# An investigation of digital skills of therapeutic radiographers/radiation therapists: A european survey of proficiency level and future educational needs



**Published in:**
Radiography

**Publication Status:**
Published (in print/issue): 31/05/2023

**DOI:**
10.1016/j.radi.2023.02.009

**Document Version**
Publisher's PDF, also known as Version of record

Radiography 29 (2023) 479–488

Contents lists available at ScienceDirect

Radiography

journal homepage: www.elsevier.com/locate/radi

# An investigation of digital skills of therapeutic radiographers/radiation therapists: A european survey of proficiency level and future educational needs

B. Barbosa [a, b, c], C. Oliveira [a, b], I. Bravo [c], J.G. Couto [d], L. Antunes [e], S. McFadden [f, *], C. Hughes [f], P. McClure [f], J. Rodrigues [g], A.G. Dias [c, h]

[a] Radiotherapy Department, Instituto Português de Oncologia do Porto (IPO Porto), R. Dr. António Bernardino de Almeida 865, 4200-072 Porto, Portugal
[b] Escola Internacional de Doutoramento, Universidad de Vigo, Circunvalación ao Campus Universitario, 36310 Vigo, Pontevedra, Spain
[c] Medical Physics, Radiobiology and Radiation Protection Group, IPO Porto Research Center (CI-IPOP), Porto Comprehensive Cancer Center (Porto.CCC) & Rise@CI-IPOP (Health Research Network), R. Dr. António Bernardino de Almeida 865, 4200-072 Porto, Portugal
[d] Radiography Department, Faculty of Health Sciences, University of Malta, Msida MSD2080, Malta
[e] School of Health, Polytechnic Institute of Porto, Rua Dr. António Bernardino de Almeida 400, 4200-072 Porto, Portugal
[f] Institute of Nursing and Health Research, School of Health Sciences, Ulster University, Jordanstown, United Kingdom
[g] Cancer Epidemiology Group, IPO Porto Research Center (CI-IPOP), Portuguese Oncology Institute of Porto (IPO Porto) / Porto Comprehensive Cancer Centre (Porto.CCC) & RISE@CI-IPOP (Health Research Network), Porto, Portugal
[h] Medical Physics Department, Instituto Português de Oncologia do Porto (IPO Porto), R. Dr. António Bernardino de Almeida 865, 4200-072 Porto, Portugal

ARTICLE INFO

*Article history:*
Received 8 September 2022
Received in revised form
23 January 2023
Accepted 8 February 2023

*Keywords:*
Digital skills
Radiotherapy
Technology
Clinical practice
Education

ABSTRACT

*Introduction:* This study aims to assess the proficiency level of digital skills, the factors influencing that level and the training needs of Therapeutic Radiographers/Radiation Therapists (TR/RTTs), due to the differences in technology availability and accessibility, variations in the regulation and education of TR/RTTs in European countries, and the lack of a digital skills framework.
*Methods:* An online survey was distributed to TR/RTTs working in Europe to capture their self-assessment of proficiency levels of digital skills when performing their clinical role. Information was also gathered regarding training, work experience and level of information and communication technology (ICT) skills. Quantitative measures were analysed using descriptive statistics and correlation between variables, and qualitative responses using thematic analysis.
*Results:* 101 respondents from 13 European countries completed the survey. Digital skills in treatment planning followed by management and research were the least developed skills, while the most developed were transversal digital skills followed by digital skills in treatment delivery. The Radiotherapy areas of practice where TR/RTT has experience (e.g. Planning Image, Treatment Planning, Treatment), as well as the level of generic ICT skills (communication, content creation and problem-solving), was related to the level of proficiency of TR/RTT digital skills. Greater scope of practice and level of generic ICT were associated with a higher level of TR/RTT digital skills. Thematic analysis allowed the identification of new sub-themes to be included in the training of TR/RTTs.
*Conclusion:* Education and training of TR/RTTs should be improved and adapted to the current needs of digitalisation to avoid differences in digital proficiency levels.
*Implications for practice:* Aligning TR/RTTs' digital skill sets with emerging digitalisation will improve current practice and ensure the best care to all RT patients.


* Corresponding author. Faculty of Life and Health Sciences, Ulster University, Newtownabbey, UK.
*E-mail addresses:* barbara.barbosa@ipoporto.min-saude.pt (B. Barbosa), celeste.m.oliveira@ipoporto.min-saude.pt (C. Oliveira), isabel.bravo@ipoporto.min-saude.pt (I. Bravo), jose.g.couto@um.edu.mt (J.G. Couto), antunes.lj@gmail.com (L. Antunes), s.mcfadden@ulster.ac.uk (S. McFadden), cm.hughes@ulster.ac.uk (C. Hughes), pa.mcclure@ulster.ac.uk (P. McClure), jessica.rocha.rodrigues@ipoporto.min-saude.pt (J. Rodrigues), anabela.dias@ipoporto.min-saude.pt (A.G. Dias).

https://doi.org/10.1016/j.radi.2023.02.009

## Introduction

During the COVID-19 pandemic, there was an increasing use of digital solutions. This trend towards further digitalisation is confirmed by the growth rate in the adoption of digital technologies by European citizens. Although most countries are making progress in digital transformation, namely in the healthcare sector, insufficient or low level of proficiency can compromise competent and safe practices in the use of clinical technologies.[1–3] This digital shift poses increasing challenges to health professionals, making continuous education of these professionals necessary to keep up with these new demands.

Radiotherapy (RT) is a scientific field demonstrating significant technological advances, where the introduction of new technologies has also demanded a broader set of skills from Therapeutic Radiographers/Radiation Therapists (TR/RTTs).[3,4] The successful digital technology use in patient care is dependent on the digital skills of the TR/RTTs, unskilled professionals can undermine patient safety and increase the incidence of errors.[5,6] However, differences in regulation and education of TR/RTTs, and differences in access to technology in European countries, leads to gaps in these same skills. In addition, the lack of a specific framework regarding the training needs of digital skills of TR/RTTs prevents their development in initial and lifelong training programmes.[2,7,8]

Although a recent study presented a list of digital skills which should be included in the educational curriculum and continuing professional development (CPD) programmes for TR/RTTs (see some examples in Table 1),[9] it has not identified which skills were developed by TR/RTTs and what their proficiency level is. It was therefore considered relevant to assess not only the proficiency level of TR/RTTs in performance digital tasks, but also to identify possible factors influencing it.

