiological protection education for radiological staff and to assess the level of satisfaction with this new kind of training.

2 Materials and Methods

Four courses have been developed in order to comply with legislation:

- Nuclear Medicine
- Radiation Oncology
- Radiology (including all the other units that use X-rays in their clinical activity)
- Physical security of high activity sources.

The courses were designed with Moodle 3.4 and integrated in an established online training platform accessible by all employees at the hospital called "Conocimiento Princesa" (Fig.1).

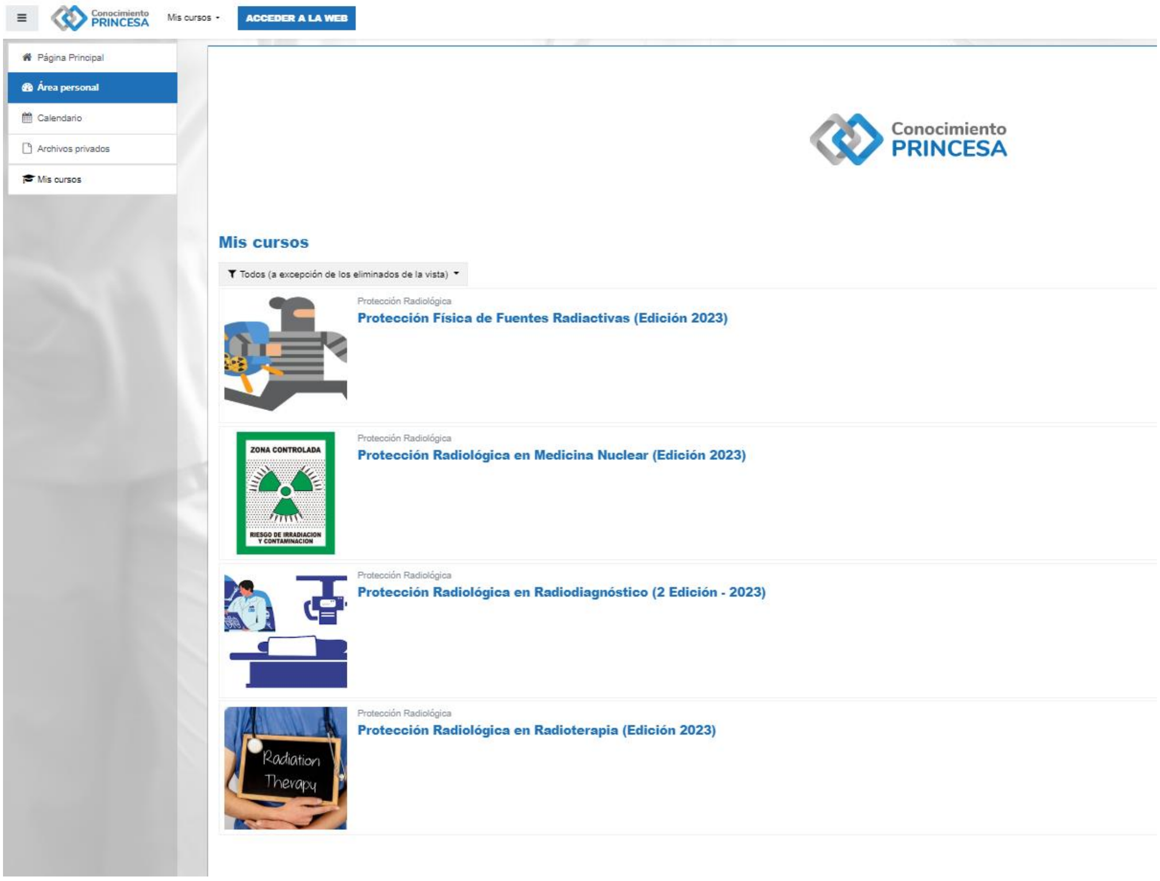

Figure 1. "Conocimiento Princesa" Moodle platform with all courses.

These courses consist of different units, between six and eleven, written in pdf format, that can be read online or downloaded and print it to read at the desired pace. Each lesson is followed by a self-evaluation test, and some of them include additional material such as videos, leaflets or infographics (Fig.2).

The contents of these courses include occupational and patient radiation protection, applied to the different techniques and procedures in each department, or specific lessons of practical situations and frequent mistakes in daily practice. Diagnostic Radiology course is composed of these topics:

- Introduction: effects of ionizing radiation, radiobiology.
- Fundamentals of X rays, tube, generator, different types of systems, image formation.
- Occupational radiation protection: dose limits, classifications of places and workers, personal and area dosimetry, pregnant workers, radiation protection devices.
- Patient dosimetry, dose management systems, optimization, pregnant patients, paediatric patients.
- Practical examples, where some frequent mistakes and special topics from clinical practice are presented such as wrong positioning or presence of artefacts (earrings, things in pockets).

Figure 2. Example of unit with pdf lesson, additional video and the self-evaluation test. All material except for the evaluations is downloadable.

Nuclear Medicine course includes:

- Nuclear medicine: basic concepts
- Operational radiation protection
- Radioactive bulks
- Radioactive waste management
- Radioactive contamination
- Radiation protection of the patient
- Therapeutic procedures
- Diagnostic procedures
- Performance rules of the facility
- Emergency plan of the facility
- Incidents: practical examples

Radiation Oncology course includes the next topics:

- Occupational Exposure
- External Irradiation
- Personal Dosimetry
- Operational radiation protection
- Brachytherapy
- Performance rules of the facility
- Emergency plan of the facility

The last course, of Physical security of high activity sources, is aimed at security personnel, brachytherapy staff and Haematology, where a biological irradiator is available. It consists of the following topics:

- Radioactive Sources
- High activity Sources
- Use of high activity sources for illegal purposes
- Personal Dosimetry
- Physical Protection of high activity sources
- Physical Protection Plan
- Practical examples

To pass each course, the trainee must complete a final virtual test, consisting of 20 multiple-choice questions (see example in Fig. 3), chosen randomly in Moodle from a question bank. It has to be completed within one uninterrupted hour.

After studying the contents, students have to fill in an anonymous satisfaction survey, with a section to offer suggestions.

All courses are open for about a month (4-5 weeks), and the estimated duration goes from eleven to sixteen hours for the different courses, so the trainees have to spend less than 5 hours a week.

There is a section in the platform where students can ask anything regarding course contents or organization, and everybody can see the information provided. The Medical Physicist Tutor answers all queries within 24-48 hours.

We apply for the accreditation at the Regional Health Council of each course and edition, so that students receive an official diploma if they pass the exam and fill the satisfaction questionnaire with official credits.

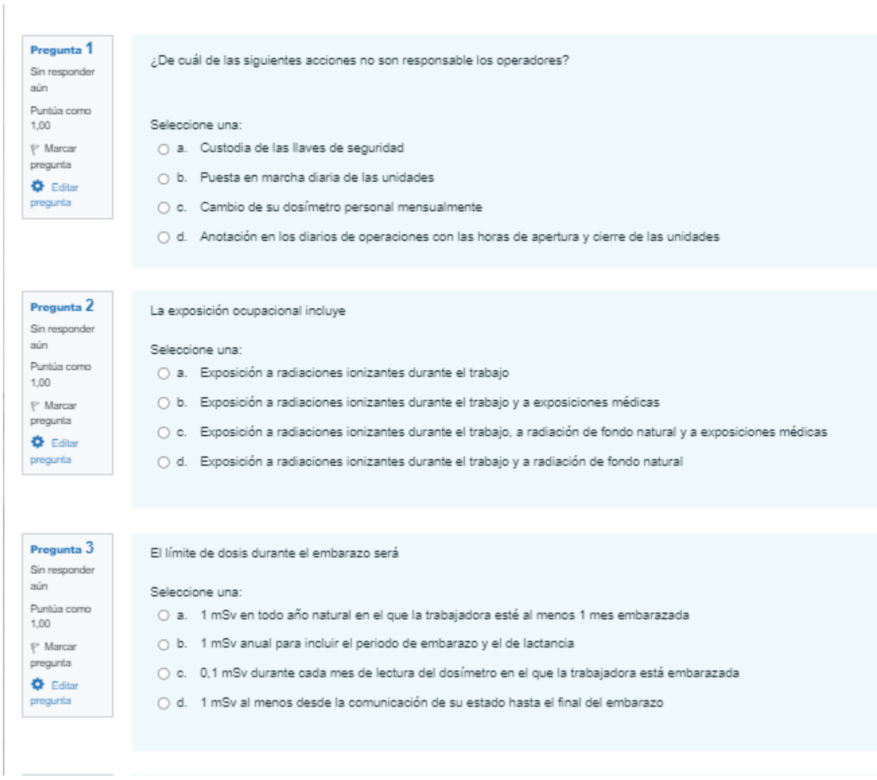

Figure 3. Example of multiple choice questions of the final test.

3 Results and Discussion

Table 1 shows the number of workers invited to each course, the number of final attendees and the attendance rate. This rate is just 31% for the diagnostic radiology course, but the number of participants was satisfactory, taking into account that many physicians of multiple specialties were invited, that are not that interested although they sometimes use radiation during their daily practice. The attendance among technicians was almost 100% and considerable among radiologists. For next editions, more publicity and information will be provided, trying to attract those professionals who did not attend.

Table 1: Attendance rate and participants for each course. RX (diagnostic radiology), NM (nuclear medicine), RO (radiation oncology), HAS (high activity sources).

Course	Number of invited workers	Number of attendees	Rate (%)
RX	283	87	31%
NM	22	21	96%
RO	45	29	64%
HAS	76	53	70%

For nuclear medicine (NM), 96% of the professionals invited have participated, so the attendance rate has increased in 30% compared to the face-to-face traditional training. For Radiation Oncology, attendance was of 64% of the invited professionals (every physician, technician, nurse and physicist), and similar for security of high activity sources, with 70%. Physicians are in both cases the least attendance collective.

The participation can be extended to so many professionals when compared to the traditional education, especially for diagnostic radiology. To provide education to so many professionals in a face-to-face format, several different sessions had to be programmed, because 80 people at a time in a classroom were difficult to lead. Also, thanks to the digital format, the contents of the course can be more complete than in face-to-face format; these traditional lessons were limited to several hours biennially, because professionals could not abandon their duties to attend and there was no good schedule for everybody.

Now, trainees have access along one whole month to accomplish the tasks at their own pace, and go deeper in the contents after passing the test if needed.

The course has been progressively extended and is quite complete, covering almost every aspect of radiation protection applied to the different departments. We plan to go further in following editions, and keep on updating the lessons and including new modules/topics.

In the following version of the course, which will take place this year, we have included a face-to-face emergency drill at the facility, complementing the online theory.

The results in the final evaluation have been very satisfactory for every course. In fact, for Radiology, 83 out of 87 participants passed the final test (95.4%) and obtained the diploma. Mean qualification was 8.89 out of 10. For nuclear medicine, all the participants passed the final exam, with an average mark of 8.95 out of 10. For radiation oncology, every participant passed the course, and the average mark was even better, with 9.5 out of 10. This result is almost the same for High activity sources, with 9.6.

From the analysis of the satisfaction surveys, it seems clear that the training programme has obtained a very considerable acceptance from the professionals involved. The course less accepted was the one on Security of High activity Sources, though, received over 8 points in every item evaluated. Table 2 shows the mean results for each course in the items suggested. Due to the accreditation of the training, which includes CME credits and an official diploma to the participants that pass the education, the participants are more satisfied with the education.

In the suggestions and comments' section, students expose that the best part are the practical examples, encouraging us to include even more cases in further editions.

Table 2: Results of the anonymous satisfaction surveys of the different courses. The scale goes from 1 (least agree) to 10 (most agree). First column is Diagnostic Radiology (RX), second Nuclear Medicine (NM), third Radiation Oncology (RO) and last security of High activity sources (HAS).

Feature	RX	NM	RO	HAS
Contents of the course	8,8	9,2	8,9	8,6
Do you consider the course useful for your work?	8,8	8,8	9,0	8,6
Degree of knowledge obtained	8,5	9,0	8,9	8,5
Platform use, documentation provided	8,9	9,4	8,6	8,6
Organization of the course, previous information	8,6	9,5	8,7	8,5
Duration	adjusted	adjusted	adjusted	adjusted
Overall satisfaction with the course	8,9	9,2	9,1	8,5
Teachers (online, answering doubts, preparing modules)	8,8	9,2	8,7	8,3

The material provided is easily exportable and may be useful for other departments to implement some similar online training programme and it is now being openly offered to other departments through the Spanish Society of Radiation Protection (SEPR).

4 Conclusions

It is possible to extend the subjects and the number of participants, through the virtualization and accreditation of the courses. Staff can receive proper education at their own pace and a more complete one.

Professionals now have more flexibility to complete the training, and this has a positive impact on the percentage of professionals who follow and successfully finish the course, as well as on the satisfaction with them.

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APPLYING INFOGRAPHICS FOR AN EFFECTIVE RADIOACTIVE WASTE MANAGEMENT IN A NUCLEAR MEDICINE DEPARTMENT

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A simple training method based on infographics was designed to optimize radioactive waste management in a nuclear medicine department. The key factors for sorting this radioactive waste are the type of waste and the half-life of the radioisotopes. Attending to this, an infographic process flow diagram was created to help the nursing personnel managing every contaminated material. The doubts and mistakes have been minimized and the evacuation of the decayed wastes is now more straightforward.

1 Introduction

Defining a procedure for an adequate management of radioactive wastes generated in a nuclear medicine department is a responsibility of the radiation protection department. According to Royal Decree 1029/2022 [1], radioactive solid disposal have to be stored in a safe and adequate place until the specific activity (Bq/kg) of the contaminated item is lower than the level specified in the Appendix 1 of the ECO/1449/2003 Order [2]. Then, after the estimated period, waste can be evacuated like a conventional disposal. Therefore, it is necessary to design a path that includes all the stages that a radiopharmaceutical has to pass through, since the arrival to the radioactive facility to the time that is placed in the waste store. In order to obtain a correct estimation of how long a radioactive material have to be warehoused prior to its evacuation, several data are required: radionuclide, resting activity, half-life, date of use, etc. There are different types of solid radioactive waste: syringes, vials, unused pills and mixed waste (gloves, papers, catheters…), which must be stored separately.

