UNIVERSITÉ DE LIÈGE
FACULTÉ DE MÉDECINE

Training in Radiation Oncology in Europe: Current status and perspectives

(FORMATION EN RADIOTHÉRAPIE ONCOLOGIQUE EN EUROPE : SITUATION ACTUELLE ET PERSPECTIVES)

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*À Ludovica Beya,
Emilio Omar et Louis
Ismaël, mon amour
inconditionnel.*

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Introduction, aim and structure of the work

Introduction

Teaching radiation oncology to medical students in Europe

Cancer represents a significant obstacle to the global effort to extend life expectancy and is among the leading causes of mortality worldwide [1, 2].

Used for approximately half of cancer patients, Radiotherapy (RT) is a pillar of multidisciplinary cancer care as it enhances local control, survival, and quality of life[3, 4, 5]. Based on projected cancer distributions in 2025, a 16% increase in the number of RT treatment courses was anticipated[6].

Although RT is one of the corner stone of the treatment of a significant number of oncology patients, it appears that general practitioners and other specialists do not receive adequate exposure to critical aspects of oncology and radiation oncology (RO) during their medical education[7, 8, 9]. In contrast to medical oncology, this deficiency in training pertaining to the curriculum taught in medical schools is even more critical for RO[10]. In their analysis of the curricula of 49 medical schools in the United States, Mattes et al.[11] found that faculty participation in curricular educational sessions on oncology-related topics was reported by only 41% of departments, with 25% of these sessions being specifically dedicated to RO.

Insufficient instruction in RO during the medical school curriculum may result in suboptimal patient care, insufficient evaluation of the potential adverse effects of combined oncology treatments and RT, and strained communication among palliative care physicians, treating physicians, radiation oncologists, and medical oncologists[12].

Limited research has been conducted over the past decade regarding the potential advantages of exposing medical students to RO during their time in medical school[13].

These initiatives were taken to encourage medical students to take more interest in RO and to play an effective role in the multidisciplinary management of a cancer patient.

Unlike in the USA[14, 15, 16] and in Canada[17, 18] for instance, data and efforts regarding the implementation of a RO curriculum for medical students[19, 20] are extremely limited in Europe.

An educational curriculum in Europe pertaining to RO has been exclusively designed for physicists, Radiation Therapists (RTTs), and Radiation Oncologists (ROs); medical students are not included in these curricula[21, 22, 23].

Training of radiation oncology professionals in Europe current status and developments

A recently published study by Bibault et al.[24] on RO training of ROs, RTTs and medical physicists showed that :

- The European Society of Therapeutic Radiation Oncology (ESTRO) Core Curriculum (ECC)[25] has moved towards a competency-based approach, replacing a knowledge-based training with competencies.

- Most participants did not know whether the ECC had been introduced in their country for physicians, physicists and RTT.

- Participants indicated that the most important aspect of their training is practical skills. They prefer practical training rather than theoretical knowledge. This underlines and supports the competence-based approach that ESTRO and the Union of European Medical Specialists (UEMS) is taking with the ECC.

- More than a quarter of the participants in this study felt that the national curricula were inadequate. This is a very worrying issue and, again, the use of the ECC could help improve these curricula.

- One of the most important obstacles was the lack of time. Students find it difficult to combine theoretical teaching with practice, research, administrative tasks and teaching less experienced colleagues/students. This is also reflected in the low percentage of participants who described themselves as rather satisfied with their time (35%).

- In addition, lack of team spirit (22%) was seen as another obstacle to an effective teaching.

Teaching and assessment methods

In Europe, there is no data describing how RO courses are delivered in medical schools, e.g. whether there is web-based teaching such as e-learning or podcasts, or whether educational technologies such as simulation-based medical education (SBME) are used.

The assessment of RO knowledge in undergraduate teaching is also unknown.

In terms of postgraduate training, we know that more web-based teaching and educational technologies are being used in Europe to make learning in radiation oncology more practical, the ESTRO School has invested in the area of simulation-based medical education (SBME) with FALCON (Fellowship in Anatomic deLineation and CONtouring)[26], a delineation platform, which has significantly reduced the differences in delineation.

In the USA, for example, where there is more data on this topic, it has been published that there are a lot of web-based learning resources available[27], Most of these resources are accessible to everyone after a subscription.

Nevertheless, these innovative learning methods are generally used to teach technical skills[28, 29], although the importance of non-technical skills is emphasized in the UEMS/ESTRO Core Curriculum (ECC).

When it comes to the assessment of residents knowledge, unlike other specialties[30, 31], there is no European RO exam.

From the study by Benstead et al[32], we know that training in RO in Europe is regulated by a logbook system in 81% of countries and that 82% of countries have a formal examination, but we lack knowledge about how the continuous assessment of residents or the examination is organized in each country in terms of the type of examination and the knowledge assessed.

This project was thus born out of a curiosity to gain a deeper understanding of RO training in Europe, encompassing both medical schools and residency training. Subsequently, an attempt was then made to formulate perspectives for the possible further development of this training in terms of teaching methods and content.

Aim of this work

The aim of this work was first to review the current state of training in RO for medical students and residents in Radiation and Clinical Oncology (RO/CO) in Europe.

A similar study was then done in our study population, professionals in RO working in the Greater Region, as we were joining the Interreg NHL-CHIREX project[33].

Secondly, we conducted a thorough analysis of incidents and safety-related events (SREs) in a radiation oncology department in the Greater Region to identify important elements that could be included in an innovative curriculum for radiation oncology.

Thirdly, we set up and tested an innovative curriculum based on radiation oncology incidentology and SBME within our study population in the third part of this work.

Structure of the work

This work is based on three successive axes:

1. Current status of training in radiation oncology in Europe

We first explored the means by which medical students (Chapter 1) and residents in radiation and clinical oncology in Europe (Chapter 2) are taught radiation oncology.

Then, as the radiation oncology department of the university hospital of Liège joined the Interreg NHL-CHIREX project, we interviewed radiotherapy professionals working in the centers and universities participating in the Interreg NHL-CHIREX project, in order to obtain a complete overview of the state of this training, its strengths and weaknesses, and thus identify its current contours in the Greater Region (Chapter 3).

This first step seemed fundamental to us in order to identify the existing elements on which we can design a practical teaching program.

2 . Incidentology to highlight relevant knowledge and skills

In the second part of our work, we have focused on the detailed analysis of SREs (Chapter 4): reported incidents (and near miss) in radiotherapy. The analysis carried out in this area focused not only on the technical aspect of these incidents, but mainly on the part related to malfunctions involving human factors. Indeed, the experience gained in industry, especially in aviation, but also in medicine (especially in acute care and in areas where interdisciplinary work is carried out) has shown that such factors play a role in almost 80% of incidents in the clinical field.

In addition to the epidemiological value and the expected safety gain for our healthcare systems, this analysis allowed the recording and creation of a series of realistic scenarios that could be used in the training modules developed.

3. Towards a relevant educational technology based practical training program

Based on the data collected in the two preliminary stages, we developed practical training modules, using educational technology to develop a practical simulation based medical training using different types of simulations (Chapter 5).

Once these tools were developed, our approach was to evaluate the specific contribution of SBME in a team of radiation oncology professionals from the Greater Region.

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Chapter 1
The status of radiation oncology (RO) teaching to medical students in Europe

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1. Abstract

Aim

To provide an overview of Radiation Oncology (RO) teaching to medical students around Europe.

Materials and methods

An electronic survey was sent to European academic teachers of RO. The survey focused on the teaching of RO to medical students throughout their undergraduate education.

Results

A total of 87 academic RO teachers from 29 countries were invited to participate in the electronic survey. Thirty-two surveys were completed by respondents from 19 European countries (response rate: 37%). The median number of hours devoted to RO teaching was 10 h (mean 16 h, range 2–60). The number of hours assigned to RO teaching was equal or inferior compared to medical oncology. In two institutions (6%) RO was delivered as a stand-alone course with an individual knowledge assessment. In 30 institutions (94%), the RO course was taught and/or assessed in a modular curriculum with other disciplines. Radiobiology, breast, lung, gastrointestinal, gynecologic malignancies, RO adverse events and palliative RO were taught in 80% of institutions. Pediatric RO, RO for benign conditions and economic topics were taught in less than 30% of institutions. In most institutions, classical written and oral examinations were used. Computer-based examinations and/or objective structured clinical examinations (OSCE) were seldom used. E-learning methods were available in less than 10% of institutions. A clerkship in RO department was available in 28 out of 32 institutions (87%), less than 5% of medical students were involved in research in RO during their undergraduate education. Strategies to encourage medical students to consider RO as a future career were offered in 53% of institutions.

Conclusions

RO teaching to medical students was not uniform in Europe. RO teaching during undergraduate education in Europe was undervalued, and its knowledge and learning tools could be broadened and updated in the core curricula of medical students.

2. Introduction

In the last decades, the overall rate of cancer diagnoses has steadily been increasing worldwide. Cancer is the second cause of death after cardiovascular diseases. Approximately 3.4 million of individuals were diagnosed with cancer in Europe in 2012 (excluding non-melanoma skin cancer).

At that date, about 80% of those patients were resident in the European Union countries[1]. Almost 50% of patients who have cancer undergo radiotherapy[2]. Tailored treatments are currently being implemented to reduce the adverse effects related to radiotherapy treatment[3, 4]. Radiotherapy has been proven a valuable and cost-effective option in both curative treatment and palliative care[5, 6, 7].

Surprisingly, despite the high number of patients treated with radiotherapy, primary care providers and other specialists are scarcely exposed to RO during their undergraduate education[8, 9, 10, 11, 12].

This lack of education in RO during the undergraduate education was even more concerning than in medical oncology[13].

In a recent article, Mattes and al. analyzed the core curriculum of medical students of 49 different academic institutions in the United States. This survey revealed that only 41% of these institutions declared a faculty participation in educational sessions for medical students focusing on specific oncology topics.

Moreover, 25% of these sessions were specifically dedicated to RO[14]. This insufficiency of education in RO during undergraduate curriculum may lead to inadequate patient management, an undervaluation of the toxicity of treatments, a suboptimal communication between patients and general practitioners, radiation oncologists, medical oncologists and palliative or supportive care specialists[15].

As a consequence, recent publications have focused on the potential interest of increasing medical student exposition to RO during their undergraduate education[16, 17, 18, 19, 20, 21, 22], even if the real impact of RO teaching to medical student to lastingly improve their clinical skills is a matter of debate[23].

These studies were designed by RO academic teachers and addressed to medical students to assess different structured core curricula[24, 25, 26].

These initiatives were undertaken to encourage medical students to focus their interest in RO and to develop the skills required to play a useful role in the management of oncologic patients in a multidisciplinary environment.

Unlike USA[27, 28, 29, 30, 31], Canada[32, 33], Australia and New Zealand[34], in Europe data regarding the teaching of RO to medical students was very limited[35, 36].

A European core curriculum implementation initiative was developed only for clinicians, medical physicists and technologist in RO, but not for medical students[37].

In addition, as reported for other related disciplines in Europe, significant differences between the health care systems and medical school curriculum may result in substantial differences of RO teaching amongst European countries[38].

The present survey, addressed to academic teachers of RO was designed to provide an overview of RO teaching to medical students in Europe and to provide a preliminary database to be used, in a second step, to build a pilot reference core curriculum in RO for European Universities.

3. Materials and methods

Survey design

The survey was designed to be addressed to academic radiation oncology teachers to investigate how RO was taught to medical students in their institutions.

A cluster 19-item questionnaire was developed and transposed in an electronic format using a commercial software (*Survey-Monkey, http://surveymonkey. net*) (Survey provided in Annex 1).

The questions were targeted to evaluate critical items including:

1 — the duration of medical and RO training;

2 — the details of the RO curriculum content;

3 — the role of other professionals (e.g. physicists) involved in RO teaching;

4 — the availability of an e-learning program;

5 — the availability and the features of clerkship in RO departments;

6 — the presence of a program to involve medical students in research in the field of RO;

7 — the presence of a policy to orient medical students towards RO as a career option.

Input fields were made of closed or non-narrative open-ended response to capture accurate standardized answers[39].

Besides, narrative open answers were possible for all of the questions to voluntarily provide additional details on a particular question and/or answer in a narrative format.

Respondents were given the possibility to save and complete the survey later, to allow participants to complete responses after verifying the corresponding information, if needed.

Survey participants selection and survey diffusion

The questionnaire was built by the main author (SBM) on basis of previous articles addressing the same topics for other medical disciplines. Those articles were extensively cited through the manuscript. In order to assess the face validity of the survey, the first draft was sent to a panel of three academic radiation oncologists from 2 different institutions (PC, NJ, PM). They were asked to validate the appropriateness and clarity of the questionnaire. In addition, their comments and suggestions were included in the provisional survey and, eventually, validated by a consensus session. The updated version of the survey was resent to the panel and eventually validated by a consensus. This consensus was used to test the intelligibility of the survey. The final version of the electronic survey was therefore sent to the academic teachers of RO in all European countries. Because the study did not focus on patients or animals and no medical records were considered in the analysis, the approval of the local ethics committee was not solicited. To build a comprehensive respondent database, we used the ESTRO site to find the national societies information including the national representing radiation oncologist (*https://www.estro.org/about-us/national-societies/external-audists-in-radiotherapy*). Further respondents were found by consulting the database of the UEMS (*Union Européenne des Médecins Spécialistes,* https://www.uems.eu/).

These databases were worthwhile to identify the first network of responders. The respondents' selection was therefore implemented by a manual search on the Internet, browsing the information provided on the website of the academic hospitals. In addition, in the survey, each respondent was invited to provide to the survey leader (SBM) the name and other details of others RO academic teacher of her/his country by a snowball recruitment. The goal was to reach at least two university hospitals of each country to assess the teaching differences within the same nation. The survey was sent by e-mail to all potential respondents with an automatic reminder at one and two months after the first invitation in the attempt to increase the response rate.

The inclusion criteria for the selection of respondents were:

1 — being a radiation oncologist actively involved in teaching RO to medical students;

2 — the acceptance to provide personal information with the guarantee that the respondent and the university details would be anonymized.

The exclusion criteria for the selection of respondents were:

1 — being involved in teaching RO as a Physicist, Radiobiologist, Medical Oncologist;

2 — multiple respondents from the same academic institution: to avoid a data redundancy from a single institution.

We selected the survey written by the teacher with the highest academic position for the analysis.

Data collection

The survey data were extracted using the automated system provided by the electronic platform Survey-Monkey (*http://surveymonkey.net*).

All the responses to the survey were collected from June 2015 to June 2017. This time was necessary to wait and collect a representative database. The survey was closed in June 2017 because longer delay would have influenced the temporal coherence of the collected data.

Statistical analysis

Statistical analysis was carried out using a biostatistics medical software (MedCalc, Morsel, Belgium, Version 18.5) and graphics were obtained by using an Excel worksheet (Office package 365- 2018, Microsoft).

4. Results

Feature of the RO teachers who participated in the survey

Eighty-seven academic teachers from 29 different countries were invited to participate in this study.

Of those, 53 completed the questionnaire (rough response rate = 61%).

However, 16 questionnaires were excluded because of missing data (16 out of 53 = 30%) and five because two academic teachers of the same university performed the survey (5 out 53 = 10%).

Hence, 32 surveys (rough response rate = 35%) were filled and were therefore included in the final analysis, representing 19 different countries.

The mean response rate per country was 1,9 (range 1–4).

Details on the number of respondent academic teachers per country are given in Table 1.

Country	# of respondents
Belgium (BE)	4
Bulgaria (BG)	1
Czech Republic (CZ)	1
Croatia (HR)	1
Denmark (DK)	2
Hungary (H)	1
France (FR)	1
Germany (DE)	2
Italy (IT)	4
Netherlands (NL)	2
Norway (NO)	1
Poland (PL)	1
Portugal (PT)	1
Romania (RO)	1
Serbia (RS)	1
Slovakia (SK)	3
Slovenia (SI)	1
Spain (SP)	2
Switzerland (CH)	2
Total: 19 countries	**32 respondents**

Table 1. — Number of respondents per country and country codes.

Timing of RO teaching

In all the 19 countries represented in this study, there was a 6-year medical undergraduate curriculum.

RO courses were delivered to medical students either during their 2nd year (n = 1, BE), 3rd year (n = 4: NL, SP, NL, BE), 4th year (n = 10: IT, BE, SI, SL,SL, FR, CH, HR, DK, BG), 5th year (n = 5: IT, BE, CZ, HU, RO) or 6th year of the undergraduate cursus (n = 3: PO, DK, NO).

Noticeably, in 9 institutions (28%) RO was delivered at different periods during the curriculum:

- Three different periods: at the 2nd, 4th and 6th year (n = 1: CH) and 4th, 5th and 6th year (n = 3: SP, DE, DE)
- Two different periods: at the 3rd and 5th year (n = 2: PL, IT), 3rd and 4th year (n = 1: IT), 4th and 6th (n = 1: SL), 3rd year and 6th (n = 1: RS).

Specialists involved in RO teaching

The number of teachers involved in the teaching of RO to medical students ranged from 1 to 12 academic teachers (mean 3,8; SD 3,3).

All the respondents provided the number of teachers involved in teaching RO to medical students in their institutions.

In nearly half of the institutions (15/32 = 47% of all institutions), RO specialists were the only teachers involved in delivering the RO courses to medical students (PO, CH, BE, FR, IT, IT, SK, IT, IT, SK, RS, NL, BE, BG, CZ).

In 10 institutions, medical oncologists also participated in the RO teaching in the same sessions with RO specialists and/or specialists from other medical disciplines (31% of all institutions participating in the survey: DK, DK, HR, BE, SW, BE, SP, SL, NO, RO).

In 8 institutions (HR, DE, SP, SL, SP, DE, PL, HU) medical physicists were also involved in the RO teaching to medical students.

Radiobiologists participated in the teaching of radiation oncology in only five institutions (DE, DE, BE, SP, NL).

Feature of RO teaching

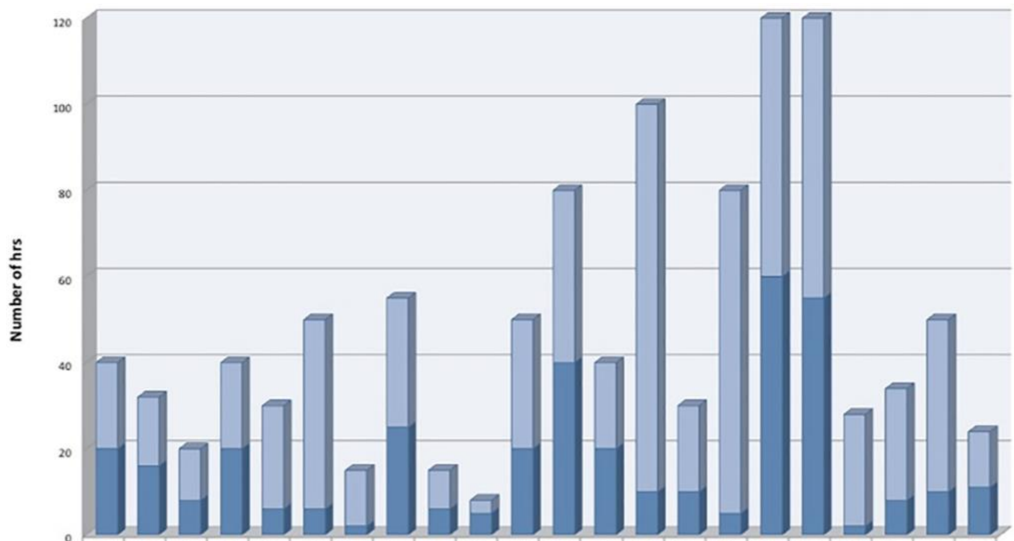
RO was a stand-alone course with an individual examination in two institutions (6%: PL, RO).

In 11 institutions (35%, PO, HR, BE, BE, BE, DE, DE, FR, IT, IT, IT) RO was taught as an independent discipline, but the knowledge assessment was embedded in a multidisciplinary examination.

In 17 (BE, DK, DK, CH, CH, SP, SL, SL, SL, IT, NL, NL, RS, NO, HU, BG, CZ) out of 32 institutions (53%) the RO teaching was part of a modular course along with other disciplines (e.g. oncology, internal medicine, surgical oncology, neurology, nuclear medicine) with a final overall examination (RO and other disciplines).

In two institutions, (6%: SL, SP) RO was also taught as a modular course along with other disciplines but with a final stand-alone examination for RO.

Twenty-two respondents (22 out of 32 = 69%) specified the total numbers of hours devoted to RO teaching and the overall number of hours devoted to oncology (RO along with Medical Oncology) (Fig. 1).



	BE 1	BE 2	BE 3	CZ	DE	DK	ES 1	ES 2	FR	HU	IT 1	IT 2	IT 4	IT3	NL	NO	PL 1	PL 2	RO	RS	SL	SL 2
ONC hrs	20	16	12	20	24	44	13	30	9	3	30	40	20	90	20	75	60	65	26	26	40	13
RO hrs	20	16	8	20	6	6	2	25	6	5	20	40	20	10	10	5	60	55	2	8	10	11

Fig. 1. — Number of hours of teaching devoted to RO (RO hrs) in deep blue and the number of hours devoted to the teaching of medical oncology for each respondent institution (ONC hrs) in light blue.

The mean time allocated to RO was of 16 h, but there were significant differences amongst the different centers, with a range from 2 to 60 h and a median of 10 h.

The key topics assessed in the present survey were not taught in all of the institutions. The percentage for each specific key topic is detailed in Fig. 2.

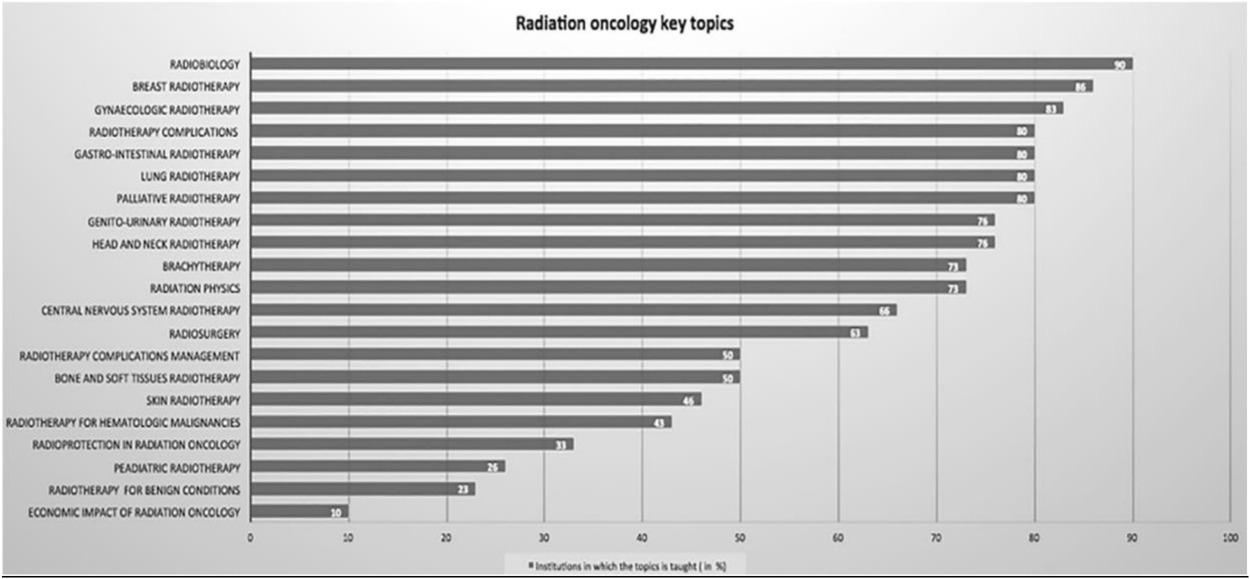


Fig. 2. — Percentage of institutions in which each key topic in RO was taught to medical students during their core curriculum.