Digital skills and related concepts such as “digital competence” have become key terms in the discussion about skills needed by all citizens to be able to participate and thrive in society, not only in terms of social and digital inclusion but also in terms of employability and economic growth.[10,11] Despite global agreement on the importance of digital skills, no common definition has been agreed upon, presenting different interpretations of the content of digital skill and the knowledge and abilities it encompasses.

Given the European context of this study, the European Qualifications Framework (EQF) for lifelong learning definition of ‘skill’ was used as a reference and is defined as “ability to apply knowledge and use know-how to complete tasks and solve problems".[12] For the purpose of the present study, digital skills in the context of RT are defined as the digital-related knowledge, abilities and critical understanding in the professional context of TR/RTTs’ practice in technology usage. Examples of some digital skills specific to Radiotherapy are “use matching view tools (e.g., split window, spyglass, reverse)” and “calculate isocentre coordinates”; or non-specific but relevant to the TR/RTT profession, such as “view application access logs” for data protection.[9,13–18]

Understanding the characteristics that influence digital skills, as well as the stage of training where they are developed, allows decision-makers to use this knowledge in the design of educational programmes and CPD. It is also fundamental to identify which digital skills are less developed in order to close these gaps, promoting standard education, which results in a better quality of practice, and consequently better patient care.

### *Aim*

The aims of this study were:

1. Assess the proficiency level of TR/RTTs digital skills;
2. Identify the training needs of TR/RTTs;
3. Identify the factors influencing the level of proficiency;
4. Assess the stage of training and phase of professional development in which the skills have been developed.

## Methods

Both qualitative and quantitative methodologies were used in this cross-sectional research.[19,20] An online survey was used as it is fast and inexpensive, especially in geographically dispersed populations.[21]

**Table 1**
Some examples of the 195 digital skills list of TR/RTTs identified in a previous research, organized by themes and sub-themes.[9]

| Dimensions (themes) | Skill |
|---|---|
| **Transversal Digital Skills** | |
| Electronic Patient Record (EPR) | - Create a new patient record<br>- Access RT patient data<br>- Add clinical data (e.g., treatment side effects, occurrences) |
| **RT Planning Image** | |
| Image Segmentation and Contouring | - Use contouring tools (e.g., geometric shapes, tracing)<br>- Use processing tools (e.g., interpolation, threshold, translation)<br>- Review and approve segmentation |
| **RT Treatment Planning** | |
| Plan Evaluation | - Use review tools (e.g., plan sum/subtract, dose comparison)<br>- Compare treatment plans<br>- Use biological optimisation tools |
| **RT Treatment Administration** | |
| Image Matching | - Use pre-analysis tools (e.g., scale and field alignment)<br>- Use matching view tools (e.g., split window, spyglass, reverse)<br>- Match 2D images (kV or MV) with reference image (DRR) |
| **Quality, Safety and Risk Management** | |
| Risk Management | - Report accidents and incidents on a platform (e.g., SAFRON, ROSEIS)<br>- Audit the workflow and treatment courses (e.g., plan changes, schedules)<br>- Create evaluation and prevention reports |
| **Management and Research** | |
| Department Administration and Management | - Use data collection tools of the activities performed (export data, productivity)<br>- Create automatic reports (e.g., daily activities, billing)<br>- Perform market research (e. g., supplies, technology) |

**Table 2**
Survey structure.

| Parts | Sections |
|---|---|
| Part 1 – Socio-demographic, education, and professional characteristics | Section I – Socio-demographic, educational and professional characteristics |
| | Section II – ICT skills |
| Part 2 – RT digital proficiency level for TR/RTTs' practice | Section III – Transversal digital skills |
| | Section IV – Specific (Planning Image, Treatment Planning and Treatment) |
| | Section V – Quality, Safety and Risk Management |
| | Section VI – Management and Research |
| Part 3 – Education of RT digital skills | Section VII – Education |

*Survey design*

A survey was designed (Appendix A), based on the list of TR/RTTs' digital skills from a previous literature analysis,[9] to identify which digital skills are being developed and what their level of proficiency is. Also, to evaluate the association between this level and the following factors: socio-demographic characteristics; educational background; professional status; and information and communication technology (ICT) skills.

The survey included three parts: part 1 examined TR/RTTs' characteristics that may affect digital skills development,[22–24] part 2 aimed at evaluating the digital proficiency level in RT, and part 3 explored the context within which these skills were developed (Table 2).

Section II comprised the following generic ICT skills areas: Information processing (e.g., "save files and retrieve them"), communication (e.g., "share files and content using simple tools"), content creation (e.g., "produce multimedia content in different formats"), safety (e.g., "check the security configuration and systems of devices"), and problem solving (e.g., "solve technological problems by exploring the settings and options of programmes or tools"). This section was adapted from the European Commission "Digital Competence Framework for Citizens".[23] The participants were asked to rate themselves, as "basic" "independent" or "proficient" users of ICT in each area.[2,13,23] Section IV explored the digital proficiency level in performing tasks in the areas of Image Planning, Treatment Planning and Treatment (referred to as specific to the TR/RTT profession). Sections III, V and VI explored the digital skills of TR/RTTs but not specific to the profession, i.e., applicable also in other professions, such as "Import and export data (e.g., DICOM images)" or "Collect and evaluate data for research". These non-RT-specific digital skills result from the rapid evolution of technology and innovation in ICT, and are common to several professions.[2,13,23,25–29]

Closed-ended questions were used to assess the skill level of TR/RTTs, as well as to explore the contribution (in %) of different educational settings to the development of these skills (section VII). These types of questions allowed a quick compilation of data and statistical analysis. However, open-ended questions were also included throughout the survey so that respondents could add any digital skill not presented in the survey and expand their answers whenever appropriate. Where necessary, relevant supporting information was introduced throughout the survey to enable the respondent to give an informed and conscious response. Online surveys allow fast and effective access to a larger number of respondents and greater flexibility regarding the time or place of their participation.[30]

*Pilot study, validity and reliability*

To check the consistency, clarity, and suitability of the developed tool, validity and reliability tests were performed on the questionnaire.

The validity test aimed to verify whether the objectives of the questionnaire were represented by the questions asked in the survey, i.e., whether the survey actually measures what is claimed in its aims.[31] To this end, seven experts from different fields of Radiotherapy and Medical Physics (Planning Image, Treatment Planning, Treatment, Quality Assurance, Management and Research) were invited to classify each question regarding their ability to measure what is proposed (content validity). A four-point Likert scale ranging from 1 to 4 (not relevant to relevant, respectively) was used to collect this data.[32,33]

The Item-Content Validity Index (I-CVI) was calculated by dividing the number of questions rated 3 or 4 by the total number of questions, with the value 1 corresponding to the best content validity index.[34,35] The survey had an I-CVI of 0.987, and it was considered valid.