In order to avoid forgetting any of the necessary parameters, it is advisable to always follow the same instructions. Therefore, a practical and self-explanatory management system has been designed to avoid non-compliance with procedures. It is designed to be understood by the nursery staff who administers radiopharmaceuticals and handles the produced waste.

The objective is to present a simple training method, based on infographics, to optimize radioactive waste management in a nuclear medicine department.

2 Material and methods

There are four types of radioactive disposals managed in the facility, all are solid (really mixed, i.e., solid waste with rest of liquid inside) waste. Liquid ones, like urine and blood, require specific management and are legislated by other decrees, so they are not a matter of discussion here.

Hence, four categories are used to classify the different types of radioactive waste handled in the facility, which are: syringes, vials, mixed waste and unused pills. Figure 1 shows a picture of all of them.

The waste named by "**Syringe**" (Figure 1.a) includes two types of syringes: the single dose syringe in which some radiopharmaceuticals are served and the syringe used to extract a radiopharmaceutical from a vial. The former allows administrating the radiopharmaceutical directly to the patient, or sometimes with the help of an intravenous line. The single dose syringe belongs to the category "Syringe" and the intravenous line to the "Mixed waste". When the radiopharmaceutical is extracted from a vial, the situation is identical to the previous one, except that there is another waste material, the vial. It can be directly injected with the same syringe used to extract the radiopharmaceutical or with an intravenous line.

The waste named by "**Vial**" (Figure 1.b) takes into account all the vials that contain a radiopharmaceutical. Some of them are served in a single dose syringe and other in vials, it depends on the manufacturer. Later on it will be discussed what to do with radiopharmaceuticals that have not been administered.

The waste named by "**Mixed waste**" (Figure 1.c) covers different contaminated items like: gloves, absorbent papers, intravenous lines, catheters, etc.

The waste named by "**Unused pills**" (Figure 1.d) refers to the radiopharmaceuticals served like pills that have not been administered to the patients. In this case, the waste is the pill plus a lead can, used for attenuating the ionizing radiation emitted during its storage.

a) b)

c) d)

Figure 1: Pictures of the four types of radioactive waste produced in the nuclear medicine department. a) Syringes; b) Vials; c) Mixed waste; d) Unused pills+lead can

Table 1 shows the different radionuclides used at our nuclear medicine department, the way in which they are served, the waste generated by each of them and their half-lives. Radionuclides that do not have a large volume of use could be stored together, if only are the same type of disposal, and using the largest half-life of them for calculating the time needed to elapse before their evacuation from the facility.

For example, syringes coming from Ga-67, In-111 and I-123 are stored together using the largest half-life of them (see Table 1), which actually is Ga-67. In the case of Tc-99m, it is stored alone due to the huge volume of use in the diagnostic activity.

Table 1: Radionuclides used and waste produced in the nuclear medicine department.

Radionuclide	$T_{\frac{1}{2}}$(d)	Served as a	Waste produced
Tc-99m	0,25	Single dose syringe	Syringe and mixed waste
Ga-67	3,26	Single dose syringe	Syringe and mixed waste
In-111	2,8	Vial	Syringe, vial and mixed waste
I-123	0,55	Vial	Syringe, vial and mixed waste
I-131	8,02	Vial	Syringe, vial and mixed waste
Ra-223	11,43	Vial	Syringe, vial and mixed waste
I-131	8,02	Pill	Pill+lead can (in case of a non-administration)
Se-75	118	Pill	Pill+lead can (in case of a non-administration)

This waste management scheme has been set into a process flow diagram made with open graphic editor yEd (see Figure 2). The system shows the different paths of waste from the three physical forms in which radiopharmaceuticals are served: pills, vials and single-dose syringes. Each radionuclide is placed in one of these three categories according to the information presented in the Table 1. Groups of radionuclides that can be stored together are represented by the same colour. The pathway of the generated waste by each radionuclide is explained below.

For the case of "**Pills**", there are discards only if the pill has not been administered to the patient. The pill is placed in the same leaded container where it arrived at the facility and moved into a well of the waste storage (see Figure 3.a).

The management of the "**Vials**" is more complex. There are two possible situations: the radiopharmaceutical is administered or not. In the first case, the most usual, the radioactive foils of the tag are removed and the empty vial is put into a small plastic bag (see Figure 1.b) inside the shielded vault of the facility. In the second one, the vial is put inside a leaded container and it is stored in the shielded vault until the activity decays. Then, the radioactive foils are also removed and the vial is put into a plastic bag as was in the first case. Inside the shielded vault there will be four different plastic bags containing each of these radionuclides: I-123, In-111, Ra-223 and I-131. When a bag is full it is moved into a well of the waste storage room. They are previously stored in the shielded vault because it is where the radiopharmaceuticals doses are prepared, and in consequence where the radioactive wastes are generated, so it makes it simpler for the nursing personnel not to carry them to the waste room for each generated waste.

At the waste store room, the plastic bags containing I-123 and In-111 are housed in the same well, as it can be seen thanks to the colour scheme presented in the Figure 2. Moreover, when a radiopharmaceutical is served in a vial, waste in form of syringes and mixed waste appear. Syringes go to yellow boxes, like the ones used for biological hazard material (see Figure 3b).

When a yellow box is full, it is also moved to a big well placed in the waste storage room, different to the ones showed in Figure 3.c.
The "**Mixed waste**" have different destinations: I-131 and Ra-223 wastes are put in different plastic bags and wells, and the rest go to a shielded bin placed in the hot chamber (see Figure 3c).

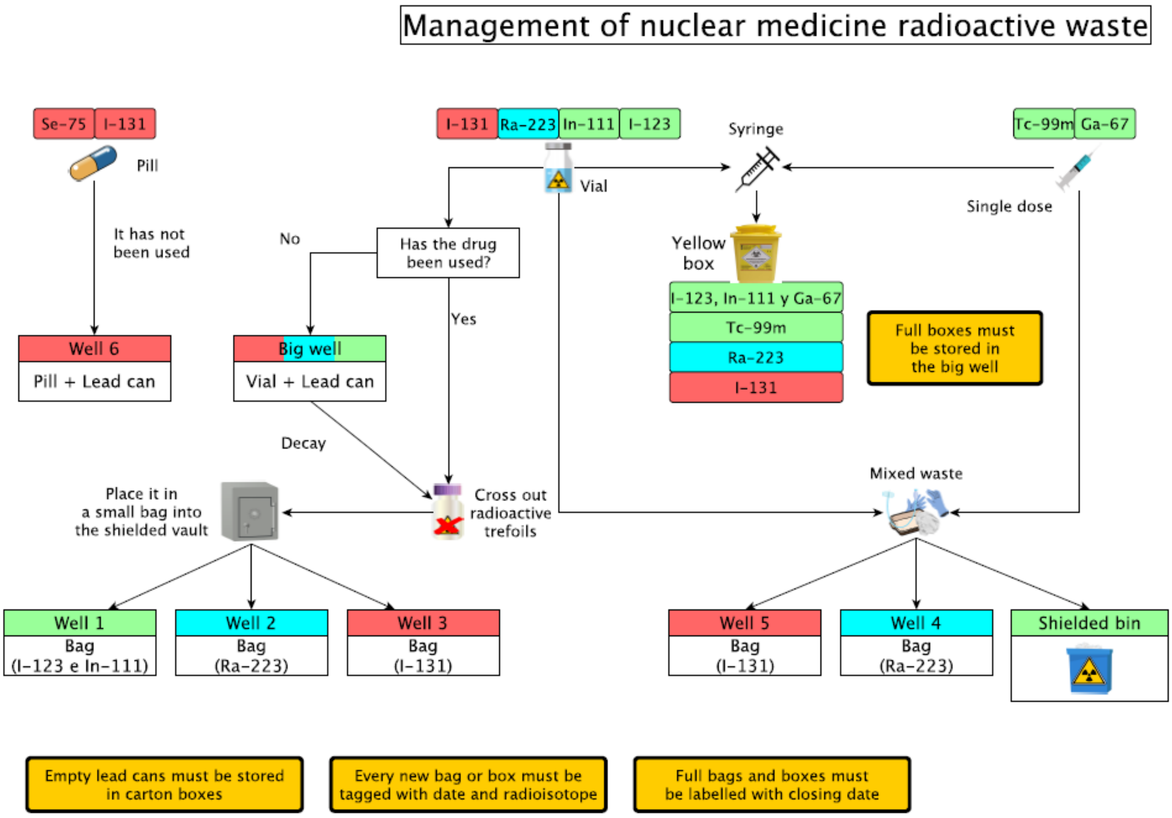

Figure 2. Process flow diagram about radioactive waste management in a Nuclear Medicine department.

Finally, a "**Single dose syringe**" produces residual material in form of syringe and mixed waste. The syringe goes to a yellow box like the formers, and the mixed waste to plastic bags, as it has been explained in the case of vials. The syringes that contain Tc-99m could be placed in the same box as Ga-67, In-111 and I-123, but due to the high volume generated, it is stored alone in bigger boxes.
When a bag or a box is opened for the first time, the opening date has to be written on it, as well as the radionuclide/s that will be put on. When it is closed, the closing date is also specified. A reference number of the box /bag could be useful in order to keep track of the number of evacuations performed (see Figure 3b). This information is necessary to estimate the number of days that must elapse until the evacuation of the waste. At the moment of the evacuation, radiation and contamination levels are measured in order to assure a correct procedure. The measure obtained and the reference number of the container is recorded in the operation logbook.

a)

b) c)

Figure 3: Pictures of the different places for storing radioactive waste. a) Wells (vials and mixed waste); b) Yellow box (syringes); c) Shielded bin (mixed waste).

3 Results and discussion

Physical copies of this infographic (Figure 2) have been placed in the hot chamber and in the waste storage room, above the wells. The nursing staff in charge of the radioactive disposal have now a check point to ensure that they are performing the management in the right way. Moreover, the radiation protection professionals explained the diagram to the nuclear medicine workers part by part in face to face lessons at the facility. They now understand more instinctively how to manage every contaminated item or radioactive material, rather than with the traditional written procedure used prior to this scheme. The staff in charge of retiring the declassified radioactive waste, a radiation protection experts from our department, has now fewer mishaps in calculating the time needed for a correct evacuation. Prior to the implantation of this method, the closing dates were not always written and occasionally radionuclides were mixed in a wrong way, or labels not removed.

A screenshot of the spreadsheet used for this calculation is showed in the Figure 4.
Nurses at our hospital are not exclusively dedicated to Nuclear Medicine, instead they also work in interventional radiology. As a consequence, when they do not work in nuclear medicine for a while, specific aspects of waste management can be forgotten by them. Visual instructions like Figure 2 can help them remember these topics rapidly and helps to face their work with confidence.
This method of training in radiation protection is included in the online courses that the radiation protection specialists give to the workers of the hospital.

Cantidad	Tipo de bulto	Radionucleido	Nº Referencia	Fecha de inicio	Fecha de cierre	N. Radiación (µGy/h)	N. Contaminación	Número de días hasta la desclasificación	Fecha prevista de evacuación	Estado del residuo	Fecha retirada
1	Cubo amarillo	Ga-67	001/21-Ga67	24/04/2021	01/07/2021	0	0	57	27/08/2021	Residuo evacuado	03/09/2021
1	Cubo amarillo	In-111	001/20-In111	07/12/2018	02/06/2021	0	0	49	21/07/2021	Residuo evacuado	03/09/2021
1	Cubo amarillo	Ga-67	002/21-Ga67	01/07/2021	23/09/2021	0	0	57	19/11/2021	Residuo evacuado	11/02/2022
1	Cubo amarillo	Ga-67	003/21-Ga67	23/09/2021	25/11/2021	0	0	57	21/01/2022	Residuo evacuado	11/02/2022
1	Cubo amarillo	Ga-67/In-111/I-123	001/21-In-111	22/07/2021	21/10/2021	0	0	57	17/12/2021	Residuo evacuado	11/02/2022
1	Cubo amarillo	Ga-67/In-111/I-123	002/21-In111	11/08/2021	30/11/2021	0	0	57	26/01/2022	Residuo evacuado	31/05/2022
1	Cubo amarillo	Ga-67/In-111/I-123	003/21-In111	30/11/2021	10/02/2022	0	0	57	08/04/2022	Residuo evacuado	31/05/2022
1	Cubo amarillo	Ga-67/In-111/I-123	001/22/Ga67	10/02/2022	29/04/2022	0	0	57	25/06/2022	Residuo evacuado	26/06/2022
1	Cubo amarillo	Ga-67/In-111/I-123	004/22/Ga67	29/04/2022	20/06/2022	0	0	57	16/08/2022	Residuo evacuado	06/09/2022
1	Cubo amarillo	Ga-67/In-111/I-123	002/22/I123	20/06/2022	22/08/2022	0	0	57	18/10/2022	Residuo evacuado	30/11/2022
1	Cubo amarillo	Ga-67	004/22/Ga67	25/04/2022	30/09/2022	0	0	57	26/11/2022	Residuo evacuado	30/11/2022
1	Bolsa de viales	Ga-67/In-111/I-123	003/22-Ga67	23/08/2022	17/01/2023	0	0	57	15/03/2023	Residuo evacuado	16/03/2023
1	Cubo amarillo	Ga-67/In-111/I-123	005/22-I123	17/10/2022	09/03/2023			57	05/05/2023	No evacuar	
1	Cubo amarillo	Ga-67/In-111/I-123	006/22-Ga67	11/11/2022	09/03/2023			57	05/05/2023	No evacuar	
1	Cubo amarillo	Ga-67/In-111/I-123	007/22-In111	26/05/2022	09/03/2023			57	05/05/2023	No evacuar	
1	Bolsa de viales	Ga-67/In-111/I-123	001/23-I123	17/02/2023	09/03/2023			57	05/05/2023	No evacuar	
1	Bolsa de viales	Ga-67/In-111/I-123	009/22-I123	16/10/2022	09/03/2023			57	05/05/2023	No evacuar	
1	Bolsa de viales	Ga-67/In-111/I-123	002/23-In111	17/02/2023	09/03/2023			57	05/05/2023	No evacuar	

Figure 4: screenshot of the spreadsheet used for the calculation of the days needed to proceed to the evacuation of the radioactive disposals.