Concerning the final assessment of acquired knowledge, the final examination format for each particular topic is detailed in Table 2.

Topics	N	O	W	OSCE	CBE	# of resp.
Radiobiology	5 (16,66%)	7 (23,33%)	14 (46,66%)	1 (3,33%)	3 (10%)	30
Radiation physics	5 (20,83%)	4 (16,66%)	11 (45,83%)	1 (4,16%)	3 (12,5%)	24
Radiosurgery	5 (20%)	8 (32%)	9 (36%)	0 (0%)	3 (12%)	25
Brachytherapy	3 (11,53%)	10 (38,46%)	10 (38,46%)	0 (0%)	3 (11,5"%)	26
Palliative RT	2 (7,4%)	10 (37,03%)	11 (40,74%)	2 (7,40%)	2 (7,40%)	27
Breast RT	3 (10%)	10 (33,33%)	12 (40%)	2 (6,66%)	3 (10%)	30
CNS RT	2 (7,69%)	8 (30,76%)	11 (42,30%)	2 (7,69%)	3 (11,53%)	26
Head and neck RT	3 (10,71%)	9 (32,14%)	11 (39,28%)	2 (7.14%)	3 (10,71%)	28
Lung RT	2 (6,89%)	9 (31,03%)	13 (44,82%)	2 (6,89%)	3 (10,34%)	29
Gastro-intestinal RT	2 (7,4%)	9 (33,33%)	11 (40,74%)	2 (7.%)	3 (11,11%)	27
Genito-urinary RT	2 (7,14%)	9 (32,14%)	12 (42,85%)	2 (7.14%)	3 (10,71%)	28
Gynaecologic RT	3 (10,34%)	10 (34,48%)	11 (37,93%)	2 (6,89%)	3 (10,34%)	29
Skin RT	6 (28,57%)	5 (23,80%)	8 (38,09%)	1 (4,76%)	1 (4,76%)	21
Bone and soft tissue RT	5 (26,31%)	7 (36,84%)	6(31.57%)	0 (0%)	1 (5,26%)	19
Benign conditions RT	7 (53,84%)	2 (15,38%)	3 (23,07%)	0 (0%)	1 (7,69%)	13
Pediatric RU	8 (50%)	1 (6,25%)	5 (31,25%)	0 (0%)	2 (12,5%)	16
Toxicities of RT	4 (15,38%)	7 (26,92%)	11 (42,30%)	2 (7,69%)	2 (7,69%)	26
Toxicities management	5 (25%)	6 (30%)	6 (30%)	1 (5%)	2 (10%)	20
RT for Hematologic malignancies	7 (36,84%)	4 (21,05%)	4 (21,05%)	1 (5,26%)	3 (15,78%)	19
Economic aspects of RT	8 (72,72%)	1 (9,09%)	1 (9,09%)	0 (0%)	1 (9,09%)	11
Radiation protection	5 (31,25%)	4 (25%)	5 (31,25%)	0 (0%)	2 (12,5%)	16

Table 2. — Final assessment of knowledge for each key topic in RO: the total number of respondents for each topic is detailed in the table. For Each topic the number of institutions using a certain method is expressed as an absolute number and in percentage. Abbreviation used in the table: N: No examination; W: Written examination, CBE: Computer based Examination; OSCE: Objective Structured Clinical Examination.

E-learning for RO was available to medical students in 10 out of 32 institutions (31%). Medical students were able to access learning cases on the Internet on a specific website in 5 institutions (RO, DK, DK, BE, SP).

In 2 institutions the learning cases were available on computers located in a University facility (NO, IT) and they were not available on the web. Interactive webinars in RO were delivered in 2 institutions.

Medical students involved in research programmes or scientific programmes reported by the institutions represent less than 5% of the entire medical student population, except for two institutions (HR, SL) that reported higher rates ranging from 5% to 20%.

In most of the institutions i.e. 28 out of 32 (90%), a clerkship for medical students was available on demand. The clerkship period was unavailable for medical students in 4 institutions out of 32 (10%) (DK, PO, SL, CZ).

A clerkship in radiation oncology was mandatory in one institution (IT).

A policy to encourage medical students to consider RO as a career option was present in 17 out of 32 institutions (53%) (DK, PO, SW, BE, BE, SW, DE, FR, BE, IT, SI, DE, NO, PL, HU, BE, CZ), while there was no such a policy in 15 out of 32 institutions (47%) (DK, HR, SP, SL, IT, IT, SL, IT, NL, SL, SP, HR, RO, NL, BG).

5. Discussion

Medical students have been traditionally reported to be poorly exposed to oncology-related topics during their undergraduate education in both North American and European Universities[40].

In Europe, a survey involving 100 universities revealed that oncology was present in medical students' core curricula in only 40% of those institutions[41].

Besides, a steady decrease of the involvement of radiation oncologists as teachers in academic institution has been reported over the last decades, with as little as 30% of academic Radiation oncologists involved in medical students' education with a mean teaching frame of 7 h[42].

It was reported that RO education was even more limited than medical oncology education[43].

Besides, the lack of a mandatory clerkship in RO hinders a practical approach to RO[44]. These observations should stimulate a bigger effort to broaden the visibility of RO. Local and multi-institutional pilot initiatives were undertaken to include RO into the core curriculum for medical students[45, 46, 47, 48, 49, 50, 51, 52].

These initiatives paralleled similar processes implemented for medical students in other medical disciplines such as internal medicine[53], surgery[54], emergency medicine[55], dermatology[56], uro-nephrology[57, 58], palliative care medicine[59], radiology[60] and nuclear medicine[61].

The present survey revealed some interesting results that provide an overview of RO teaching to medical students in Europe.

There was a lack of a systematic investigation for this topic. First, the present survey showed that in most European academic institutions (10/32, 31%) RO education was delivered to medical students during their fourth year.

However, in almost one-third of the respondent institutions (9/32, 28%) RO courses were delivered at different periods of the core curriculum, usually from the third year onward. Second, RO was a stand-alone course with a focused knowledge assessment in 6% of the institutions participating in the survey.

In most European academic institutions, RO was taught in modular courses and the final examination was part of a broader knowledge assessment.

Third, the time devoted to oncology-related topics significantly varies amongst the different institutions, ranging from 2 to 60 h.

However, the ratio of the time assigned to RO teaching was always equal or inferior to that scheduled to medical oncology.

Interestingly, this variability regarding hours was also present amongst universities in the same country.

These data confirm that RO was even more neglected than medical oncology in European universities.

Fourth, the critical topics in RO education were: Radiobiology, RO for breast, gynecologic, lung malignancies and RO toxicities, taught in at least 80% of the responding institutions.

The choice to focus on particular cancers in the RO teaching seemed to be in accordance, at least partly, with cancer incidence in Europe and radiation oncology efficacy in those diseases.

Hence, the selection of topics was influenced by other factors (differences between institutional/country guidelines, competition with other established treatments (chemotherapy, surgery), RO availability, different techniques of RO availability, socioeconomic factors...). Investigating this observation even further in another study would be interesting. Fifth, new teaching and knowledge evaluation tools such as e-learning techniques, OSCE and computer-based examination were available in only few institutions.

E-learning techniques were proven to improve the learning in other disciplines individually and when used in groups of students in case-based sessions[62].

Clerkship in RO was available in most of the institutions but only on demand.

Sixth, there was a minor involvement of medical students in research programs in the field of RO. In the present survey a policy to encourage medical students to consider RO as a future career option was present in only half of the respondent institutions.

Because medical schools are in charge of the quality of education provided to medical students, as suggested by previous articles on this matter[63], the teaching of radiation oncology to medical students should be improved at institutional and university level in the environment of the local medical schools.

The European societies such as the ESTRO and the UEMS along with the national societies could play a role in this process in promoting and backing the local initiatives.

This could be of help to build a template core curriculum of RO for medical students as a reference for the local institutions.

However, the present study has several limitations. First, the collected data were provided by teachers willing to participate in this initiative with a low rate of valid respondents (30%).

In addition, not all the European countries are represented in the survey and some countries were overrepresented.

This bias could have substantially influenced our results.

Noticeably, a survey performed in a hundred institutions in the USA[64] revealed that only 30% of the institutions offered a RO education in their mandatory core curriculum, while in the present survey, all the respondents declare that there was a RO teaching in their core curriculum.

A more extensive survey should be launched to have access to a more comprehensive data set. Second, because of the long turn-around time between the electronic invitation and the responses, the collection of the database was long (approximately two years).

Nevertheless, the extent of the collected data and the absence of studies on the same matter could be considered related to difficulties to yield data on this particular matter.

Finally, there was a low rate of answers completed in the free text window associated with each particular question.

Therefore, the results were likely to be influenced by the inherent structure and/or type of questions established in the survey.

6. Conclusion

The results of our study are in line with the results reported by similar investigations performed in North America indicating the necessity of broadening the visibility and the diffusion of knowledge in RO to medical students around Europe. A reference core curriculum definition, adapted to European academic institutions, including e-learning techniques and a practical clerkship program are possible ways to improve RO knowledge during the undergraduate education.

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Chapter 2

Training and certification in Radiation and Clinical Oncology (RO/CO) in Europe: A UEMS survey

ESTRO 2024: (Abstract E24-951 titled *Training and certification in Radiation and Clinical Oncology (RO/CO) in the countries of the UEMS*. accepted for **presentation as a Mini-Oral**)
Training and certification in Radiation and Clinical Oncology (RO/CO) in Europe: A UEMS survey
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1. Abstract

Aim

To get a picture of how the training of residents in Radiation Oncology and/or Clinical Oncology (RO/CO) is carried out and assessed across different countries that are members of the of RO/CO section of the European Union of Medical Specialists (UEMS).

Materials and methods

An anonymous 51-item electronic survey was sent to UEMS representatives or president of national societies to get information about current RO/CO training, examination, continuous assessment, scientific activity requirements in UEMS countries. Opinions were also gathered about the interest in implementing a European certification in RO/CO.

Results

Twenty-eight out of 35 (80%) UEMS countries sent a complete survey filled through their UEMS national delegates or president of the national society of RO/CO.

The mean duration of the training in radiation oncology for radiation and/or clinical oncologists was 4.3 years (range: 0.5 - 6 years; median: 5 years).

In 3 of 28 countries (10.7%), training was purely in radiation oncology. In 17/28 countries (60.7%) part of the training time was spent in another specialty, and in 8/28 countries (28.6%), the training in radiation oncology was part of the training in clinical oncology.

The training program was assessed by an internal and/or external audit in 24/28 (85.7%) countries.

In 20 out of 28 (71.4%) countries, residents had at least one examination during the RO/CO training. Twenty-three countries (82.1%) had a continuous assessment system of residents.

Nineteen out of 28 countries (67.8%) would be in favor of a European certification in RO/CO.

Conclusion

The training and assessment of residents in RO/CO is heterogeneous across UEMS countries. Most responding UEMS countries have a system for assessing residents' knowledge during their training, and most respondents would support a European certification in RO/CO. This last finding needs to be further explored among residents and training supervisors in RO/CO in the UEMS countries.

2. Introduction

Radiation oncology is a challenging specialty that encompasses various fields such as physics, anatomy, medical imaging, medical oncology, palliative care, etc. The ESTRO core curriculum was developed to reflect the rapid evolution of the profession and to ensure the best evidence-based training across Europe or, more generally, in the UEMS countries and has evolved from a knowledge-based training to a focus on Entrustable Professional Activities (EPAs) since its inception in 1991[1] to its most recent version in 2019[2].

Because training in radiation oncology in some UEMS countries is mixed between radiation oncology and medical oncology to become a clinical oncologist, a clinical oncology module was added to the ESTRO core curriculum in 2021[3].

Medical school education[4] and residency programs leading to board certification as a radiation oncologist or clinical oncologist[5, 6] differ significantly between UEMS countries.

Training in radiation oncology (RO) for different RO Professionals (Radiation oncologists, Physicists, RTTs) remains very heterogeneous in terms of duration and content and is sometimes deemed inadequate by the diverse radiation oncology professionals who are consulted on the subject[7, 8].

Nonetheless, many countries appear to have adopted the ESTRO core curriculum EPAs in the training of radiation oncologists[9].

The purpose of this study was to bring the field of radiation oncology and clinical oncology (RO/CO) residency training up to date, with a particular emphasis on assessment practices in UEMS countries.

In addition, feedback on a RO/CO-based European examination was sought.

3. Materials and methods

A 51-item cluster questionnaire was developed and transferred to an electronic format using commercial software (Survey-Monkey™, *http://surveymonkey.net*) (Survey provided in Annex 2). The questions aimed to assess critical issues including:

1 — General information about the participants

2 — General questions about residents' training in RO/CO in Europe

3 — Questions about examinations during training in RO/CO in Europe

4 — Questions about continuous assessment during training in RO/CO in Europe

5 — Questions on requirements for scientific activities during training in RO/CO in Europe

6 — Opinions and questions on European certification for radiation oncologists and/or clinical oncologists in training.

The survey targeted UEMS representatives radiation oncologists or clinical oncologists from UEMS countries to explore how residents' skills were assessed and their opinion regarding a UEMS certification in RO/CO.

Closed or non-narrative open-ended input fields were used to collect accurate, standardized answers. All questions also permitted open-ended responses to share further information or answer narratively. Participants could save the survey and finish it later after collecting the pertinent information.

The first, second, and last authors, radiation oncologists, (SBM, PM, PL) created the questionnaire.

JGE and JJ, two clinical oncologists, reviewed the survey's first draft to determine its validity, suitability, and clarity.

Their input was included in the preliminary survey. The final electronic survey was delivered to UEMS RO/CO representatives in all UEMS countries.

As the study did not focus on patients or animals and no medical records were included in the analysis, no approval was needed from the local ethics committee.

The aim was to reach a UEMS representative in each European country.

The survey was sent by e-mail to all potential respondents, with an automatic reminder one month later.

The inclusion criteria for selecting respondents were:

1 — Being a radiation or clinical oncologist representing the UEMS or a national society of RO/CO in a European country.

2 — Willing to provide information, with a guarantee that respondents' data will be anonymized.

3 — Agreeing with the publication of the results in a scientific journal.

The exclusion criteria for the selection of respondents were:

1 — A survey whose incompleteness makes analysis impossible

2 — Multiple respondents from one country: to avoid data redundancy from a single country, we selected the respondent who completed the survey in full.

The survey was conducted from the first of October 2022 to the ninth of January 2023 and the data was extracted using the automated system of the Survey-Monkey electronic platform (http://surveymonkey.net). Descriptive statistics were performed on the dataset with N=28 responses representing the 28 European countries. For categorical responses, frequencies were given with the corresponding percentages (%). For questions with multiple options, countries with similar response patterns were grouped together. Quantitative answers were summarized as mean (standard deviation), median (P1-P3; interquartile range), together with minimum and maximum values. Missing data were handled by pairwise deletion, i.e., missing cases with available data on other variables were retained. The analysis was performed in R version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria).

4. Results

General information about the participants

The questionnaire was sent to UEMS delegates of 35 countries. For each country, it was asked to provide just a single questionnaire for their country after a consensus.

Thirty-four surveys were collected. Six surveys were discarded, 5 because they were incomplete and one because the respondent was unknown.

Twenty-eight surveys from 28 countries were included finally. Twenty-seven surveys were completed by UEMS delegates and 1 by the president of a national society (Germany has no UEMS delegate). The 28 respondent countries included: Albania, Austria, Belgium, Bulgaria, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom.

Twenty out of 28 participants (71.4%) indicated that they responded for their entire country.

Twenty-two participants (78.6%) worked in a university hospital.

General question on RO/CO training in UEMS countries.

The minimum duration of radiation oncology training during the RO/CO residency in the participating countries was 0.5 years, the maximum was 6 years, the mean was 4.3 years, and the median was 5 years.

In 39.3% of participating countries, training could be completed at the same institution; in 21.4%, it depended on the institution.

The training had to be completed entirely in a university hospital in 7/28 countries (25%), and in 8/28 countries (28.6%), at least partially in one.

The centers coordinating the full RO/CO training are always university centers in 15/28 (53.6%) countries.

In 3 out of 28 countries (10.7%), the training was exclusively in radiation oncology. In 17/28 countries (60.7%), part of the training time was spent in another specialty, and in 8/28 countries (28.6%), the training in radiation oncology was part of the training in clinical oncology.

UEMS delegates were asked about the supervisory authorities responsible for the duration, content, and organization of training in RO/CO.

Table 1 shows which regulatory authorities in the responding countries are primarily responsible for the duration, content, and organization of training in RO/CO.

The program director/training supervisor interacts with a wide range of bodies, including a recognition committee, the dean of the faculty, the national radiation oncology society, the Ministry of Health, universities, research and medical associations, councils, or chambers.

Responses	**Who is primarily responsible for the duration of training in radiation oncology in your country?** (*Multiple answers are possible*)	**Who is primarily responsible for deciding the content of radiation oncology training in your country?** (*Multiple answers are possible*)	**Who is primarily responsible in your country for organizing the training in radiation oncology?** (*Multiple answers are possible*)
A recognition committee	8 (28.6%)	9 (32.1%)	6 (21.4%)
The program director/training supervisor	7 (25.0%)	10 (35.7%)	16 (57.1%)
(The Dean of) The Faculty of Medicine of the University	5 (17.9%)	5 (17.9%)	3 (10.7%)
The national society of radiation oncology	4 (14.3%)	10 (35.7%)	6 (21.4%)
The Ministry of Health	11 (39.3%)	8 (28.6%)	6 (21.4%)
The Ministry of Universities and / or Research	2 (7.2%)	1 (3.6%)	2 (7.2%)

A medical council, association, or chamber	4 (14.3%)	1 (3.6%)	2 (7.2%)
Other	6 (21.4)	8 (28.6%)	7 (25%)

Table 1. — Regulatory authorities in the responding countries primarily responsible for the duration, content, and organization of training in RO / CO.

Figure 1 shows the number of residents in RO/CO in the UEMS countries:

Figure 1a shows, for each participating country, the number of inhabitants/residents in RO/CO.

Figure 1b shows for each country that responded the number of residents in RO/CO.

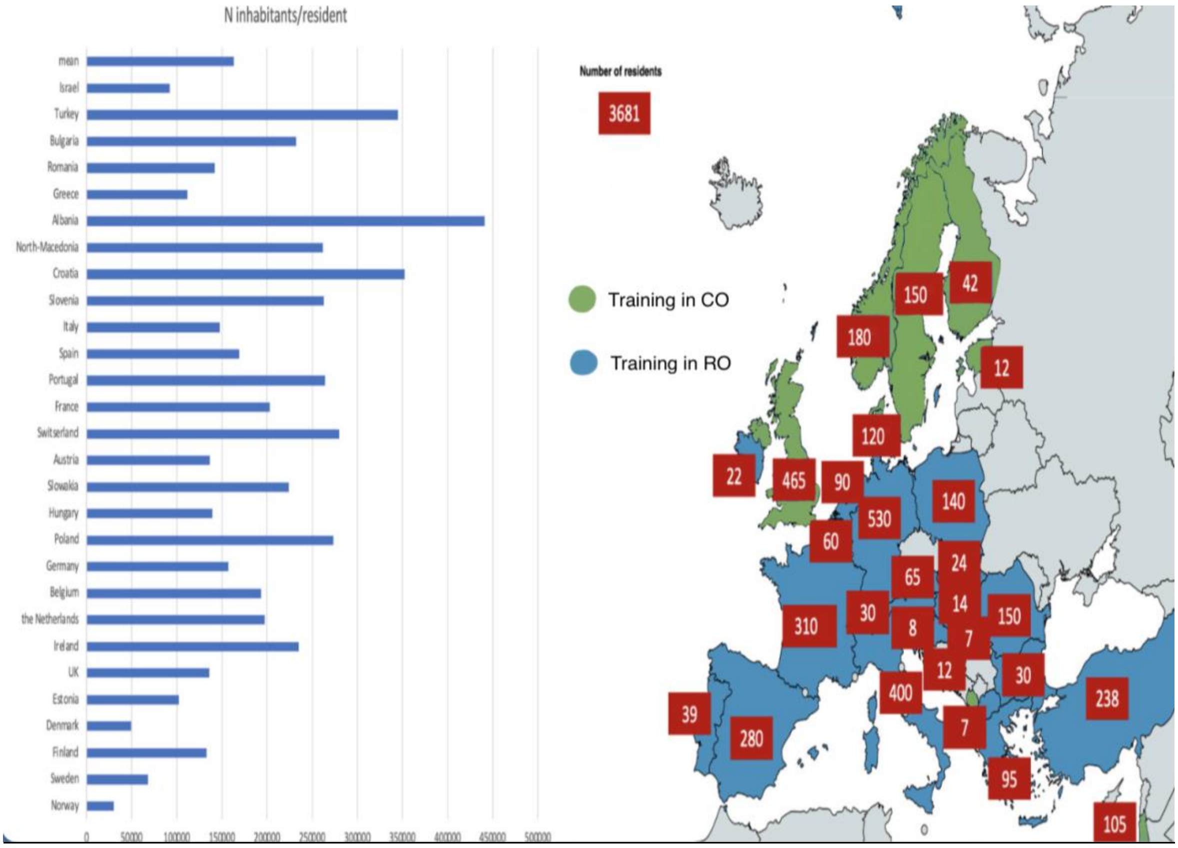

Fig. 1. — Number of residents in RO/CO in the UEMS countries.

Figure 2 shows the number of training centers (coordinating and non-coordinating training centers) per responding country.