Before any measurement instruments or assessment tools can be used for research, their reliability must be established. Reliability is defined as the extent to which measurements can be replicated, which reflects not only the degree of correlation but also an agreement between measurements. A test-retest was performed[36] where the same survey was administered twice to three RT professionals two weeks apart. The reliability was assessed by calculating the interclass correlation coefficient (ICC) using a two-way mixed and absolute agreement model. An ICC of 0.811 ($p < 0.001$), 0.836 ($p < 0.001$), and 0.884 ($p < 0.001$) were obtained for each RT professional respectively, showing a good reliability.

The pilot survey was distributed to 66 TR/RTTs in a large oncology hospital, of which 52 responses were gathered, six were excluded for being incomplete, leaving 46 valid responses (response rate of 69.7%).

Some amendments were made to the questionnaire following feedback from the participants. The internal consistency (reliability) was measured through the evaluation of the responses to repeated questions within the questionnaire using the Cronbach's alpha reliability coefficient. The value obtained was 0.983, i.e., there was high internal consistency.[37]

*Survey distribution*

This study is part of the SAFE EUROPE project funded by the European Commission (under an Erasmus+ Sector Skills Alliance grant).[38] Therefore, the survey was distributed by the professional organisations within the consortium: Associação Portuguesa de Radioterapeutas - ART (Portugal), Society of Medical Radiographers - SRM (Malta), Polskie Towarzystwo Ekonomiczne - PTE (Poland) and the European Federation of Radiographer Societies – EFRS (across Europe).

The target population included all TR/RTTs working in Europe. The accessible population included all European TR/RTTs who were members of the professional organisations mentioned above or linked with the SAFE EUROPE project.

Invitations were sent via email by the professional organisations (ART, PTE, SRM and EFRS) to professionals who agreed to receive this type of information (email lists). The EFRS distributed the survey to the national associations' members. To increase the number of participants, invites were posted on the SAFE EUROPE social media platforms (Twitter, Facebook and LinkedIn) and shared by the consortium members. The survey was electronically distributed using Google Forms software and was available from March to November 2021.

### RT digital skills score

The assessment of the RTT/TRs' skills level was performed by analysing the results obtained in sections Ill to VI of the survey. In these sections, participants were asked to rate their level of proficiency for an extensive list of digital skills in a Likert scale ranging between 1 (underdeveloped) and 5 (highly developed).[19] It was considered that all questions contribute equally to the outcome of each segment, just as each segment contributes equally to the final score of the RT digital skills. Thus, a score was assigned to each participant on a scale from 0 to 100, in which the higher their digital proficiency level, the higher their score; 100 corresponds to a participant who rated every skill as "highly developed".

### Data analysis

Statistical analysis was performed using R software v4.0.5. Categorical variables were summarized as frequencies and percentages. Continuous variables were presented as median, minimum, and maximum.

Comparisons between independent groups were performed using Mann–Whitney or Kruskal–Wallis tests for continuous variables. The Spearman's rank correlation coefficient (r) was used to measure the strength of the relationship between two continuous variables.

The Friedman test was used to determine if there was a statistically significant difference between the different digital skills presented to the participants. The Nemenyi test was conducted as a post hoc test, to determine which digital skills were the most and least developed. All tests of statistical significance were two-sided; a p value $< 0.05$ was considered significant.

For the collection of additional information from the survey, a thematic analysis using a free and open-source qualitative data management software (Taguette Version 1.3.0, European Organization for Nuclear Research, Switzerland) was carried out, which allowed the analysis of data from the open-ended questions.[39,40] A theoretical analysis[41] was used with the aim of identifying digital skills from the open-ended questions and not listed in the close-ended questions. The data collected was analysed individually and organised under the appropriate pre-existing themes as identified in previous research,[9] keeping in mind that new themes may also emerge during the data analysis process. Investigator triangulation was used to provide multiple observations and conclusions. This type of triangulation allows both the confirmation of results and the presentation of different perspectives, adding breadth to the phenomenon of interest.[42,43]

The pilot survey was not included in the data analysis.

### Ethical considerations

Ethical permission was granted by the Institute of Nursing and Health Research Ethics Committee at Ulster University, Belfast (FCNUR-20-032-A). Participant Information was provided at the beginning of the survey, and all data was kept safe, either by locks or passwords, for physical and electronic data respectively.

## Results

From a total of 123 responses, 101 valid responses were analysed, and 22 were removed according to the exclusion criteria (Fig. 1).

### Statistical analysis

#### Socio-demographic characteristics and ICT skills

The socio-demographic characteristics of the respondents are presented in Table 3, and the level of their ICT Skills is in Table 4. The median age of the participants was 34 years, ranging between 23 and 66 years old. The median years of experience in RT were 12 years, ranging between less than a year and 36 years.

The sample was distributed by 13 European countries, according to Table 3. However, there was a predominance of answers from Portugal, the United Kingdom (UK) and Poland.

Although the UK is no longer a member state of the European Union/European Economic Area (EU/EEA), it was decided to include the responses in the data analysis, since the survey was designed, and its pilot study applied, in 2019, in the period before the UK left the EU/EEA. The survey was distributed across Europe from March 2021, just after the transition period, and therefore it was considered that the responses of UK participants still reflected their membership status.

Most respondents replied that the educational level that gave them access to the profession was the bachelor's degree (EQF6). However, more than 40% of the respondents have additional postgraduate education at Master's and Doctorate levels.

Regarding the number of Radiotherapy areas where respondents indicate having experience, 40.6% refer to two areas of Radiotherapy practice, with the majority selecting the areas of pretreatment imaging and treatment administration.

When asked about training in digital skills in the last 12 months, 62.4% of respondents reported not having received any training.