4 Conclusion

A more uniform method for radioactive waste management, easy to consult and straightforward to interpret, has led to a more robust procedure. It optimizes the radiation protection for workers and public and also for the environment, as more efforts are dedicated to do a thorough waste characterization segregation and evacuation. As is the case with other traditional procedures, the associated infographics must be reviewed and adapted to changes or new radiopharmaceuticals periodically.

References

[1] Real Decreto 1029/2022, de 20 de diciembre, por el que se aprueba el Reglamento sobre protección de la salud contra los riesgos derivados de la exposición a las radiaciones ionizantes. Artículo 66.

[2] ORDEN ECO/1449/2003, de 21 de mayo, sobre gestión de materiales residuales sólidos con contenido radiactivo generados en las instalaciones radiactivas de 2.a y 3.a categoría en las que se manipulen o almacenen isótopos radiactivos no encapsulados.

BUILDING A NEW GRADUATE-LEVEL HEALTH PHYSICS PROGRAM: CHALLENGES AND SUCCESSES

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The University of Alabama at Birmingham (UAB) in Alabama, USA, began a master's-only health physics program in Fall 2016. The program is housed in the School of Health Professions, Department of Clinical and Diagnostic Sciences, alongside other more clinically focused programs such as Nuclear Medicine Technology and Genetic Counselling. The program was started while several other health physics programs in the USA were shutting down due to lack of interest in the programs. The UAB Health Physics program is now the only one of its kind in the South. This paper will cover how UAB built a health physics program in the USA while most programs were actively shutting down.

1 Introduction

The University of Alabama at Birmingham (UAB) in Alabama, USA, began a master's-only health physics program (MHP) in Fall 2016. The program is housed in the School of Health Professions, Department of Clinical and Diagnostic Sciences, alongside other more clinically focused programs such as Nuclear Medicine Technology and Genetic Counselling. The program was started while several other health physics programs in the USA were shutting down due to lack of students and interest in the programs. The UAB Health Physics program is now the only active Health Physics master's program in the southern United States.

The program faced several challenges immediately after its inception. The acting program director and developer of the curriculum was a nuclear medicine technologist. Despite accepting the first cohort of students in Fall 2016, the program had no full-time health physics faculty until mid-2017. Even once staffed, the lab equipment remained severely outdated, there was no cohesive recruitment strategy, no ability to fund students, and no connection to the relevant professional societies. Most concerning, the program lacked direction.

Despite these difficulties, the program maintained a consistent albeit small student market, primarily because of passionate faculty willing to work hard to make the program unique amongst the declining competition. The program's key component, a practicum requirement, likely contributed greatly to the program's direction and a focus on applied health physics. After retirement of the original program director, health physics faculty were promoted and given administrative support that led to new equipment, grants supporting students, and additional faculty. The result was an enrolment increase from four students to 12 from the Fall 2021 cohort to the Fall 2022 cohort. The program currently has over 30 applicants for the fall 2023 cohort to date.

2 Growing a Master's Level Health Physics Program

At its inception, the leadership of the Health Physics program was able to create and maintain program momentum despite their efforts being split between multiple programs. Once new leadership came in, the Health Physics Master's program was able to start growing quickly due to: passionate leadership, focused goals, and consistent marketing. New leadership came onto the program with only this one program to be responsible for. Because of this, they were able to maximize their efforts in defining the program goals by creating a mission, student outcomes, and educational objectives.

At the same time, federal and local funding were pursued, and additional faculty were recruited. Many of these pursuits were successful leading towards partial student funding and new equipment.

The new leadership was also well recognized within relevant national scientific communities and their outreach and marketing efforts were well received at national conferences. Focused leadership was also an asset when it came to recruiting. Previous leadership had multiple goals for recruiting to multiple programs, under the new leadership one passion was clearly conveyed and students found it contagious. This led to an increase in program applicants and enrolments by over 200%.

2.1 Mission Statement

The first step in redeveloping the program was to define the mission, student outcomes, and educational objectives. These are the items that build the foundation of a program. The UAB MHP program mission is "To provide a quality educational experience in health physics that prepares students to be skilled professionals who will equitably serve in a diverse workforce, who will contribute to the profession throughout their careers, and who will uphold the highest standards of ethics and integrity both personally and professionally." The goal of developing these higher-level statements and objectives was to guide how the program is implemented, how classes are taught, how the practicum requirement is managed, and how the overall program is managed. These high-level statements structure the entirety of our program.

Practically, the MHP program required an investment in all new lab equipment for students, as the previous equipment was so outdated it was no longer functional. It also required an additional faculty member, research lab space, office space, and a commitment from the Chair to support the program while it was being built up. Clear goals plus the substantial nationwide need for Health Physicists combined with the drive from the leadership led to extremely supportive administration willing to support the programs endeavour.

2.2 Student Outcomes

Student outcomes drive the curriculum and inform the student and prospective future health physicists of expected behaviour. These outcomes dictate the courses taught and the key assignments in each class. In contrast to bachelor's level programs, the master's level program includes development of research and additional critical thinking skills.

The MHP program currently has the following student outcomes:

- Identify, formulate, and solve broad and diverse technical problems by applying knowledge of the sciences and mathematics to areas relevant to health physics. This is evaluated in the Certified Health Physicist exam preparation class, where students solve technical problems to prepare for the certification exam.
- Develop hypotheses, conduct experiments or data gathering to test hypotheses, analyze and interpret data, and apply scientific judgment to draw conclusions. This is evaluated in the two MHP research courses, which guide students through best practices for conducting health physics related research. Students then conduct their research under the mentorship of an MHP faculty member.
- Develop and implement key elements of a radiation safety program. This is taught and evaluated in Radiation Shielding and Protection, which requires students to develop a radiation safety plan for a hypothetical laboratory.
- Demonstrate the ability to work independently and on multi-disciplinary teams across cultural and socioeconomic divides. This is taught across all courses in MHP and is evaluated by our partner sites explicitly as part of the student practicum.

- Communicate effectively orally and in writing across a broad range of audiences. This is taught across all courses in MHP and is evaluated by our partner sites explicitly as part of the student practicum.
- Understand both ethical and professional responsibilities and the impact of technical solutions in global, economic, environmental, and societal contexts. This is taught across all courses in MHP and is evaluated by our partner sites explicitly as part of the student practicum.
- Recognize the importance of professional certification in health physics and the need to engage in life-long learning. This is taught across all courses in MHP and is evaluated by our partner sites explicitly as part of the student practicum. Further, all MHP students attend and present at the annual Health Physics Society meeting.

2.3 Educational Objectives

Educational objectives detail higher level outcomes expected of students when they join the profession. They are the ideals that the program expects all students to meet when they graduate.

The MHP program currently has the following educational objectives:

- Professionalism. To be successful in the professional realm, graduates will employ responsible teamwork, clear communication skills, effective project management capabilities, professional attitudes, and a clear understanding of the ethical issues faced by our profession. Graduates will engage in life-long learning and professional development, as demonstrated by participation in technical seminars, professional conferences and symposiums, discipline specific trainings, and advancement in the professional certification process.
- Problem solving. In their careers, graduates will integrate their technical knowledge, applied skills, and professional judgement to design and evaluate radiological systems considering safety, reliability, security, economics, and societal impact.
- Community. Graduates will contribute to the growth of their professional and scientific field, will provide for their own development, and will contribute to the expansion and development of their colleagues. They will do so while engaging the radiation safety and broader community in an inclusive and equitable manner.
- Breadth. Graduates will employ their broad technical knowledge in their careers. Graduates will identify, formulate, analyse, and solve radiological problems by applying fundamental and advanced scientific and technical knowledge coupled with applied skills. Breadth also includes a continuing awareness of contemporary issues, influences, and trends needed to understand the impact of radiological issues in global and societal contexts.

3 UAB Health Physics Strategic Plan

The strategic plan defines the direction for the program over the next five years, and contains measurable metrics for determining success. The UAB MHP strategic plan consists of three pillars: (1) Education, (2) Community and Professional Society Engagement, and (3) Research & Innovation Coupled with Clinical & Industry Enterprise.

3.1 Pillar 1: Education

The core of any academic program is the education that students receive. The UAB strategic plan has four key goals:

1. Achieve accreditation from the Accreditation Board for Engineering and Technology (ABET). UAB aims to become the second accredited, hybrid health physics program in the US, and the only one in the Southern USA. This brings us credibility and advances the research program.

2. Start a PhD program. There are only four health physics PhD programs in the USA, none of which are in the Southern or Eastern USA. A PhD program also enhances our research capabilities.
3. Continuously improve hybrid learning. Hybrid learning is here to stay. We aim to ensure our online offerings are in line with cutting edge science for adult learners, while maintaining flexibility for the wide range of students we serve.
4. Continuously increase pool of elective courses and expand offerings to wider population. Our goal is not just to reach the next generation of health physicists, but also to encourage the continued learning and engagement of current professionals.

Like all academic programs across the world, UAB had to adapt during the COVID-19 pandemic but had already experimented with the idea of remote course offerings. All classes were converted to hybrid where they were available to all students in three forms: live in person, live online, and recorded for later viewing. These adaptations were found to be extremely valuable without jeopardizing student engagement. Students who learn best in person are still afforded that opportunity, and if an interruption occurs such as illness, traffic, or personal they can log in and watch and participate with the class online. Students who work full time and cannot adapt their schedules are able to watch lectures later but still see normal student interaction. These adaptations continue to expand the student market and experience.

3.2 Community and Professional Society Engagement

The program quickly found that participating in and giving back to the community and professional society is of the upmost importance for a strong profession. UAB is a university that prides itself on giving back and engaging with the community, and our program will participate in this endeavour in several key ways:

1. Restarting our local Health Physics Society Chapter. The Alabama chapter of the HPS offers an excellent opportunity for students to take on leadership roles and give back to their profession and community through outreach events. It also gives students the opportunity to practice networking skills on a smaller scale than at the national level.
2. Increase student attendance at the HPS annual meeting. These national level meetings give students the opportunity to present their research, get feedback, connect with mentors and other students, and to network.
3. Start annual outreach programs for younger kids. By coordinating with local schools to host “discovery days” or boy/girl scout merit badge events, we can increase our community presence and impact.

These are starting points for UAB MHP students to give back to their community and professional society, which in turn increases our visibility and attractiveness to potential students and employers.

3.3 Research & Innovation Coupled with Clinical & Industry Enterprise

UAB was already well known for its medical school, and the health physics program resides in the school of health professions. As such, the program has a strong research interest in medical health physics, and is leveraging connections with the medical school, comprehensive cancer centre, and cyclotron facility. It has built partnerships with commercial radiopharmaceutical companies as well to further enhance opportunities for students in the medical health physics arena.

The program hosted an inaugural research days event in 2022, where it brought in researchers from UAB and across the US, industry leaders, national labs, and others to discuss their research with our students, with a focus on how MS level students could get involved. This resulted in half the fall 2022 cohort finding research mentors in their first semester of graduate school.

The MHP program is further expanding on the 2022 event this year, and plan to have second year students participate as well. The longer-term goal with research days is to keep MHP research connected with the needs of industry such that long lasting partnerships are built.

These industry interactions have proven fruitful for industry, students, and the program's marketing plan. Program graduates are currently at a 100% employment rate, and this is appealing for both future students and industry partners as they struggle to find health physicists due to the market.

The third goal under this pillar of the strategic plan is to increase scholarship by publishing student work. The program has worked with the Health Physics Journal to produce a special issue that contains student papers from programs across the US. The first issue is scheduled for mid-2024.

4 Summary

Three pieces were synergistically fundamental to the quick growth of this program and will continue to contribute to its sustained growth and development: (1) goal driven and passionate leadership, (2) strong administrative support, and (3) a strong employment market for graduates to fill. In summary, the UAB program was built on the hard work and dedication of its faculty members, with the unequivocal support of the Chair and Dean. All educational programs face uncertainty in a post-COVID world and must learn to adapt to the needs of a new generation of students. Successful educational programs are likely to be those that partner with industry, research, and government to ensure their graduates are prepared to fulfil workforce needs.

IMPROVEMENTS FOR RADIATION SAFETY TRAINING IN A POST COVID ENVIRONMENT

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At the University of Alabama at Birmingham (UAB) hundreds of diagnostic and therapeutic procedures involving radioactive materials or radiation-producing machines are performed daily. A growing number of minor but preventable incidents related to radiation safety have brought up concerns related to the effectiveness of the training program. A comprehensive literature review was performed to summarize post-covid insights into andragogic online training practices, statistical analyses, and overall retention competencies in radiation safety. Andragogic research shows that the best method of training adult learners is controlled simulations that test one's critical thinking and problem-solving capabilities, drawing upon previous knowledge or experiences. The authors propose a radiation safety training curriculum that will be tested within a subgroup at UAB, using pre- and post-testing. The training will make efficient use of limited university resources and attempt to maximize retention of key radiation safety concepts.

1 Introduction

Across a variety of jobs and careers, employees are exposed to several occupational risks. Occupational hazards can be organized into several categories such as physical, chemical, biological, fire/explosion, environmental, and radiation [1]. To ensure than occupational hazards are prevented or mitigated, employees must be educated on their relevant hazards and proper protection measures. Education is delivered by safety professionals either in a formal academic setting or in on-the-job settings, like during a safety inspection.