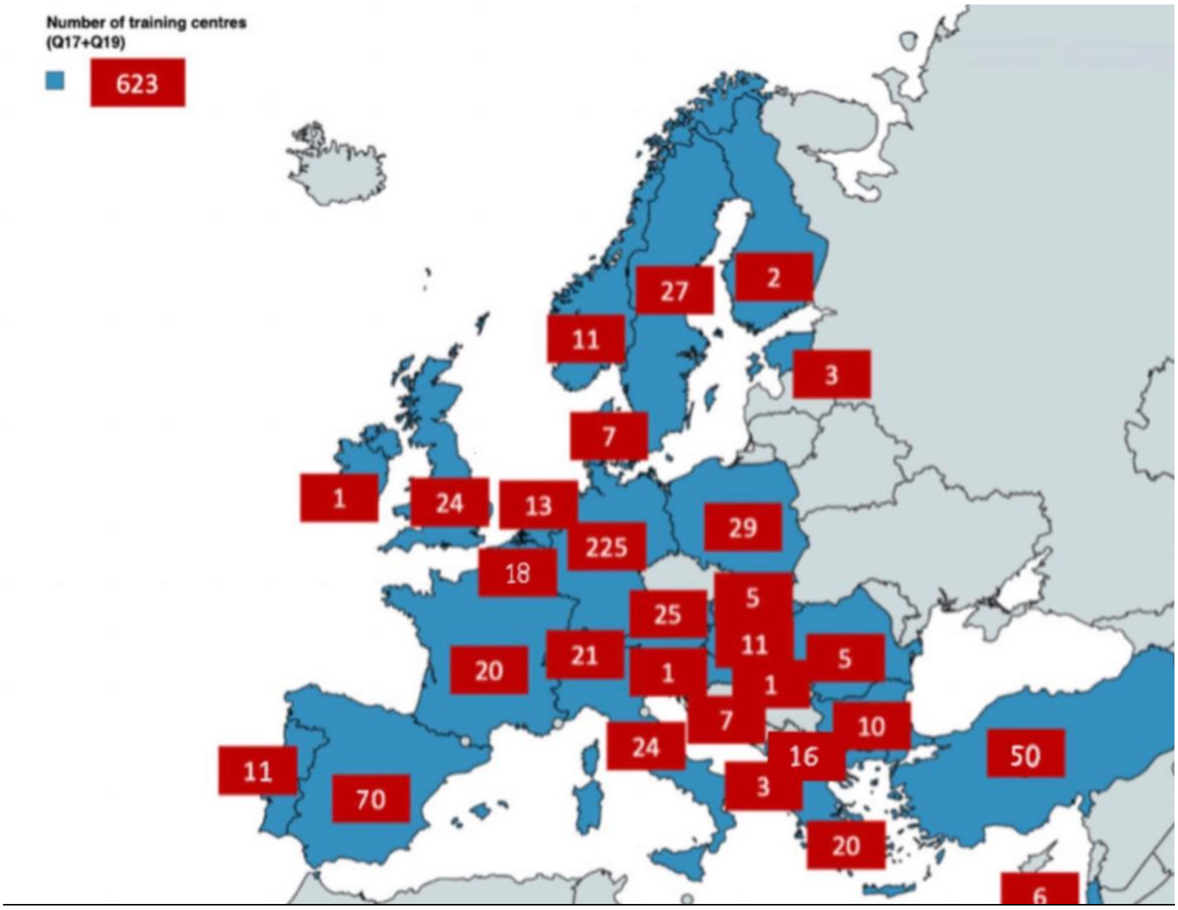

Fig. 2. — Number of training centers (coordinating and non-coordinating training centers) per responding country.

Figure 3 shows, for each responding country, the number of inhabitants per number of training center.

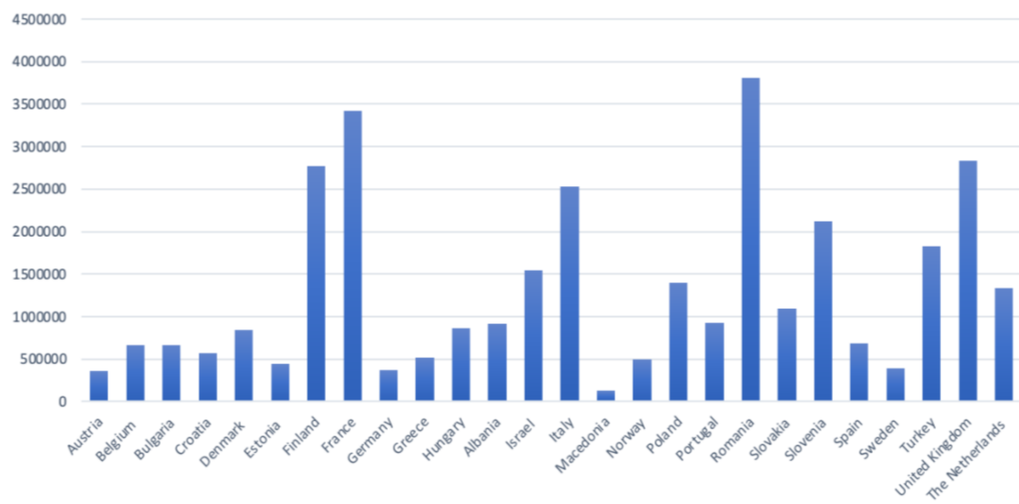

Fig. 3. — Number of inhabitants per number of training center.

Half of participants (14/28) have an internal evaluation or audit of the training program, 15/28 (53.6%) have an external audit, and 10/28 (35.7%) have an audit done by the residents. However, 4/28 (14.3%) participants reported no audit at all.

In 19/24 (79.2%) participant countries, training program evaluations/audits are mandatory.

Twenty-two (84.6%) participants in non-English-speaking countries (26) said the training could not be done in English.

Finally, twenty-six (92.8%) participating countries have a uniform RO/CO certification procedure apart from the fact that a certain number of years of training is compulsory for 100% of participants.

Examination(s) and continuous assessment in RO/CO in the UEMS countries

Eight (28.6%) participants reported no RO/CO examination(s) during residents training in their country, 12/28 (42.9%) said there was only one exam, and 8/28 (28.6%) said there was more than one.

Twenty-three countries (82.1%) had a formal continuous assessment of residents during RO/CO training.

Continuous assessment occurred every 3 months in 4 countries, 4 months in 2 countries, 6 months in 5 countries, and annually in 5 countries.

Questions	**Official Examination(s) (Total 20 countries)** ***N* (%)**	**Formal Continuous assessment (Total 23 countries)** ***N* (%)**
"What assessment tool is used?" *(more than one answer is possible)*		
Direct Clinical Examination	8 (40%)	16 (69.6%)
Oral examination	17 (85%)	14 (60.9%)
Logbook/Portfolio	—	17 (73.9%)
Multiple choice questionnaire	9 (45%)	4 (17.4%)
Objective Structured Clinical Examination	13 (65%)	8 (34.8%)
Essays/papers/assignments	—	4 (17.4%)
Feedback from multiple sources	—	12 (52.2%)
Simulation Examination	7 (35%)	5 (21.7%)
Mini clinical assessment exercise	7 (35%)	11 (47.8%)
Standardized patient examinations	—	5 (21.7%)
Video Assessment	0 (0%)	0 (0%)
None	0 (0%)	1 (4.5%)

"Are the Entrustable Professional Activities (EPAs) of the ESTRO/UEMS core curriculum assessed during examination(s) or continuous assessment?"		
Yes	9 (45%)	9 (39.1%)
No	9 (45%)	10 (43.5%)
Number of respondents who skipped the question	2 (10%)	4 (17.4%)
"Are the examination(s) or the continuous assessment mandatory?"		
Yes	20 (100%)	20 (87%)
No	0 (0%)	3 (13%)
"Who organises the examination(s) and/or the continuous assessment(s) in your country?" *(more than one answer is possible)*		
The program director/ Training supervisor	8 (40%)	17 (74%)
The head of department of the radiation oncology training center/department	2 (10%)	8 (34.8%)
(The Dean of) The Faculty of Medicine of the University	2 (10%)	3 (13%)
The national society of RO/CO	5 (25%)	2 (8.7%)
An Agreement Committee / Recognition board	3 (15%)	0 (0%)
The Ministry of Health	5 (25%)	4 (17.4%)
A national examination committee	3 (15%)	3 (13%)
Other	4 (20%)	3 (13%)

Table 2. — Information about Examination(s) and continuous assessment in radiation oncology during RO/CO training

Participants were asked if there were consequences if a resident failed national examination(s) or continuous assessment in RO/CO (urgent advice to stop RO training, prolongation, individualization, etc.): A procedure exists in 19 countries (67.8%).

Scientific activities required during the training in RO/CO in UEMS countries

Five (17.9%) participants stated that a publication in a peer-reviewed journal was mandatory to obtain a board certification in RO/CO in their country, 5 (17.9%) participants stated that an abstract or congress presentation was mandatory, and 4 (14.3%) participants stated that either a publication or a congress abstract/presentation was mandatory. None of the above-mentioned scientific activities were mandatory in 18 (64.2%) participating countries.

Attendance at scientific congresses was not mandatory in 20 (71.4%) of the participating countries. Attendance at international congresses, national radiation oncology congresses or other national oncology congresses was mandatory in 2 (7.1%), 5 (17.9%) and 4 (14.3%) of the participating countries, respectively to get board certified.

Attendance at RO/CO courses was not mandatory to obtain board certification in 10 (35.7%) of the participating countries, while attendance at ESTRO courses was mandatory in 4 (14.3) countries and at national courses in radiation oncology in 13 (46.4%) of the participants.

Opinions and questions on a UEMS certification for RO/CO in training

Participants were asked about their opinions on a UEMS certification in RO/CO.

Eighteen participants (64.3%) thought UEMS certification could promote the harmonization of national examinations, 17 (60.7%) participants thought it could provide national assessments on the conduct of an assessment and promote the introduction of national assessments as a quality feature, and 11 participants (39.3%) thought it could replace national assessments when appropriate.

Participants were asked if they supported a UEMS RO/CO certification, 19 (67.8%) would support it.

Participants were asked if a UEMS RO/CO certification should be mandatory in Europe, six (21.4%) thought UEMS certification should be mandatory, while 17 (60.7%) did not.

Participants were asked which assessment tools to use for a UEMS RO/CO certification, 21 (75.0%) participants suggested a multiple-choice questionnaire, 12 (42.9%) an objective structured clinical examination, 11 (39.3%) an oral exam, 10 (35.7%) a simulation exam, 9 (32.1%) a mini clinical evaluation exercise, 7 (25.0%) direct clinical observation and feedback, 6 (21.4%) a video assessment, and 1 (3.6%) a contouring and planning exam.

One participant (3.6%) suggested taking the exam from the 2nd year of residency onward, 2 (7.2%) from the 3rd year, 7 (25.0%) from the 4th year, 4 (14.3%) during the 5th year, and 6 (21.4%) one year before national board certification.

Finally, when asked in which language a UEMS certification should be taken in RO/CO, 14 (50.0%) chose English, 4 (14.3%) chose the language of the resident who will take the exam, and 9 (32.1%) picked English with the option of translating it to the language of the resident.

5. Discussion

This study provides an overview of the training and assessment of RO/CO residents in most UEMS countries and collects the opinions of UEMS delegates on a European examination.

First, according to a previous study from 2017[10], the number of residents per population is very heterogeneous from country to country. This has not changed five years later, as our study shows the same heterogeneity within more or less the same group of countries.

Secondly, as already reported[11], training is mostly hospital-based and regulated by national authorities. We were also able to show that these regulating national authorities are not always experts in RO/CO.

Thirdly, as shown in the publication by Benstead et al[12], training is regulated by a logbook system and/or a final examination. We could also show that most countries still have a system to assess residents' knowledge, but we could further analyze how these continuous assessments or exams are conducted.

These analyses show some homogeneity in the topics assessed, but also some heterogeneity in the use of the ECC core competencies to assess residents.

Fourth, this is the first publication to assess opinions on a European or UEMS examination, most of the UEMS delegates would be in favor of a UEMS Exam in RO/CO and this could help to synthesise all national efforts into a multinational assessment.

Some examples from the literature about European evaluations in other specialties in Europe show that this can be successful and persist on the long run[13, 14].

In the US, for example, residents in RO are assessed using the milestones of the six core competencies and subcompetencies of the Accreditation Council for Graduate Medical Education ACGME[15]. These competencies include not only medical, professional skills but also communication skills.

However, Aspects of RO training like simulations, contouring, planning, treatment set-up, and mastery of procedures such as brachytherapy, etc. may not be fully assessed using existing assessment methods[16].

Given the lack of a standardised assessment tool within RO, this is an area that would benefit from further analysis.

Furthermore, RO/CO is encompassing a lot of other specialties like medical oncology, medical imaging, palliative care etc. and efforts are underway in this direction to make training more open to other specialties[17].

We are aware that our study has biases.

First, certain questions may be difficult to understand due to country-specific training and assessment methods.

Second, it is difficult to estimate the number of residents. In France, for example, the first year of residency training is the same for medical oncologists and radiation oncologists, and residents decide at the end of the first year which specialty they wish to pursue. In this context, there is also the question of the difference between the number of residents and the number of board-certified RO especially in countries where there is training in clinical oncology.

6. Conclusion

The training and assessment of residents in RO/CO is heterogeneous across UEMS countries. Most responding UEMS countries have a system for assessing residents' knowledge during their training, and most respondents would support a European certification in RO/CO. This last finding needs to be further explored among residents and training supervisors in RO/CO in the UEMS countries.

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Chapter 3

Training of radiotherapy professionals: status, content, satisfaction and improvement suggestions in the Greater Region

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1. Abstract

Background

The initial training of Radiation Oncology professionals can vary widely across Europe. The aim of this study was to assess the status and content of the initial training programs currently implemented in the Greater Region: Lorraine (Nancy, France), Saarland (Homburg, Germany), Luxembourg, and Liège (Wallonia, Belgium).

Methods

A survey was developed to investigate (1) the overall satisfaction, learning objectives, and teaching methods used during initial training programs and (2) the perceptions of the importance of key professional competencies as described by the CanMEDS (a framework that identifies and describes the abilities physicians require to effectively meet the health care needs of the people they serve). In addition, open-ended questions were used to elicit opinions on room for improvement. Participants (N = 38) were physicians (radiation oncologists (ROs) seniors and residents) and radiation therapists (RTTs).

Results

Only 21.1% of the respondents declared having acquired all the competencies required for their professional practice during their initial training. Heterogeneity in teaching methods was noted within professional programs but there is no difference between those from ROs and RTTs in the teaching of technical and non-technical skills. non-technical skills were not addressed in a range of 39.5–57.9% of respondent's curricula. More practical lessons were deemed necessary to improve radiotherapy (RT) training programs.

Conclusions

Radiation oncology professionals expressed the need for more practical teaching, especially in the training of non-technical skills. Regarding the perceived importance of professional aptitudes, radiation oncology professionals highlighted medical and soft skills as the most important competencies.

2. Introduction

The burden of cancer is a global concern with 18.1 millions of newly diagnosed cases a year and 9.6 million cancer-related deaths in 2018[1].

The scientific community, supported by continuous technological advances, is constantly developing and improving therapies to address the issue.

Currently, about 50% of cancer patients receive radiotherapy (RT) during their treatment process.

Indeed, RT alone or in combination with other therapeutic modalities, improves the cure rate for 3.5 million people and provides palliative relief for an additional 3.5 million people[2, 3]. In 2008, the International Atomic Energy Agency (IAEA) drew attention on the heterogeneity of RT support worldwide and made recommendations on hospital infrastructures and staff training programs[4].

In Europe, an European society for Radiotherapy and Oncology (ESTRO) multidisciplinary survey assessed the organization, content, duration and cost of RT training programs, and found considerable variation among European countries despite attempts at standardization[5].

As a result, the ESTRO proposed timely updated core curricula available for each RT specialty based on theoretical knowledge and emphasizing on competency based training programs[6, 7].

These curricula, based on the CanMEDS skills model that describes the seven roles carried out by all physicians[8], aim to define the minimum skills RT professionals may require to improve patients outcomes.

RT treatment involves multiple tasks and responsibilities in a complex interprofessional setting including not only radiation oncologists (ROs) but also physicists and Radiation Therapists (RTTs).

Existing differences in their expectations and practices are challenging and question the need for professional skills training to work effectively as a team[9, 10].

In order to contribute to the joint-effort to standardize and update training programs in RT institutions in a European cross-border region (the Greater Region)[11], we investigated the status and content of the initial training programs currently implemented in universities and associated cancer treating centers in the Greater Region, as well as the satisfaction and improvement suggestions from a professional perspective.

Based on the findings, we will try to identify key elements for a relevant, standardized and updated training that echoes the expectations of the professional community as well as the quality requirements for daily practices.

3. Methods

Study design and procedures

An anonymous online survey using a protected document was sent through an open-source software (Google drive) to ROs (including residents) and RTTs (radiation therapists) working in RT departments and training institutions of the Interreg project in the Greater Region (EU Interreg Va Greater Region Program N°043–1-01–125). Invitations to participate in the study were sent to the professional mailing lists of the institutions after approval by each RT head of department leading to a voluntary non-probability sampling method. The survey was kept open during 1 year from July 2019 to July 2020.

Survey description

This survey was created by a radiation oncologist and senior author (SBM) and a pedagogical expert (ND) to get an overview of the initial training of RT professionals.

The survey first addressed:

• The sociodemographic data of the respondents (4 items).

• The second part consisted in questions about the self-perceived satisfaction about the general organization (4 items; multiple choice)

• The content and teaching materials used during the training (6 items about teaching materials and rating for relevance and adequacy).

Content topics were divided into 3 categories: knowledge of basic and applied RT sciences, technical skills related to the workflow of cancer patients during the treatment process and finally non-technical skills.

Participants were also asked about the relevance of the topics taught in their training curriculum in view of their daily professional practice and the appropriateness of the teaching materials used by rating them using a 3-point Likert scale.

Participants were then asked to rate (from 1 to 7) the CanMEDS professional skills in terms of their perceived importance in RT practice.

Finally, open-ended questions were used to make suggestions for improving the training program.

In total, the survey consisted of 18 items. (Survey provided in Annex 3)

Data analysis and statistical methods

Classical descriptive statistics were performed to describe the data.

More specifically, frequencies and percentages were reported for qualitative variables, whereas median and interquartile ranges (IQR) (Q25-75) were used to summarize quantitative variables due to non-normality.

Furthermore, chi-square tests were applied to assess the association between the types of teaching methods used and the training programs of the participants.

In case there were cells with expected count less than 5, Fisher's exact test was employed. Once the omnibus chi-square test was significant, post-hoc examination using adjusted standardized residuals was performed to find out the significant associations.

All results were considered to be significant at the 5% critical level ($p<0,05$).

Statistical analyses were carried out using R packages version 3.5.3 (R Foundation for Statistical Computing, Vienna, Austria).

For the analysis of open-ended questions, we used a combined approach for each individual question with a direct content analysis realized by one reviewer, followed by a summative content analysis.

This allowed us to structure our process in identifying and creating coding categories. Concepts that did not belong to existing categories were grouped into an "others" category. Quantification focusing on frequency was then performed[12].

4. Results

Participants' characteristics

A total of 40 questionnaires were obtained, of which two were removed because of incomplete data, yielding 38 valid questionnaires for analysis.

The response rate was, therefore, 21.35% (number of professionals contacted=178), with a completion rate of 95.00%.

The majority of participants were between 31 and 40 years of age (50%, n=19), and had initial training as Radiation Therapists (44.74%, n=17) or as RO (seniors or residents) (42.11%, n=16).

Because RTTs may have multiple initial educational backgrounds, the survey included several response options: Nurse ±RT specialty, MIT±RT specialty, and RTT.

Table 1 summarizes the socio-demographics data of the participants.

Categories	Number (%)
Gender	
Female	24 (63.16)
Male	14 (36.84)
Age (years)	
20-25	0 (0)
26-30	3 (7.89)
31-40	19 (50.00)
41-50	5 (13.16)
+50	11 (28.95)
Institution	
Sarre-Hombourg	4 (10.53)
Lorraine-Nancy	19 (50)
French high school	3 (7.89)
Liège	12 (31.58)
Initial training	
RO seniors and residents	16 (42.11)
RTT	22 (57.98)
Nurse	2 (5.26)
Nurse + RT specialty	2 (5.26)
MIT	0 (0)
MIT + RT specialty	1 (2.63)
RTT	17 (44,74)
Other	0(0)

Table 1. — Socio-demographic data of the participants (*N*=38).
RO Radiation Oncologist, *RT* Radiotherapy, *MIT* Medical Imaging Technologist, *RTT* Radiation Therapists

Self-perceived satisfaction of general organization and content

More than half of the participants (n=22, 57.89%) felt that they had acquired an extended field of core competencies, and about 21.05% (n=8) were confident that they possessed all the required ones as regards to their clinical daily practice (with significantly more ROs).

In contrast, 21.05% (n=8) of respondents were not satisfied with the level of knowledge and competencies acquired. Most participants indicated that sufficient or too much time was spent on theoretical training (n=31, 81.58%) and clinical work (n=30, 78.94%).

On the other hand, 52.63% (n=20) advocated that the time spent on practical training was not sufficient. This lack of practical lessons was deemed stressful for 13.16% (n=5) of respondents.

Only one third of the participants attended seminars abroad (n=13, 34.21%), although 73.68% (n=28) stated that seminars could be useful to their profession.

Only 36.84% (n=14) experienced simulation based medical education (SBME) during their training.

Among professionals having received SBME, 85.70% reported a positive opinion (n=12). Most of them pointed out the importance of SBME to fill the gap from theory to practice using scenarios that reflected reality, such as stressful or urgent cases (75%).

Others reported a better understanding of anatomy (16.70%), and one participant also mentioned the interest of SBME to learn patient safety and security skills as well as error analysis (8.3%).

Topics and teaching methods addressed in initial training

• Theoretical knowledge

Regarding theoretical knowledge, 26.32% (n=10) of the participants indicated that clinical oncology was not adequately covered in the curriculum. This lack was also observed for Radiation physics, general oncology, and radiotherapy techniques.

Biological effects of radiation (median=3 [2; 3]), general oncology (median=3 [2; 3]), and radiotherapy techniques (median=3 [2; 3]) were considered the most relevant topics to their professional practice.

Regarding the adequacy of teaching support, more than half of participants considered that the teaching supports used to address biological effects of radiations, radiation physics, oncological pathology and radiotherapy techniques quite adequate.

The majority indicated that the training they had received was fairly adequate (medians of ratings: 2).

Ex cathedra lecture was the most frequently mentioned teaching method (range 47.4–65.8%), followed by practical lessons (range 5.3–57.9%).

About 25% of the participants added that e-learning was organized mainly in the teaching of radiation protection. SBME was only used in some cases, mainly in teaching clinical oncology (10.5%) and medical imaging (10.5%).

Instructors tended to use more practical teaching for medical imaging. Other methods (range 10.5–28.9%) were also used, especially in teaching general and clinical oncology. Results are shown in Table 2.

The association of teaching methods and initial training programs were investigated. Background training as Nurse, Nurse + RT specialty and MIT + RT specialty have been collapsed into the RTT group. Fisher's exact tests revealed that the teaching methods employed were significantly different in the teaching of four RT knowledge topics. Accordingly, ex-cathedra (87.5%) was more observed in the RO training while other methods (40.9%) were more employed in the RTT training in the teaching of radiation physics ($p < 0.001$).