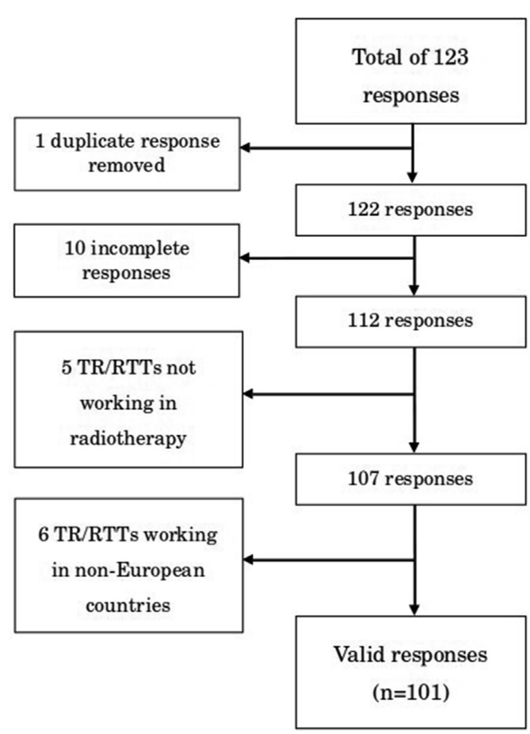


**Figure 1.** Flow chart of excluded survey responses.

**Table 3**
Respondents' socio-demographic characteristics.

| | | n (%) |
|---|---|---|
| Gender | Female | 73 (72.3%) |
| | Male | 27 (26.7%) |
| | Prefer not to say | 1 (1.0%) |
| Initial academic level (EQF) | EQF4 | 1 (1.0%) |
| | EQF5 | 5 (5.0%) |
| | EQF6 | 72 (71.3%) |
| | EQF7 | 11 (10.9%) |
| | EQF8 | 12 (11.9%) |
| Highest academic level (EQF) | EQF4 | 1 (1.0%) |
| | EQF5 | 3 (3.0%) |
| | EQF6 | 54 (53.5%) |
| | EQF7 | 29 (28.7%) |
| | EQF8 | 14 (13.9%) |
| Country where respondents currently work | Austria | 3 (3.0%) |
| | Belgium | 2 (2.0%) |
| | Croatia | 1 (1.0%) |
| | Denmark | 1 (1.0%) |
| | Finland | 1 (1.0%) |
| | France | 6 (5.9%) |
| | Italy | 1 (1.0%) |
| | Malta | 2 (2.0%) |
| | Netherlands | 4 (4.0%) |
| | Norway | 5 (5.0%) |
| | Poland | 17 (16.8%) |
| | Portugal | 36 (35.6%) |
| | United Kingdom | 22 (21.8%) |
| Radiotherapy areas of practice where participants have experience (participants were allowed more than one selection, with the "other" option corresponding to an open question) | Planning Image, Treatment Planning, Treatment | 22 (21.8%) |
| | Planning Image, Treatment Planning; Treatment, Other | 8 (7.9%) |
| | Planning Image, Treatment | 31 (30.7%) |
| | Planning Image, Treatment; Other | 8 (7.9%) |
| | Treatment Planning, Treatment | 7 (6.9%) |
| | Treatment Planning, Treatment, Other | 2 (2.0%) |
| | Treatment, Other | 3 (3.0%) |
| | Treatment | 17 (16.8%) |
| | Treatment Planning | 3 (3.0%) |
| Number of radiotherapy areas with experience | 1 | 20 (19.8%) |
| | 2 | 41 (40.6%) |
| | 3 | 32 (31.7%) |
| | 4 | 8 (7.9%) |
| Training in digital skills in the last 12 months | No | 63 (62.4%) |
| | Yes | 28 (27.7%) |

EQF - European Qualifications Framework, EQF4 - Secondary level course, EQF5 - Short higher education programme, EQF6 - Bachelor's degree, EQF7 - Master's degree, EQF8 - Doctoral Degree.

In Table 4, where ICT skills levels are presented, most respondents consider themselves basic users regarding content creation, while for information processing, only 10% consider themselves as a basic user and the majority as a proficient user. In the skills related to problem solving and security, 53% and 50% of respondents reported themselves as proficient, respectively, while in communication, only 25% identify themselves as proficient.

*Level of RT digital skills*

The RT digital skills score in Table 5 shows that Transversal Digital Skills was the section with the highest score, followed by the Treatment section. On the other hand, Treatment Planning and Management and Research sections showed the lowest score. With the Friedman test showing a statistically significant difference between all sections, followed by the post hoc test (Table 6), these scores translate into the sections with the most and least developed digital skills.

*Socio-demographic characteristics relationship with RT digital skills score*

The relationship between the socio-demographic characteristics and the digital skills score was also studied (Table 7).

The Spearman's rank correlation test showed a weak positive relationship between age ($r = 0.20$) and time of experience ($r = 0.28$) with the digital skills level score obtained, in which the higher the age and time of service, the higher the score. The number of areas of practice in which TR/RTTs have experience also demonstrates a significant difference, where the greater the number of areas of practice, the higher the score obtained. No relationship was found between the other demographic characteristics and the score.

*ICT skills level relationship with RT digital skills score*

A statistically significant difference was found between the generic ICT skills of communication, content creation, and problem-solving, with the RT digital skills scores obtained by the participants (Table 8).

*Educational context in which the digital skills are developed*

With regard to the stage at which digital skills were developed, the Friedman test (Table 9), showed a significant difference between the different contexts studied ($p < 0.001$). The Nemenyi's post-hoc test (Table 10) identified that respondents develop the RT digital skills mostly in informal CPD contexts, followed by basic education and voluntary CPD. Less importance was given by the

**Table 4**
Respondents' ICT skill level.

| | | n (%) |
|---|---|---|
| Information processing | Basic user | 10 (9.9%) |
| | Independent user | 39 (38.6%) |
| | Proficient user | 52 (51.5%) |
| Communication | Basic user | 14 (13.9%) |
| | Independent user | 62 (61.4%) |
| | Proficient user | 25 (24.8%) |
| Content creation | Basic user | 52 (51.5%) |
| | Independent user | 15 (14.9%) |
| | Proficient user | 34 (33.7%) |
| Safety | Basic user | 29 (28.7%) |
| | Independent user | 22 (21.8%) |
| | Proficient user | 50 (49.5%) |
| Problem-solving | Basic user | 29 (28.7%) |
| | Independent user | 19 (18.8%) |
| | Proficient user | 53 (52.5%) |

**Table 5**
RT digital skills score by section.

| Sections | Number of questions | Score | p-value |
|---|---|---|---|
| Transversal | 27 | 85.2 (35.2–100.0) | <0.001 |
| Treatment | 59 | 75.5 (0.4–100.0) | |
| Planning Image | 29 | 69.8 (3.4–100.0) | |
| Quality, Safety, and Risk | 25 | 57.0 (4.8–100.0) | |
| Management and Research | 14 | 50.0 (0.0–100.0) | |
| Treatment Planning | 41 | 31.0 (0.0–100.0) | |
| Total | 195 | 62.4 (20.6–98.4) | |

survey respondents to “mandatory CPD” and “postgraduate education” for the development of digital skills.

*Thematic analysis*

At the end of each section from III to VI, the participant was given the opportunity to identify any other digital skills that are used in their practice and not identified in the list of digital skills included in the survey (through open-ended questions).