In occupational settings, radiation hazards are present through several different sources: diagnostic imaging, therapeutic procedures, radioactive materials, nuclear power plants, terrestrial/cosmic radiation, etc.. Given its wide impact, it is critical to educate personnel that may interact with radiation on the hazards involved with the uses. It has been demonstrated recently that both radiation safety training and knowledge is lacking at multiple different institutions [2-6]. Institutions have found that employees without proper training suffer from a lack of understanding about how to correctly use Personal Protective Equipment (PPE), how to operate radiation-producing machines, or how to utilize foundational radiation safety concepts like ALARA (As Low As Reasonably Achievable) or time, distance, and shielding [2-6]. A lack of understanding in radiation safety in a clinical setting can have multiple deleterious effects including increased frequency of occupational accidents, decreased effectiveness of treatments and financial impacts through wage losses and decreased profits [7-9]. On the other hand, providing proper radiation safety training can lead to positive outcomes such as reducing radiation exposure to orthopaedic residents, increased understanding in PPE and foundational radiation safety concepts, and increased support for pregnant workers [7-9]. There are multiple factors that could cause this deficit in understanding. At smaller or less-funded institutions, there might not be a dedicated Office of Radiation Safety to help train personnel. This task might be passed on to a contracted vendor, who will likely have significantly less hands-on interaction than dedicated staff. Other researchers have speculated it is more of a cultural issue within clinics than it is the availability of training.

One group at the University of Malaya found that with the recent increase in CT scanning, an increased misuse of machinery has made deficiencies in proper techniques more pronounced [10].

At the University of Alabama at Birmingham (UAB), hundreds of diagnostic therapeutic procedures involving radiation-producing machines and radioactive materials are performed daily. UAB has a radiation safety program (RSP) that manages a broad-scope license encompassing both research and clinical licensees. Prior to the COVID-19 pandemic, the RSP delivered a very comprehensive training curriculum designed to educate prospective licensees and personnel on the field of health physics. The curriculum featured a 40-hour in-person seminar run by RSP personnel. Content focused on foundational health physics concepts such as the different types of radioactive particles, various radiation detection meters, ALARA, time, distance and shielding, regulatory bodies like the U.S. Nuclear Regulatory Commission (NRC), etc. The curriculum concluded with a comprehensive 100-question exam designed to test competency, with a score of 80 being deemed a passing grade. Personnel were required to pass this exam before they were allowed to begin their respective job duties involving exposure to radiation. It was reported that the curriculum was very helpful in terms of the depth and thoroughness of the material. However, over time, licensees and personnel began to request that the length of the training curriculum become shorter. This reflected a gradual shift towards wanting to start new employees on work tasks immediately, as opposed to spending a large amount of time with training. The training was shortened from 40 hours to 32 hours, and then again to 24 hours to increase participant completion rate.

Alabama is a US agreement state, which is a state that has signed an agreement with the Nuclear Regulatory Commission (NRC) to regulate specific uses of radioactive materials within that state [11]. The procedures involving radiation at UAB are managed under radioactive material (RAM) licences distributed by the Alabama Department of Public Health (ADPH). A license is a document that details the storage, use and maintenance of a radioactive source, by-product, or special nuclear material. The term used to describe the owner of an individual RAM license is a "licensee." The ADPH has granted UAB a broad scope license, which gives UAB the authority to possess and utilize a wide range of radioisotopes on its campus. Anybody at UAB that works with radioactive materials in some capacity must do so under the supervision of a licensee. Licensees are responsible for the safe handling of all radioactive materials in their research lab or clinic and corresponding documentation. They are also responsible for managing the training of all workers who handle the materials, which are called authorized users (AUs). At UAB, radiation workers refresh their training either on a 1 or 5-year basis, depending on regulations and the researcher's specific needs.

In response to the COVID-19 pandemic, the UAB RSP converted its training from in-person seminars to an online format to promote social distancing. Rather than a 40-hour in-person seminar, training was distributed over a variety of text-based documents. These documents are variable in length depending on the subgroup being trained, but they are typically under 10 pages long. The breadth of content is similar to pre-COVID, but the depth of the content has been decreased. Content now focuses on a variety of vocabulary terms, ALARA, regulatory bodies, and a couple of basic equations like the inverse-square law and the calculations for activity and exposure. The comprehensive exam at the end of training was also reduced to a 5-10 question quiz.

Andragogic research stresses that it is important to make the distinction that these are adults being taught as opposed to children [12-13]. This distinction is essential because adult learners understand and comprehend material differently than children [12-13]. Andragogy, the branch of science dedicated to understanding how adults learn, focuses on these differences. Popularized by the American adult educator Malcolm Knowles in 1980, andragogy contrasts with pedagogy, the art and science of teaching students, typically children.

In discussing the differences between the two groups, Knowles developed several assumptions about adult learners. He posited that the adult learner [12]:

1. Moves from dependency to increasing self-directedness as he/she matures and can direct his/her own learning;
2. Draws on his/her accumulated reservoir of life experiences to aid learning;
3. Is ready to learn when he/she assumes new social or life roles;
4. Is problem-centered and wants to apply new learning immediately; and
5. Is motivated to learn by internal, rather than external, factors.

There are two schools of thought with the design of training curriculum in occupational training. One claims, the purpose of the program could be for it to be **actionable**. At the conclusion, personnel would have gone through such a rigorous and in-depth program that they would immediately have the capabilities to go out and perform actions related to their job description. This is found in practicums or other in-person training seminars, which are designed to be more interactive. However, a structure like this also tends to be available on an infrequent basis to personnel. If ORS staff are expected to be able to provide this training on a given moment, they would have their entire schedule tentatively blocked off and could make their other job duties incredibly difficult to perform. In the case of the COVID-19 pandemic, this structure was also forbidden due to public health concerns and social distancing rules.

The other school of thought argues that radiation safety training needs to focus on being **accessible**. New technologies and software allow people to perform tasks on a much more flexible schedule. Most peoples' smartphones allow them to be able to navigate to new locations, check their financial details, and look up any piece of information from seemingly anywhere in the world. It follows logically that some would use this technology for work-related tasks, which would include training. The development of a robust training curriculum could be incorporated into mobile phones or other mobile devices to allow personnel more access to this training outside of normal work hours and environments. However, this type of training also (arguably) leads to less actionable outcomes compared to in-person training. Without any kinaesthetic activities to test participants, it is very easy to zone out or fly through the training just to satisfy a mandatory requirement. The lack of any active engagement can lead to reduced compliance and overall understanding.

With these assumptions in mind, the UAB ORS aimed to create a new model where it would train personnel based on achieving the highest standard in two areas: safety and compliance. Personnel are trained with the goal that they will have an in-depth understanding of radiation safety and health physics and will be able to carry out all necessary duties and responsibilities in a safe and secure manner. Achieving these standards will be possible by developing a training program that is andragogic in nature and focuses on the adult learning experience. Since the average attention span of an adult is about 15-20 minutes [13] timing would also have to be balanced.

2 Methods

The UAB ORS hypothesize that the best training structure is one that is both **actionable and accessible**. The weaknesses of one individual training structure are the same strengths of the other structure. Combining the two structures into one curriculum allows for a more robust experience and for greater appeal to various individual learning styles of participants. To test this hypothesis, pre- and post-testing analysis will be performed to compare compliance and understanding of radiation safety before and after intervention. *Figure 1* below shows a schematic that details the steps of our proposed training program.

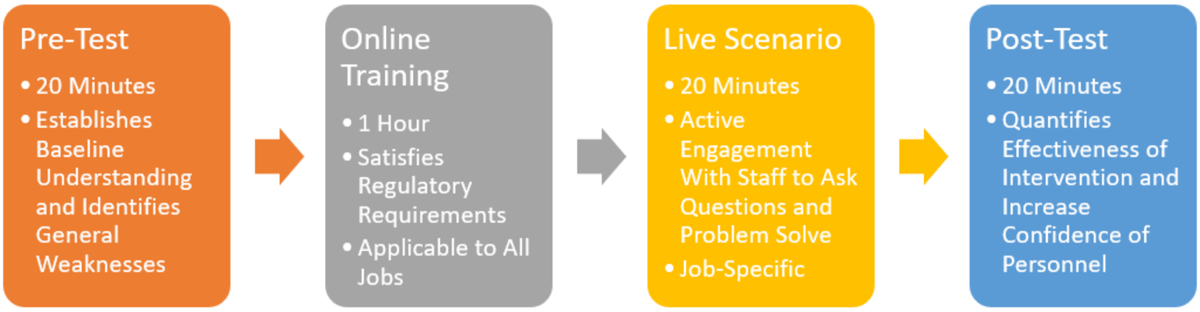

Figure 1. Roadmap for a Post-COVID radiation safety training program. This program is designed to be both accessible and actionable, while having statistical analysis to quantify effectiveness and short overall time commitment to respect work schedules of participants.

While our program is designed to be accessible and actionable, it is also designed to be respectful of personnel's time as well. In an ideal world, the ORS would be able to train people for a much longer length of time to guarantee they understand as much about radiation safety as humanly possible. However, personnel in the past have expressed dissatisfaction with the length of the training program, citing 40 hours as too large of a time commitment. At 2 hours, this program is designed to fit as much content in as possible without suffering from attention span loss or tuning out of a presentation. This program also ensures that personnel can begin their respective job responsibilities faster. As the curriculum is completed in its entirety, the curriculum can be iterated upon many times. Post-test results will allow the ORS to identify continuous areas of weakness and will give the opportunity to modify the existing structure to focus on specific topics of interest. The individual steps of this program are detailed below.

2.1 Pre-Test

The pre-test is a 20 multiple-choice question examination that will allow ORS to establish a baseline understanding of radiation safety and health physics for personnel beginning their job at UAB. This will be given regardless of their career length, job title, or experience at another institution. Questions will be developed based on NRC guidance document NUREG-1556 Volume 9, Rev. 3. Topics will be for individuals involved in both medical and nonmedical use of byproduct materials. Topics will include but are not limited to: basic radiation biology, basic radiation protection, posting requirements, proper use of personnel dosimetry, radiation shielding, occupational dose limits, emergency procedures, etc [14]. These questions are designed to be the guiding framework for the subsequent online training and live scenarios. Questions will be randomly selected from a comprehensive bank of questions with similar wording. Before assigning personnel the online training, these questions will also allow us to identify areas of weakness or misunderstandings, especially as this program is carried iteratively. With each question being weighted the same, participants will have the ability to see their score immediately upon completion of the exam. They will also have the opportunity to express any comments they feel are necessary for the ORS to know before continuing their training. Scores will be collected and can be analysed based on several factors that include but are not limited to: age, job title, years of experience, etc. The estimated time of completion is 20 minutes.

2.2 Online Training

The online training segment is designed to be both interactive and readily accessible. Participants will be able to log in and complete the training once they have been given access to the course in their respective training software. In this course, participants will be given a broad overview of a variety of foundational concepts in radiation safety and health physics. The information will be given through a series of short videos and text-based files.

Throughout the modules, participants will be required to take a series of 1-2 question quizzes on topics they have recently covered. These questions are designed to check understanding throughout the modules and to ensure participants are actively engaged in learning the material as they progress. The training will be designed not only around teaching health physics concepts deemed important by the ORS, but also those that are required by various regulatory bodies. Current training modules are based around relevant guidelines and regulations. Incorporating these into the online training will ensure compliance with all regulatory requirements. With these guidelines, the online training will also be designed to be applicable to all jobs at UAB. Whether the employee is a campus researcher, physician, or maintenance/sanitation staff, they will develop a strong grasp of health physics and radiation safety and will be able to respond to any scenario deemed appropriate by their job responsibilities. The estimated time of completion is about 1 hour.

2.3 Live Scenarios

The live scenarios segment is designed to employ the andragogic teaching principles previously discussed. The goal is to create a welcoming, safe environment for personnel to come and demonstrate their understanding of the training through a controlled scenario specific to their job responsibilities. In this scenario, personnel will have the opportunity to draw upon previous experience (if applicable) to solve a series of tasks using a set of pre-determined tools. Depending on the size of the department or group in training, participants will complete these tasks as a group or as individuals. Participants will draw a scenario out of a comprehensive bank of similar scenarios. As the scenario progresses, personnel will have access to an ORS facilitator to assist them if they should get stuck or require clarification on an idea. These scenarios are designed to engage participants in critical thinking and problem solving while utilizing skills specific to their uses of radiation. By engaging the radiation worker in these skills, they will develop a greater understanding of the material and increase their confidence in responding to a relevant scenario they might be exposed to with their job. They will also identify and tentatively correct any shortcomings they still have after completing the online training and may be given additional materials if needed. The estimated time of completion is about 20 minutes.

2.4 Post-Test

The post-test is another 20 multiple-choice question examination that is designed to reflect the concepts and teachings of both the online training and live scenarios. Questions will be randomly selected from the same comprehensive test bank as the pre-test. Upon completion of the exam, participants will immediately have access to their overall score to determine if they have improved in their understanding of the material. Under the direction of the UAB Center for Clinical and Translational Science (CCTS), several statistical tests will be conducted to determine if (a) there is any improvement in score post-intervention and (b) if these improvements are statistically significant. Participants will also have the ability to leave comments to explain any positive thoughts, critiques, areas of improvement, or general questions about the material. The estimated time of completion is 20 minutes.

2.5 Timeline

The process from pre- to post-test is designed to generate quick results and feedback and to train personnel at a rapid pace. By the end of their first week as a radiation worker, all personnel should have their pre-test examination assigned and completed. During the second week, personnel will be assigned their online training and should have it completed within one week's time. Upon completion of the online training, personnel will need to set up their live scenario within one week, but they will still have access to their training modules for future perusal or review.

Finally, upon completion of the live scenario, personnel will immediately have access to their post-test examination, which they will need to complete within one week. This will ensure quick completion of the entire curriculum and will allow personnel to have sufficient time to learn the material while keeping it fresh enough that they won't forget due to prolonged periods of time in between steps. This entire curriculum will be repeated on an annual basis to ensure consistent compliance and understanding of material. Refresher trainings offered every 1, 3, or 5 years depending on internal requirements will consist of the same procedure as new radiation worker training.