Furthermore, other methods were also more prevalent in the teaching of biological effects of radiation (40.9%, $p < 0.001$), general oncology (50.0%, $p < 0.001$), and medical imaging (27.3%, $p = 0.029$) in the RTT training. In the RO training, on the other hand, practical lessons (31.3%) were more employed in the teaching of general oncology and e-learning in medical imaging (25.0%). Results are shown in Table 2.

Topics	Not addressed			Ex-cathedra			E-learning			Practical			SBME			Others			*p*-value
	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	
Radiation physics	0 (0)	3 (13.6)	3 (7.9)	14 (87.5)	10 (45.5)	24 (63.2)	2 (12.5)	0 (0)	2 (5.3)	2 (12.5)	1 (4.5)	3 (7.9)	1 (6.3)	0 (0)	1 (2.6)	0 (0)	9 (40.9)	9 (23.7)	< 0.001
Biological effects of radiation	0 (0)	2 (9.1)	2 (5.3)	14 (87.5)	11 (50)	25 (65.8)	2 (12.5)	0 (0)	2 (5.3)	2 (12.5)	0 (0)	2 (5.3)	1 (6.3)	0 (0)	1 (2.6)	0 (0)	9 (40.9)	9 (23.7)	< 0.001
Radiation protection	0 (0)	1 (4.5)	1 (2.6)	13 (81.3)	10 (45.5)	23 (60.5)	5 (31.3)	5 (22.7)	10 (26.3)	4 (25)	4 (18.2)	8 (21.1)	2 (12.5)	1 (4.5)	3 (7.9)	0 (0)	4 (18.2)	4 (10.5)	0.351
General oncology	0 (0)	1 (4.5)	1 (2.6)	13 (81.3)	10 (45.5)	23 (60.5)	3 (18.8)	0 (0)	3 (7.9)	5 (31.3)	0 (0)	5 (13.2)	2 (12.5)	1 (4.5)	3 (7.9)	0 (0)	11 (50)	11 (28.9)	< 0.001
Clinical oncology	0 (0)	0 (0)	0 (0)	13 (81.3)	11 (50)	24 (63.2)	3 (18.8)	0 (0)	3 (7.9)	8 (50)	5 (22.7)	13 (34.2)	2 (12.5)	2 (9.1)	4 (10.5)	0 (0)	10 (45.5)	10 (26.3)	0.002
Medical imaging	4 (25.0)	2 (9.1)	6 (15.8)	8 (50)	10 (45.5)	18 (47.4)	4 (25.0)	0 (0)	4 (10.5)	8 (50)	14 (63.6)	22 (57.9)	2 (12.5)	2 (9.1)	4 (10.5)	0 (0)	6 (27.3)	6 (15.8)	0.029
Radiotheraphy techniques	0 (0)	1 (4.5)	1 (2.6)	13 (81.3)	11 (50)	24 (63.2)	1 (6.3)	0 (0)	1 (2.6)	6 (37.5)	10 (45.5)	16 (42.1)	1 (6.3)	2 (9.1)	3 (7.9)	1 (6.3)	7 (31.8)	8 (21.1)	0.199

Notes: For each category, the percentage was calculated within each type of training; SBME: Simulation-based Medical Education

Table 2. — Teaching methods employed (n (%)) in the teaching of RT knowledge topics (*N* = 38).

• Technical skills

Participants highlighted four items as being particularly relevant for their clinical practice: Managing the initial outpatient consultation (median=3, IQR: 2–3), the simulation/planning sessions (median=3, IQR: 2–3), the short - and long-term patient follow-up (median=3, IQR: 2–3), and the management of emergencies (median=3, IQR: 2–3).

All topics were perceived as quite relevant or highly relevant by the participants. In terms of appropriateness, a similar trend was observed.

All participants reported that the skills related to the cancer patient workflow were adequately taught in the curriculum, with (median value of 2).

However, 21.05% reported that management of emergencies was not adequately addressed; 18.42% reported that risk and incident management, contouring, dose prescription and dosimetry should have received more attention in the curriculum.

Concerning technical skills, many participants reported that several topics were not covered in the curriculum.

For more than half of the respondents, these included the initial outpatient consultation and quality management.

Participants reported more hands-on teaching, particularly in simulation/planning session training (55.3%), contouring, dose prescription and dosimetry (55.3%).

Ex-cathedra lectures remained the dominant approach (range: 13.2–47.4%).

Interestingly, SBME, was mentioned by more participants. The topic that was strengthened by SBME was dose constraints for organs at risk (15.8%).

The teaching methods were found to be not different between the RO and RTT training in the teaching of technical skills in general.

It was noted that the topic 'undertake the initial outpatient consultation' was largely not addressed in the RTT training (72.7%) and in terms of teaching methods, practical lessons were more observed in teaching this topic in the RO training (50.0%, p = 0.016).

The result can be found in Table 3.

Topics	Not addressed			Ex-cathedra			E-learning			Practical			SBME			Others			*p*-value
	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	
Undertake the initial outpatient consultation	5 (31.3)	16 (72.7)	21 (55.3)	2 (12.5)	3 (13.6)	5 (13.2)	1 (6.3)	0 (0)	1 (2.6)	8 (50)	2 (9.1)	10 (26.3)	1 (6.3)	1 (4.5)	2 (5.3)	3 (18.8)	1 (4.5)	4 (10.5)	0.016
Treatment strategy according to the organ/area to be irradiated	1 (6.3)	4 (18.2)	5 (13.2)	9 (56.3)	9 (40.9)	18 (47.4)	3 (18.8)	0 (0)	3 (7.9)	8 (50)	5 (22.7)	13 (34.2)	3 (18.8)	2 (9.1)	5 (13.2)	3 (18.8)	7 (31.8)	10 (26.3)	0.229
Simulation session	5 (31.3)	2 (9.1)	7 (18.4)	6 (37.5)	8 (36.4)	14 (36.8)	1 (6.3)	0 (0)	1 (2.6)	7 (43.8)	14 (63.6)	21 (55.3)	2 (12.5)	3 (13.6)	5 (13.2)	2 (12.5)	5 (22.7)	7 (18.4)	0.436
Contouring, dose prescription, dosimetry	0 (0)	6 (27.3)	6 (15.8)	10 (62.5)	7 (31.8)	17 (44.7)	1 (6.3)	0 (0)	1 (2.6)	10 (62.5)	11 (50)	21 (55.3)	2 (12.5)	3 (13.6)	5 (13.2)	3 (18.8)	3 (13.6)	6 (15.8)	0.146
Organs at risk dose constraints	0 (0)	3 (13.6)	3 (7.9)	10 (62.5)	8 (36.4)	18 (47.4)	1 (6.3)	0 (0)	1 (2.6)	10 (62.5)	5 (22.7)	15 (39.5)	3 (18.8)	3 (13.6)	6 (15.8)	3 (18.8)	7 (31.8)	10 (26.3)	0.183
Short and long term follow-up of the patient	4 (25)	9 (40.9)	13 (34.2)	6 (37.5)	7 (31.8)	13 (34.2)	1 (6.3)	0 (0)	1 (2.6)	8 (50)	1 (4.5)	9 (23.7)	2 (12.5)	1 (4.5)	3 (7.9)	2 (12.5)	4 (18.2)	6 (15.8)	0.067
Risk and incident management	7 (43.8)	4 (18.2)	11 (28.9)	2 (12.5)	8 (36.4)	10 (26.3)	2 (12.5)	1 (4.5)	3 (7.9)	4 (25)	3 (13.6)	7 (18.4)	1 (6.3)	1 (4.5)	2 (5.3)	3 (18.8)	8 (36.4)	11 (28.9)	0.229
Quality management	7 (43.8)	13 (59.1)	20 (52.6)	4 (25)	5 (22.7)	9 (23.7)	1 (6.3)	0 (0)	1 (2.6)	4 (25)	0 (0)	4 (10.5)	1 (6.3)	0 (0)	1 (2.6)	4 (25)	4 (18.2)	8 (21.1)	0.134
Medical informatics	4 (25)	9 (40.9)	13 (34.2)	5 (31.3)	5 (22.7)	10 (26.3)	1 (6.3)	0 (0)	1 (2.6)	6 (37.5)	7 (31.8)	13 (34.2)	1 (6.3)	1 (4.5)	2 (5.3)	3 (18.8)	3 (13.6)	6 (15.8)	0.851
Management of emergency cases	2 (12.5)	9 (40.9)	11 (28.9)	8 (50)	4 (18.2)	12 (31.6)	1 (6.3)	0 (0)	1 (2.6)	6 (37.5)	3 (13.6)	9 (23.7)	2 (12.5)	2 (9.1)	4 (10.5)	2 (12.5)	5 (22.7)	7 (18.4)	0.089

Notes: For each category, the percentage was calculated within each type of training; SBME: Simulation-based Medical Education

Table 3. — Teaching materials employed in the teaching of technical skills (*N* = 38).

• Non technical skills

All participants recognized the relevance of non-technical skills to their professional practice. Among these, teamwork (median=3.0, IQR: 2–3) and interprofessional communication (median=3.0, IQR: 2–3), were given the highest ranking.

Teamwork (mean=2.0, IQR: 2.0–2.75) was deemed highly adequate by the participants.

For other non-technical skills, some respondents indicated that interprofessional communication (13.16%) and communication with patients and their relatives (13.16%) were not adequately addressed.

The teaching of soft skills appeared to be less prevalent in the present sample and even absent from the curriculum of almost half of the participants.

Teaching of non-technical skills was mostly done during practical (range 13.2–34.2%), SBME (range 5.3–15.8%) or ex-cathedra lessons (range 10.5–28.9%).

The skill that was mostly taught by practical (34.2%) and SBME (15.8%) was communication with patients and their relatives.

No significant differences in the teaching methods employed were observed in the RO and RTT programs as presented in Table 4.

Topic	Not addressed			Ex-cathedra			E-learning			Practical			SBME			Others			*p*-value
	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	RO	RTT	Total	
Communication with patients and their relatives	5 (31.3)	10 (45.5)	15 (39.5)	1 (6.3)	4 (18.2)	5 (13.2)	0 (0)	0 (0)	0 (0)	8 (50)	5 (22.7)	13 (34.2)	4 (25)	2 (9.1)	6 (15.8)	3 (18.8)	2 (9.1)	5 (13.2)	0.321
Patient's therapeutic education	6 (37.5)	16 (72.7)	22 (57.9)	4 (25)	2 (9.1)	6 (15.8)	1 (6.3)	0 (0)	1 (2.6)	5 (31.3)	1 (4.5)	6 (15.8)	1 (6.3)	1 (4.5)	2 (5.3)	3 (18.8)	3 (13.6)	6 (15.8)	0.079
Ethical standards	10 (62.5)	6 (27.3)	16 (42.1)	2 (12.5)	9 (40.9)	11 (28.9)	0 (0)	1 (4.5)	1 (2.6)	4 (25)	1 (4.5)	5 (13.2)	1 (6.3)	1 (4.5)	2 (5.3)	3 (18.8)	4 (18.2)	7 (18.4)	0.103
Interprofessional communication	10 (62.5)	10 (45.5)	20 (52.6)	1 (6.3)	3 (13.6)	4 (10.5)	0 (0)	1 (4.5)	1 (2.6)	4 (25)	3 (13.6)	7 (18.4)	1 (6.3)	2 (9.1)	3 (7.9)	3 (18.8)	4 (18.2)	7 (18.4)	0.920
Teamwork (collaboration, leadership, decision making)	11 (68.8)	11 (50)	22 (57.9)	0 (0)	4 (18.2)	4 (10.5)	0 (0)	1 (4.5)	1 (2.6)	3 (18.8)	3 (13.6)	6 (15.8)	1 (6.3)	2 (9.1)	3 (7.9)	2 (12.5)	4 (18.2)	6 (15.8)	0.504

Notes: For each category, the percentage was calculated within each type of training; SBME: Simulation-based Medical Education

Table 4. — Teaching materials used to teach soft skills (*N* = 38).

Some professionals highlighted the satisfaction they obtained and the response to their needs, especially when less common teaching methods were used such as exchanges with clinical experts or clinical hands-on interventions.

The most valued teaching tool for half of the respondents was practical, hands-on lessons (50.0%).

Second in row, they preferred teaching that allows relational exchanges, such as work or discussions in small groups (29.4%), theoretical lessons (20.6%) and digital materials (17.6%).

SBME and case studies were each reported by only one professional (total n for this question=34).

- **Professional competencies**

When respondents were asked to rate the seven professional competencies defined in the CanMEDS model from 1 (least important) to 7 (most important) according to their own practice [8], 5 competencies were rated as important (median scores well above 4).

These were professional, medical experts, followed by communicator, collaborator, and finally patient advocate.

Leadership and scholarship were indicated as the least important competencies.
The results are shown in Table 5.

Professional competencies	Median (IQR)
Medical experts (theoretical and practical knowledge)	5.00 [3.00; 7.00]
Professional (ethical standard and excellence)	5.00 [2.00; 7.00])
Communicator (appropriate and effective communication)	4.00 [3.00; 6.00]
Collaborator (collaboration with other health professional)	4.00 [3.00; 6.00]
Patient advocate (supporter and advisor)	4.00 [3.00; 6.00]
Scholar (continuing education, teaching, and research)	3.00 (2.00; 4.00]
Leader (management of human and technical resources)	1.00 [1.00; 4.00)

Table 5. — Median and interquartile ranges (IQR) of the ranking of professional competences (*N*=38).

Further analysis revealed almost no correlations between participants' age groups and gender and their ratings of the professional competencies, except in the area of scholarship for which, male participants (median=4.0, IQR: 3.0–4.75) had a higher mean rank (p<0,01) than female participants (median=2.0, IQR: 2.0–3.25).

Specific initial education and perceived level of knowledge acquisition were not significantly related to participants' professional competency rankings.

• Improvement strategies: qualitative analysis

At the end of the survey, participants were asked what courses could be added to their initial training (n=38), the codification has led to the emergence of major themes covering teaching methods but also major crosscutting skills.

Communication with patients and/or with other professionals was mentioned frequently (n=10, 26.3%).

They also expressed the need for more practice (n=8, 21.1%) and more specific courses (n=9, 23.7%) in the fields of dosimetry, medical oncology, and radiation therapy-specific software. Four professionals also mentioned a need for more teamwork training to improve inter- and intra-team collaboration and team management (10.5%). Other ways of improving training that were mentioned were medical simulation, ergonomics, hypnosis, time management and administrative matters.

5. Discussion

The aim of this study was to provide an overview of the topics and teaching materials that have been used to teach radiation oncology in the Greater Region in recent decades.

We also intended to explore the possibilities for improving radiotherapy education according to professional's opinions.

A recent study found that 16.7% of German young RO were not satisfied with their residency program[13].

Similarly, among Australian and New Zealand RO trainees, 7.5% reported that they were dissatisfied with their professional activities as trainees. Regarding their sense of self-efficacy, 54% were very satisfied with their feeling of being able to handle technical and non-technical aspects of RO, but 2.8% were not at all satisfied with this [14].

We found the same dichotomous pattern in our cohort, with 21.05% of participants reporting having acquired all the competencies required for their clinical practice on the one hand, and 21.05% of participants reporting that they had not acquired enough competencies on the other hand. Interestingly, one of the factors contributing to professional well-being has been shown to be related to workload or time management.

Excessive workload and time pressure create stress and can eventually lead to burnout as reported by Leung et al., which showed that 13% of trainees in RO suffered from one and/or the other[14]. In line with this, 13.16% of our population experience stress due to a lack of time.

A large proportion of participants, 39.47–57.89%, reported that non-technical skills were not addressed through their curriculum. Accordingly in the literature, only tumor-specific learning was mentioned in addition to basic science and training in RT technical skills without attention for non-technical skills training[15, 16, 17].

Therefore, the fact that more than a third of our surveyed population recommended to further emphasize non-technical skills in their education, such as communication and team training, reflected the training needs from a professional perspective.

In fact, the importance of these skills have been re-emphasized in the ESTRO core curricula and several small studies revealed that communicational workshop for professionals could improve not only self-efficacy but also patient satisfaction[18, 19, 20].

In view of these findings, it would be important to conduct surveys on this topic among a larger number of RO and RTT to confirm them.

It would also be interesting to think about national or international initiatives offering specific soft skills courses for RO and RTT to fill this gap.

This is important because we know that although the various tasks of RO and RTT are becoming more and more automated and artificial intelligence (AI) is in full expansion, the fact remains that patients like human contact with their caregivers and that soft skills like good communication and empathy are the basis of good patient care[21, 22.]

Respondents rated all the teaching method mostly as quite adequate, or very adequate. Ex cathedra lectures and practical training lessons were the most commonly used to acquire knowledge and technical skills.

Nontechnical skills, despite not being covered very frequently, were mainly addressed through practical lessons, followed by ex-cathedra lectures and SBME.

In the RT field, SBME appeared to be used to train various skills and procedural actions. A literature review by Rooney et al. found that more than half of the studies involved screen based simulators and contouring exercises in particular.

This review showed that SBME appeared to be more helpful than traditional teaching tools to learn specific radiation oncology skills[23].

In our cohort, we noticed that the teaching methods were found to be not different between the RO and RTT training in the teaching of technical skills and soft skills.

In contrast, ex-cathedra, practical lessons and e-learning were more employed in the RO training for theoretical knowledge including: radiation physics, general oncology and medical imaging respectively.

Indeed, it was demonstrated that in Europe, on average, 30% of medical student programs proposed e-learning for radiotherapy[24].

Web-based learning tools such as e-learning should not be underestimated as they enable the development of self-awareness and the improvement of radio-anatomical knowledge and treatment planning skills among RTT and RO trainees[25, 26].

It should however be noted that teaching methods, especially simulation modalities, should carefully be selected and fit the intended learning outcomes[27].

Regarding the seven professional competencies investigated, our study reveals that RT professionals overemphasize medical (medical expert and professional) and soft (communicator and collaborator) skills.

The former is the most described and present in training programs, but the latter is perceived as important even if it is not well represented in the programs. Leadership comes last, although its importance in this radiation oncology was defined in a Delphi consensus study[28].

All competencies are valuable for each professional function and should be present in the curriculum of RT professionals, as reported by ESTRO and the updated curricula for RO and RTT[29, 30].

The small sample size of the study entails a limitation in the generalizability of the results, even though the findings are in accordance with previously published studies on the same topic. The limited number of participants may be due to the prior approval required from the heads of departments and also because the survey was launched during the COVID-19 pandemic.

6. Conclusions

According to RT professionals working in the Greater Region, more practical lessons are needed to improve their training curriculum.

Only one-fifth of the respondents declared having acquired all the competencies required for their professional practice during their initial training; and some of the professionals expressed the stress caused by the lack of time for practical lessons.

Heterogeneity in teaching methods was noted within professional programs but there was no significant differences observed in the teaching methods employed to teach technical and non-technical skills in RO and RTT initial training programs.

Furthermore, soft skills were not addressed in about half of the respondent’s curricula.

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Chapter 4

Comparison between the WHO-CFICPS and the PRISMA classification of safety-related events in a radiation oncology department

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1. Abstract

Introduction

Describing Safety-Related Events (SREs) in a radiotherapy (RT) department and comparing WHO-CFICPS (World Health Organization's Conceptual Framework For The International Classification For Patient Safety) and PRISMA (Prevention and Recovery Information System for Monitoring and Analysis) methods for classifying SREs.

Methods

From February 2017 to October 2020, two Quality Managers (QMs) randomly classified 1173 SREs using 13 incident types of WHO-CFICPS. The same two QMs, reclassified the same SREs according to 20 PRISMA incident codes. Statistical analysis was performed to assess the association between the 13 incident types of WHO-CFICPS and the 20 PRISMA codes. The chi-squared and post-hoc tests using adjusted standardized residuals were applied to detect the association between the two systems.

Results

There was a significant association between WHO-CFICPS incident types and PRISMA codes ($P < 0.001$). Ninety-two percent of all SREs were categorized using 4 of 13 WHO-CFICPS incident types including Clinical Process/Procedure (n = 448, 38.2%), Clinical Administration (n = 248, 21.1%), Documentation (n = 226, 19.2%) and Resources/Organizational Management (n = 15,613.3%). According to PRISMA classification, 14 of the 20 codes were used to describe the same SREs. PRISMA captured 41 Humans Skill Slips from 226 not better defined WHO-CFICPS Documentation Incidents, 38 Human Rule-based behaviour Qualification from not better defined 447 Clinical Process/Procedure and 40 Organization Management priority events from 156 not better defined WHO-CFICPS Resources/Organizational Management events ($P < 0.001$).

Conclusion

Although there was a significant association between WHO-CFICPS and PRISMA, The PRISMA method provides a more detailed insight into SREs compared to WHO-CFICPS in a RT department.

2. Introduction

Radiotherapy (RT) treatments have become more complex and automated, leading to a greater reliance on record and verify systems that enable a precise delivery of increasingly complex treatments. These record and verify systems are capable of eradicating a large number of errors, but require the vigilance of the RT team[1, 2, 3].

In addition, patient management in RT involves numerous human interactions and exchange of information between different professionals such as radiation oncologists (ROs) (senior and residents), radiation therapists (RTTs), medical physics experts (MPEs) and assistants (MPAs), quality managers (QMs) and administrative staff.

Safety-related events (SREs) can occur at any point in this complex chain of interactions between people, medical devices and software[4].

Previous publications have explored how a reliable adverse event reporting system could help prevent healthcare incidents[5, 6, 7, 8]. In RT clinical setting, it was suggested that using an incident reporting tool and analyzing the reports can help reduce the error rate[9].

The World Health Organization (WHO) has proposed the WHO-CFICPS[10] (World Health Organization's Conceptual Framework For The International Classification For Patient Safety) as a classification of SREs specifically designed for healthcare.
The WHO-CFICPS was introduced to facilitate incident reporting in all healthcare settings and is intended to provide a comprehensive understanding of the field of patient safety[11]. It is intended as a tool for continuous learning and improvement and focuses on risk identification, prevention, detection, risk mitigation, incident management and system resilience[12].

However, a single classification system may not be suitable for all medical departments[13, 14, 15, 16]. Therefore, specific classification systems have been proposed for reporting SREs in particular domain such as neonatology[17] and critical care[18].

In the last two decades, some reporting and analysis classifications such as ROSEIS (*Radiation Oncology Safety Education and Information System*) in Europe[19], SAFRON (Safety in Radiation Oncology) in the united states, NCIR (National System for Incident Reporting) in Canada[20], and PRISMA-RT[21, 22] in Belgium and the Netherlands were specifically developed for RT.

In particular, the PRISMA method using the Eindhoven classification[23] has been adopted by some RT departments in Belgium and the Netherlands to collect and analyze SREs.