The suggestions made were scanned for similarity and examples, marking similar intended meanings (e.g., “planning system database management” and “active directory management”). The participants' input resulted in additional digital skills coded into two previously identifies themes and subthemes,[9] and one new sub-theme was created (see Table 11).

The new codified sub-theme was “Departmental Information Systems (IS) administration and management".

References were also made to RT technologies/techniques that were not included in the survey, such as “perform MRI imaging”, “use MRI images for treatment planning”, “use of adaptive radiotherapy”, “perform adaptive radiotherapy (Cone-beam Computed Tomography based)" and “perform proton therapy".

## Discussion

This is the first study exploring the proficiency of RT digital skills of TR/RTTs in Europe. As such, this paper constitutes a relevant contribution to knowledge. The main conclusion of this study was that TR/RTTs develop different digital skills at different levels. Friedman's test and the corresponding post-hoc tests suggest that

**Table 6**
Nemenyi Post-Hoc test results.

| Sections | Planning Image | Treatment Planning | Treatment | Quality, Safety and Risk | Management and Research |
|---|---|---|---|---|---|
| Transversal | <0.001 | <0.001 | 0.388 | <0.001 | <0.001 |
| Planning Image | | <0.001 | 0.430 | 0.131 | 0.003 |
| Treatment Planning | | | <0.001 | <0.001 | 0.015 |
| Treatment | | | | <0.001 | <0.001 |
| Quality, Safety and Risk | | | | | 1.000 |

**Table 7**
Relationship between socio-demographic characteristics and survey score.

| | | Total Score (Min-Max) | p-value |
|---|---|---|---|
| Age/years | 34 (23–66) | 62.4 (20.6–98.4) | 0.047 (r = 0.20)* |
| Initial academic level (EQF) | EQF4 | 74.7 (74.7–74.7) | 0.211 |
| | EQF5 | 73.4 (61.5–82.6) | |
| | EQF6 | 63.7 (31.3–98.4) | |
| | EQF7 | 60.6 (50.7–93.2) | |
| | EQF8 | 55.8 (20.6–84.5) | |
| Highest academic level (EQF) | EQF4 | 74.7 (74.7–74.7) | 0.364 |
| | EQF5 | 75.5 (61.5–82.6) | |
| | EQF6 | 62.9 (39.7–98.4) | |
| | EQF7 | 63.7 (31.3–93.2) | |
| | EQF8 | 59.7 (20.6–84.5) | |
| Years practising Radiotherapy | 12 (0–36) | 62.4 (20.6–98.4) | 0.005 (r = 0.28)* |
| Number of Radiotherapy areas with experience | 1 | 49.9 (20.6–76.3) | <0.001 |
| | 2 | 60.4 (33.8–98.4) | |
| | 3 | 69.8 (31.3–97.7) | |
| | 4 | 78.1 (63.3–97.0) | |
| Training in digital skills in the last 12 months | No | 60.2 (20.6–92.5) | 0.289 |
| | Yes | 70.0 (41.2–98.4) | |

EQF - European Qualifications Framework *Spearman's rank correlation coefficient.

**Table 8**
Relationship between ICT skills level and RT digital skills score.

| | | n (%) | Total Score Median (Min-Max) | p-value |
|---|---|---|---|---|
| Information processing | Basic user | 10 (9.9%) | 54.4 (39.7–80.3) | 0.130 |
| | Independent user | 39 (38.6%) | 66.9 (27.6–98.4) | |
| | Proficient user | 52 (51.5%) | 63.0 (20.6–97.7) | |
| Communication | Basic user | 14 (13.9%) | 54.5 (20.6–75.2) | 0.008 |
| | Independent user | 62 (61.4%) | 68.7 (27.6–98.4) | |
| | Proficient user | 25 (24.8%) | 58.3 (31.9–96.6) | |
| Content creation | Basic user | 52 (51.5%) | 58.8 (20.6–96.6) | 0.005 |
| | Independent user | 15 (14.9%) | 76.3 (43.6–98.4) | |
| | Proficient user | 34 (33.7%) | 67.5 (31.3–97.7) | |
| Safety | Basic user | 29 (28.7%) | 60.7 (41.1–97.7) | 0.190 |
| | Independent user | 22 (21.8%) | 73.7 (40.3–98.4) | |
| | Proficient user | 50 (49.5%) | 62.1 (20.6–97.0) | |
| Problem-solving | Basic user | 29 (28.7%) | 59.3 (27.6–92.5) | 0.048 |
| | Independent user | 19 (18.8%) | 72.6 (40.3–98.4) | |
| | Proficient user | 53 (52.5%) | 63.7 (20.6–97.7) | |

**Table 9**
TR/RTTs' educational context where digital skills were developed.

| Digital skills education | Percentage | p-value |
|---|---|---|
| Informal CPD | 33 (0–100) | <0.001 |
| Basic radiographer education | 20 (0–100) | |
| Voluntary CPD | 20 (0–40) | |
| Mandatory CPD | 16 (0–40) | |
| Postgraduate education | 0 (0–60) | |

CPD - Continuous Professional Development.

digital skills related to “treatment planning” and “management and research” were the least developed themes. This agrees with previous literature that showed that “management and leadership” and “research and education” were underdeveloped by TR/RTTs working in the linear accelerator.[8] Furthermore, another study showed that training programmes do not always include RT treatment planning.[44] This may be due to the fact that many educational programmes have a low percentage of RT in the curriculum and treatment planning may not be covered in every course. Additionally, after graduation only a few TR/RTTs work in treatment planning, and they may be losing skills in this area. However, this study shows that digital skills corresponding to treatment planning are also underdeveloped.

Even though the RT digital skills median score was 62.4 (out of 100), the score ranged from 20 to 98.4. As such, it is essential to understand the heterogeneity of the TR/RTT workforce. This range also suggests that some TR/RTTs have very underdeveloped digital skills, with TR/RTTs with a score of 0 in some RT digital skills sections (“Treatment Planning” and “Management and Research”).

Additionally, the larger the number of areas of expertise of the TR/RTT (Planning Image, Treatment Planning; Treatment, Other), the higher the score. This shows that digital skills may be developed as TR/RTTs gain experience in different areas of practice. These results are supported by the fact that age and years of experience correlated with an increased RT digital skills score, giving them time to learn new digital skills in practice. However, this must be confirmed by additional research.

