

Radiographer educational requirements for adaptive radiotherapy techniques: A mixed-methods regional scoping study

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ABSTRACT

Introduction: In the study region an off-line approach is currently taken to adaptive radiotherapy delivery with plans to implement on-line approaches imminently. This is a step-change in how radiotherapy is delivered and represents a shift in traditional professional roles and responsibilities. This research aimed to explore therapeutic radiographer educational needs at a regional level and strategise how the therapeutic radiographer workforce can be enabled to deliver on-line adaptive radiotherapy.

Methods: A mixed methods study was undertaken consisting of a quantitative on-line survey followed by qualitative interviews and a focus group. Survey invites were sent to all registered therapeutic radiographers in the region. All survey participants were invited to a focus group. There were 32 respondents to the survey and six focus group participants from all three radiotherapy centres in the region. There were four interview participants who were local service and education leads.

Results: 16 of 32 survey participants were moderately familiar with the concept of adaptive radiotherapy but 22 participants felt not confident at all or slightly confident to adapt treatment plans. A key area for development was decision making and clinical judgment prior to plan adaptation. Upskilling radiographers were seen as essential and inter-disciplinary collaborations were key to this, particular with physicist, dosimetrist and clinical oncologists. Robust educational programmes were identified as a requirement at and pre and post registration level.

Conclusion and implications for practice: The academic underpinning of adaptive radiotherapy needs to be addressed to streamline the rapid uptake of advanced radiotherapy technologies. There was a consensus that a regional, inter-organisational approach to addressing radiographer educational needs is warranted to ensure efficiency and sustainability of clinical on-line adaptive radiotherapy implementation.

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Introduction

Clinical background

Adaptive Radiotherapy (ART) is defined as changing the radiotherapy plan delivered to a patient during a course of radiotherapy to account for temporal changes in anatomy or changes in tumour biology/function.¹ State-of-the-art technology can deliver on-line ART (oART) in real-time at the point of treatment to deliver truly personalised care.² The feasibility of oART in practice has

been evidenced with its efficient integration into clinical workflows by early adopters of the technology.³ There is acknowledgement that further outcome data is needed through prospective clinical trials, however, the clinical benefits of ART in terms of target volume margin reduction and normal tissue sparing has been highlighted.³ Such innovation is more pertinent than ever before with increasing cancer incidence and a strong focus on long-term survivorship.

Radiographer role change

oART delivery represents an extended scope in practice for Therapeutic Radiographers (TRs). Leech et al. (2024) authored a position paper based on workshop outcomes to gain international consensus on practice development for TRs considering technical advancements in radiotherapy, including ART.⁴ TRs have already

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extended their roles to take on technical decision making in ART however, clinical decision making is often held by other professions.⁴ Key oART workflow steps that differ from standard non-adaptive treatment delivery include re-contouring the OARs and target volume and on-line re-planning or re-optimisation. A study involving multi-disciplinary focus groups from UK centres experienced with oART via magnetic resonance image-guided radiotherapy (MRIGRT) came to a consensus that having a Clinical Oncologist present for treatment delivery is not sustainable and there is a future requirement for TRs to deliver oART.⁵ To progress the TR role within this domain, inter-disciplinary practice and knowledge transfer is needed.⁴

Existing training needs analyses

The increasing adoption of oART highlights the need for specialised training for TRs to deliver oART workflows.⁶ Such a framework will ensure that TRs develop the required skills, confidence, and competence to manage complex ART treatments, supported by a multidisciplinary approach and continuous professional development.⁶ Training analyses have been conducted to establish the content of such an educational intervention. An extensive UK based study conducted a training needs analysis of UK-based TRs to identify their roles, responsibilities, and training needs for MRIGRT.⁷ Although some focus was given to MRI competence, ART skillsets were also reviewed. Out of 261 respondents from 78 radiotherapy centres, only 13 individuals were involved with planning and checking ART plans with little correlation between the number of years qualified and ability to assess plans and images. A European study assessing the roles and educational needs of advanced practice (AP) among TRs corroborated this finding.⁸ Out of 272 respondents from 21 European countries ART was highlighted as the highest training and educational need for AP roles, advanced treatment planning was the second and multi-modal imaging being the third. In both studies the authors suggest that standardised education programs for TRs involved with ART should be introduced to ensure they have the necessary skills and knowledge. It was also recommended that existing educational programmes should be regularly revised and updated to keep pace with emerging TR roles and evolving RT technologies.^{7,8} There is further international evidence from single centres that have adopted oART that concepts of new technologies are not always covered during formal education training and extensive 'hands-on' practice as a pivotal part of the profession.⁹