The PRISMA method[24] was originally developed to assess human error in the chemical industry, and is now used in the steel and energy industries.

The main objective of the PRISMA method is to build a quantitative database of incidents and process deviations from which conclusions can be drawn to propose optimal countermeasures.

As the PRISMA method focuses on human error, it is inherently suited to RT[25], which requires the interaction of multiple professionals. To date, no general consensus has been reached on a coding system to describe adverse events in radiation oncology. Therefore, there is insufficient information on the extent to which the use of a specific classification system for RT may influence the assessment of SREs compared to a general classification, such as the WHO-CFICPS, suitable for all clinical scenarios.

We conducted a monocentric retrospective study describing SREs in a single RT department and comparing the WHO-CFICPS and PRISMA methods to assess the changes in classification when moving from a general healthcare classification to a more specific to human errors classification.

3. Materials and methods

We retrospectively and consecutively analyzed 1173 consecutive incidents reported in our RT department from 2017 to 2020. For this retrospective and anonymized monocentric study, approval was waived by the ethics committee because our study did not involve testing, investigation or research on humans and therefore the committee had no ethical objection to conducting this study.

Source database

The incident reports were anonymously submitted by the RT staff including ROs, RTTs, MPEs, MPAs, and administrative staff in an institutional database software ("QUALIT" BlueKanGo® https://www.bluekango.com/en/). In this software, the staff members can enter a narrative description of the SREs.

Inclusion criteria

All consecutive reports introduced by the radiation oncology department staff were included in the analysis.

Exclusion criteria

Incomplete reports or not validated reports in which both PRISMA and WHO-CFICPS could not be performed were discarded.

Incidents that occurred before 2017 were excluded from this retrospective study because they were classified in a written database.

Database assessment

During their collection, the incidents were assessed by two QMs with 7 and 5 years of experience and classified based on 13 different incident types and severity levels using the WHO-CFICPS classification in accordance with the hospital quality and safety policy.

WHO-CFICPS incident types[26] are listed in Table 1.

WHO-CFICPS	Incident Type
	Clinical Administration
	Clinical Process/Procedure
	Documentation
	Healthcare Associated Infection
	Medication/Intravenous Fluids
	Blood/Blood Products
	Nutrition
	Oxygen/Gas/Vapour
	Medical Device/Equipment
	Behaviour
	Patient Accidents
	Infrastructure/Building/Fixtures
	Resources/Organisational Management

Table 1. — WH0-CFICPS incident type list.

During the classification process, each event was randomly assigned to the one of the two QMs. The WHO-CFICPS was also used to determine the degree of harm.

The incidents database was randomly reviewed from November 2020 to January 2021 by the same two QMs, blinded to the WHO-CFICPS and classified according to the PRISMA method to join the PRISMA-RT project[27].

PRISMA conceptual framework is based on a tree structure of codes[28]. PRISMA categories and related codes are summarized in Table 2.

Categories	Codes	Abbreviations
Technical	External	(T-EX)
	Design	(TD)
	Construction	(TC)
	Materials	(TM)
Organisational	External	(O-EX)
	Transfer of Knowledge	(OK)
	Protocols	(OP)
	Culture	(OC)
	Management priorities	(OM)
Human	External	(H-EX)
	Knowledge	(HKK)
	Qualifications	(HRQ)
	Coordination	(HRC)
	Verification	(HRV)
	Intervention	(HRI)
	Monitoring	(HRM)
	Slips	(HSS)
	Tripping	(HST)
Others	Patient related factor	(PRF)
	Unclassifiable	(X)

Table 2. — PRISMA classification.

The incidents classification according to WHO-CFICPS and PRISMA were coded in an Excel spreadsheet.

Statistical Analysis

Descriptive analyses were presented by histograms representing counts and percentages for each category of WHO-CFICPS and PRISMA.

To obtain robust statistical analysis, we focused on cells with more than 50 SREs, resulting in 1072 (92%) of the initial incident reports used for data analysis. To test the association between WHO-CFICPS and PRISMA classification, a chi-square independence test was performed with a p-value calculated by Monte Carlo estimation as there were cells with expected values less than Five. Once the omnibus chi-square was significant, post-hoc analyses with Bonferroni correction were performed using the adjusted standardized residuals to find out which of the observed values were larger or smaller than expected. Accordingly, a p-value of 0.001 was considered significant. For each category of WHO-CFICPS, the proportion of PRISMA categories were examined, followed by a z-test of independent proportions to compare column proportions with p-values being adjusted by Bonferroni correction. The analysis was conducted using IBM SPSS, version 26.

4. Results

Degree of harm

A total of 1173 SREs were included and classified using the WHO-CFICPS incident types and PRISMA codes. Sixty-five SREs were not included in the analysis because the reported data were not complete enough to perform the PRISMA and/or WHO-CFICPS analysis (5.25%).

The severity and frequency of the SREs is detailed in Fig.1.

The majority of SREs presented no harm to the patients (n=563, 48%), 563 (43%) reported SREs caused mild harm to patients, 70 SREs (6%) caused moderate harm to patients. Three (0.3%) SREs caused severe harm to patients while there was no death related SREs and 31(3%) SREs didn't fit into any degree of harm (Fig1).

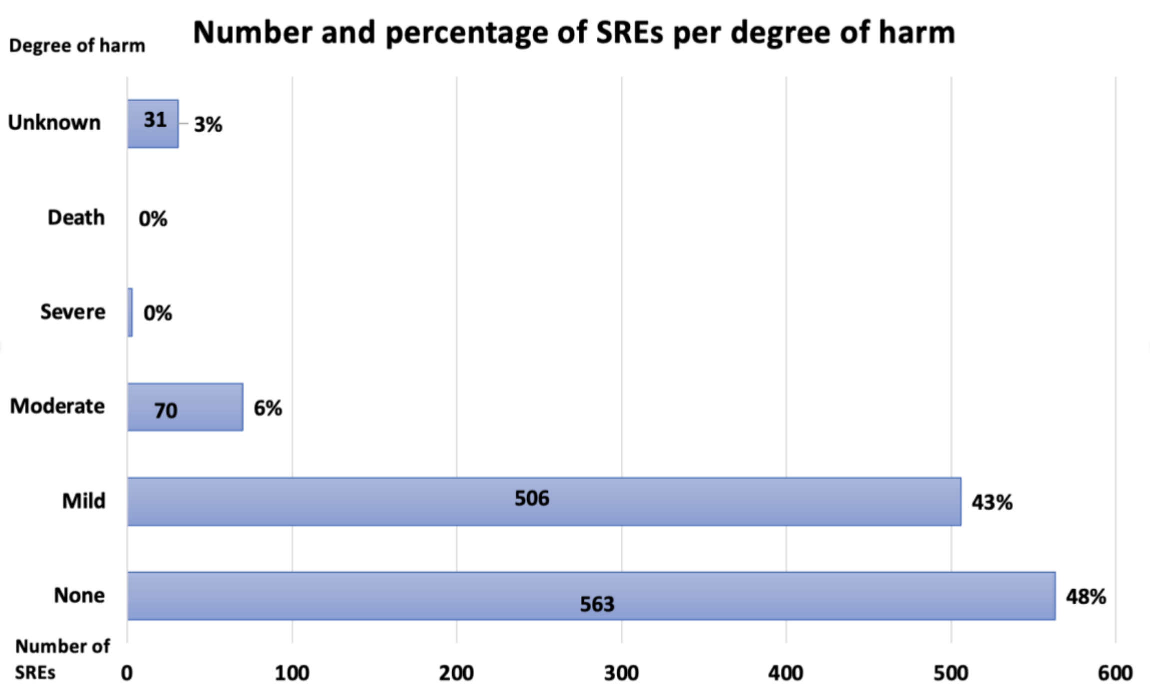

Fig. 1. — Number and percentage of safety-related events per degree of harm.

Reporting professional categories

Radiation therapists is the most reporting professional category (n=405, 35%) followed by ROs (n=261, 22.5%) then administrative staff (n=257, 22.2%).

MPEs/MPAs and QMs reported less SREs, respectively 11% and 3.4% (Fig2).

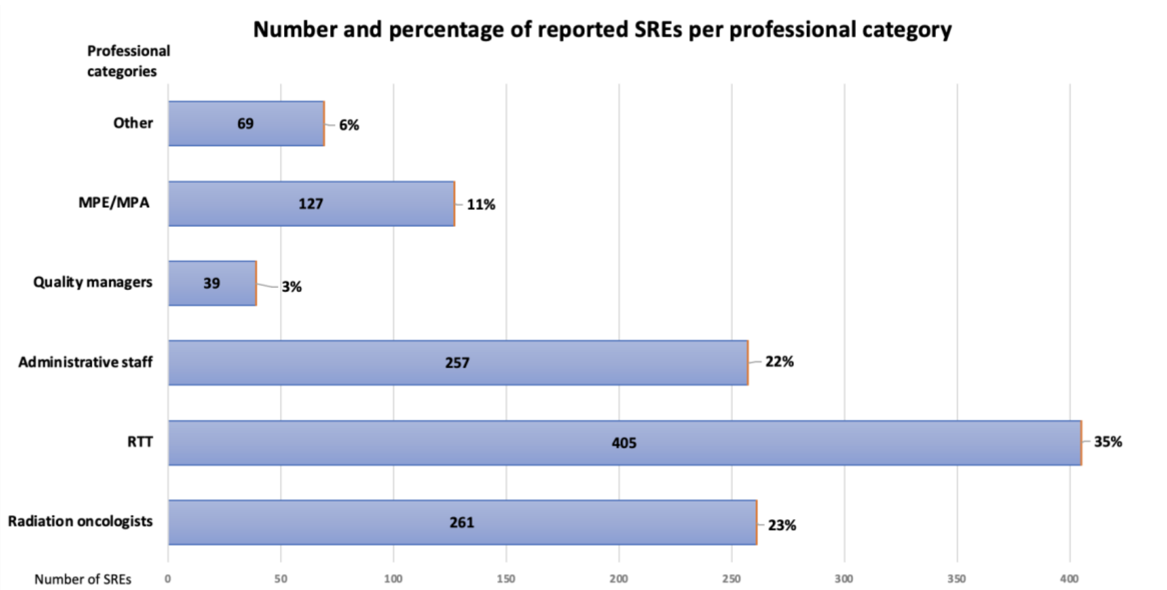

Fig. 2. — Percentages and numbers of safety-related events per professional category.

SREs distribution according to WHO-CFICPS incident types and PRISMA codes

The absolute number and relative percentage of SREs according to WHO and PRISMA classifications are shown in Fig 3 and Fig 4 respectively.

Using the WHO-CFICPS classification (Fig 3), more than one third of SREs (n=448, 38.19%) were attributed to Clinical process/procedure. The second and third most frequently assigned categories were Clinical administration (n=248, 21.14%) and Documentation (n=226, 19.27%), respectively.

Overall, 1077 (92%) of all SREs were described with only 4 WHO-CFICPS incident types, while according to the PRISMA classification (Fig4), 14 of the 20 codes were used to describe the same SREs.

The Human category was the most represented PRISMA category with 717 SREs (61.2%). In the Human category, the three most frequently represented codes were HKK, HRC, HRM with 11.7%, 10.2% and 9% of all SREs, respectively.

There were 323 (27.5%) SREs in the Organisational category and the two most frequently assigned codes in this category were the OC code with 98 SREs (8.4%) and the OM code with 96 SREs (8.2%).

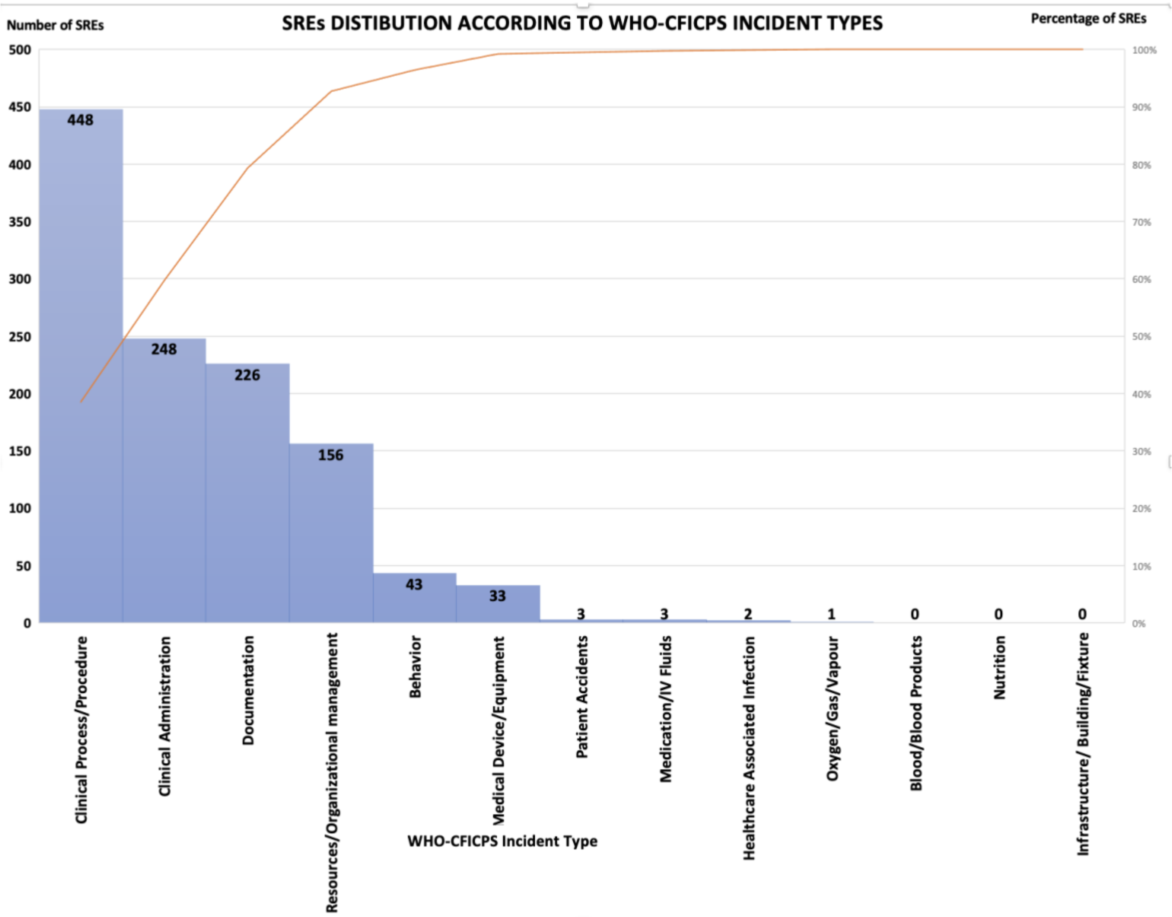

Fig. 3. — Safety-related events distribution according to the WHO-CFICPS incident types.

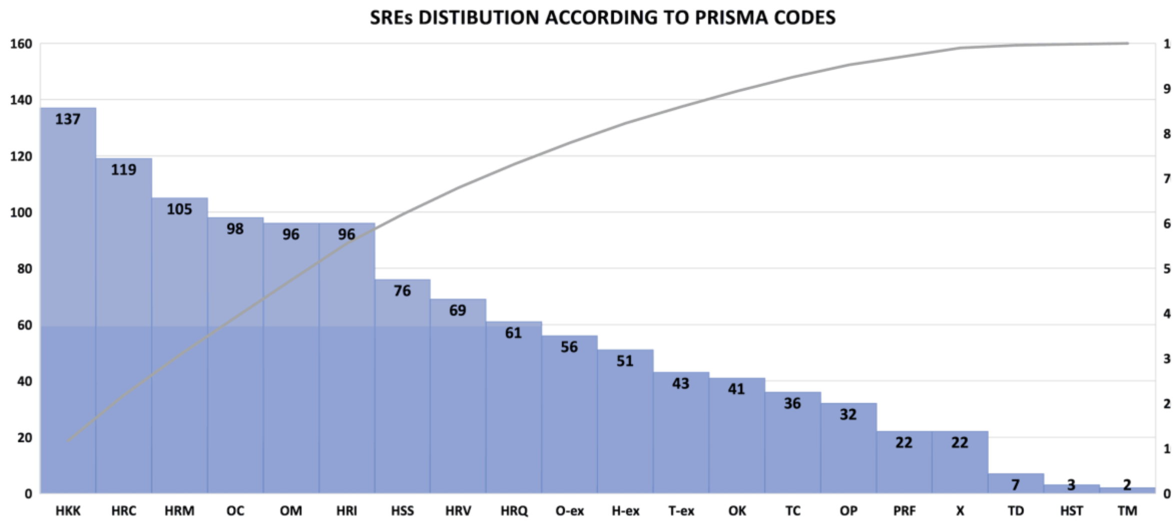

Fig. 4. — Safety-related events distribution according to the PRISMA codes.
Note: PRISMA codes are detailed in Table 2.

Eighty-eight (7.5%) SREs fell into the Technical category where the two most represented codes were the T- EX code with 43 SREs (3.7%) and the TC code with 36 SREs (3.1%)

Forty-four (3.8) SREs were reported into the Other category, the PRF code contained 22 SREs (1.9%), and 22 SREs (1.9%) were classified into the (X) code.

Association between the WHO-CFICPS and PRISMA classification:

To derive robust statistical analysis results, we focused on cells with more than 50 SREs resulting in 1072 (92%) of the initial incident reports used for data analysis. Chi-square test revealed a significant association between the WHO-CFICPS and PRISMA classifications ($p<0.001$). Post-hoc analyses showed significant differences in the proportions between pairs of categories as follows (Table 3).

In each column, values that were statistically higher or lower compared to the expected values of a random distribution are marked with three asterisks. For each significant value, the keys underneath indicate categories with a statistically smaller column proportion than the expected value.

As an example, among the incidents classified as Documentation in the third column of the WHO-CFICPS incident types, the number of events classified as HSS (Key H) in PRISMA (n=41, 18.1%) was observed more frequently than expected (adjusted standardized residual = 7.5, $p < 0.001$). Further examination revealed that the HSS category had a significantly higher proportion of adverse events than nine other categories, including HKK (Key B) (n=32, 14.2%), HRC (Key C) (n=17, 7.5%), HRI (Key D) (n=22, 9.7%), HRM (Key E) (n=20, 8.8%), HRQ (Key F) (n=7, 3.1%), O- EX (Key J) (n=3, 1.3%), OC (Key K) (n=11, 4.9%), OK (Key L) (n=6, 2.7%) and OM (Key M) (n=5, 2.2%).

PRISMA codes	Key	WHO-CFICPS (n, %)				Total
		Clinical administration	Clinical process/ procedure	Documentation	Resources/ Organizational management	
H-EX	**A**	*13 (5.2)* ***H***	13 (2.9)	10 (4.4)	4 (2.6)	40 (3.7)
HKK	**B**	33 (13.3)	59 (13.2)	32 (14.2) **M**	9 (5.8)	133 (12.3)
HRC	**C**	*39 (15.7)* ***H***	43 (9.6)	17 (7.5)	14 (9.0)	113 (10.5)
HRI	**D**	20 (8.1)	36 (8.1)	22 (9.7)	15 (9.6)	93 (8.6)
HRM	**E**	*27 (10.9)* ***H***	32 (7.2)	20 (8.8)	16 (10.3)	95 (8.8)
HRQ	**F**	8 (3.2)	*38 (8.5)**** ***E, H, M***	7 (3.1)	5 (3.2)	58 (5.4)
HRV	**G**	15 (6.0)	28 (6.3)	21 (9.3) **M**	4 (2.6)	68 (6.3)
HSS	**H**	5 (2.0)***	24 (5.4)	*41 (18.1)**** ***B, C, D, E, F, J, K, L, M***	4 (2.6)	74 (6.9)
HST	**I**	0 (0.0)[a]	2 (0.4)	0 (0.0)[a]	0 (0.0)[a]	2 (0.2)
O-EX	**J**	*21 (8.5)* ***H***	19 (4.3)	3 (1.3)	10 (6.4)	53 (4.9)
OC	**K**	19 (7.7)	50 (11.2)	11 (4.9)	16 (10.3)	96 (8.9)
OK	**L**	*13 (5.2)* ***H***	13 (2.9)	6 (2.7)	6 (3.8)	38 (3.5)
OM	**M**	17 (6.9)	31 (6.9)	5 (2.2)***	*40 (25.6)**** ***A, B, C, D, E, F, G, H, K, P***	93 (8.6)
OP	**N**	5 (2.0)	11 (2.5)	6 (2.7)	9 (5.8)	31 (2.9)
PRF	**O**	5 (2.0)	10 (2.2)	0 (0.0)[a]	0 (0.0)[a]	15 (1.4)
T-EX	**P**	4 (1.6)	12 (2.7)	11 (4.9) **M, J**	2 (1.3)	29 (2.7)
TC	**Q**	0 (0.0)[a]	17 (3.8)	9 (4.0) **M**	0 (0.0)[a]	26 (2.4)
TD	**R**	0 (0.0)[a]	6 (1.3)	1 (0.4)	0 (0.0)[a]	7 (0.6)
X	**S**	4 (1.6)	3 (0.7)	4 (1.8)	2 (1.3)	13 (1.2)
Total		**248 (100.0)**	**447 (100.0)**	**226 (100.0)**	**156 (100.0)**	**1077(100.0)**

Notes: For each significant pair, the key of the category with the smaller column proportion appears in the category with the larger column proportion.

*[a]This category is not used in comparisons because its column proportion is equal to zero or one; ***p<0.001. PRISMA Codes are detailed in Table 2.*

Table 3 — Number and percentages of SREs classified according to PRISMA and WHO-CFICPS.

That was also the case for 38 HRQ which were observed more frequently than expected in Clinical Process/Procedure and 40 OM priority events from 156 not better defined WHO-CFICPS Resources/Organizational Management events ($p < 0.001$).

The detailed result can be found in Table 3, in which the number and percentages of adverse events were classified according to the PRISMA and WHO-CFICPS respectively.

5. Discussion

Accurate recording and analysis of SREs is essential to establish effective and targeted procedures, continuous training based on incident learning, and potentially improve patients safety[29].

Although general and radiotherapy-specific systems are available in the scientific literature, there are no data on the reclassification of events from a general healthcare-focused system to a more specific human error-focused system.

On the other hand, there are no data in the literature on the demonstrated superiority of systems specific to radiotherapy compared to more general error reporting systems in the medical setting.

This retrospective study describes the SREs reported in a single RT department according to two classifications and assesses the reclassification effect of the same SREs from a general medical WHO-CFICPS system to a classification system considered by some departments of RT to be better adapted to the profile of RT.

First, descriptive analysis showed that the majority of SREs were of no or mild severity for patients. There were no deaths associated with SREs and severely harmful events were rare, which is consistent with previously published data[30].

Although these SREs did not cause significant harm in most cases, they may affect the workflow and efficiency of the RT department. This issue should be investigated in a separate study focusing on the impact of SREs on the management of a RT department.