3 Discussion

In discussing possible interventions, it is important to consider any confounding variables or potential weaknesses that are currently or may potentially be experienced. One potential weakness is the overall length of the training program. It is unreasonable to expect that personnel understand the entire fields of health physics and radiation safety in a mere 2 hours of training and examinations. While 2 hours can seem too short, this time limit considers factors from both groups involved in the training. This time constraint will be adjusted accordingly based on feedback from radiation workers and/or evidence provided by statistical analysis. With the UAB ORS, spending more time on training can lead to a decrease in other job responsibilities without a staff member fully dedicated to running the training. Keeping the online training and live scenarios this short allows the ORS staff to still carry out training without being over encumbered by the sheer volume of participants. For the training participants, keeping the training short respects both their job responsibilities and their individual engagement in the process. Multiple studies have found that the average adult attention span starts to decrease after 15-20 minutes. To achieve maximum engagement, training must be compact and to the point. This time restraint also ensures that staff in more immediate or critical areas within the hospital will still have adequate time to respond to emergencies without being tied up in a training program all day.

Another consideration is how to manage the administration of training. Between all the staff at an institution that could potentially be involved with radiation safety, it can seem daunting to keep track of current training records, assignment of training to new personnel, etc. This task can be managed through robust software that can act as a database and repository of training modules. UAB is in the process of implementing a program that could satisfy this requirement. Known as Environmental Health and Safety Assistant (EHSA), this software has the capability to track new personnel that are assigned to a radioactive materials license and manage their training history and requirements. The software could be set up to administer certain modules based on a license's involvement with radiation and could help automate the process of tracking expired/overdue training.

4 Conclusion

A number of small but preventable errors involving radioactive materials have been identified at UAB in the past, with training being a possible contributor. A comprehensive literature review and research was performed to identify possible improvements. A new training curriculum was developed based on andragogic teaching principles, which will be tested in the 2023-2024 academic year. Using statistical analysis, the authors hope to learn that this new training program will lead to greater safety, compliance, and an overall more positive attitude towards radiation safety. Based on the research, we anticipate better feedback from participants, stronger interpersonal connections with licensees, and a lowered incidence of small but preventable incidents.

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EFFECTIVENESS OF THE POST-PANDEMIC HYBRID EDUCATION IN RADIATION PROTECTION: FIRST RESULTS

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After the Covid-19 pandemic restrictions were lifted and educational institutions were able to conduct face-to-face lectures, returning to the old model of education was not easy. Despite, the fact that distance and hybrid forms of education were known and used before, COVID-19 pandemic became a certain trigger that led to the development of a hybrid system of education and training on radiation safety. Over 108 healthcare professionals from the country used the hybrid trainings on radiation protection during post-pandemic learning. 10 working days lasting training, contained online learning, face to face learning and practical part was accompanied by mandatory Google Form-Based questionnaires contained pre and post-training tests. Regardless of the fact, that the number of students who have completed a hybrid learning course is still relatively small compared to students who have completed a course of study in person or remotely, even the first obtained results allow us to be very optimistic towards a hybrid form of education and training in radiation protection.

1 Introduction

The past COVID-19 pandemic was certainly one of the most serious challenges of this kind for whole humanity, and for healthcare, and naturally it also affected related areas, such as training on Radiation Safety for medical staff at all levels, including the radiation protection officers (RPOs). Like any system call on a planetary scale, it has become not only a challenge, but also a trigger for new opportunities and approaches. Of course, the experience that we gained as a result of the Covid-19 pandemic still requires careful analysis and evaluation, but already during the pandemic, it became clear that by the time it ended, there would be no return to the previous, full-time form of education. All these issues have been discussed at many international forums, including with the participation of the IAEA and other authoritative international organizations, as well as at the regional and national levels and in general, in scientific articles devoted to this issue. New ways of learning that worked well during the pandemic, after the end of the pandemic and the restrictions associated with it, we began to use it on an ongoing basis, and thus we got a blended form of learning, with some modules of a hybrid form of learning [1-8]. Evaluation of the effectiveness of such a hybrid form of education, as well as its comparison with full-time and completely remote forms, was planned by us from the very beginning. [1-9,28]

2 Methods

Before the training, the trainees complete a pre-test consisting of 12 compulsory questions, and after the training, a google-based 12-question final test. The tests provide some self-assessment of the trainees both before and after the training. The duration of the training is 10 working / training days. Participants answered the questionnaire anonymously and their date was completely protected. Participants were informed about the purpose and content of the study.

They also were informed that the results will be presented in the form of a scientific research (article). Before taking part in the survey, they were warned that if they filled out the forms and sent it to us, they were confirming their consent. Organization and personnel who did not wish to participate in the study did not complete the questionnaire and did not answer any questions. [9-13]

3 Results

In total, 4 hybrid training courses were conducted, with a maximum of 30 trainees per group, providing appropriate training modules for all levels of medical staff, including RPOs. A total of 108 students attended, of which 54 were first-time attendees, whilst 54 had a repeat course. Including radiographers 58 (54%), doctors 31 (28%) and RPO19 (18%). The main modules of the Radiation Safety Training Course are: (1) Overview of International and National Legislation on Nuclear and Radiation Safety; (2) Fundamentals of Physics; (3) Basic and special dosimetric quantities and units, dosimetry; (4) Ionizing radiation sources; (5) Biological effects of ionizing radiation; (6) Basic principles of radiation protection and safety; (7) Radiation protection of staff, patients and population; (8) Quality assurance. Practice is not included and discussion is not scored. We used to carry out the similar survey with the same questions before the COVID-19 pandemic, when only face-to-face trainings were conducted and during the COVID-19 pandemic, when online trainings were conducted. Comparative assessment of hybrid, face-to-face and online lectures showed that in most cases the number of points of assessments of each module in hybrid learning and the final grades are slightly higher than those in face-to-face and online learning. A total of 10 mandatory questions were provided after the completion of each module. Each question was evaluated with one point. Eight points or more means successful completion of the module. Currently hybrid training is still ongoing and the number of students who have completed a retraining hybrid course, is still relatively small and therefore the final results will be presented upon its completion (Figure 1).

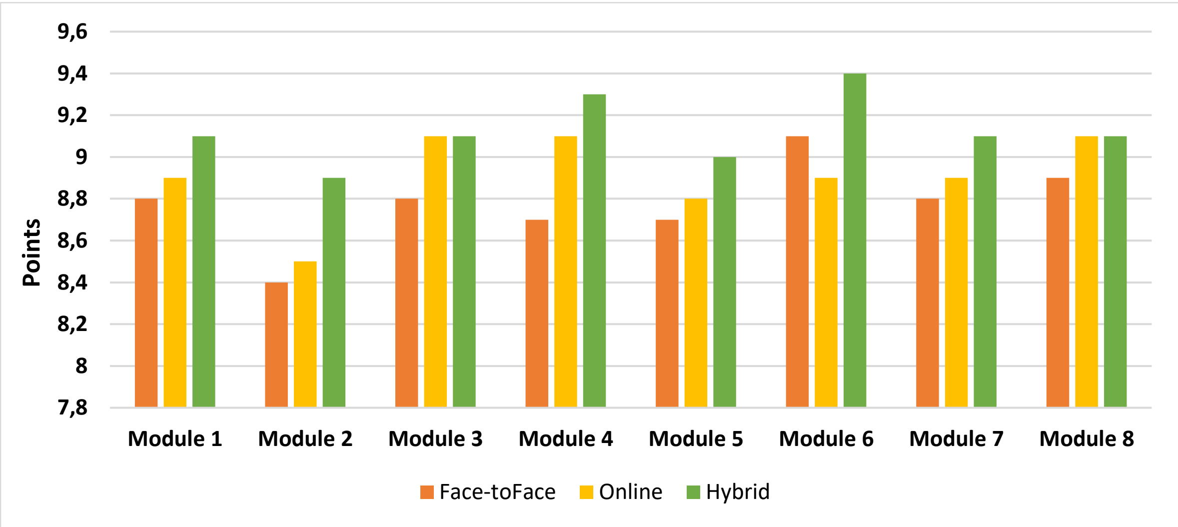

Figure 1. Comparative evaluation of face-to-face, online and hybrid learning according to modules
Module 1- Overview of International and National Legislation on Nuclear and Radiation Safety; Module 2- Fundamentals of Physics; Module 3- Basic and special dosimetric quantities and units, dosimetry; Module 4- Ionizing radiation sources; Module 5- Biological effects of ionizing radiation; Module 6- Basic principles of radiation protection and safety; Module 7- Radiation protection of staff, patients and population; Module 8- Quality assurance.

We also used student self-assessment to fully analyses and evaluate the effectiveness of hybrid learning. The trainees were able to evaluate the training as separate modules according to each topic mandatory test, as well as the effectiveness of the whole course using the final tests. The student could answer the following question during the final test: Do you think that your consciousness after taking a course in nuclear and radiation safety issues. The answer was possible in three forms: increased; significantly increased; not changed. Also, after completing each module, the question, how would you rate the increase in your awareness after completing the module, could be answered in three ways: Increased; Increased significantly; Unchanged (Figure 2).

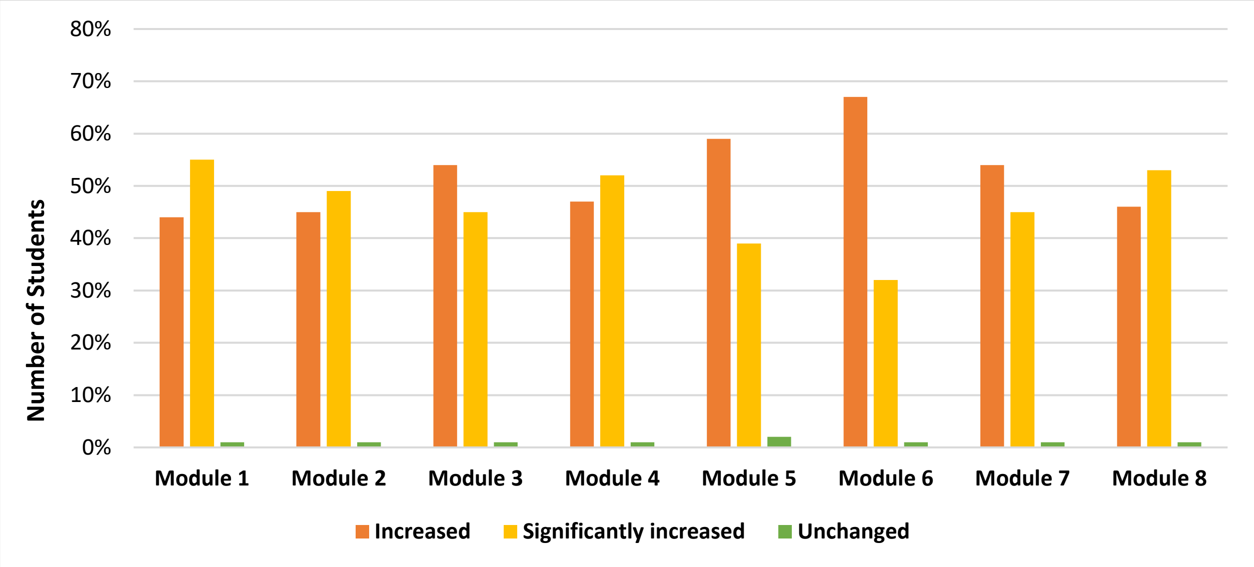

Figure 2: Hybrid learning students' self-assessment according to each study module
Module 1- Overview of International and National Legislation on Nuclear and Radiation Safety; Module 2- Fundamentals of Physics; Module 3- Basic and special dosimetric quantities and units, dosimetry; Module 4- Ionizing radiation sources; Module 5- Biological effects of ionizing radiation; Module 6- Basic principles of radiation protection and safety; Module 7- Radiation protection of staff, patients and population; Module 8- Quality assurance.

Compared to the self-assessment of online learners during the pandemic, the self-assessment of hybrid learners is slightly different, according to current data. Interviews with trained medical personnel during the renewed regulatory inspections, which were suspended due to the Covid pandemic, show that online and even more hybrid training is no less effective than fully face-to-face training. This may be considered as one of the indirect indicators in terms of evaluation of results.
It should be noted that the practical part of the classes also takes place in a hybrid form. In addition to the face-to-face form taking place in the host clinic, there is an online broadcast of a practical lesson and a recording, which allows students from other cities to be included in practical classes. If the current group of students is mainly from two large cities, then practical classes take place in both, and and, accordingly, there are two host clinics, and students choose which one to visit or can visit both. This greatly increases the experience, exchange of knowledge and information among listeners. [23,25]

4 Discussion

Both the advantages and disadvantages of online learning are well known and described many times in the scientific literature of recent years, many of the disadvantages were associated precisely with the lack of social relationships, personal participation and involvement, and teamwork.

Hybrid training is designed to eliminate precisely these disadvantages, as well as to introduce elements of e-learning into the training system, the lack of which was already observed in the pre-pandemic period when we used the full-time training system. Therefore, we can count on the fact that at least the introduction of a new system of education will improve the system of education. It is impossible not to note the increased understanding of the importance of the system of education and retraining among the students themselves. Our questionnaires, which our students have been answering since the post-pandemic period, also played a certain role in this, and, accordingly, many of them answered both as online students and face-to-face in the pre-pandemic period, and soon a certain number of students who have completed a hybrid training course will appear. Since, in accordance with international and national standards, trainings are held at regular intervals (every 3-5 years, depending on the position taken by the students), thus, unlike many other educational processes, trainings in the field of radiation protection for medical staff imply a certain cyclicality for the same students. In the future, this will make it possible to evaluate and compare the effectiveness of various forms of education for the same students in a new way. This approach can also help to obtain important information. [14,15,24]

5 Conclusions

Undoubtedly, the pandemic served as a certain trigger both for various education systems in the whole world, and, in particular, for training on radiation safety for medical personnel. It should be noted that today post-pandemic learning is a form of hybrid training, which will mainly be a kind of online learning, but incorporate the necessary elements of attending learning and e-learning. Today, already in the post-pandemic period, which, it seems to us, should be considered as an opportunity to consolidate and combine in practice a number of methods for teaching, as well as serving students, it is necessary to use and permanently improve a new training system and constantly search for new opportunities. A number of issues such as recording lectures, their availability, Internet resources and platforms, including in several languages to reach a larger audience, simulators, virtual reality, computer and digital software, etc. require certain financial and human resources and do not can be solved at once only by training providers relying only on their own capabilities. The development and unification of approaches and requirements for hybrid learning in the world could facilitate these processes and improve the possibility of obtaining additional funding both at the national and international levels, including within the framework of various projects.