Evidence of effective training programmes

There is evidence of successful Radiographer oART training and subsequent delivery amongst early-adopter centres of oART technologies. Following a local structured educational programme, treatment plans generated from TR contours in an oART workflow met the clinical dosimetric criteria.¹⁰ This indicates that TRs can perform contouring, which could significantly impact clinical practices by optimising workflow and resource allocation. Another centre reported similar favourable outcomes following a local TR training package where skills were acquired via varied educational methods such as tutorials, workshops, self-directed learning, and interdisciplinary boot camps.¹¹ The author's centre initially involved a full multidisciplinary team to facilitate workflow discussions and adjustments. After the TR educational intervention, the need for oncologist presence during treatments significantly reduced to 1.5 % of 200 treatment fractions.¹¹

Rationale for this study

The radiotherapy centres within the region of the UK included in this study deliver off-line ART for but are yet to implement oART. Local future adoption of oART and the associated equipment is anticipated in the coming years. TRs are key to efficient implementation and it represents a pressing need for advancing practice both regionally, nationally and internationally.⁸ A pro-active, regional approach is being sought for TR regional workforce development of oART knowledge and skills to enhance the efficacy of successful technological implementation. Studies to date have focused on single centre experiences or a particular vendor application with the majority of oART studies looking at MRIGRT.^{5,7,9-11} The variability in training practices and resource availability across centres is noted as a significant barrier to widespread adoption of oART.^{5,10,11} Consensus on an intervention that addresses this is yet to be reached. More evidence from case studies or pilot programs demonstrating the benefits of expanded TR roles in ART would strengthen the argument.¹² This research aimed to explore TR educational needs at a regional level with a vendor-neutral approach and strategise how the TR workforce can be enabled to deliver oART.

Methods

A mixed methodology of qualitative and quantitative components was adopted for this study to enable a panoramic view of the educational needs within the region.¹³ Careful appraisal of the strengths and weaknesses of recognised approaches to defining training needs was undertaken.^{14,15} A sequential explanatory approach was undertaken, involving a cross-sectional survey followed by qualitative interviews and a focus group.

The research team consisted of a female TR, a male TR, a female clinical scientist and a female health researcher and a male research assistant who was third year TR student. All members of the research team worked at a Higher Education Institute (HEI) within the region with one member being a practicing TR in the region alongside their HEI role (AC). Inclusion criteria consisted of registered TRs working in the local region only to give a specific picture of the local educational need. All participants were provided with an information sheet prior to taking part and assured of confidentiality and anonymity of results and a consent form was completed by all participants.

Survey data collection

The survey was designed following stakeholder engagement with local radiotherapy leaders and key themes ascertained from the literature analyses. The survey contained 17 questions to obtain information about the participants' professional background, the level of confidence the participant feels with particular areas of ART using a Likert scale,¹⁶ what further education the participant requires and how this could be optimally delivered. Invitations were sent via social media (Twitter© and LinkedIn©) to obtain several perspectives from a range of participants. The aim was to reach at least ten TRs from each of the three radiotherapy centres in the region.

Qualitative data collection

Purposive sampling was used to select interview participants to gain perspective from education and service lead TRs within the region. Seven individuals were invited to participate in an interview via email with four choosing to participate. Interviews were conducted online by AC to address the intricacies of the topic. AC

had a prior relationship with the interviewees through other regional project work. A topic guide was followed for each interview and adapted during the conversation to allow for further exploration. Interviews ranged from 30 to 60 min. A full list of the interview questions is provided as supplementary information.