A digital skill is underpinned by skills in ICT to retrieve, assess, store, produce, present and exchange information, to communicate and participate in networks.[2,10] In the context of RT, ICT skills are included not only in the performance of more general tasks, but also in specific ones. For example, in one of the ICT skills assessed, “communication”, for the TR/RTTs to be able to share images and content using simple tools, they need to have at least the basic level of this previous ICT skill. In this study, there was a relationship between higher ICT skills and RT digital skills scores. “Basic users” in “communication”, “content creation” and “problem-solving” ICT skills had statistically lower RT digital skills scores. This relationship was expected since higher ICT skills are essential to developing professional-specific digital skills.[1,10,24]

Regarding the educational context in which digital skills are developed, it was pointed out that TR/RTTs develop most digital skills through CPD (69%). Of these, 33% developed digital skills through informal CPD, which may include on-the-job training, once again, supporting the prior hypothesis that digital skills are mostly gained through practice. Nevertheless, only 20% of the digital skills were developed in their training to become TR/RTTs and 36% through voluntary and mandatory CPD. Although, less relevance was given to mandatory CPD (16%) and postgraduate education (0%) by the respondents, some of the skills are developed through this training and this should be considered when designing RT educational programmes and CPD activities.

In the thematic analysis of the open-ended questions only one new sub-theme was identified. However, all the digital skills coded and presented in Table 11 differed from the skills already published in a previous review, and an opportunity arose for their inclusion in the published list of digital skills for TR/RTTs.[9]

The reference, by the participants, to RT technologies and techniques that were not mentioned in the survey demonstrate the heterogeneity of knowledge and skills of TR/RTTs, conditioned by the variability of technology available[45] but also by the divergence

**Table 10**
Nemenyi Post-Hoc Test results.

| Digital skills education | Postgraduate education | Mandatory CPD | Voluntary CPD | Informal CPD |
|---|---|---|---|---|
| Basic education | <0.001 | <0.001 | 0.020 | <0.001 |
| Postgraduate education | | 0.376 | 0.009 | <0.001 |
| Mandatory CPD | | | 1.000 | <0.001 |
| Voluntary CPD | | | | <0.001 |

CPD - Continuous Professional Development.

**Table 11**
Digital skills identified by survey participants, organised by themes and sub-themes.

| Themes | Sub-themes | Digital skills |
|---|---|---|
| Transversal | - Technologies/IS<br>- Patient agenda | - Set up the IS<br>- Use of a checklist for activities |
| Management, Research | - Departmental IS administration and management | - Manage the TPS database<br>- Manage IS<br>- Manage hardware<br>- Access all the functions of IS<br>- Manage directories |

IS- Information Systems, TPS- Treatment Planning System.

in the training of these professionals.[46] This is reflected in the role development of the TR/RTTs' practice, where in some countries there is another level of practice - advanced practice (AP). Professionals working in AP roles extend or expand areas of practice using different skill sets. These practitioners work with more autonomy and accountability in the RT setting.[47] For this, their radiotherapy-specific skills should always be updated, which also includes digital skills to work with the radiotherapy IS.

In order to address the digital skills proficiency, it is necessary to adapt undergraduate and further education in the TR/RTT profession. A focus can pass through the curricular implementation of digital literacy,[48] ICT skills,[16] but also RT-specific digital skills, using the published list of digital skills as educational guidance.[9]

Some universities have already successfully implemented and evaluated an elective curriculum for the promotion of digital skills in healthcare, as is the case of the University Medical School of the Johannes Gutenberg University of Mainz[49] or the University of Hamburg[50] with the introduction of a longitudinal interdisciplinary elective course “Digital Health” for medical students in year 3 or above. These examples can serve as a basis for training TR/RTTs, and can be a starting point for developing a joint digitization strategy. The aim is to provide a structured teaching of digital skills. In the future, it would be interesting to research the training strategies implemented with regard to their effectiveness in later working life.

### *Limitations*

Convenience sampling was used since only members of the professional organisations or those with access to the SAFE EUROPE consortium media could participate in the survey. Therefore, the respondents may not be a true reflection of the European TR/RTTs population. To compensate, a strong emphasis was placed on disseminating the survey across European professional organisations. Although there is no formal estimate available globally for the number of TR/RTTs,[51] based on the most recent HCPC data,[52] the number of TR/RTTs females/males in this study (72.3% and 26.7%, respectively) was similar to the TR/RTT population in the UK, and can be expected that the proportion is similar across Europe. The survey was sent via email by the professional organisations (ART, PTE, SRM and EFRS) to professionals who agreed to receive this type of information and picked up by social media. Therefore, the exact response rate is difficult to determine.

Since the digital proficiency level is directly related to the respondent's perception of them, the answers may have some bias. The researchers tried to minimise this possibility by clarifying the questions as much as possible. In addition, the questionnaire was kept anonymous to minimise social desirability bias.

Further research is recommended to understand the digital gaps identified in the survey. This additional research should allow a deeper understanding of the factors influencing these digital proficiency levels and at what stage these skills should be integrated into the education of TR/RTTs.

### *Recommendations*

It is recommended that training for TR/RTTs should also develop the digital skills required to perform tasks in this profession at a high level of proficiency. This training can be offered as part of their RT education. However, since CPD (voluntary, mandatory, and informal) seems to have a role in developing digital skills, this may be an adequate option to upskill TR/RTTs.

The development of ICT skills is an essential base for developing RT-specific digital skills. As such, it is recommended that TR/RTTs develop these skills prior to or during their RT training programmes. Since the number of RT areas of practice where the professional has experience seems to be related to the RT digital skills score, it is recommended that all TR/RTTs have the opportunity to gain experience across all areas of RT.

This study addressed the digital skill needs for the whole TR/RTT profession. However, it would be pertinent to study what are the specific needs for different roles of TR/RTTs. This is, therefore, suggested as a future study.

It is also recommended to further investigate the digital skills and RT technologies/techniques highlighted by the participants. The aim would be to update the list of digital skills available in the literature with new sub-themes, based on emerging and future practice of TR/RTTs.

## Conclusion

Digital skills are essential in the radiotherapy workforce. The digitalisation of the economy is one of the most important drivers behind the transformation of healthcare and the way healthcare professionals work, and this digitalisation is likely to become even more significant in the years to come. This new paradigm poses a challenge for TR/RTTs, as current RT practice depends entirely on the support of digital equipment. As such, they must develop the necessary digital skills to provide appropriate care to cancer patients.

The education and training sector for TR/RTTs must be intelligence-driven to develop and adapt its provision to meet the changing needs of this digitisation. Education programmes should ensure that digital skills are part of the required skills at all levels.

These skills can be developed in many ways: during TR/RTTs' initial education, through formal CPD (mandatory or voluntary) and informal CPD, such as on-the-job training.