In general, despite the above facts, there is a qualitative and systematic development of vocational training, which also implies the evolution of training providers and an increase in their effectiveness. [16-22,26,27]

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HYBRID TRAINING OF FIRST RESPONDERS FOR NUCLEAR AND RADIOLOGICAL EMERGENCY PREPAREDNESS AND RESPONSE IN LITHUANIA

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In Lithuania, great attention is paid to the preparedness of first responders in the case of a nuclear or radiological emergency, as a nuclear power plant is operating in the neighbouring country, just 20 kilometres from the Lithuanian border. To ensure adequate training, Lithuania therefore has legislation in place to regulate aspects of training for first responders. It would not be possible to adequately train a sufficient number of people in Lithuania in radiation protection by contact training only. Following an analysis of the advantages and disadvantages, a hybrid training method for first responders was chosen.

1 Introduction

In Lithuania there are no operating nuclear power plant or research nuclear reactors, but neighbouring country operates a nuclear power plant just 20 kilometres from Lithuania national border, which is classified as Emergency Preparedness Category (EPC) V (according International Atomic Energy Agency safety standards) [1]. An emergency at this nuclear power plant would have a major impact on Lithuania, that’s why it is very important to ensure adequate preparedness and response to potential nuclear or radiological emergencies. One of the most important aspects of ensuring first responders' (firefighters, police officers and emergency medical personnel) adequate preparedness and response to potential nuclear or radiological emergencies is radiation protection training. It is very difficult to train all first responders in radiation protection due to the lack of human resources (competent trainers), the different working hours of first responders, geographical location, etc. Also, in Lithuania radiation protection training is provided to personal health care workers, personnel from responsible institutions and other governmental or municipal institutions, agencies and member of non-governmental organisations (NGO) that have designated functions in the case of a nuclear or radiological emergency. Hybrid training is the best way to train all the necessary groups of personnel in radiation protection.

According to the Resolution of the Government of the Republic of Lithuania No 99 of 18 January 2012 "On the Approval of the State Plan for the Protection of the Population in the Event of a Nuclear or Radiological Emergency", first responders, personal health care workers, personnel of the responsible institutions and other state or municipal institutions and agencies, and members of non-governmental organisations (NGO), have their functions established in the case of a radiological or nuclear accident and that’s they need to be trained in radiation protection [2].

1.1 Compulsory remote training in radiation protection

In accordance with the Law on Radiation Protection of the Republic of Lithuania and the Order of the Minister of Health of the Republic of Lithuania No V-1001 of 22 November 2011 " On Issue of Radiation Protection and Physical Radioactive Sources Protection Training and Instructions", all first responders are obliged to undergo compulsory training in radiation protection and to repeat the training every five years [3], [4]. Radiation protection training focuses on preparing for and responding to nuclear or radiological emergencies.

They receive remote learning based on pre-prepared methodological material. This training is followed by an assessment of the radiation protection knowledge of first responders.

1.1.1 Compulsory remote radiation protection training for firefighters

Radiation protection training is an integral part of a firefighter's general training programme. Every year, several hundred firefighters and their managers have to undergo radiation protection training (Figure 1). They are self-trained through the Firefighters' School's remote training system, using pre-developed methodological material. The radiation protection training materials for firefighters and their managers are different (Table 1). Radiation protection training provides firefighters and their managers with information about ionising radiation, its biological effects, basic radiation protection, and how to prepare and respond in the case of a nuclear or radiological emergency. Also, the duration of radiation protection training for firefighter managers is shorter and consists only of basic radiation protection knowledge because they would not directly work in contaminated areas [4].

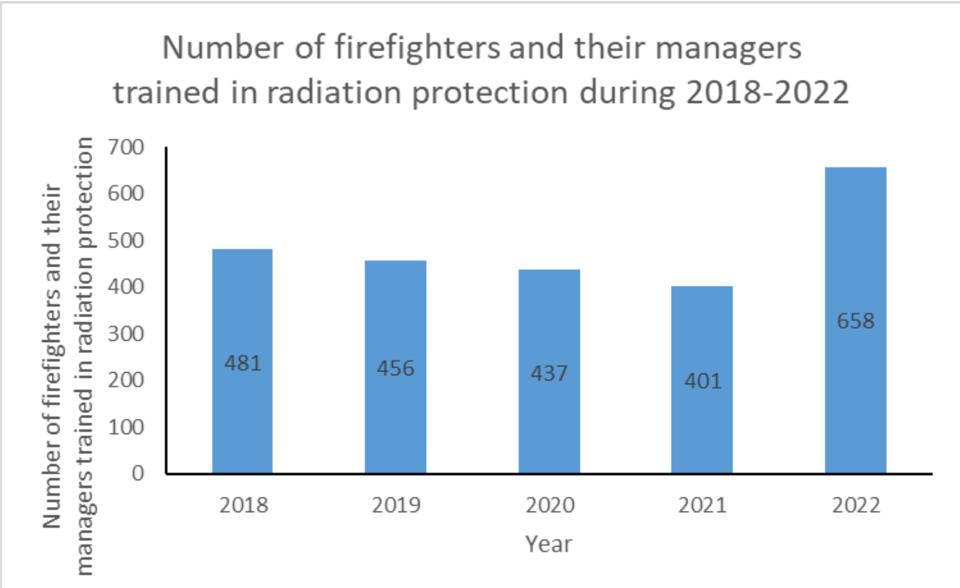

Figure 1. Number of firefighters and their managers trained in radiation protection during 2018-2022.

Table 1. Topics and duration of radiation protection training for firefighters and firefighters' managers.

Group of persons	**Radiation protection training topics**	**Duration of training (in academic hours)**
Firefighters	1. International and Republic of Lithuania legislation on emergency preparedness. 2. Functions, responsibilities and cooperation of Civil Protection System forces in case of emergencies. 3. The scale of the emergency problem and an overview of accidents. 4. The threat of terrorism using radioactive and nuclear materials. 5. Warning marking of radioactive sources (including during transport). 6. Biological effects of ionising radiation: causal and accidental effects. 7. Working in environments contaminated with radioactive substances. Principles of radiation protection. Selection,	8

	preparation and handling of measures to protect the health of exposed workers, dosimetric control. 8. Radioactive substances: their physical and chemical properties, protection against harmful effects. 9. Ionising radiation doses and their units of measurement, interactions with materials. 10. Emergency preparedness, response actions and planning by officers and employees of the Fire Protection and Rescue Department under the Ministry of the Interior and its regional fire rescue boards and their affiliated fire rescue services. 11. Ionising radiation measuring devices and their use. 12. External and internal exposure. Methods of decontamination. 13. Methods of sampling air, water, soil and vegetation and use of sampling equipment.	
Firefighters' managers	1. Introduction. Concept of radiation protection. Legislation on radiation protection. 2. Ionising radiation. 3. Biological effects of ionising radiation: causative and accidental effects. Types of doses and their units of measurement. 4. Orphan radioactive sources or objects contaminated with radioactive material, their identification and management.	5

After receiving radiation protection training, firefighters and their managers take a knowledge test remotely via the Firefighters' Radiation Protection Training System. The knowledge test consists of 30 test questions prepared by the Radiation Protection Centre. The test is considered to be passed when 70 percent of questions are answered correctly [4].

According to the legislation of the Republic of Lithuania, the number of trainees is limited per contact radiation protection training group, while the number of trainees in remote radiation protection training is not limited [4]. This allows a larger number of firefighters and their managers to receive radiation protection training at the same time. This also optimises human and material resources.

1.1.2 Compulsory remote radiation protection training for police officers

Police officers receive radiation protection training remotely by studying on their own using pre-prepared methodological material. The training covers preparedness and response in the case of a nuclear or radiological emergency and at least 6 academic hours. Police officers have less functions in the case of nuclear or radiological emergency than firefighters. Therefore, the scope of radiation protection training for police officers is smaller in terms of content and time. After the remote training, police officers take a knowledge test [4].

1.2 Contact radiation protection training

First responders, forces of the civil protection system, personal health care workers and NGOs receive practical and theoretical radiation protection training organised and delivered by radiation protection specialists from the Radiation Protection Centre.

Such training is conducted on a contact basis and priority is given to the first responders, forces of the civil protection system, personal health care workers and NGOs who would be working in municipalities within the extended planning distance (100 km) of a nuclear power plant in neighbouring country (Emergency Preparedness Category V) [1]. These training sessions include such topics: biological effects of ionising radiation, methods of protection against exposure to ionising radiation, the use of personal protective equipment, the use of dosimetric devices, methods of decontamination, etc.

The number of first responders, forces of the civil protection system, personal health care workers and NGOs trained in radiation protection is increasing every year. (Figure 2).

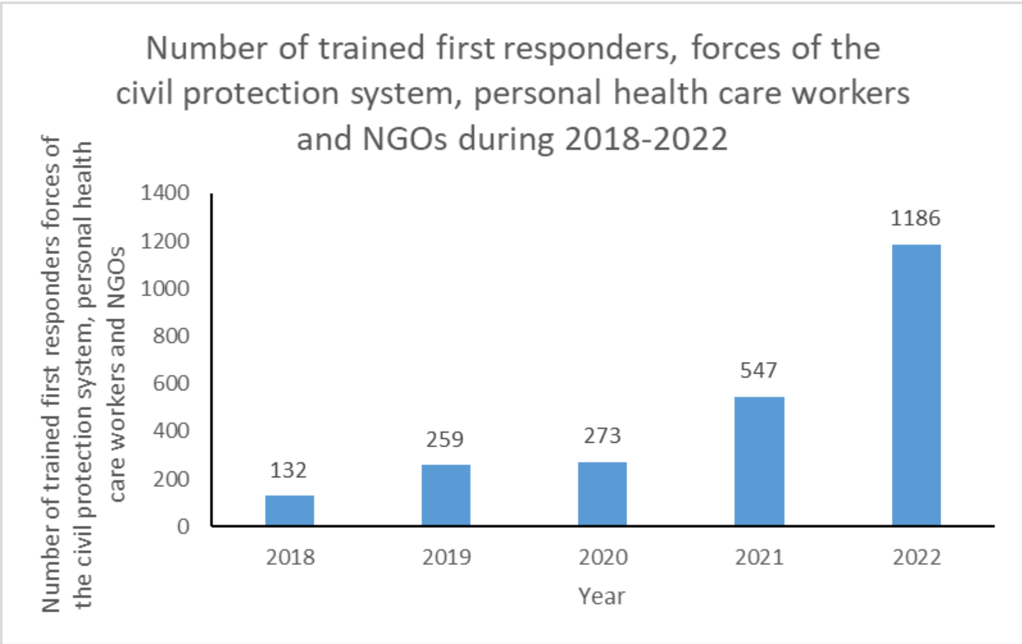

Figure 2. Number of trained first responders, forces of the civil protection system, personal health care workers and NGOs during 2018-2022.

1.3 Exercise of emergency preparedness and response

Exercises are essential part of preparedness and response to nuclear or radiological emergency, and allows to put to the test theoretical and practical skills received during hybrid (remote and contact) training. Various types of exercises (institutional, municipal, national) are organised annually in Lithuania and involve first responders, personal health care workers, personnel from responsible institutions and other governmental or municipal institutions, agencies and NGOs that have designated functions in the case of a nuclear or radiological emergency. In accordance with the Resolution of the Government of the Republic of Lithuania of 8 September 2010 on the Approval of the Description of the Procedure for the Organisation of Civil Protection Exercises, the following types of exercises are distinguished [5]:

- table-top exercise - a detailed discussion of the management of an case, emergency or situation described in the exercise description, in which the representatives of the participating entities of the civil protection system mutually refine, improve and coordinate response and recovery actions;
- functional exercise means an exercise between civil protection authorities to assess, improve and learn how to perform individual functions or procedures within the civil protection framework of these actors;
- complex exercise means an exercise designed to test and improve the capability of forces of civil protection system to manage a specific emergency situation.

The Minister of the Interior of the Republic of Lithuania approves the State-level exercise plan for 3 years. [5]. In accordance with this plan, annual exercises on preparedness and response to the nuclear emergency are conducted in Lithuania which vary both in scenario and type.

Since January of 2023, a new Law on Crisis Management and Civil Protection of the Republic of Lithuania has been adopted, which requires the participation of non-governmental organisations in exercises [6]. Since then, exercises involves first responders, personal health care workers, personnel from responsible institutions and other governmental or municipal institutions, agencies and NGOs.

The exercises are followed by an assessment, which identifies best practices and gaps to be corrected within a deadline set by the Minister of the Interior of the Republic of Lithuania. The results of previous exercises showed that first responders and the staff of the personal health care institutions are well prepared. This also suggests that the hybrid training is effective.

Before 2018 exercises on preparedness and response to the nuclear emergency were rarely organised at national level, but since 2018, exercises on this topic has become more frequent. In the period 2018-2022 alone, seven national-level civil protection exercises on preparedness and response to the nuclear emergency were organised, including four functional exercises (Figure 3).

Lessons learned are also reinforced in other exercises.

Figure 3. Moments from the 2022 state-level exercise.

1.4 Advantages and disadvantages of hybrid training

There is currently no comprehensive research on the advantages and disadvantages of hybrid training. Hybrid training is one of the most recent concepts in the teaching process and has many advantages over any other teaching methods. In this context, we have analysed the advantages and disadvantages from Radiation Protection Centre experience of hybrid training for first responders preparing and responding to nuclear or radiological emergencies.

Advantages of hybrid training:

- Theoretical knowledge of radiation protection can be delivered to dozens of first responders from different geographical areas at the same time;
- Due to their busy schedules, first responders are able to attend mandatory radiation protection training at their convenience.;
- Trainees have access to the prepared methodological material and can repeat it when needed;
- Hybrid training requires a relatively small number of competent lecturers.