Participants that completed the survey were invited to partake in a focus group. A topic guide was created to allow for dynamic discussions between participants and obtain further information that did not emerge in the survey or interviews. Key to this was gathering a consensus on an educational intervention to address local gaps in oART knowledge. The topic guide is provided as supplementary information. The focus group was conducted by AC and KC.

Data analysis

Descriptive statistics from the survey were generated using Microsoft Excel™. Full verbatim from the interviews and focus groups was independently transcribed and analysed alongside qualitative feedback within the survey using thematic analysis^{17,18,19} using NVivo v1.5.2™. Initial inductive coding was performed by a health researcher (MH), independent to the local radiotherapy services. Codes were examined for patterns and refined by one researcher (MH) to develop initial themes, which were shared with the wider team. The team triangulated the findings during the interpretation stage.²⁰ During this phase, relationships and refined patterns between qualitative themes and quantitative survey findings, to develop final themes, representing a higher order interpretation of the qualitative and quantitative data. The final themes were written up with example quotes from participants and in accordance with the consolidated criteria for reporting qualitative studies.²¹

Results

Four themes were developed across the qualitative and quantitative data: There were 32 respondents to the survey, four interview participants and six focus group participants. Participants were across each radiotherapy centre within the region, with 62 % of participants from Centre 1, 24 % from Centre 2, and 14 % from Centre 3 (see Tables 1 and 2).

Table 1

Numbers and agenda for change band²² of TRs that responded across the three methods of data collection.

Method	B4	B5	B6	B7	B8a	B8b	B8c
Survey	0	4	12	8	5	2	1
Focus group	1	0	1	3	0	0	1
Interview	0	0	0	2	0	0	2

Table 2

Overview of respondent job titles.

Job Titles (grouped) of survey respondents	Frequency
Therapeutic radiographer	7
Senior therapeutic radiographer	8
Education lead therapeutic radiographer	1
Pre-treatment lead/Advanced practitioner	3
Radiotherapy management role	5
Advanced practitioner/Clinical specialist/Team leader	6
Radiotherapy technical lead	2

1. “Enormous void of knowledge” – Familiarity, knowledge and confidence

Participants anticipated the future benefits of ART: *“I cannot imagine in 10 years time we won’t do adaptive for everything. I can’t imagine there’s anything we wouldn’t want to use adaptive for”* (Interview Participant 2). Survey respondents indicated familiarity with the concept of ART as shown in Fig. 1.

However, participants acknowledged a lack of widespread knowledge: *“I don’t think there’s the skill set or knowledge at the moment”* (Interview Participant 1). The lack of familiarity with the technique was demonstrated with minimal use in current practice *“I don’t hear the desire for it.”* (Interview Participant 3). One explanation for this was the lack of understanding regarding the benefits of ART: *“I think the bigger educational need is in what adaptive radiotherapy actually is, what the evidence for it is and educating the clinical teams and the leadership teams.”* (Focus Group Participant 2). It was identified that TRs would need further training to support its use, *“We don’t understand enough about the changes that we’re doing”* (Interview Participant 3).