Second, the distribution of reporters across the different professional groups involved in a RT department was uneven, with RTTs and ROs being the two groups that reported most SREs.

These findings are consistent with published studies that have previously reported that RTTs are more likely to report SREs than any other professional group in RT departments[31].

Third, both classifications showed that SREs classified as Technical in the PRISMA method and medical device/equipment or infrastructure/building/fixtures in the WHO-CFICPS were relatively rare in the RT setting, indicating that the equipment used in RT is quite reliable and confirming that the main weaknesses in RT are due to the human factor and human organization.

Fourth, there is consistency between a general classification such as WHO - CFICPS and PRISMA. As an example, documentation errors are classified as document management related errors in both systems.

This general agreement between WHO - CFICPS and PRISMA is statistically significant. This shows that reclassification of SREs using a system considered more appropriate for human errors does not lead to a random reclassification of SREs and that these systems can be considered correlated.

Fifth, compared to the WHO system, which classified the majority of SREs (92%) using only 4 accident types, the PRISMA system was able to disaggregate the data in a way that allowed a fine-grained analysis of SREs, as 14 of the 20 codes were used to describe the same SREs. Hence, PRISMA was able to more specifically flag 41 HSS from 226 not better defined WHO-CFICPS Documentation Incidents, 38 HRQ out of not better defined Clinical Process/Procedure and 40 OP events out of 156 not better defined WHO-CFICPS Resources/Organizational Management events ($p < 0.001$), demonstrating a potential advantage in describing events in a RT clinical setting.

Finally, in our single center experience, the most common SREs recorded by PRISMA are related to HKK, HRC and HRM codes. This observation suggests that PRISMA can effectively capture SREs due to the human factor. In addition, PRISMA has the advantage that actions can be proposed for each type of code, making this system an effective tool for implementing corrective actions[32].

Our study has several limitations:

SREs were randomly classified by a single quality manager and we are unable to measure interobserver agreement.

However, in most of clinical settings, SREs are not classified in a double-blind fashion. Analysis of interobserver agreement could be the subject of a future multicenter and prospective study.

In addition, the PRISMA reclassification was performed by QMs who had experience with WHO-CFICPS over several years. In this respect, the design of the study did not allow for an analysis of possible biases due to the different experience with the two systems.

However, the statistical analysis confirmed the coherence of the two systems by showing a statistically significant association between the two systems and the occurrence of clusters.

As the study was conducted in a single radiotherapy center, the observed reclassification effects need to be confirmed in multicenter studies, as the profile of SREs might differ between different institutions.

6. Conclusion

Although there was a significant association between the WHO-CFICPS and PRISMA classifications, the PRISMA methods provided a more detailed insight into SREs compared to the WHO-CFICPS and it is particularly suitable to specifically classify human errors in radiation oncology.

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Chapter 5

Simulation-based medical education to learn soft skills in radiation oncology: a preliminary experience

ESTRO 2024 : Abstract E24-2052 titled *Simulation-based medical education to learn soft skills in radiation oncology* is accepted for a Digital Poster

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Foreword

In the framework of the Interreg project NHL-Chirex (EU-Interreg Va Greater Region Program N°043-1-01-125), the Department of Radiation Oncology of the University Hospital of Liège organized a 2-day training module for radiation oncology professionals working or being trained in the RT centers of the Greater Region (University Hospital of Liège, Oncology Institute of Lorraine, Center François Baclesse).

The role of the RO department of the University Hospital of Liège within the Interreg NHL-Chirex project was to use SBME to offer teaching modules focused on soft skills.

Thus, using the database of SREs analyzed in Chapter 4, we identified SREs whose problematic roots were the methods and means of communication between professionals and with patients in order to build a complete scenario from the first consultation with the patient to the treatment of the wrong vertebra.

In addition to communication skills, quality management training was provided to the participants, which essentially involved reporting and analyzing an SRE and setting up procedures to avoid this type of SRE in the future.

The aim was to set up a practical training, focusing on soft skills as that was the need reported by RO professionals who answered the survey in Chapter 3.

1. Abstract

Aim

To assess the effectiveness of simulation-based medical education (SBME) in implementing communication skills and quality management procedures in a team of radiation oncology professionals.

Material and methods

As part of an international educational initiative (INTERREG Va Greater Region Program), Radiation Therapists (RTTs), Board Certified Radiation Oncologists (BCROs) and Radiation Oncology Residents (RROs) were invited to participate in a two-day simulation-based training module. The module included a session on communication with patients and healthcare providers and a separate session on reporting, analyzing a safety-related event (SRE) and implementing improvement procedures. Overall Satisfaction (OS), self-confidence in learning (SCIL), and simulation design (SDS) were measured with questionnaires.

Participants were sent a practice-change questionnaire six months after the simulation modules to assess the training's impact on daily practice. Statistics were used to describe participant feedback.

Results

Twenty-one participants, including 4 BRCOs, 7 RROs and 10 RTTs from 3 different countries participated in the 2-day module.

The OS was rated a median of 9 on a scale of 10, SCIL was rated 4 on a scale of 5 and SDS was rated 5 on a scale of 5.

In the practice-change questionnaire, most of participants indicated that they had implemented their communication methods and their skills to implement improvement measures after safety-related events, whereas the reporting and analysis of SREs was not impacted by this training.

Conclusion

Simulation-based medical education (SBME) appears to be an effective method to implement communication skills and encourage radiation oncology staff to take improvement actions after analyzing safety-related events.

2. Introduction

Simulation in education is defined as "a technique to replace or amplify real experience with guided experiences, often immersive in nature, that evoke or replicate substantial aspects of the real world in a fully interactive manner"[1].

Simulation-based medical education (SBME) to improve patient safety and healthcare quality has grown in popularity in recent decades[2] and improves student competence compared to traditional teaching methods, according to several reviews[3, 4, 5]. These Improvements in medical education lead to better procedures and outcomes[6].

SBME is increasingly used in radiation oncology but mainly to learn technical skills[7].

A recent study of the radiation oncologists' and radiation therapists' curriculum in the Greater Region found that a large proportion of participants indicated that soft skills were not included in their curriculum[8], despite the importance of this type of competence being highlighted in the ESTRO core curriculum[9] and some studies showing that soft skills workshops (e.g. patient communication) can improve self-efficacy and patient satisfaction[10, 11].

This study examines the efficacy of a 2-day simulation-based teaching module to learn soft skills, particularly communication and quality management in a radiation oncology clinical setting, and the integration of newly acquired competencies into clinical practice over time.

3. Material and methods

Study design and settings

In the framework of the Interreg project NHL-Chirex[12] (EU-Interreg Va Greater Region Program N°043-1-01-125), the University Hospital of Liège's Department of Radiation Oncology held a 2-day training module for radiation oncology professionals working or training in the Greater Region centers (University Hospital of Liège, Oncology Institute of Lorraine, François Baclesse Centre).

The University Hospital of Liège Ethics Committee was asked for an opinion, but regulations did not require it. Participants signed an informed consent form before participating in the simulation modules to allow anonymized data analysis and dissemination.

Population

Participants were board certified radiation oncologists (BCROs), radiation oncologists in training (RROs) and radiation therapists (RTTs) actively working or in training in a radiation oncology department of the centers participating in Interreg NHL-CHIREX.

Intervention

After an in-depth analysis of an SREs database[13], an incident that resulted in the irradiation of a bad vertebra and involved many communication issues with the patient and between radiotherapy professionals was used to create a two-day training module. The module focused on learning soft skills such as communication techniques and behaviors, as well as quality management procedures. Communication skills included the SPIKES method of delivering bad news[14] which consists of six steps, the goal is to enable the clinician to fulfill the four most important objectives of the interview disclosing bad news: gathering information from the patient, transmitting the medical information, providing support to the patient, and eliciting the patient's collaboration in developing a strategy or treatment plan for the future. The other communication skills were interprofessional communication methods and behaviors: SBAR (situation, background, assessment, recommendations), *Speak up*, a technique to express one's opinions frankly and openly[15, 16] and *Time out*, a form of behavioral modification that involves temporarily separating a person from an environment where an unacceptable behavior has occurred[17].

Participants had also to report and analyze a safety-related event (treatment of an incorrect vertebra) using the PRISMA[18] approach and apply improvement methods. Two SBME methods were used: role plays with and without virtual environment for radiation training.

The simulation sessions started with a pre-briefing to provide a safe container[19] for the simulation and a briefing to introduce the simulation scenario, and ended with a debriefing in a safe environment. The debriefing was conducted in 3 phases (reactions, understanding, summary), using the Advocacy Inquiry communication strategy[20].

The simulation scenarios for the role plays were created for a double loop learning system in Simzone 3[21].

E-learnings were provided to the participants with further theoretical information on the communication methods used and on quality and safety management.

Data collection and analysis

At baseline, we collected participants socio-demographic data (age, sex, nationality, place of work and profession). Participants were also asked about their prior knowledge of communication skills and their use of simulation in their training.
After the 2-day module, participants completed several questionnaires in accordance with our study objectives; the Overall satisfaction (OS) rated on a scale of 1 to 10, Student Confidence In Learning (SCIL) and Simulation Design Scale (SDS) questionnaires.

SCIL and SDS are validated questionnaires[22] (The SCIL is a series of statements about learners' personal attitudes toward the instructions they received during the simulation activity and their confidence in receiving the instructions they needed. The SCIL is rated using a 5-point Likert scale ranging from “strongly disagree” to “strongly agree”. The SDS is a 20-item instrument that uses a five-point scale to assess the trainers’ five simulation design features. The SDS questionnaire is scored using a 5-point Likert scale ranging from “strongly disagree” to “strongly agree”.

At the end of the training, we asked the participants if they would agree to recommend the training to others.

Finally, 6 months after the program, we assessed the module's impact on participants' daily practice with a practice-change qualitative questionnaire. We also interrogated them about the management of safety-related events since training.

OS, practice change and management of safety-related events' questionnaires were original, unvalidated, questionnaires, developed by the researchers.

Statistical analyses

Participants' socio-demographic parameters were described, qualitative variables were summarized by modality using counts and percentages. For normal distribution, quantitative variables were summarized using mean and standard deviation (±SD), while asymmetric distribution variables were presented using median and interquartile range (P25-P75). Quantitative variables were tested for normality by comparing the mean and median, using the histogram and quantile-quantile diagram, and using the Shapiro-Wilk normality test.

All questionnaire responses were Likert scales and summarized in a frequency table with numbers and percentages for each modality and the median and interquartile range (P25-P75). RTTs versus BCROs and RROs were compared using Mann-Whitney tests.

Statistics were performed with the maximum number of data, without replacing missing data. The uncertainty level was 5% ($p < 0.05$). The statistical software was SAS 9.4 for Windows, SAS institute, North Carolina.

4. Results

Socio-demographic data of participants (Table 1)

A total of 21 participants took part in the 2-day simulation module.

Variable	Categories	*N*	Number (%)
Sex		21	
	Men		**5 (23.8)**
	Women		**16 (76.2)**
Age (years)	Median (P25-P75)	21	**29 (27-36)**
Nationality		21	
	Belgium		**16 (76.2)**
	France		**5 (23.8)**
Place of work		21	
	University Hospital of Liège, Belgium		**18 (85.7)**
	François Baclesse Center - Luxembourg		**1 (4.8)**
	Institute of Oncology - Lorraine - France		**1 (4.8)**
	Hospital Sainte Elisabeth, Namur		**1 (4.8)**
Profession		21	
	Board certified Radiation Oncologists (BCROs)		**4 (19.0)**
	Residents in Radiation Oncology (RROs)		**7 (33.3)**
	Radiation Therapist (RTTs)		**10 (47.6)**

Table 1. — Descriptive statistics of socio-demographic parameters of participants (*N*=21).

Prior knowledge

One (5.6%) participant knew about the spikes method, 7 (38.9%) participants knew about the SBAR method, 6 (33.3%) knew about the speak up and 10 (55.6%) knew about time out. Five (27.8%) participants did not know anything at all about a communication technique.

Overall Satisfaction

The overall satisfaction of the participants of the 2-day simulation module had a median score of 9.0 (9.0-10.0). No statistical significant differences were noted among the different groups.

SCIL Questionnaire (Table 2)

Grading	Total		BRCOs & RROs		RTTs		P-value
	N	Number (%)	*N*	Number (%)	*N*	Number (%)	
Q1 — *"I am confident that I am mastering the content of the simulation activity that my instructors presented to me"*							
Median (P25-P75)	**21**	**4.0 (4.0-4.0)**	**11**	**4.0 (3.0-4.0)**	**10**	**4.0 (4.0-5.0)**	**0.022**
1- Strongly disagree		0 (0.0)		0 (0.0)		0 (0.0)	
2- Disagree		0 (0.0)		0 (0.0)		0 (0.0)	
3- Undecided		0 (0.0)		4 (36.4)		0 (0.0)	
4- Agree		4 (19.0)		6 (54.5)		6 (60.0)	
5- Strongly Agree		12 (57.1)		1 (9.1)		4 (40.0)	
Q2 — *"I am confident that this simulation covered critical content necessary for the mastery of radiotherapy curriculum"*							
Median (P25-P75)	**21**	**4.0 (4.0-5.0)**	**11**	**5.0 (4.0-5.0)**	**10**	**5.0 (4.0-5.0)**	**0.99**
1- Strongly disagree		0 (0.0)		0 (0.0)		0 (0.0)	
2- Disagree		0 (0.0)		0 (0.0)		0 (0.0)	
3- Undecided		1 (4.8)		1 (9.1)		0 (0.0)	
4- Agree		7 (33.3)		3 (27.3)		4 (40.0)	
5- Strongly Agree		13 (61.9)		7 (63.6)		6 (60.0)	
Q3 — *"I am confident that I am developing the skills and obtaining the required knowledge from this simulation to perform necessary tasks in a clinical setting"*							
Median (P25-P75)	**20**	**4.5 (4.0-5.0)**	**11**	**4.0 (4.0-5.0)**	**9**	**5.0 (4.0-5.0)**	**0.27**
1- Strongly disagree		0 (0.0)		0 (0.0)		0 (0.0)	
2- Disagree		0 (0.0)		0 (0.0)		0 (0.0)	
3- Undecided		2 (10.0)		1 (9.1)		1 (11.1)	
4- Agree		8 (40.0)		6 (54.5)		2 (22.2)	
5- Strongly Agree		10 (50.0)		4 (36.4)		6 (66.7)	

Q4 — *"My instructors used helpful resources to teach the simulation"*

Median (P25-P75)	**21**	**5.0 (5.0-5.0)**	**11**	**5.0 (5.0-5.0)**	**10**	**5.0 (5.0-5.0)**	**0.99**
1- Strongly disagree		0 (0.0)		0 (0.0)		0 (0.0)	
2- Disagree		0 (0.0)		0 (0.0)		0 (0.0)	
3- Undecided		1 (4.8)		1 (9.1)		0 (0.0)	
4- Agree		3 (14.3)		1 (9.1)		2 (20.0)	
5- Strongly Agree		17 (81.0)		9 (81.8)		8 (80.0)	

Q5 — *"It is my responsibility as the student to learn what I need to know from this simulation activity"*

Median (P25-P75)	**19**	**5.0 (4.0-5.0)**	**11**	**4.0 (4.0-5.0)**	**8**	**5.0 (5.0-5.0)**	***0.015***
1- Strongly disagree		0 (0.0)		0 (0.0)		0 (0.0)	
2- Disagree		0 (0.0)		0 (0.0)		0 (0.0)	
3- Undecided		1 (5.3)		1 (9.1)		0 (0.0)	
4- Agree		5 (26.3)		5 (45.5)		0 (0.0)	
5- Strongly Agree		13 (68.4)		5 (45.5)		8 (100.0)	

Q5 — *"It is my responsibility as the student to learn what I need to know from this simulation activity"*

Median (P25-P75)	**19**	**5.0 (4.0-5.0)**	**11**	**4.0 (4.0-5.0)**	**8**	**5.0 (5.0-5.0)**	***0.015***
1- Strongly disagree		0 (0.0)		0 (0.0)		0 (0.0)	
2- Disagree		0 (0.0)		0 (0.0)		0 (0.0)	
3- Undecided		1 (5.3)		1 (9.1)		0 (0.0)	
4- Agree		5 (26.3)		5 (45.5)		0 (0.0)	
5- Strongly Agree		13 (68.4)		5 (45.5)		8 (100.0)	

Q6 — *"I know how to get help when I do not understand the concepts covered in the simulation"*

Median (P25-P75)	**20**	**5.0 (4.5-5.0)**	**11**	**5.0 (4.0-5.0)**	**9**	**5.0 (5.0-5.0)**	**0.19**
1- Strongly disagree		0 (0.0)		0 (0.0)		0 (0.0)	
2- Disagree		0 (0.0)		0 (0.0)		0 (0.0)	
3- Undecided		1 (5.0)		1 (9.1)		0 (0.0)	
4- Agree		4 (20.0)		3 (27.3)		1 (11.1)	
5- Strongly Agree		15 (75.0)		7 (63.6)		8 (88.9)	

Q7 — *"I know how to use simulation activities to learn critical aspects of these skills"*

Median (P25-P75)	**21**	**5.0 (4.0-5.0)**	**11**	**4.0 (4.0-5.0)**	**10**	**5.0 (5.0-5.0)**	***0.043***
1- Strongly disagree		0 (0.0)		0 (0.0)		0 (0.0)	
2- Disagree		0 (0.0)		0 (0.0)		0 (0.0)	
3- Undecided		1 (4.8)		1 (9.1)		0 (0.0)	
4- Agree		8 (38.1)		6 (54.5)		2 (20.0)	
5- Strongly Agree		12 (57.1)		4 (36.4)		8 (80.0)	

Q8 — *"It is the instructor's responsibility to tell me what I need to learn of the simulation activity content during class time"*							
Median (P25-P75)	**21**	**4.0 (4.0-5.0)**	**11**	**4.0 (3.0-4.0)**	**10**	**5.0 (4.0-5.0)**	***0.0067***
1- Strongly disagree		0 (0.0)		0 (0.0)		0 (0.0)	
2- Disagree		0 (0.0)		0 (0.0)		0 (0.0)	
3- Undecided		5 (23.8)		5 (45.5)		0 (0.0)	
4- Agree		7 (33.3)		4 (36.4)		3 (30.0)	
5- Strongly Agree		9 (42.9)		2 (18.2)		7 (70.0)	
Overall rating							
Median (P25-P75)	**21**	**36.0 (34.0-38.0)**	**11**	**34.0 (34.0-36.0)**	**10**	**37.5 (36.0-39.0)**	**0.093**

Table 2. — Participants responses at the Student confidence in learning (SCIL) questionnaire and comparison between the RTTs group and the BCROs and RROs group

Confidence in mastery of simulation content was significantly higher for RTTS than for RROs and BCROs (4.0 (4.0-5.0) vs. 4.0 (3.0-4.0), p=0.022). Confidence in students' responsibility to learn what is necessary was also higher for RTTS than for RROs and BCROs (5.0 (5.0-5.0) vs. 4.0 (4.0-5.0), p=0.015). The same interpretation can be made for confidence in the use of simulation activities in radiotherapy (5.0 (5.0-5.0) vs. 4.0 (4.0-5.0), p=0.043) and confidence in teacher responsibility (5.0 (4.0-5.0) vs. 4.0 (3.0-4.0), p=0.0067). The other items and the total score were similar for doctors and RTTs (p > 0.05).

The SDS questionnaire (Table 3)

The descriptive statistics for the SDS questionnaire during the training are summarized in Table 4.

The results of the SDS questionnaire are comparable between RTTs, radiation oncologists (residents or board certified) in total and for each question (p > 0.05).

Strongly Disagree ***N (%)***	**Disagree** ***N (%)***	**Undecided** ***N (%)***	**Agree** ***N (%)***	**Strongly Agree** ***N (%)***	**Median**
OBJECTIVES AND INFORMATION					
Q1 — *"There was enough information provided at the beginning of the simulation to provide direction and encouragement"*					
1 (4.8%)	0 (0%)	1 (4.8%)	1 (4.8%)	18 (85.7%)	5
Q2 — *"I clearly understood the purpose and objectives of the simulation"*					
1 (4.8%)	0 (0%)	1 (4.8%)	5 (23.8%)	14 (66.7%)	5
Q3 — *"The simulation provided enough information in a clear manner for me to problem-solve the situation"*					
1 (5%)	1 (5%)	0 (0%)	5 (25%)	13 (65%)	5

Q4 — *“There was enough information provided to me during the simulation”*					
1 (4.8%)	1 (4.8%)	0 (0%)	5 (23.8%)	14 (66.7%)	5
Q5 — *“The cues were appropriate and geared to promote my understanding”*					
1 (4.8%)	0 (0%)	1 (4.8%)	3 (14.3%)	16 (76.2%)	5
SUPPORT					
Q6 — *“Support was offered in a timely manner”*					
1 (4.8%)	0 (0.0%)	1 (4.8%)	1 (4.8%)	18 (85.7%)	5
Q7 — *“My need for help was recognized”*					
1 (5.0%)	0 (0.0%)	1 (5.0%)	2 (10.0%)	16 (80.0%)	5
Q8 — *“I felt supported by the teacher’s assistance during the simulation”*					
1 (4.8%)	0 (0.0%)	1 (4.8%)	3 (14.3%)	16 (76.2%)	5
Q9 — *“I was supported in the learning process”*					
1 (4.8%)	0 (0.0%)	1 (4.8%)	3 (14.3%)	16 (76.2%)	5
PROBLEM SOLVING					
Q10 — *“Independent problem-solving was facilitated”*					
1 (4.8%)	0 (0.0%)	1 (4.8%)	7 (33.3%)	12 (57.1%)	5
Q11 — *“I was encouraged to explore all possibilities of the simulation”*					
1 (4.8%)	0 (0.0%)	0 (0.0%)	6 (28.6%)	14 (66.7%)	5
Q12 — *“The simulation was designed for my specific level of knowledge and skills”*					
1 (4.8%)	0 (0.0%)	1 (4.8%)	4 (19.0%)	15 (71.4%)	5
Q13 — *“The simulation allowed me the opportunity to prioritize nursing assessments and care”*					
1 (4.8%)	0 (0.0%)	1 (4.8%)	4 (19.0%)	15 (71.4%)	5
Q14 — *“The simulation provided me an opportunity to goal set for my patient”*					
1 (4.8%)	0 (0.0%)	1 (4.8%)	5(23.8%)	14(66.7%)	5
FEEDBACK/GUIDED REFLECTION					
Q15 — *“Feedback provided was constructive”*					
1 (4.8%)	0 (0.0%)	0 (0.0%)	1 (4.8%)	19(90.5%)	5
Q16 — *“Feedback was provided in a timely manner”*					
1 (4.8%)	0 (0.0%)	0 (0.0%)	1 (4.8%)	19(90.5%)	5
Q17 — *“The simulation allowed me to analyze my own behavior and actions”*					
1 (4.8%)	0 (0.0%)	0 (0.0%)	4(19.0%)	16(76.2%)	5

Q18 — *"There was an opportunity after the simulation to obtain guidance/feedback from the teacher in order to build knowledge to another level"*					
1 (4.8%)	0 (0.0%)	0 (0.0%)	4(19.0%)	16(76.2%)	5
FIDELITY (REALISM)					
Q19 — *"The scenario resembled a real-life situation"*					
1 (4.8%)	0 (0.0%)	0 (0.0%)	5 (23.8%)	15 (71.4%)	5
Q20 — *"Real-life factors, situations, and variables were built into the simulation scenario"*					
1 (4.8%)	0 (0.0%)	0 (0.0%)	4(19.0%)	16(76.2%)	5

Table 3. — Participants responses at the Simulation Design Scale (SDS) questionnaire

Recommendation of the training

The majority of participants (n = 14 , 77.8%) strongly agreed or agreed (n = 4, 22.2%) to recommend the training to colleagues.