Treatment planning, management and research-related digital skills were the least developed. As such, training in these areas is recommended.

Finally, work experience across the different areas of RT (such as pre-treatment imaging, planning and treatment) is one factor that seems to impact digital skills score. This conclusion is supported by the increase in digital skills with age and years of experience.

It is imperative to continue the research on the digital skills of TR/RTTs, to include new themes and sub-themes that can cover new technologies and the corresponding skills, which are considered essential in the current TR/RTT curriculum.

## Conflict of interest statement

This work was co-funded by the SAFE EUROPE project under the Erasmus+ Sector Skill Alliances programme [grant agreement 2018-2993/001-001]. The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein. Jéssica Rodrigues is supported by a PhD fellowship from Fundação para a Ciência e a Tecnologia, Portugal (UI/BD/152282/2021).

## Acknowledgements

The research team would like to acknowledge the contribution of the external experts: Ana Filipa Barros, Fátima Borges, Teresa Viterbo, Silvana Miranda, Diana Ribeiro, Luís Cunha, Lourenço Carvalho, Diana Pinto, Isabel Pinto e Paula Rocha. We also want to thank the participation of the TR/RTTs from the Portuguese Oncology Institute of Porto (Portugal) in the pilot survey.

We would like to acknowledge the partners of the SAFE EUROPE project that distributed it throughout Europe: Associação Portuguesa de Radioterapeutas (ART) from Portugal; Society of Medical Radiographers (SRM) from Malta; Polskie Towarzystwo Elektroradiologii (PTE) from Poland; and European Federation of Radiographers' Societies (EFRS) across Europe; and to all respondents who took the time to complete this survey. This study would not be possible without their support.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2023.02.009.

## References


1. European commission. *Digital economy and society index (DESI)*. 2022. https://digital-strategy.ec.europa.eu/library/digital-economy-and-society-index-desi-2022.
2. European Commission. *ICT for work: digital skills in the workplace*. 2017. https://digital-strategy.ec.europa.eu/en/library/ict-work-digital-skills-workplace.
3. Chamunyonga C, Edwards C, Caldwell P, Rutledge P, Burbery J. The impact of artificial intelligence and machine learning in radiation therapy: considerations for future curriculum enhancement. *J Med Imag Radiat Sci* 2020;**51**(2):214–20. https://doi.org/10.1016/j.jmir.2020.01.008.
4. Eccles CL, Campbell M. Keeping up with the hybrid magnetic resonance linear accelerators: how do radiation therapists stay current in the era of hybrid technologies? *J Med Imag Radiat Sci* 2019;**50**(2):195–8. https://doi.org/10.1016/j.jmir.2019.04.0.

[5]. Konttila J, Siira H, Kyngäs H, Lahtinen M, Elo S, Kääriäinen M, et al. Healthcare professionals' competence in digitalisation: a systematic review. *J Clin Nurs* 2019;**28**(5–6):745–61. https://doi.org/10.1111/jocn.14710.

6. Salahuddin L, Ismail Z. Classification of antecedents towards safety use of health information technology: a systematic review. *Int J Med Inf* 2015;**84**(11):877–91. https://doi.org/10.1016/j.ijmedinf.2015.07.004.
7. European Health Parliament. *Re-thinking European healthcare - digital skills for health professionals*. 2nd ed. 2017.
8. Couto JG, McFadden S, McClure P, Bezzina P, Camilleri L, Hughes C. Evaluation of radiotherapy education across the EU and the impact on graduates' competencies working on the linear accelerator. *Radiography* 2021;**27**(2):289–303. https://doi.org/10.1016/j.radi.2020.08.010.
9. Barbosa B, Bravo I, Oliveira C, Antunes L, Couto JG, McFadden S, et al. Digital skills of therapeutic radiographers/radiation therapists – document analysis for a European educational curriculum. *Radiography* 2022;**28**(4):955–63. https://doi.org/10.1016/j.radi.2022.06.017.
10. Gallardo-Echenique E, Oliveira J. Marqués molías L, esteve F. Digital competence in the knowledge society. *MERLOT Journal of Online Learning and Teaching (JOLT)* 2015;**11**:1–16.
11. Lanvin BD, Králik M. E-skills: who made that big dent in my flat world?*. *Inf Technol Int Dev* 2009;**5**:81–4.
12. Parliament European. *European Council. Recommendation of the European parliament and of the Council on the establishment of the European qualifications framework for lifelong learning*. 2008. C:2008:111:1:7:EN: [PDF], https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ.
13. *Broadband Commission for Sustainable Development Working Group on Education: digital skills for life and work*. 2017. https://unesdoc.unesco.org/ark:/48223/pf0000259013.
14. Aakhus M, Ågerfalk PJ, Lennmyr F. Digital innovation as design of digital practice: doctors as designers in healthcare. In: proceedings of the 51st annual Hawaii international conference on system sciences, HICSS. *IEEE Computer Society* 2018;**2018**:4594–601. https://doi.org/10.24251/HICSS.2018.579.
15. Zhang S, Liao R, Alpert JS, Kong J, Spetzger U, Milia P, et al. Digital medicine: emergence, definition, scope, and future. *Editorial. Digit Med* 2018;**4**:1–4. https://doi.org/10.4103/digm.digm_9_18.
16. Kijsanayotin B, Pannarunothai S, Speedie SM. Factors influencing health information technology adoption in Thailand's community health centers: applying the UTAUT model. *Int J Med Inf* 2009;**78**(6):404–16. https://doi.org/10.1016/j.ijmedinf.2008.12.005.
17. Munck B, Fridlund B, Mårtensson J. District nurses' conceptions of medical technology in palliative homecare: conceptions of medical technology in palliative homecare. *J Nurs Manag* 2011;**19**(7):845–54. https://doi.org/10.1111/j.1365-2834.2011.01231.x.
18. World Health Organization, Regional office for Europe. In: *From innovation to implementation: eHealth in the WHO European region*. World Health Organization. Regional office for Europe; 2016. https://apps.who.int/iris/handle/10665/326317.
19. Sale C, Halkett G, Cox J. National survey on the practice of radiation therapists in Australia. *J Med Radiat Sci.* 2016;**63**(2):104–13. https://doi.org/10.1002/jmrs.155.
20. Griffiths F. *Research methods for health care practice*. SAGE Publications; 2009. https://books.google.pt/books?id=PJWZ1viySVUC.
21. Hulley SB, Cummings SR, Browner WS, Grady D, Newman TB. *Designing clinical research. Wolters kluwer/Lippincott williams & wilkins*. 2013. https://books.google.pt/books?id=jJIHywAACAAJ.
22. European Commission, Joint research centre, brande L, carretero S, Vuorikari R, punie Y. DigComp 2.0 : the digital competence framework for citizens. *Publications Office* 2017. https://doi.org/10.2791/11517.
23. European Commission. Joint research centre, carretero S, Vuorikari R, punie Y. DigComp 2.1 : the digital competence framework for citizens with eight proficiency levels and examples of use. *Publications Office* 2018. https://doi.org/10.2760/38842.
24. Cedefop. *The great divide: digitalisation and digital skills gaps in the EU workforce. #ESJsurvey insights*. 2016. https://www.cedefop.europa.eu/files/esj_insight_9_digital_skills_final.pdf.
25. Li S, Bamidis PD, Konstantinidis ST, Traver V, Car J, Zary N. Setting priorities for EU healthcare workforce IT skills competence improvement. *Health Inf J* 2019;**25**(1):174e85. https://doi.org/10.1177/1460458217704257.
26. European Commission. *Coordination actions in the scientific era of medical education informatics for fostering it skills for healthcare workforce in the EU and USA*. 2013. https://cordis.europa.eu/project/id/611967.
27. Cedefop. *Health professionals: skills opportunities and challenges*. 2016. https://skillspanorama.cedefop.europa.eu/en/analytical_highlights/healthprofessionals-skills-opportunities-and-challenges-2016.
28. European Commission. *Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions: a new skills agenda for Europe*. 2016. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri¼CELEX:52016DC0381.
29. European Commission. *Digital skills and jobs coalition*. 2016. https://digital-strategy.ec.europa.eu/en/policies/digital-skills-coalition.
30. Leininger MM. *Qualitative research methods in nursing*. Grune & Stratton; 1985.
31. Boynton PM, Greenhalgh T. Selecting, designing, and developing your questionnaire. *BMJ* 2004;**328**(7451):1312–5. https://doi.org/10.1136/bmj.328.7451.1312.
32. Lawshe CH. A quantitative approach to content Validity1. *Person Psychol* 1975;**28**(4):563–75. https://doi.org/10.1111/j.1744-6570.1975.tb01393.x.
33. Wilson FR, Pan W, Schumsky DA. Recalculation of the critical values for Lawshe's content validity ratio. *Meas Eval Counsel Dev* 2012;**45**(3):197–210. https://doi.org/10.1177/0748175612440286.
34. Almanasreh E, Moles R, Chen TF. Evaluation of methods used for estimating content validity. *Res Soc Adm Pharm* 2019;**15**(2):214–21. https://doi.org/10.1016/j.sapharm.2018.03.066.
35. LoBiondo-Wood G, Haber J. *Nursing research - E-book: methods and critical appraisal for evidence-based practice*. Elsevier Health Sciences; 2014.
36. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med* 2016;**15**(2):155–63. https://doi.org/10.1016/j.jcm.2016.02.012.
37. Revicki D. *Internal consistency reliability. In: Michalos AC, ed. Encyclopedia of quality of life and well-being research*. 2014. p. 3305–6. https://doi.org/10.1007/978-94-007-0753-5_1494. Springer Netherlands.
38. SAFE EUROPE project. Safe Europe | safe & free exchange of EU radiography professionals across Europe. https://www.safeeurope.eu/.
39. Rampin R, Rampin V. Taguette: open-source qualitative data analysis. *JOSS* 2021;**6**(68):3522. https://doi.org/10.21105/joss.03522.