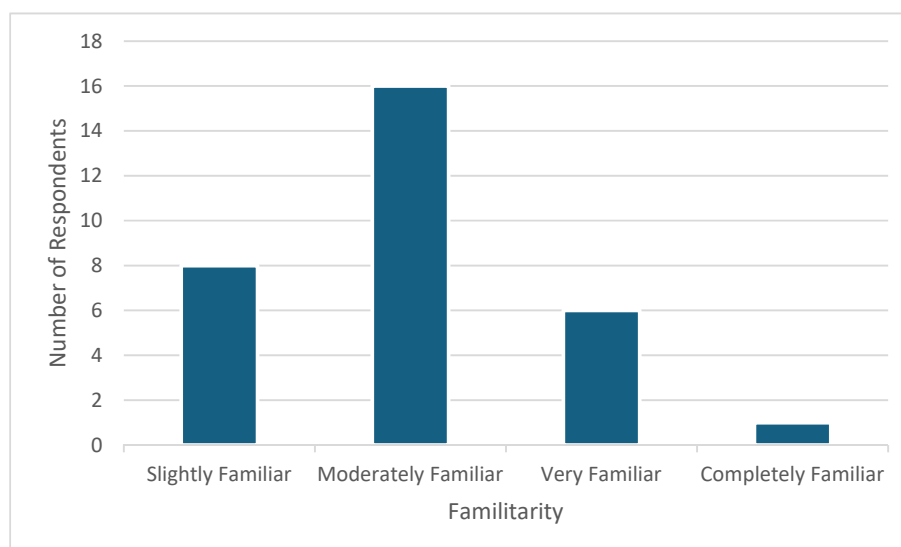


Figure 1. Familiarity with ART.

Survey respondents indicated a lack in confidence in carrying out ART as shown in Fig. 2. No correlation could be found between banding and confidence levels as shown in Table 3.

Essential interdisciplinary collaborations were noted in the survey with clinical oncologists, dosimetrists and physicists playing a crucial role in TR ART education as shown in Fig. 3. "I feel that physics involvement in the education of ART would be helpful to support learning and understanding of any dosimetric implications of having differing plans" and "Working closely with physicists,

treatment planners and the clinical oncologists will be essential as they have all the skills and knowledge that many radiographers lack." (Survey Participants).

Further, refreshing anatomy knowledge was suggested as key: "A lot of the time people seem to kind of lose their knowledge just scanning this, you know, doing the same images day in, day out. They're not looking for different things and not realising you know what they're actually looking at half the time" (Focus Group Participant 4).



Figure 2. Confidence in ability to adapt treatment plans during course of radiotherapy.

Table 3
Survey respondent band and confidence level.

Confidence Level	Band 5	Band 6	Band 7	Band 8a	Band 8b	Band 8c	Band 8
Not confident at all	2	7	4	0	0	0	0
Slightly confident	2	7	3	4	1	0	1
Moderately confident	2	6	4	0	0	1	1
Completely confident	1	0	0	0	0	0	0

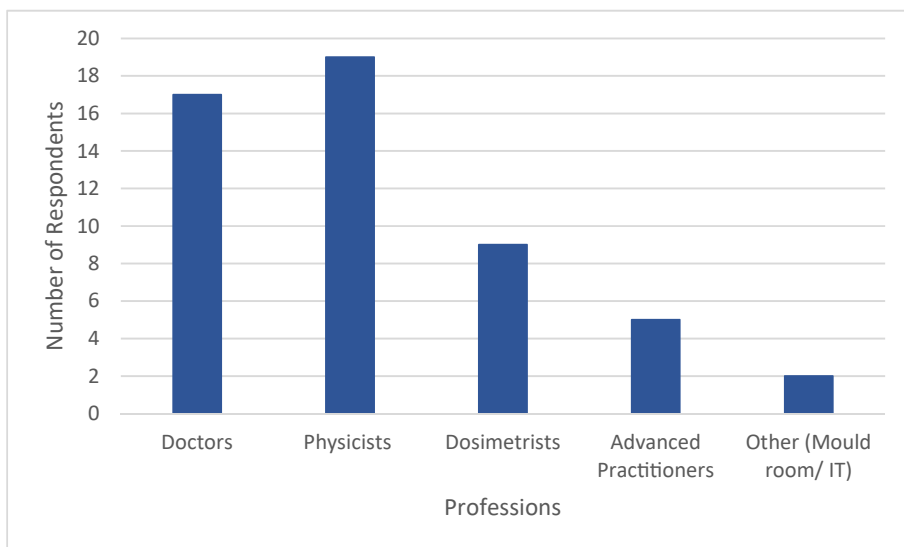


Figure 3. Perceptions of crucial interdisciplinary collaborations for advancing education in ART.