Use of communication skills in daily practice

Table 4 shows the distribution of the use of communication methods in participants' daily practice 6 months after the training. The SPIKE was used slightly more than before by 7 (38.9%) participants and much more than before by 8 (44.4%) participants. The SBAR was used much more than before by 11 (61.1%) participants and slightly more than before by 6 (33.3%) participants. Five (27.8%) participants reported using the Speak Up a little more than before and 5 (27.8%) used it a lot more than before and 1 (5.6%) always used it while not using it before the training.

Seven (38.9%) participants used the Time Out tool much more than before and 3 (16.7%) used it a little more than before and 1 (5.6%) participant always used it since the training while he did not use it before. The use of communication methods in daily practise did not differ between doctors and RTTs($p > 0.05$).

Method	Categories	Total		BRCOs & RROs		RTTs		P-value
		N	Number (%)	*N*	Number (%)	*N*	Number (%)	
Spike	**Median (P25-P75)**	**18**	**3.5 (3.0-4.0)**	**8**	**3.5 (3.0-4.0)**	**10**	**3.5 (3.0-4.0)**	**0.85**
	1-Never		1 (5.6)		0 (0.0)		1 (10.0)	
	2- As much as before		1 (5.6)		0 (0.0)		1 (10.0)	
	3- A little more		7 (38.9)		4 (50.0)		3 (30.0)	
	4- A lot more		8 (44.4)		4 (50.0)		4 (40.0)	
	5-Always		1 (5.6)		0 (0.0)		1 (10.0)	
SBAR	**Median (P25-P75)**	**18**	**4.0 (3.0-4.0)**	**8**	**4.0 (3.0-4.0)**	**10**	**4.0 (3.0-4.0)**	**0.92**
	1- Never		1 (5.6)		1 (12.5)		0 (0.0)	
	2- As much as before		0 (0.0)		0 (0.0)		0 (0.0)	
	3- A little more		6 (33.3)		2 (25.0)		4 (40.0)	
	4- A lot more		11 (61.1)		5 (62.5)		6 (60.0)	
	5-Always		0 (0.0)		0 (0.0)		0 (0.0)	

Speak up	**Median (P25-P75)**	**18**	**3.0 (2.0-4.0)**	**8**	**3.0 (2.5-4.0)**	**10**	**2.5 (2.0-4.0)**	**0.44**
	1- Never		2 (11.1)		1 (12.5)		1 (10.0)	
	2- As much as before		5 (27.8)		1 (12.5)		4 (40.0)	
	3- A little more		5 (27.8)		3 (37.5)		2 (20.0)	
	4- A lot more		5 (27.8)		2 (25.0)		3 (30.0)	
	5- Always		1 (5.6)		1 (12.5)		0 (0.0)	
Time out	**Median (P25-P75)**	**18**	**3.0 (2.0-4.0)**	**8**	**2.5 (2.0-3.5)**	**10**	**4.0 (2.0-4.0)**	**0.28**
	1- Never		1 (5.6)		1 (12.5)		0 (0.0)	
	2- As much as before		6 (33.3)		3 (37.5)		3 (30.0)	
	3-A little more		3 (16.7)		2 (25.0)		1 (10.0)	
	4-A lot more		7 (38.9)		1 (12.5)		6 (60.0)	
	5-Always		1 (5.6)		1 (12.5)		0 (0.0)	

Table 4. — Distribution of use of communication skills in daily practice and comparison between the RTTs group and the BCROs and RROs group.

Management of safety-related events since training

The management of safety-related events 6 months after training is shown in Table 5.

In terms of reporting safety-related events, 11 (61.1%) participants reported reporting the same amount as before the training, 5 (27.8%) reported doing so much more than before, 1 (5.6%) participant reported reporting a little more, and 1 (5.6%) reported never reporting an adverse event.

Participation in influencing factors research was used as much as before by 9 (50.0%) participants, a little more than before by 5 (27.8%) participants and a lot more than before by 3 (16.7%) participants. One participant (5.6%) stated that they never engaged in the search for influencing factors. Nine (50.0%) participants reported being slightly more able to implement improvement actions than before the training, 5 (27.8%) were as good as before and 4 (22.2%) felt much more able than before the training. Management of SREs is comparable between RTTs and radiation oncologists ($p > 0.05$).

Safety reported event (SRE) management	Categories	Total		BRCOs & RROs		RTTs		P-value
		N	Number (%)	*N*	Number (%)	*N*	Number (%)	
Reporting of SRE								
	Median (P25-P75)	**18**	**2.0 (2.0-4.0)**	**8**	**2.0 (2.0-3.5)**	**10**	**2.0 (2.0-4.0)**	**0.84**
	1-Never		1 (5.6)		1 (12.5)		0 (0.0)	
	2- As much as before		11 (61.1)		4 (50.0)		7 (70.0)	
	3- A little more		1 (5.6)		1 (12.5)		0 (0.0)	
	4- A lot more		5 (27.8)		2 (25.0)		3 (30.0)	
	5-Always		0 (0.0)		0 (0.0)		0 (0.0)	

Involvement in the research of influencing factors								
	Median (P25-P75)	**18**	**2.0 (2.0-3.0)**	**8**	**2.0 (2.0-3.0)**	**10**	**2.5 (2.0-3.0)**	**0.77**
	1-Never		1 (5.6)		0 (0.0)		1 (10.0)	
	2- As much as before		9 (50.0)		5 (62.5)		4 (40.0)	
	3- A little more		5 (27.8)		2 (25.0)		3 (30.0)	
	4- A lot more		3 (16.7)		1 (12.5)		2 (20.0)	
	5-Always		0 (0.0)		0 (0.0)		0 (0.0)	
Implementation of improvement actions								
	Median (P25-P75)	**18**	**3.0 (2.0-3.0)**	**8**	**3.0 (2.5-3.0)**	**10**	**3.0 (2.0-4.0)**	**0.74**
	1-Never		0 (0.0)		0 (0.0)		0 (0.0)	
	2- As much as before		5 (27.8)		2 (25.0)		3 (30.0)	
	3- A little more		9 (50.0)		5 (62.5)		4 (40.0)	
	4- A lot more		4 (22.2)		1 (12.5)		3 (30.0)	
	5-Always		0 (0.0)		0 (0.0)		0 (0.0)	

Table 5. — Distribution of safety related events management since training and comparison between the RTTs group and the BCROs and RROs group.

5. Discussion

In this study, we describe the use of SBME to teach communication skills and quality management procedures to radiation oncology professionals.

The questionnaires yielded positive responses on overall satisfaction, such that the majority of participants would recommend the training to others.

The SCIL, and SDS also showed a high level of agreement, indicating that the students were satisfied, but more importantly that the design of the simulations was well designed and the participants had high confidence in their learning through the training.

As has been shown in other studies[23, 24], SBME was able to improve communication skills with patients in a radiation oncology clinical setting. But this study has also shown that it can be used to improve interprofessional skills.

Besides, participants reported increased use of all communication techniques 6 months after the 2-day simulation module.

This increase occurred even when the majority of participants were already familiar with at least one communication method or behavior, suggesting that SBME could be used for continuous learning or to improve daily practice of these skills in a settings.

The 2-day module had little impact on the reporting and analysis of SREs, but the ability to implement improvement actions was improved six months after participation.

Due to the small sample size, one of the main shortcomings of this study is that it is difficult to draw definitive conclusions.

Further research on the same topic in different contexts and with larger samples is needed to develop reliable analyses.

The fact that most participants were from Belgium, where reporting of SREs is mandatory and a national database exists in which all SREs are recorded using PRISMA[25], may explain why the 2-day module had little impact on the reporting and analysis of SREs. However, the majority of participants were more interested in implementing improvement actions. This result is particularly significant considering the insufficient knowledge and training of RO professionals regarding quality management[26].

6. Conclusion

Simulation-based medical education (SBME) appears to be effective in improving learners' communication skills and behaviours in encouraging radiation oncology staff to take improvement actions after analyzing safety-related events. These results need to be further confirmed in larger groups of radiation oncology professionals.

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General discussion, perspectives and conclusion

General discussion and perspectives

This work describes the training in radiation oncology in Europe for medical students, residents, and other RO professionals.

Another goal of this project was to use a database of safety-related events to develop a creative, interactive training program that emphasizes teamwork and non-technical skills.

First, In terms of teaching RO skills to medical students, the results of our study[1] are consistent with the results of similar studies in the US[2] and Canada[3] and suggest that there is a need to improve the visibility and dissemination of RO to medical students across Europe.

One way to improve this lack of training in RO in academic institutions would be to create a reference core curriculum adapted to European academic institutions. This raises the question of the general knowledge of RO, which we, as radiation oncologists consider important knowledge that should be taught to medical students as a foundation for RO.

This important task could be done together with primary care physicians such as general practitioners and all physicians who care for cancer patients and are not medical or radiation oncologists.

Indeed, it is extremely important to assess what primary care physicians need to know about oncology in order to create a reference database for building a curriculum for undergraduate education.

Besides, in most cases, radiotherapy is part of a multimodal treatment that includes systemic therapy and surgery, among others. This raises the question of a common core curriculum for oncology that provides an integrative approach to the cancer patient and a collaboration with all specialists involved in oncology care at the academic level.

Our study has also shown that the means by which medical students are taught and assessed in RO are still quite old-fashioned. The use of new educational technologies could be beneficial to increase the visibility and attractiveness of RO, such as SBME to develop a virtual journey of a patient in RO or a physician in oncology.

In this work, for example, we have also used incidentology as a mean of building an innovative curriculum. Incidents, i.e., medical errors[4], are not included in undergraduate curricula even if some initiative are existing. It would be interesting to bring SREs out of the basement and into medical schools, because they are part of our everyday work, are responsible for a lot of stress[5] , although they are a huge and interesting source of learning.

Second, in relation to opinions regarding postgraduate training, when asking various RTTs and ROs in the Greater Region[6], only one-fifth stated that they had acquired all the skills required for professional practice during their initial training, and some of the professionals expressed the stress caused by the lack of time for practical teaching.

About half of the participants reported that soft skills were not addressed in their curriculum.

The fact that more than a third of our respondents recommended that non-technical skills such as communication and team training should be emphasized more in their training has to be taken into account, indeed, the importance of these skills was re-emphasized in the ECC.

Another larger study[7] gathering more opinions of more RO professionals (ROs, MPE/MPAs, RTTs and radiobiologists) in Europe showed Large differences in the organization and duration of national training programs as well as in the perceived quality in Europe within the individual disciplines, as participants indicated that only a minority of countries had implemented the ECC and that a quarter of the participants indicated that their national education program is insufficient.

These findings underline the need for a discussion on how to move forward with this diversity of training programs and the potential contribution ESTRO and UEMS can make.

Third, regarding the postgraduate training of ROs in Europe, our research (Chapter 2) revealed that, according to the UEMS delegates, not only the training but also the assessment of residents' knowledge in RO/CO varies from country to country in Europe.

By way of illustration, it is fascinating to learn that in eight of the countries that are members of the UEMS, training in RO is training in CO[8]. This means that once you have completed your training, you have the option of working either as a medical oncologist or as a radiation oncologist.

The fact that this is the case shows that it is possible to be trained in both radiation oncology and medical oncology. It would be interesting to understand the reasons why this is not common in Europe as this could be the way to go in the future.

One way to improve training is indeed to open it up to other specialties, as in the Interract project, which aims to develop an interdisciplinary cancer training program across Europe (https://www.interact-eu.net/). Another way to improve training is to define for each specialty the minimum requirements that a specialist in radiation oncology should meet. Indeed, RO is a very demanding specialty that encompasses a wide range of fields, including medical oncology, medical imaging, palliative care, physics, etc.

The ESTRO and the UEMS are doing an excellent job with the ESTRO courses and congresses as well as with the ECC, which states that radiation oncologists should acquire a range of entrustable professional activities during their training, namely medical expert, collaborator, communicator, leader, health advocate, scholar and professional[9].

Yet there is no course on soft skills; in fact, so far there is no European course on communication in RO, no course on how to deal with medical errors, how to handle difficult conversations and so on...

Interestingly, there has been an ESTRO course on leadership for a few years, which has been a success every year[10].

Nevertheless, it would be very interesting to brainstorm and collect the initiatives that incorporate teamwork, collaboration and communication or, more generally speaking, more soft skills into the already existing initiatives.

All these training initiatives and suggestions for improvement should not only refer to the training of medical students or residents, but also to the continuous training of professionals in radiation oncology.

One of the ways to modernize the radiotherapy curriculum for already graduated professionals would be to use the SREs that occur in radiotherapy departments to further develop what is already widely used in the US, the Incident Learning System (ILS). By analyzing the safety-related events using the Prisma method, our study provides an interesting database for building an innovative incident-based learning program that can be very practical, as desired by radiation oncology professionals[11].

Actually, the idea is not new, it is rarely used in Europe, but after a few articles were published in the New York Times in 2010 about incidents in RO departments[12, 13, 14, 15], the rate of publication about ILS in the US has increased abruptly, as reporting became mandatory and it became clear that ILS is an essential element in maintaining safety and quality in healthcare[16, 17, 18, 19]. The use of this practice is now well established and supported by recommendations from professional societies (ASTRO), regulations (WHO) and accreditation programs (the National Patient Safety Agency in the UK, the Joint Commission for Hospital Accreditation in the US...).

Interestingly, as our publication[20] shows that only a few SREs cause harm to patients, it is therefore important to broaden the scope of ILS beyond incidents affecting patients to include near misses and other SREs, as they represent “free lessons” that should not be ignored[21], [22].

It is estimated that 70% of medical errors are due to poor teamwork. Thus, when addressing healthcare errors, teamwork and communication are one of the most important causal factors to consider[23].

Fourth, our study in Chapter 5 was conducted to test a hands-on training program using SBME to learn non-technical skills. The scenario of the simulation was based on ILS, for which we used the database of our SREs study[24].

This hands-on training for radiation oncologists and RTTs appeared to be effective in improving learners' communication skills and behavior and encouraging radiation oncology teams to take improvement actions after analyzing safety-related events. The results were confirmed 6 months after the training in the participants' daily work.

Some other studies on the use of SBME for soft skills learning in oncology or RO have also shown positive results, such as improving communication skills, reducing stress when delivering bad news and improving patient satisfaction[25, 26], so although these results still need to be confirmed in larger groups, they are promising and should be incorporated in RO training.

Finally, as discussed in Chapter 2, training also raises the issue of its assessment, which in practice is carried out in most European countries.

There are several examples in the literature of European assessments in different specialties that demonstrate the potential for success and long-term sustainability[27, 28].

In the United States, residents in RO are assessed based on the milestones of the six core competencies and subcompetencies established by the Accreditation Council for Graduate Medical Education[29]. These competencies include not only medical and professional aptitudes, but also effective communication skills.

However, certain components of RO education, such as simulation, contouring, planning, treatment setup, and mastery of procedures such as brachytherapy, cannot be adequately assessed using current assessment methods[30] .

For example, it would be very difficult to assess contouring skills or communication skills using a multiple-choice questionnaire.

In light of this, it might be worthwhile to survey training coordinators and residents in RO in Europe to ascertain interest in and necessity for a European examination or assessment, as well as to try and raise awareness of the matter among UEMS and ESTRO.

And for this to work, an assessment needs to be developed that is tailored to RO (without forgetting a specific module for CO) that assesses the different specificities of our profession.

This leads us, as with undergraduate training in RO, to the discussion of what should be considered basic knowledge and skills that should be acquired and assessed by the end of RO or CO residency in the different UEMS/European countries; and for that, the ECC is a good foundation.

This does not preclude the possibility that more specific assessments may be required for certain procedures or specialties, such as brachytherapy or Stereotactic Body Radiotherapy (SBRT).

Conclusion

In a comment published in the Lancet in November 2022, Richard Horton, editor-in-chief of the Lancet, wrote: “*Science is important. But education is the vector that transmits to every new generation curiosity, passion and commitment to reimagine the future, extend the limits of human possibility and achieve a more just social world*”.

This project therefore serves as an appeal to question and analyze training in RO for medical students and RO professionals, as it is essential for patient care.

There are several initiatives and opportunities to update and better adapt this teaching approach to the needs of learners and their practical experience. One of these, for example, is the use of SBME, an educational technology that can bridge the existing gap where soft skills are currently acquired through trial and error in the workplace.

It is also a request to incorporate soft skills into the various existing curricula and training initiatives and recognize their equal importance as technical skills in terms of knowledge and acquisition.

It is finally a call to lift the veil on medical errors and use them as an inexhaustible source of learning about our field.

Because ultimately, improving training in radiation oncology to be more aligned with students' aspirations, whether they have graduated or not, and more in line with the core competencies of the ESTRO/UEMS curriculum as well as the very rapid technological change in the specialty, and freeing up training to make it accessible to all, would ensure that every patient has access to the most qualified RO specialist.

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Annexes

Annex 1: Survey chapter 1

The status of radiation oncology (RO) teaching to medical students in Europe

1. Personal information

- First name - Family name
- University - Department
- Position: Full Professor, Associate Professor, Lecturer…)
- City/town
- Country
- Email address
- Phone number

2. How is undergraduate teaching in radiation oncology structured in your medical school?
Possible answers:

- Classical type with its own exam: RO as independent discipline with its own exam
- Classical type but part of a large exam: RO as an independent discipline and part of a large exam (E.G internal medicine, surgery, oncology, radiology)
- Modular type with its own exam: RO taught as part of other disciplines but with its own exam
- Modular type and part of a large exam
- Other teaching methods: specify

3. Are e-learning methods available in your university for the teaching of radiation oncology?
Possible answers:

- Web-based case-based learning
- Case-based learning on computers in a university facility
- Online courses and/or webinars on particular topics (MOOC, SPOC…) - No e-learning available in my university?
- Other: please specify

4. How long is medical school in your country (to be qualified as medical doctor)

Possible answers:

- 3Y
- 4Y
- 5Y
- 6Y
- 7Y
- 8Y
- Other: please specify

5. In which year(s) of medical school do students have radiation oncology classes

(more than one answer possible)

- first year
- second year
- 3rd year
- 4th year
- 5th year
- 6th year
- 7th year
- 8th year

6. How many hours are devoted to Radiation Oncology in your Medical School?(please sum up the number of hours in the curriculum of medical students)

- Open answer

7. How many hours are devoted to oncology in general in your medical school: (Medical oncology + Radiation oncology)

- Open answer

8. Who teaches radiation oncology in your medical school (more than one answer is allowed)
Possible answers:

- radiation oncologist
- medical oncologist
- physicist
- Radiobiologist
- Each organ specialist (i.e. gastroenterologist, neurologist, pneumologist) in its own course
- Other: specify

9. What domains of radiation oncology are discussed in the course?

Possible answers, more than one answer is possible:

- Radiobiology
- Radiation physics
- Radiosurgery `
- Brachytherapy
- Palliative radiotherapy
- Breast radiotherapy
- Central Nervous system radiotherapy
- Head and neck radiotherapy
- Lung radiotherapy
- Gastro-intestinal radiotherapy
- Genito-urinary radiotherapy

- Gynecologic radiotherapy
- Skin radiotherapy
- Bone and soft tissue radiotherapy
- Benign conditions radiotherapy
- Pediatric radiotherapy
- Complications of radiotherapy
- Economical aspects of radiotherapy
- Radiotherapy for hematologic malignancies
- Radioprotection

10. What domain of radiation oncology are assessed in the final exam and how:

- Oral exam, Written exam, OSCE: objective structured clinical examination or CBE: computer based examination.
- Possible answers:
- Radiobiology
- Radiation physics
- Radiosurgery
- Brachytherapy
- Palliative radiotherapy
- Breast radiotherapy
- Central Nervous system radiotherapy
- Head and neck radiotherapy
- Lung radiotherapy
- Gastro-intestinal radiotherapy
- Genito-urinary radiotherapy
- Gynecologic radiotherapy
- Skin radiotherapy
- Bone and soft tissue radiotherapy
- Benign conditions radiotherapy
- Pediatric radiotherapy
- Complications of radiotherapy
- Economical aspects of radiotherapy
- Radiotherapy for hematologic malignancies
- Radioprotection

11. How many teachers are involved in teaching radiation oncology in your medical school?
Possible answers:

- 1 dedicated teacher
- 2 dedicated teachers
- Other: *please specify*

12. Is there an online course of radiation oncology in your university? *Yes/no*

13. If yes, please provide the link below.

14. What percentage of medical students enrolled in your university are involved in a research or scientific program in RO each year (e.g. scientific article, communication, poster...) *Possible answers:*

- less than 5%
- between 5–20%
- between 21–40%
- more than 41%

15. Describe the radiation oncology clerkship in your medical school:

Possible answers :

- there is no clerkship in RO
- Clerkship in RO is optional
- Clerkship in RO is mandatory
- Other : please specify

16. From what year of medical school onward can internship in radiation oncology be attended by medical students:

- 3
- 4
- 5
- 6
- 7
- 8
- never

17. Is there a policy to attract students to consider RO as a career option? *Yes/no*

18. If yes, please specify

In case you have questions or remarks concerning this project, please feel free to add them below.

Thank you for completing this survey.

Annex 2: Survey Chapter 2

Dear colleagues,

This survey entitled "*Radiation Oncology certification in Europe*", conducted under the auspices of the UEMS, aims to find out how radiation oncology skills are assessed during residency training in Europe.

Our main aim is to provide an overview of how radiation oncology residency skills are assessed across Europe. We also want to find out whether there is a need for European certification in radiation oncology, as in many other medical specialties. As the assessment may vary slightly in the different sub-regions of some countries, we do not mind if you fill in a new questionnaire for each sub-region. In this case, please clearly indicate the country and region in the questionnaire.

The survey is to be completed by UEMS delegates in radiation oncology from all European countries.

The survey can be completed in about 30 minutes. You can pause the survey at any time and continue later if you need more information.

If one or more questions do not match the practice in your country, please leave a comment in the free text field "*Other*".