40. Guest G, MacQueen K, Namey E. Applied thematic analysis. *SAGE Publications, Inc* 2012. https://doi.org/10.4135/9781483384436.
41. Percy W, Kostere K, Kostere S. Generic qualitative research in psychology. *Qual Rep* 2015;**20**(2):76–85. https://doi.org/10.46743/2160-3715/2015.2097.
42. Denzin NK. *Sociological methods: a sourcebook*. New York, NY: McGraw-Hill; 1978.
43. Carter N, Bryant-Lukosius D, DiCenso A, Blythe J, Neville AJ. The use of triangulation in qualitative research. *Oncol Nurs Forum* 2014;**41**(5):545–7. https://doi.org/10.1188/14.ONF.545-547.
44. McNulty JP, England A, Shanahan MC. International perspectives on radiography practice education. *Radiography* 2021;**27**(4):1044–51. https://doi.org/10.1016/j.radi.2021.04.004.
45. Murawski M, Bick M. Digital competences of the workforce – a research topic? *BPMJ* 2017;**23**(3):721–34. https://doi.org/10.1108/BPMJ-06-2016-0126.
46. Couto JG, McFadden S, McClure P, Bezzina P, Hughes C. Competencies of therapeutic radiographers working in the linear accelerator across Europe: a systematic search of the literature and thematic analysis. *Radiography* 2020;**26**(1):82–91. https://doi.org/10.1016/j.radi.2019.06.004.
47. Oliveira C, Barbosa B, Couto JG, Bravo I, Khine R, McNair H. Advanced practice roles of therapeutic radiographers/radiation therapists: a systematic literature review. *Radiography* 2022;**28**(3):605–19. https://doi.org/10.1016/j.radi.2022.04.009.
48. Hautz SC, Hoffmann M, Exadaktylos AK, Hautz WE, Sauter TC. Digital competencies in medical education in Switzerland: an overview of the current situation. *GMS J Med Educ* 2020;**37**(6):Doc62. https://doi.org/10.3205/zma001355.
49. Kuhn S, Müller N, Kirchgässner E, Ulzheimer L, Deutsch KL. Digital skills for medical students - qualitative evaluation of the curriculum 4.0 "Medicine in the digital age.". *GMS J Med Educ* 2020;**37**(6):Doc60. https://doi.org/10.3205/zma001353.
50. Werner R, Henningsen M, Schmitz R, Guse AH, Augustin M, Gauer T. Digital Health meets Hamburg integrated medical degree program iMED: concept and introduction of the new interdisciplinary 2nd track Digital Health. *GMS J Med Educ* 2020;**37**(6):Doc61. https://doi.org/10.3205/zma001354.
51. Laskar SG, Sinha S, Krishnatry R, Grau C, Mehta M, Agarwal JP. Access to Radiation Therapy: From Local to Global and Equality to Equity. *JCO Global Oncology* 2022;(8):e2100358. https://doi.org/10.1200/GO.21.00358.
52. HCPC. *Number of therapeutic radiographers on the HCPC Register*. 2018. Available online at, https://www.hcpc-uk.org/resources/freedom-of-information-requests/2018/number-of-therapeutic-radiographers-on-the-hcpc-register-may-2018/.