Disadvantages of hybrid training:

- Not all learners thoroughly analyse all the methodological material provided to them;
- Limited opportunity to question the lecturer on any uncertainties;
- Not all learners take the test over remote in good faith.

Hybrid training of first responders in preparedness and response to nuclear or radiological emergencies has more advantages than disadvantages and is the most appropriate radiation protection training method in Lithuania.

2 Conclusion

Lithuania has an effective radiation protection training infrastructure for first responders. The radiation protection training infrastructure consists of legal basis, competent lecturers and well-chosen training methods. It is not possible to adequately train and prepare first responders by contact training only, so they are trained using a hybrid method. The analysis in section 1.4 "Advantages and Disadvantages of Hybrid Training" shows that hybrid training has a lot of advantages compared to other training methods. The effectiveness of the hybrid training is also verified by the results of the post-compulsory radiation protection training and various exercises.

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SELECTION AND EVALUATION OF LECTURERS FOR EEAE 's TRAINING ACTIVITIES

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The Greek Atomic Energy Commission (EEAE) is the national competent authority for radiological and nuclear safety. Among other activities, it provides and ensures the training in radiation protection and safety of occupationally exposed workers involved in practices with radiation sources. In this respect, EEAE implements a national strategy to identify and address education and training needs. This includes the design, development and conduct of appropriate training courses for different categories of occupationally exposed workers and professionals involved in radiation safety arrangements.
This work presents the procedures and the related criteria that EEAE applies within its implemented management system for the selection and evaluation of the lecturers supporting its training activities.

1 Introduction

The Greek Atomic Energy Commission (EEAE) is the national competent authority for radiation and nuclear safety and security, as well as for the protection of the public, workers and the environment from ionizing and artificially produced non-ionizing radiation. As education and training in radiation safety and the development of a safety culture are considered cornerstone for the establishment of an effective and sustainable radiation protection system, EEAE among other activities [1]:

- provides training in radiation safety to occupationally exposed workers involved in practices with radiation sources (e.g., medicine, industry, research, etc.) and professionals involved in radiation safety arrangements, and
- supports the creation and continuous enhancement of a safety culture at national level.

To fulfil its role, EEAE implements a national strategy for E&T in radiation safety and radiation protection, safety in the transport of radioactive materials and the safe management of radioactive waste. The strategy is based on the design, development and conduct of appropriate training programs to cover identified training needs at national level. For this purpose, the related IAEA methodology was applied [2], [3] which includes four steps:

a) the assessment of training needs,
b) the design of training programs,
c) the development and implementation of the training programs, and
d) the evaluation of the effectiveness of the training programs.

Currently, EEAE is finalizing the revision of this national strategy for E&T which concerns the period 2024-2030. For the assessment of the training needs at national level, related information and data included in the national database kept by EEAE were considered.

2 Training programs

The implementation of the training programs within the national strategy is achieved through the conduct of appropriately designed courses such as those presented in Table 1.

Table 1: Indicative list of training courses designed and conducted by EEAE

A/a	Training course
1	Radiation protection of patients and staff in image guided interventional procedures
2	Radiation protection in industry
3	Radiation protection in industrial radiography
4	Radiation protection of patients and staff in interventional cardiology
5	Detection and identification of radioactive sources
6	Radiation protection of outside workers (practices with medical exposure)
7	Radiation protection of nuclear medicine technologists
8	Special training for advisers on the safe transport of class 7 dangerous goods
9	Course for radiation protections officers in facilities using radioactive sources for geological studies, industrial, research and educational purposes, calibration, and metrological purposes
10	Course for radiation protection officers of practices operating radiation generators for security purposes
11	Radiation protection in veterinary medicine
12	Radiation protection in research applications with open radioactive sources
13	Radiation protection for industrial uses of nuclear gauges

For the conduct of its training activities, EEAE collaborates with national and international educational and research organizations and with professional societies. Moreover, these activities are fully supported by its experienced scientific personnel, and its state-of-the-art technical infrastructure. In addition, at national level EEAE is a participant and major contributor to the Interuniversity Programme for Postgraduate Studies in Medical Physics – Radiation Physics in Greece.
At international level, EEAE has been operating since 2003 as an IAEA's Regional Training Centre (RTC). Following its successful evaluation in 2008 and 2015 by an international team of experts - Education and Training Appraisal (EduTA) – EEAE was recognized by the IAEA as a RTC (in English) for the region of Europe and Central Asia on the safety in the use of ionizing radiation, transport of radioactive materials and management of radioactive waste. The relevant long-term recognition agreement was signed in July 2011, while its legislative ratification was completed in October 2012 [4].

The agreement:
- underpins the high competence level of EEAE personnel and the Greek scientific,
- certifies the country's expertise and leadership in E&T in radiation and nuclear safety, and
- strengthens the safety culture both nationally and internationally.

As an RTC, EEAE operates the Postgraduate Education Program "Radiation protection and safe use of radiation sources" (PGEC) [5], which provides education and training in radiation protection and basic safety principles. The 22-week program is co-organized and co-financed by the IAEA and concerns mainly young scientists from Europe and Central Asia. The successful implementation of the program is ensured by the contribution of educational and research institutions collaborating with EEAE, such as:
- the Medical Physics Laboratory of the Medical School of the National and Kapodistrian University of Athens,
- the Medical Physics Laboratory of the Department of Medicine of the University of Ioannina,
- the Department of Nuclear Technology of the National Technical University of Athens, and
- the National Centre for Scientific Research (NCSR) "Demokritos".

Since 2003, about 120 scientists from 30 European and Central Asia countries have been trained in the PGEC.

Furthermore, EEAE organizes international training seminars in radiation and nuclear safety. The seminars are attended by scientists and security officials from Europe, Asia, and Africa. It also hosts scholarships, scientific visits, and internships for foreign scientists in radiation safety, regulatory policies, dosimetry, calibration, and environmental radioactivity matters. So far, more than 660 scientists from 50 countries in Europe, Asia and Africa have been trained in EEAE.
In 2015 EEAE established its own e-learning courses based on the Moodle platform (http://edu.eeae.gr). In this respect EEAE is capable to support and complement the PGEC and the other specialized training courses with the necessary training capabilities. In addition, a blended learning approach is gradually adopted.

3 Management system

To ensure a continuous improvement in the quality of the learning services provided and for optimizing the available resources, EEAE has developed and implements a management system (MS) for the design, development, and provision of services of non-formal E&T based on the ISO 29993:2017 standard ("Learning services outside formal education - Service requirements"). The standard specifies requirements for learning services outside formal education, including all types of life-long learning (e.g. vocational training and in-company training, either outsourced or in-house). Moreover, it defines the requirements for the design, development, and provision of educational services, by entities operating, mainly, outside of primary, secondary, and higher education.
The MS is implemented in the framework of EEAE's integrated management system (IMS) which is based on the ISO 9001:2015 standard. For the development of the MS the following standards were also considered:

- ISO 9000:2015 "Quality management systems – Fundamentals and vocabulary",
- ISO 9004:2018 "Quality management - Quality of an organization - Guidance to achieve sustained success",
- ISO 15489-1:2016 "Info & Documentation – Records Management" (Part 1: Concepts and principles)
- ISO 30300:2020 – Records management – Core concepts and vocabulary,
- ISO 30301:2019 – Management systems for records – Requirements,
- ISO 30302:2022 – Management systems for records – Guidelines for implementation, and
- ISO/TR 21946:2018 – Information and Documentation – Appraisal for managing records.

4 Selection of lecturers

The MS implemented for EEAE's training activities includes a procedure describing the methods which are applied by the Directorate of Training, Regulatory Policy, Infrastructure and Research of EEAE for selecting, maintaining the capacity of and determining the obligations of the lecturers participating in the training activities.
For the training activities, the Directorate selects lecturers who have the qualifications and competence to manage the tasks assigned to them. The selection is carried out by a specialized EEAE's committee based on:

- the evaluation of their CVs,
- their educational qualifications,
- their certificates and other documents confirming skills and knowledge, as well as letters of recommendation,
- the evaluation of their work experience in areas related to the subject to be taught,
- the evaluation of their training experience,
- interviews,
- their evaluation by an already appointed partner or EEAE representative during their participation in a training activity.

5 Training of lecturers

Before their first participation in training activities, the new lecturers are trained by EEAE's personnel in the principles and procedures of the implemented MS and provided with the necessary material (documents, forms, etc.) In addition, the head of the Directorate appoints an EEAE member to update the lecturers about the MS requirements and the available training material for the thematic areas to be addressed.

To maintain the training capacity, the lecturers' training needs are assessed by an EEAE's committee on an annual basis. The training of the lecturers' mainly takes place through their participation in training programs (within and outside EEAE) concerning:

- their ability to support new training activities,
- changes in legislation, regulatory requirements, training methods, and new technologies,
- changes in the training material of the established activities, and
- EEAE's MS requirements.

6 Evaluation of lecturers

The evaluation of the lecturers participating in EEAE's training activities is part of the evaluation of each training course, according to the related MS procedure. For this purpose, a dedicated questionnaire is used. The first part of the questionnaire addresses issues related to the organization of the training course and the respective training material (Table 2), while the second one the evaluation of the lecturers (Table 3). In case of online seminars, the questionnaire is distributed to the participants in an electronic form using one of the available online tools, such as Survey monkey, Google forms, etc.

Table 2: Questionnaire for the evaluation of the organization, conduct, and training material of EEAE's training courses

Title of training activity:
Date and place:

Circle the number corresponding to your opinion for the seminar: (1= fully disagree, 2= disagree, 3= neutral, 4 = agree and 5= fully agree)

1	The seminar was well organized	1	2	3	4	5
2	The goals of the seminar were accomplished	1	2	3	4	5
3	The seminar was useful for my general update	1	2	3	4	5
4	The tutorial was useful for the subject of my work	1	2	3	4	5
5	The seminar helped me to understand the challenges I face in my work	1	2	3	4	5
6	The seminar helped me to be more effective in my work duties	1	2	3	4	5
7	I would like to participate again in a similar seminar	1	2	3	4	5
8	I would recommend my colleagues to attend the seminar	1	2	3	4	5

The duration of the seminar was**:**

Too long:	Long:	Appropriate:	Short:	Very short:

The level of the seminar regarding your knowledge, skills and professional experience was:

Too low:	Low:	Appropriate:	High:	Very high:

Evaluate the training material regarding: (Scale 1-5)

1	Structure	:
2	Presentation	:
3	Correctness of content	:
4	Completeness of material	:

Table 3: Questionnaire for the evaluation of lecturers in EEAE's training activities

Evaluate the lecturers using the scale 1-5 (1=not effective, 2= moderate, 3= good, 4=very good, 5=excellent)

	Score					
Lecturer *(alphabetic order)*	Preparation of lecturer	Contagiousness of the lecturer	Adequacy of presentation	Encouraging dialogue & questions	Motivating & maintaining the interest of trainees	Breadth of knowledge
....	....	....	....	....	....	....

Moreover, the adequacy of the lecturers' competence is ensured through their annual evaluation. The evaluation is based on data from their participation in EEAE's training activities and related reports from designated EEAE staff. Should a lecturer's performance does not meet the corresponding criteria set in EEAE's MS his/her replacement in the EEAE's list of approved lecturers is considered.
Currently, 13 lecturers are involved in EEAE's training activities. All of them were evaluated based on Table 3 questionnaire. The average score for the 6 evaluation categories ranges from 4.3 to 5. This result indicates that the high quality of the selected lecturers and the effectiveness of the related MS procedure.
Lowest evaluation scores concern the contagiousness of the lecturers and their capability to encourage dialogue & questions. However, it should be stressed out that the majority of these scores concern the pandemic period when training was mainly provided online. This indicates that the lecturers' skills in online training should be further improved. An option is their participation in appropriately Train the Trainers courses. It should be also emphasized that the number of the courses conducted during the pandemic period was limited, as well as the responses to the on line form of the evaluation questionnaire.
In the light of the above, EEAE could further improve the lecturer's evaluation capabilities by using the available tools in the Moodle platform. This will facilitate the implementation of a more homogenized and effective evaluation approach and allow the continuous and reliable analysis of the collected data. Furthermore, the platform could be used for the follow up of trainees of past courses in order to assess the added value of the training programs to their professional activities.

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DEVELOPMENT OF A RADIATION PROTECTION HYBRID TRAINING PLAN FOR THE STAFF OF THE NEW PROTON THERAPY FACILITIES

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Proton therapy has growing potential in dealing with some tumors and in the last decade proton centers are growing fast across the world, with a forecast that will double by next five years. The advent to Spain was very recent, with a first PTC operating from December 2019, and the second in April 2020. A third centre, the first of Public Health System, is under construction, and, finally, in August 2022, was announced the building of ten new proton therapy rooms for the Public Health System, thanks to a donation of 280 million euros from the Amancio Ortega Foundation. This scenario highlights the need to train professionals in radiation protection in these facilities, therefore, the main objective of this project is to develop a proposal on training in operational radiation protection in proton centres. The training plan will be developed in a hybrid way, with activities followed remotely, mainly the lessons in fundamentals on radiation protection, others carried out in person at the laboratory of nuclear technology, and finally, in a third stage, activities in situ inside a real proton center. Training plan will be based on evaluating competences and capabilities rather than on the qualifications. Asynchronous lessons and learning platform, 60 learning hours in two weeks. Training plan will be certified within the national health system. Main topics on radioprotection in PTC, from technology to legal requirements and challenges on new delivery modes, future developments, and CPTC. The training plan will be developed at national and international level.

1 Introduction

1.1 Motivation

Proton therapy is a radiotherapy modality, especially indicated for the treatment of pediatric cases, young people, and tumors hardly accessible, being the most precise and advanced technology available to fight against cancer nowadays [1]. Proton therapy significantly reduces the unnecessary dose in healthy tissues, which is especially beneficial when treating childhood cancer with long life expectancy, diminishing probabilities of secondary tumor appearance. In addition, it is an effective alternative for tumors where conventional radiotherapy is not effective, and surgery is not an option [2].