2. “Everyone’s going to have to learn” – Upskilling staff

Respondents to the survey indicated several areas of the oART workflow where further education or training was required as shown in Fig. 4.

Upskilling the team was seen as important for all TRs “Well, if its becoming standard practice then everyone should be able to do it” (Interview Participant 3). However, others acknowledge that the level of knowledge was role dependent, “I do think it’s there’s a really good part for advanced practitioners to get some advanced knowledge and be the person who does lead on that.” (Focus Group Participant 4).

Participants noted the challenge in upskilling staff, “I think it would be, you know, a massive learning curve for everybody” (Focus Group Participant 5). Participants highlighted the eagerness to engage with training in early career radiographers: “I think we’ve got a younger group of staff now. And I think they’re itching for the future.” (Focus Group Participant 6).

3. “A robust training programme” - Necessary training for delivering ART techniques

Participants highlighting previous issues with training TRs: “we have an extended period where people aren’t being signed off as competent and aren’t adopting new techniques as a standard part of their practice” (Interview Participant 2). One suggestion across the survey and focus group was around standardised competencies that would be transferrable across organisations, showcased with: “An educational passport for using, decision making, imaging that could be a standard of practice.” (Survey Participant). Participants felt that higher education institutions needed to have a role within the training to ensure it is academically rigorous “the importance of academic. To underpin clinical is becoming more, more essential” (Interview Participant 1). This included higher education institutions incorporating this in the training of undergraduates to prepare the future workforce with all survey respondents stating that ART clinical skills should be incorporated into pre-registration radiotherapy programmes. Enhanced imaging skills and 3D anatomy visualisation were highlighted as important at an undergraduate level; “Radiographer training must include basic imaging - many are coming through with hardly any experience.” (Survey Participant).

For current staff, a flexible approach to training was preferred, combining short courses and more extensive units depending on the needs and roles of the radiographers. “I think somewhere between a ‘short’ CPD course and an MSc unit would suffice” (Survey Participant). Short CPD style courses could be provided that would allow individuals to develop and demonstrate competencies that could be put into an educational passport “But possibly some of the lower bands, if they didn’t want to do the Masters module, they need to know enough to be able to treat, but maybe not lead the treatment.” (Focus Group Participant 7). However, others suggested higher-level training such as Master’s level units for clinical specialists and advanced practitioners. This was reflected with findings from the survey with participants identifying different levels of education requirements, with a short CPD course identified by 42 % of participants and MSc unit 32 %. Only one individual felt a full MSc was appropriate.

Within the survey, 37 % of participants felt there were no barriers to accessing educational opportunities, with 26 % of participants identifying lack of time as a significant barrier. Participants felt this included releasing staff for training and a lack of non-clinical time for study and training was a common barrier. “When everybody is short staffed at the moment, I think it’d be, you know, a problem to have more than a couple of staff at a time attending anything at all. So I think that would be the main kind of problem” (Focus Group Participant 5). Survey respondents indicated that they had encountered barriers in accessing education to new technologies with 20 % citing funding as a key challenge. Technology was also seen as a barrier with training for new technologies being seen as reactive rather than planned ahead of time. “Potentially, the research and changing technologies come out quicker than the academic institutions can actually cope with sometimes because so it’s how adept are they at adapting to new things coming out?” (Interview Participant 1). Another challenge was seen as the different technologies between organisations “but technology is going to be different as well.” (Interview Participant 1). Recommendations included standardised treatment delivery protocols, technology specific training within organisations and training from manufacturers as well regional champions for ART.