This survey is divided into 5 main parts:

- Information about the respondent
- General questions about training in radiation oncology
- Questions about examinations in radiation oncology
- Questions about continuous assessment in radiation oncology
- Questions about the scientific activities required during training in radiation oncology
- Questions and opinions on European certification in radiation oncology

All survey data will be anonymised. By participating in this survey, you agree that the collected data will be analysed after anonymisation and discussed in a scientific article.

We thank you in advance for the valuable time you will spend answering this survey. If you have any questions or comments, you can send an email to this address: selma.bm.1985@gmail.com

Sincerely,
UEMS Radiation Oncology Section.

1. Full name (First and last name)

2. Country

3. Province or region or area of the country you are filling this survey for (please leave blank, do not answer if you are answering for a whole country)

4. Do you work in a university hospital:

- Yes
- No
- Other (please specify)

5. Name of the hospital you are currently working in

General questions about the training of residents in Radiation Oncology in Europe.

6. What is the (minimum) duration of the training in radiation oncology in your country?

7. Can the training be completed in the same institution for the entire duration of the residency?

- Yes
- No
- Other (please specify)

8. Does the entire training have to be completed in a university hospital?

- Yes
- No
- Yes, at least for a certain period of time
- Other (please specify)

9. Can the training also be completed in a non-university hospital?

- Yes, for the whole duration of the training
- No
- Yes, but only for a certain period of time during the training
- Other (please specify)

10. How is the training in radiation oncology organised in your country?

- The entire training is dedicated to radiation oncology, without a certain amount of time spent training in another specialty (e.g. medical oncology, radiology…).
- The entire training is dedicated to radiation oncology, but some training time in another specialty (e.g. medical oncology, radiology…) is part of the training.

- The training in radiation oncology has a common core (a shared part) with another specialty
- The training in radiation oncology is organized as a part of the training in Clinical Oncology
- Other (please specify)

11. Who is primarily responsible for the duration of training in radiation oncology in your country? (multiple answers are possible)

- A recognition committee
- The programme director/training supervisor
- (The Dean of) The Faculty of Medicine of the University
- The Ministry of Health
- The national society of radiation oncology
- Other (please specify)

12. Who is primarily responsible for deciding the content of radiation oncology training in your country? (multiple answers are possible)

- A recognition committee
- The programme director/training supervisor
- (The Dean of) The Faculty of Medicine of the University
- The Ministry of Health
- The national society of radiation oncology
- Other (please specify)

13. Who is primarily responsible in your country for organizing the training in radiation oncology? (multiple answers are possible)

- A recognition committee
- The programme director/training supervisor
- (The Dean of) The Faculty of Medicine of the University
- The Ministry of Health
- The national society of radiation oncology
- Other (please specify)

14. What is the total number of residents currently training to become specialists in radiation oncology in your country who will be certified by your national board at the end of their training? (please do not count residents who are only in your country for a clerkship or internship and will not be recognized by your national board).

15. What is the number of NON-EU residents in training in Radiation Oncology in your country right now?

16. What is the number of EU residents not from your country in training in Radiation Oncology in your country right now?

17. What is the total number of coordinating training institutions (institutions responsible for an entire training/residency programme) in radiation oncology in your country?

18. Are the coordinating training centres (for radiation oncology) in your country always university departments?

- Yes
- No
- Other (please specify)

19. What is the number of NON University training centres (for radiation oncology) in your country right now?

20. Are non-university training centres (for radiation oncology) linked to a university or do they take part in any kind of post-graduate academic course which is an integral part of the training?

- Yes
- No
- Other (please specify)

21. What are the prerequisites/requirements to enter the certification process to become a national board-certified radiation oncologist in your country? (multiple answers are possible)

- A minimum number of years of training/internship required
- One final examination
- Yearly or quarterly examinations
- Portfolio/Logbook
- Other (please specify)
- Continuous assessment publication(s)
- Congress attendance
- Congress talk/ presentation

22. Is there a uniform certification procedure in your country, or are there differences in local/regional procedures?

- Yes, the certification of residents in radiation oncology is uniform in the whole country
- No, the certification is not uniform, there are local and/or regional differences Please explain :

23. Please describe the certification process to become a board-certified radiation oncologist in your country, or give us a link to the national law/text/organization for certification of specialists:

24. Is there an evaluation of the training programme in radiation oncology in your country (multiple answers are possible):

- No
- Yes, an internal evaluation (For example by the university, the training hospital...)
- Yes, an external evaluation (For example by the national society of radiation oncology, an external audit of the training program...)
- Yes, an evaluation from the trainees or residents.
- Other (please specify)

25. If the answer to the previous question is "yes", is the evaluation of the training programme in radiation oncology mandatory?

- Yes
- No
- Other (please specify)

26. Is it possible to undertake the training in radiation oncology in English in your country ? (in addition to the native language).

- Yes
- No
- Other (please specify)

Questions about examinations in radiation oncology in Europe

Examination : a formal test of a person's knowledge or proficiency in a subject or skill

27. Does your country have one or more official examinations in radiation oncology during residency training? (If there is no official examination in your country, you can tick "none" and proceed to the next part of the survey about the continuous assessment: question 34)

- There is only one official examination during the whole residency
- There is more than one official examination
- None: there is no official examination
- Other (please specify)

28. What assessment tools are used for the examination(s) in radiation oncology? (Multiple answers are possible)

- Direct clinical observation and feedback
- Oral examinations
- Multiple choice questions/exams
- Objective structured clinical examination
- Simulation exam
- Mini clinical evaluation exercise
- Video assessment

- None
- Other (please specify)

29. Are the Entrustable Professional Activities (EPA) of the ESTRO/UEMS core curriculum assessed during the radiation oncology examination(s)?

- Yes
- No
- Other (please specify)

30. If you answered yes to the previous question, please indicate which of the following Entrustable Professional Activities EPA are assessed during the examination(s)? (Multiple answers are possible)

- Medical Expert : Develop a management plan for patients with cancer diagnosis, Implement a treatment strategy, develop and implement aa management plan for survivorship
- Communicator : Communicate appropriately and effectively with patients and their relatives
- Collaborator : work effectively with other health care professionals to provide safe care and to optimize the quality of treatment
- Leader: Discuss the context in which they work and apply the principles of change management including quality improvement methodology in this context, use resources appropriately, demonstrate the ability to work in, build and lead teams.
- Advocate: Advocates for cancer patients
- Scholar : plan personal learning experiences and use them to enhance patient care, educate others to enhance patient care, contribute to the knowledge base that underpins patient care
- Professional: demonstrate that the care of their patients is their first concern, manage their work life balance to maintain their own wellbeing.
- None
- Other (please specify)

31. Please indicate which of the following competencies are assessed during the examination(s) in your country? (Multiple answers are possible):

- Clinical Oncology: systemic treatments, side effects, toxicities, effects and toxicities when combined to radiation.
- Radiotherapy for breast cancer
- Radiotherapy for urological cancer
- Radiotherapy for lung cancer Radiotherapy for gastro-intestinal cancer
- Radiotherapy for gynecological cancer
- Radiotherapy for central nervous system cancer
- Radiotherapy for sarcomas
- Radiotherapy for head and neck cancers
- Radiotherapy for hematological malignancies
- Emergencies in radiotherapy

- Radiotherapy for skin cancers
- Benign indications in radiotherapy
- Pediatric and adolescent oncology and radiotherapy
- Brachytherapy SBRT/SRS/RS
- Total body irradiation
- Particle therapy/ Proton therapy
- Oligometastatic disease
- Radiation protection
- Physics for radiotherapy
- Radiology
- Nuclear medicine
- Contouring guidelines
- Dose prescription
- Dosimetry/Planning
- Simulation CT
- Palliative care
- Pain management
- Breaking bad news, Communication with patients.
- Team work
- None
- Other (please specify)

32. Who organises the exam(s) in your country? (Multiple answers are possible)

- The programme director/ Training supervisor
- The head of department of the radiation oncology training centre/department?
- (The Dean of) The Faculty of Medicine of the University
- The national society of radiation oncology
- A committee of agreement/ Recognition board
- The Ministry of Health
- A national examination committee
- Other (please specify)

33. Is the examination/ Are the examinations mandatory to get the final board certification in radiation oncology in your country?

- Yes
- No
- Other (please specify)

Questions about the continuous assessment during the training in radiation oncology in Europe

34. Is there a formal continuous assessment during the training of radiation oncology residents in your country? (If the answer is no, you can move on to the next part of the survey about the requirements for scientific activity: Question 43)

- Yes
- No
- Other (please specify)

35. How frequent is the continuous assessment?

- One every 3 months
- One every 4 months
- One every 6 months
- One every year
- One every 2 years
- None
- Other (please specify)

36. What continuous assessment tools are used during postgraduate training in radiation oncology in your country? (multiple answers are possible)

- Direct clinical observation and feedback
- Oral assessments
- Logbook/Portfolio
- Multiple choice questions/exams
- Objective structured clinical examination
- Essays/papers/assignments
- Feedback from multiple sources
- Simulation exam
- Mini clinical assessment exercise
- Standardized patient examinations
- Video assessment
- None
- Other (please specify)

37. Are the Entrustable Professional Activities (EPA) of the ESTRO/UEMS Core Curriculum assessed in the continuous assessment of radiation oncology residents in your country:

- Yes
- No
- Other (please specify)

38. If you answered "yes" to the previous question, please indicate which of the following Entrustable Professional Activities (EPA) are assessed during continuous assessments? (multiple answers are possible)

- Medical Expert : Develop a management plan for patients with cancer diagnosis, Implement a treatment strategy, develop and implement aa management plan for survivorship
- Communicator : Communicate appropriately and effectively with patients and their relatives
- Collaborator : work effectively with other health care professionals to provide safe care and to optimize the quality of treatment
- Leader: Discuss the context in which they work and apply the principles of change management including quality improvement methodology in this context, use resources appropriately, demonstrate the ability to work in, build and lead teams.
- Advocate: Advocates for cancer patients
- Scholar : plan personal learning experiences and use them to enhance patient care, educate others to enhance patient care, contribute to the knowledge base that underpins patient care
- Professional: demonstrate that the care of their patients is their first concern, manage their work life balance to maintain their own wellbeing.
- None
- Other (please specify)

39. Please indicate which of the following competencies are assessed during continuous assessment in your country? (multiple answers are possible)

- Clinical Oncology: systemic treatments, side effects, toxicities, effects and toxicities when combined to radiation.
- Radiotherapy for breast cancer
- Radiotherapy for urological cancer
- Radiotherapy for lung cancer Radiotherapy for gastro-intestinal cancer
- Radiotherapy for gynaecological cancer
- Radiotherapy for central nervous system cancer
- Radiotherapy for sarcomas
- Radiotherapy for head and neck cancers
- Radiotherapy for hematological malignancies
- Emergencies in radiotherapy
- Radiotherapy for skin cancers
- Benign indications in radiotherapy
- Pediatric and adolescent oncology and radiotherapy
- Brachytherapy SBRT/SRS/RS
- Total body irradiation
- Particle therapy/ Proton therapy
- Oligometastatic disease
- Radiation protection

- Physics for radiotherapy
- Radiology
- Nuclear medicine
- Contouring guidelines
- Dose prescription
- Dosimetry/Planning
- Simulation CT
- Palliative care
- Pain management
- Breaking bad news, Communication with patients.
- Team work None
- Other (please specify)

40. Who organises the continuous assessment(s) in your country: (Multiple answers are possible)

- The programme director / training supervisor
- The head of department of the radiation oncology training centre/department
- (The Dean of) The Faculty of Medicine of the University
- The national society of radiation oncology
- A committee of agreement/ Recognition board
- The Ministry of Health
- A national examination committee
- Other (please specify)

41. Is the continuous assessment mandatory to get the final board certification in radiation oncology?

- Yes
- No
- Other (please specify)

42. if a candidate fails the continuous assessments or the examination(s), are there consequences for the candidate? (urgent advice to stop RO training, prolongation of the training, etc...)

- Yes
- No
- Other (please specify)

Questions about scientific activities requirements for the training in radiation oncology in Europe

43. Is it mandatory in your country to have one or more publication(s) in a peer-reviewed journal or an abstract/presentation at an (inter)national congress in order to obtain board certification as a specialist in radiation oncology? (multiple answers are possible)

- At least one publication in a peer-reviewed journal
- More than one publication in a peer-reviewed journal

- An abstract or a presentation in an (inter)national congress
- An abstract/presentation in an (inter)national congress or a publication in a peer-reviewed journal
- Other (please specify)

44. Is attendance at scientific congresses mandatory in your country in order to get board certified in radiation oncology? (multiple answers are possible)

- Yes, attendance at an international radiation oncology conference (ESTRO, ASTRO, others)
- Yes, attendance at an international oncology conference (f.i. ESMO, ASCO or tumor oriented conferences)
- Yes, attendance at national radiation oncology conferences
- Yes, attendance at other national oncology conferences
- No
- Other (please specify)

45. Is attendance at educational courses mandatory to get board-certified in radiation oncology in your country? (multiple answers are possible)

- Yes, the ESTRO courses
- Yes, national radiation oncology courses
- No
- Other (please specify)

Opinions and questions about a European certification for radiation oncologists in training.

46. Do you think that a European examination in radiation oncology could: (Multiple answers are possible)

- Promote the harmonisation of national examinations
- Provide national assessments with guidelines on how to conduct an assessment
- Promote the introduction of national assessments as a quality feature
- Offer an alternative to national assessments where appropriate.
- Other (please specify)

47. Would you support a European certification in radiation oncology? (please explain why by clicking ALSO on the "Why" case)

- Yes
- No
- Why?

48. If a European examination in radiation oncology is implemented, do you think it should be mandatory for the national certification in radiation oncology?

- Yes
- No
- Other (please specify)

49. In your opinion, What assessment tools should be used for a European examination in radiation oncology? (multiple answers are possible)

- Direct clinical observation and feedback
- Oral examinations
- Multiple choice questions/exams
- Objective structured clinical examination
- Simulation exam
- Mini clinical evaluation exercise
- Video assessment
- None
- Other

50. At what point during the training in radiation oncology do you think the exam should be taken?

- From the 2nd year of residency onward
- From the 3rd year of residency onward
- From the 4th year of residency onward
- During the 5th year of residency
- One year before the national board certification
- Other (please specify)

51. If a European examination is set up, in which language should it be taken?

- English
- In the language of the resident who is going to sit for the exam
- In English but with the possibility of translating it to the language of the resident
- Other (please specify)

Annex 3: Survey chapter 3

Training of radiotherapy professionals: status, content, satisfaction and improvement suggestions in the Greater Region.

1. In your curriculum, did you discuss these notions, under which pedagogical support(s)? (check for yes)

	Not addressed	Ex-cathedra	E-learning	Practical	SBME	Others
Radiation physics	☐	☐	☐	☐	☐	☐
Biological effects of radiation	☐	☐	☐	☐	☐	☐
Radiation protection	☐	☐	☐	☐	☐	☐
General Oncology	☐	☐	☐	☐	☐	☐
Clinical oncology	☐	☐	☐	☐	☐	☐
Medical imaging	☐	☐	☐	☐	☐	☐
Radiotherapy techniques	☐	☐	☐	☐	☐	☐

2. In comparison with the previous table, evaluate the relevance* of the pedagogical support used, as well as the adequacy* of the courses with your daily practice. (1: Bad to 3: Very good)

	Not relevant: 1	Quite relevant : 2	Very relevant:3	Not adequate : 1	Quite adequate: 2	Very adequate:3
Radiation physics	☐	☐	☐	☐	☐	☐
Biological effects of radiation	☐	☐	☐	☐	☐	☐
Radiation protection	☐	☐	☐	☐	☐	☐
General Oncology	☐	☐	☐	☐	☐	☐
Clinical oncology	☐	☐	☐	☐	☐	☐
Medical imaging	☐	☐	☐	☐	☐	☐
Radiotherapy techniques	☐	☐	☐	☐	☐	☐

3. In your curriculum, did you discuss these notions, under which pedagogical support(s)? (check for yes)

	Not addressed	Ex-cathedra	E-learning	Practical	SBME	Others
Undertake the initial outpatient consultation	☐	☐	☐	☐	☐	☐
Treatment strategy according to the organ / area to be irradiated	☐	☐	☐	☐	☐	☐
Simulation/planning session	☐	☐	☐	☐	☐	☐
Contouring, dose prescription, dosimetry	☐	☐	☐	☐	☐	☐
Organs at risk constraints	☐	☐	☐	☐	☐	☐

Short and long term follow-up of the patient	☐	☐	☐	☐	☐	☐
Risk and Incident management	☐	☐	☐	☐	☐	☐
Quality management	☐	☐	☐	☐	☐	☐
Medical Informatics	☐	☐	☐	☐	☐	☐
Management of emergency cases	☐	☐	☐	☐	☐	☐

4. In comparison with the previous table, evaluate the relevance of the pedagogical support used, as well as the adequacy of the courses with your daily practice. (1: Bad to 3: Very good)

	Not relevant: 1	Quite relevant : 2	Very relevant:3	Not adequate : 1	Quite adequate: 2	Very adequate:3
Undertake the initial outpatient consultation	☐	☐	☐	☐	☐	☐
Treatment strategy according to the organ / area to be irradiated	☐	☐	☐	☐	☐	☐
Simulation session	☐	☐	☐	☐	☐	☐
Contouring, dose prescription, dosimetry	☐	☐	☐	☐	☐	☐
Organs at risk constraints, treatments	☐	☐	☐	☐	☐	☐
Short and long term follow-up of the patient	☐	☐	☐	☐	☐	☐
Risk and Incident management	☐	☐	☐	☐	☐	☐
Quality management	☐	☐	☐	☐	☐	☐
Medical Informatics	☐	☐	☐	☐	☐	☐
Management of emergency cases	☐	☐	☐	☐	☐	☐

5. In your curriculum, did you discuss these notions, under which pedagogical support(s)? (check for yes)

	Not addressed	Ex-cathedra	E-learning	Practical	SBME	Others
Communication with patients and their relatives	☐	☐	☐	☐	☐	☐
Patient therapeutic education	☐	☐	☐	☐	☐	☐
Ethical standards	☐	☐	☐	☐	☐	☐
Interprofessional communication	☐	☐	☐	☐	☐	☐
Teamwork (collaboration, leadership, decision making)	☐	☐	☐	☐	☐	☐

6. In comparison with the previous table, evaluate the relevance of the pedagogical support used, as well as the adequacy of the courses with your daily practice. (1: Bad to 3: Very good)

	Not relevant: 1	Quite relevant : 2	Very relevant:3	Not adequate : 1	Quite adequate: 2	Very adequate:3
Communication with patients and their relatives	☐	☐	☐	☐	☐	☐
Patient therapeutic education	☐	☐	☐	☐	☐	☐
Ethical standards	☐	☐	☐	☐	☐	☐
Interprofessional communication	☐	☐	☐	☐	☐	☐
Teamwork (collaboration, leadership, decision making)	☐	☐	☐	☐	☐	☐

If other pedagogical support used, which ones? ....

Comment on pedagogical support? ....

7.During your training (assistantship/internship) in radiotherapy-oncology,
During your training as a radiation therapist,

What kind of educational support did you appreciate most?
What benefits did you get from it (at educational level)?

Justify: ....

What kind of educational support did you appreciate the least?

Justify: ....

8. Concerning the distribution of training time,

Training	Stressful, not enough time	Not enough time	Enough time	Too much time
Theoretical lessons	☐	☐	☐	☐
Practical lessons	☐	☐	☐	☐
Clinical work	☐	☐	☐	☐

9. Have you attended any courses or seminars abroad?

Yes/No	Yes	No
If so, did it help you?	☐	☐
If no, do you think it would have been useful?	☐	☐

10. Did you received courses using medical simulation (high fidelity manikin, role games, virtual reality,..)

☐ Yes	☐ No

If you have received any medical simulation lessons, what benefits did you get from it (in terms of learning knowledge and clinical practice)? ....

11. According to you, rank these 7 skills in order of importance in the practice of a radiation oncologist or a radiation therapist.(7: the most important, 1: the least important)

	1	2	3	4	5	6	7
Professional (ethical standards and excellence)	☐	☐	☐	☐	☐	☐	☐
Leader (management of human and technical resources)	☐	☐	☐	☐	☐	☐	☐
Collaborator (collaboration with other health professionals)	☐	☐	☐	☐	☐	☐	☐
Medical expert (theoretical and practical knowledge)	☐	☐	☐	☐	☐	☐	☐
Scholar (continuing education, teaching, research)	☐	☐	☐	☐	☐	☐	☐
Patient advocate (supporter and advisor)	☐	☐	☐	☐	☐	☐	☐
Communicator (appropriate and effective communication)	☐	☐	☐	☐	☐	☐	☐

12. After completion of your assistantship / internship, of your training, Do you think you have acquired all the knowledge and skills necessary to practice the profession of radiation oncologist or radiation therapist?

☐ Yes
☐ A large majority, but not all
☐ No

13. If you could add one (or more) course(s) to this training to improve it, which one(s) will it be?

Justify: ....

14. Age

20-25	26-30	31-40	41-50	+50
☐	☐	☐	☐	☐

15. Gender

☐ Female	☐ Male

16. Institution

Hombourg-Sarre	Lorraine-Nancy	French high school	Liège
☐	☐	☐	☐

17. Initial training

☐ Medicine + Radiotherapy-Oncology
☐ Nurse without additional training
☐ Nurse + training in radiotherapy
☐ Medical imaging technologist without additional training
☐ Medical Imaging Technologist + Training in radiotherapy
☐ Manipulator in radiotherapy, radiology
☐ Other

List of abbreviations*

WHO	World Health Organisation
RO	Radiation Oncology
ECC	ESTRO Core Curriculum
ESTRO	European SocieTy for Radiotherapy and Oncology
RTT/RTTS	Radiation Therapist/ Radiation Therapists
UEMS	Union Européenne des Médecins Spécialistes
SBME	Simulation Based Medical Education
FALCON	Fellowship in Anatomic delineation and CONtouring
SREs	Safety Related Events
RO/CO	Radiation Oncology and/or Clinical Oncology
CO	Clinical Oncology
EPA/EPAs	Entrustable Professional Activity / Entrustable Professional Activities
ACGME	Accreditation Council for Graduate Medical Education
RT	Radiotherapy
ROs	Radiation Oncologists
RO	Radiation Oncology
MIT	Medical Imaging Technologist
IQR	InterQuartile Range
PRISMA	Prevention and Recovery Information System for Monitoring and Analysis
WHO-CFICPS	World Health Organization's Conceptual Framework For The International Classification For Patient Safety
AI	Artificial intelligence
ILS	Incident Learning System
BRCO/BRCOs	Board Certified Radiation Oncologist/ Board Certified Radiation Oncologists
RRO/RROs	Resident in Radiation Oncology/ Residents in Radiation Oncology

* Country codes and abbreviations for PRISMA and WHO codes can be found in the relevant chapters, not in the list of abbreviations.