These benefits of proton therapy in some treatments have led to an exponential growth in proton therapy centers worldwide, and a significant expansion of proton centers under development, with slightly more than one hundred in operation nowadays, and over fifty new projects at different stages of execution. Forecasts estimate that current number of proton centers will double by next five years [3].

Based on International Basic Safety Standards and Regulatory Principles [4], main radiological risks in proton centers (PTC) have been widely stated in several research works [5], and are summarized in international guidelines and standards [6], [7]:

1. External exposure to secondary radiation yielded by interaction of protons in beam elements and patients, neutrons and photons, however, the main concert are neutrons.
2. External exposure from activation of technical equipment, shielding, materials of barriers, and ambient (mainly water, air and soil).
3. Internal exposure for inhalation of radioisotopes in activated air, or in dust of mechanical elements, in maintenance operations.

Despite its more than sixty years of existence, the advent of proton therapy to Spain is very recent, with a first center in operation since December 2019, and the second one since April 2020, both private investments [8]. A third center of the Public Health System in this case, is under construction in the north of the country, in the city of Santander. Finally, in August 2022, the Ministry of Health announced the acquisition of equipment for ten new proton therapy rooms for the Public Health System, thanks to a donation of 280 million euros by a private foundation. With the incorporation of these new proton therapy facilities, the situation of the Spanish healthcare system will be remarkable around the world. Spanish healthcare will be at the forefront of technology, and each year thousands of patients will be able to be treated near their place of residence [9]. This process is collected in Figure 1.

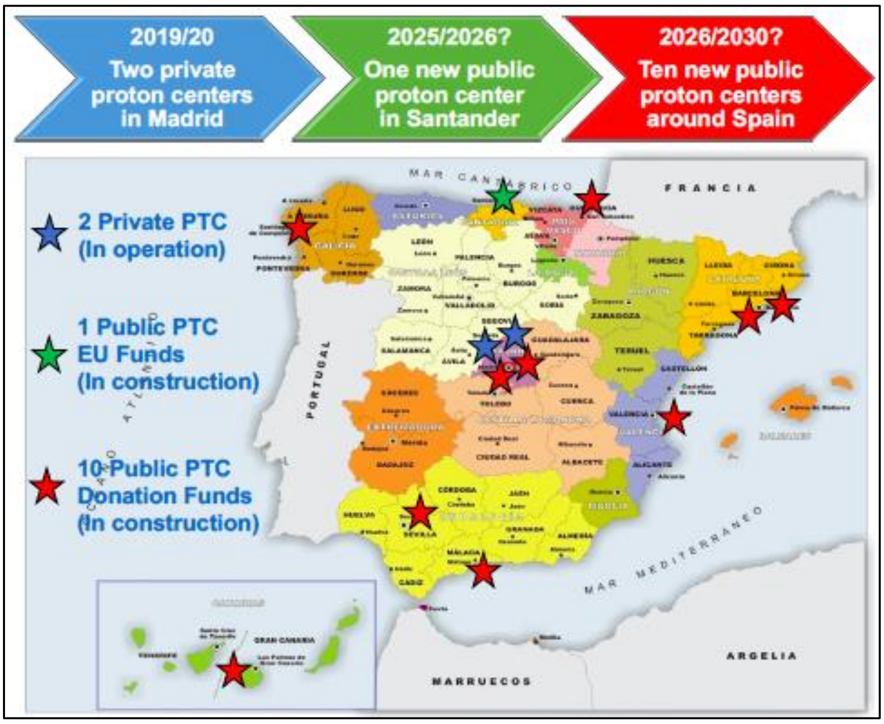

Figure 1. The advent of proton therapy to Spain [10]

Although the requirements of proton centers are very demanding in terms of radiation protection, proton therapy is in continuous ever evolving to improve its performance. Current trends are the renovation of primaries large multiple room proton therapy centers, the use of cutting-edge delivery methods [11], or to build small compact facilities, as those planned for Spain [9]. There is a current general trend to reduce the size of proton therapy centers to decrease the investment, with the final hypothetical goal of matching the size of proton therapy rooms and conventional photon radiotherapy rooms [12]. The final objective is to achieve more affordable proton facilities, since it is estimated that currently only 1% of patients receive proton therapy, when, if they could have access, between 15% and 50% could benefit from these treatments. The reason is the high capital cost of proton equipment [13].

Developments have a direct impact in radiation protection of proton facilities. Compact Proton Therapy Centers (CPTC), act out latest advances in particles therapy and have specific features to reduce their size while achieving more affordable facilities. From the point of view of operational radiation protection, CPTC face significant challenges [14]:

1. Usually have one single room (sometimes two) and small footprint.
2. They have a higher radiation density (Sv/m^2).
3. They have a standard geometry and configuration elsewhere.
4. There is an intensive use of new materials and technology.
5. They use the most advanced equipment and machinery to reduce their size.

6. The delivery mode of protons is *Pencil Beam Scanning* (PBS).
7. There is a mix of professional exposed workers (clinical and technical staff).

The evolution and current trends in proton therapy technology is resumed in Figure 2.

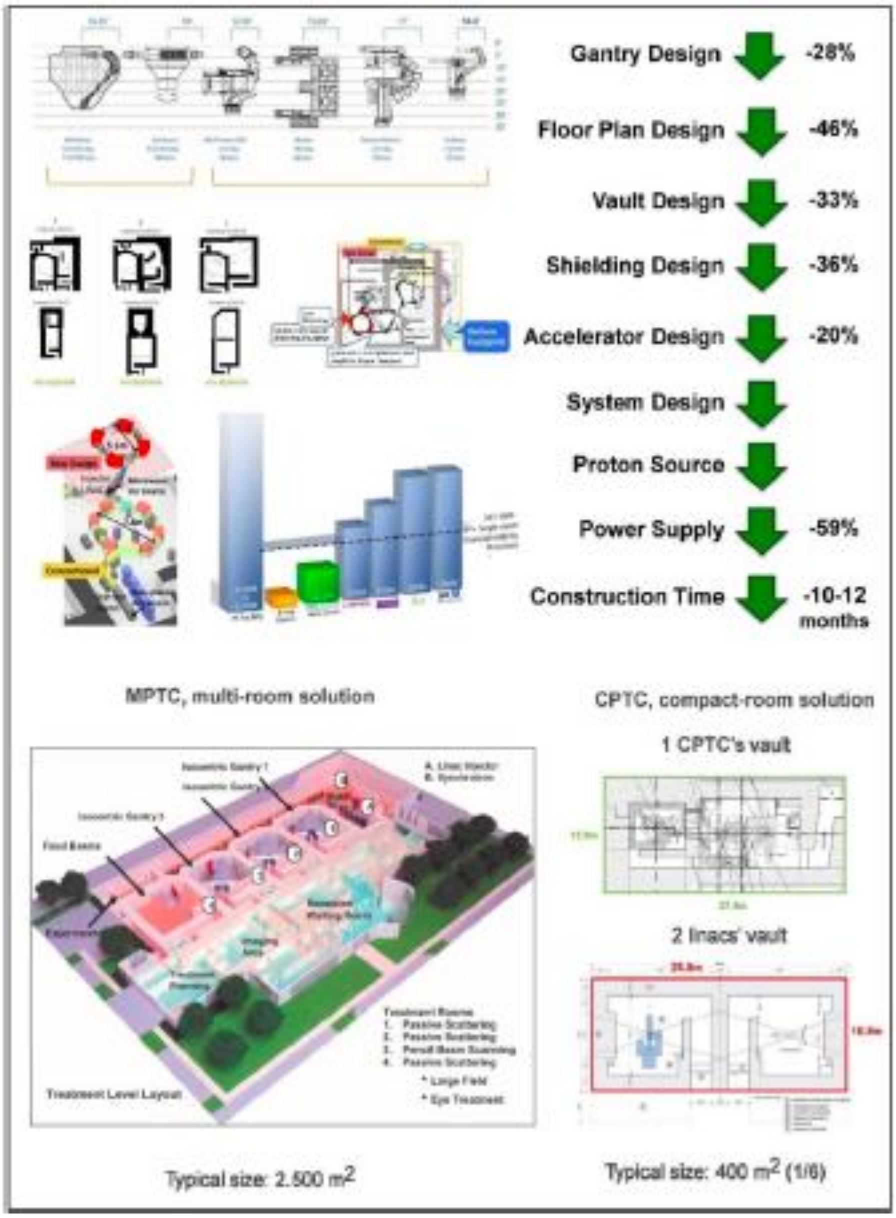

Figure 2. Evolution in the size of proton therapy centers [10]

1.2 Purpose

Considering the knowledge that supervisors and technical team, as well as the staff and people of clinical teams, must have and know to operate the facility safely, in terms of radiation protection, the main goal of this project is to develop a training plan specifically focused on operational radiation protection in proton therapy centers. In these facilities there are two different areas of work involved in radiation protection, therefore, there will be a specialization depending on the profile of the professional.

Since these professionals must carry out the training simultaneously with their regular work for the health system, the training plan will be developed in a hybrid way, with activities followed remotely and asynchronous lesson. After that, a second group of activities linked with radiation measurements, must be carried out in person at the laboratory of Nuclear Technology of UPM (LTN-UPM). Finally, in a third stage, the training will be completed with activities in a proton center quite similar to which they are going to work in the future. The training plan will be based on evaluating the radiation protection competences and capabilities of the teams, rather than on the qualifications.

2 Trainees and trainers

The training is oriented to the staff responsible for the radiation protection of proton therapy centers, both on the health area and on the technical side, considering the two task forces present at the facility.
Trainers will be Radiation Protection Expert (RPE) following the Basic Safety Standards of EURATOM [15], and the European guidelines on medical physics expert [16].

3 Main topics in the training course

The syllabus of the course will include the main topics on radioprotection in PTC:

1. Technology in PTC.
2. Physics foundation of proton therapy.
3. Sources of radiation in PTC.
4. Basic in shielding
5. Ambient detection.
6. Personal dosemeters.
7. Activation of shielding, mechanical elements and ambient.
8. Operational radiation protection.
9. Legal requirements.
10. Challenges on new delivery modes, future developments, and CPTC.

Regarding point ten, is important to highlight that several new delivery modes are under investigation, such as Proton Flash Therapy (PFT), an emerging technique with significant interest and a great potential to revolutionize radiotherapy, by targeting an increase in the therapeutical Index (TI) due to the biologic advantages of reduced normal tissue complications through the tissue-sparing flash effect. Other methods under study are Proton Monoenergetic Arc Therapy (PMAT), and Proton Minibeams (PMB) [11]. In any case, changes and developments in technical systems and equipment of proton therapy facilities always have an impact on the generation of secondary radiation, sometimes reducing it, and others just the opposite, elsewhere, it should be necessary to develop a suitable methodology to assess the impact of new delivery methods on radiation protection [17].
A key aspect with radiation treatments is the method use to deliver the dose, since generation of secondary radiation is highly dependent on the elements used in the line and nozzle to shape the tumor. In proton therapy and charged particles radiotherapies, the target volume is covered by the transverse and longitudinal Spread-Out Bragg Peaks (SOBP). With passive systems, this is accomplished by combining some metallic and plastics elements as scatterers, range shifter, collimator and SOBP modulator, with the result of generating a large amount of secondary radiation, and unnecessary exposure to normal tissues.

With active methods, using Pencil Beam Scanning (PBS), the target coverage is achieved by scanning the beam laterally, in x and y axis, respectively, and delivering spots at a given depth, in consecutive layers of different energy, from the distal to the proximal, until the irradiation of the whole volume. The cornerstone of current active methods is IMPT, Intensity Modulated Proton Therapy [2].

4 Methodology and planification

The training plan will be developed in a hybrid way, with asynchronous activities and a second group in person, about radiation measurements, at the laboratory of nuclear technology of UPM. LTN-UPM, and finally, in a third stage, in a proton center quite similar as they are going to work in the future.
The basic theory and foundations will be developed online, through asynchronous lessons and Moodle learning platform (modular object-oriented dynamic learning environment).
The training plan will be developed in 60 learning hours in two weeks and will be certified within the national health system.
Main planification and activities of the training course are summarized in Table 1

Table 1: Main topics of the course in radiation protection in proton therapy centers

Topic	Time (h)	Asynchronous Lessons	Laboratory	Proton center
Technology in PTC.	2	Yes	No	No
Physics foundation of proton therapy	2	Yes	No	No
Sources of radiation in PTC.	2	Yes	No	Nos
Basic in shielding	2	Yes	No	No
Ambient detection.	2	Yes	Yes – 6 h	Yes – 6h
Personal dosemeters.	2	Yes	Yes – 4 h	Yes – 4h
Activation of shielding, mechanical elements and ambient.	2	Yes	Yes – 4 h	Yes – 4h
Operational radiation protection.	2	Yes	Yes - 4h	Yes – 4h
Legal requirements.	2	Yes	No	No
Challenges on new delivery modes, future developments, and CPTC	2	Yes	No	Yes – 4h

5 Facilities for practical training

The facility to develop the practical stages on radiation measurements will be the Laboratory of Nuclear Technology at UPM {18]
Some activities and radiation devices are collected in Figure 3.

Figure 3. Main elements and radiation measurement devices at LTN-UPM [19]

The radiation and neutron devices have been characterized in previous works [19]. Considering that the radiation protection system is under revision, the impact of new proposed protection quantities from ICRU 95 [20] will be considered in the training

The facility to develop the practical stages on training in proton therapy will be a CPTC similar to those under development in Spain [14].

The main elements of proton centers for the training are shown in Figure 4.

Figure 3. Main elements of proton centers for training [17, 19]

6 Expected results and main conclusions

1. The scenario foreseen, both in Spain and worldwide, highlights the need to train professionals in radiological protection in proton therapy facilities.
2. The training plan proposed will be developed in a hybrid way, with activities followed remotely, others carried out in person at the laboratory, and finally, in a third stage, activities in situ inside a real PTC.
3. The training plan will be developed at national and international level.

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