4. “I think everyone learns differently” – Challenges and preferred modalities for educational opportunities

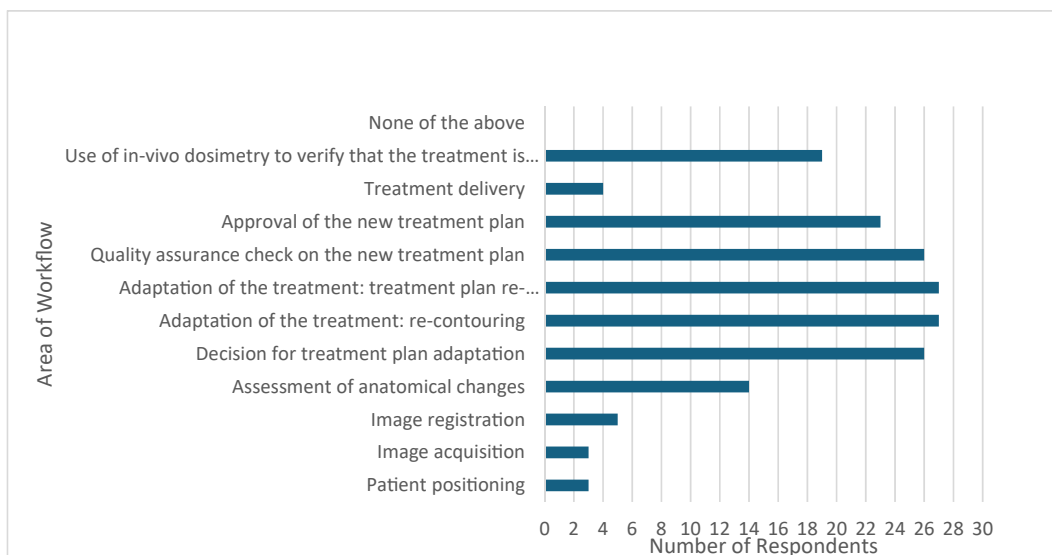


Figure 4. Areas of oART workflow for further education or training.

Within the survey, participants highlighted differences in training opportunities based on when and where radiographers studied and their subsequent experiences, including access to departmental training and expertise. Overall, having a variety of blended learning activities in different forms was seen as beneficial to support differences in learners with online sessions to increase uptake but face-to-face training seen as valuable “you’ve got that sort of small group training, haven’t you where you can ask questions and talk to each other and things” (Focus Group Participant 7). Survey findings corroborated this as shown in Fig. 5 with survey participants expressing a preferences for combined modality learning. Practical sessions were highly valued with participants emphasising their importance in solidifying their knowledge and skills. However, discussions around case-studies were also seen as a valuable tool, which could be constructed with clinical expertise “I don’t know if maybe you know you could use real life case studies and take them back to university and then like, unpick them in a different kind of environment to sort of work across.” (Interview Participant 4).

Virtual environments for radiotherapy training and simulation were seen as a positive tool to learn without patient pressure “People can use that training that they learned virtually and put it into practise and then link it that way and always come back.” (Interview Participant 4). 94 % of survey respondents indicating that virtual reality and simulation platforms could be useful for ART education. However, the effectiveness of the simulation platforms depended on their ability to simulate real-life clinical workflows and immersive technologies. It was noted in the survey that virtual reality and simulation could overcome pressures in the clinical setting “I think it would be an excellent way to reduce departmental pressures” (Survey Participant).

Discussion

This study explored TR educational needs at a regional level, a multi-centre perspective was gained from this study which had participants from all three centres in the region. Participants expressed a high level of awareness of ART and its benefits. Survey results indicated that awareness of ART within the region was high with the majority of respondents being moderately, very or completely familiar with the concept of ART (30 out of 32). However, participants also recognised the challenges of implementing real-time adaption via oART in practice. The current gap in knowledge and skills to deliver oART was identified as a key

issue. Participants indicated a lack of confidence in their ability to adapt treatment plans with most respondents to the survey not being confident at all (8 out of 32) or being slightly confident (13 out of 32). No correlation could be found between banding²² and confidence levels indicating that this is confidence level applies throughout the registered work force in the region.

Crucial workflow areas influencing this lack of confidence were found to be re-contouring of anatomy and re-optimisation of the treatment plan. This was closely followed by the initial decision about whether to adapt and quality assurance processes of the adapted plan. It is important to note that there were no participants that were based in dosimetry and job titles from the respondents indicated that they all worked in radiotherapy treatment or pre-treatment. Half of survey respondents indicated that they felt no additional training was required around the assessment of anatomical change on verification imaging. This was also noted in an extensive multi-centre training needs analysis where 223 respondents verified CBCTs as part of their role.⁷ Deeper exploration of this in the qualitative components of this study indicated concern around this area with commentary around current image verification practices being very process driven and less attention given to dosimetric consequences of the decisions made. Participants identified existing challenges in the imaging training of undergraduate TRs not currently keeping pace with the level and depth of image review warranted in modern practice. Joyce et al. (2022) and McNair et al. (2021) also found that at an undergraduate level, many required skills for oART delivery via MRIgRT are not routinely taught.^{5,7} In this study, there was unanimous agreement that ART should be embedded in the undergraduate curriculum.

Multiple studies have emphasised that to progress the TR role within oART, inter-disciplinary knowledge transfer is needed.^{4,5,9} Participants in this study frequently emphasised the role of dosimetrists and medical physicists in implementing oART and supporting TR learning and understanding of the dosimetric implications of differing plans in oART. Other essential inter-disciplinary collaborations identified by participants were with clinical oncologists, particularly in the clinical judgment around anatomical changes and in-depth image review processes for contouring. Tsang & Routsis (2021) conducted a literature review including 34 studies to explore TR roles and responsibilities within 4DART and concluded that TRs should have clinical decision-making skills and greater authority within multi-disciplinary teams to effectively implement ART.¹²

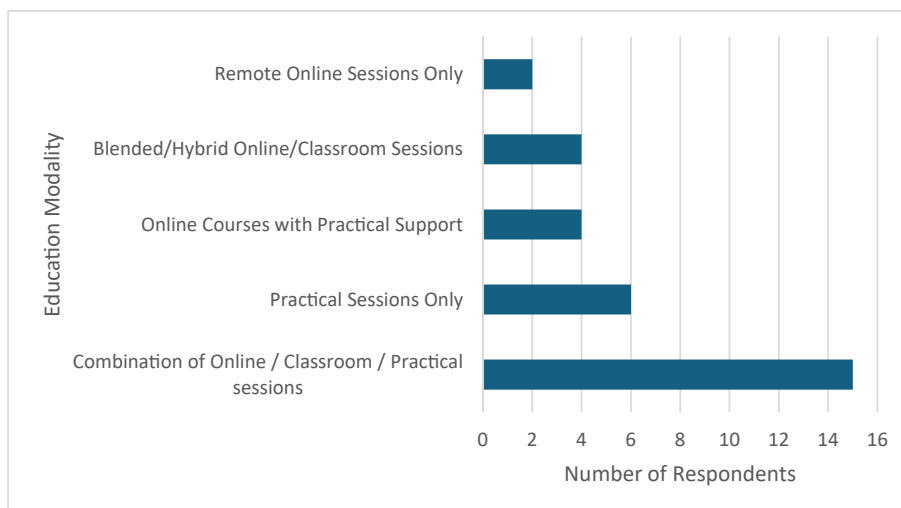


Figure 5. Preferred modality for education on new technology.

There are reports of single-centre approaches to inter-professional TR education. TRs included in a UK oART study undertook training that included contouring exercises with clinical oncologist supervision and presentations on disease staging, anatomy, contouring considerations and decision making based on anatomical changes at the point of treatment. Alongside regular updates, TRs in this centre were able to deliver oART.¹⁰ Another study reported that TRs acquired oART skills through varied educational methods such as tutorials, workshops, self-directed learning, and interdisciplinary boot camps.¹¹ Whilst successful in enabling safe oART delivery, these interventions are labour intensive when undertaken at a department level and represent a significant time burden on the national health care system. A regional or national approach to TR oART education would alleviate this pressure.

Participants from this study indicated that the preferred modality for collective inter-departmental oART education could be delivered via a CPD course or MSc module. There was a consensus that safe oART delivery required academic underpinning due to the clinical judgment being made and the level of education was role dependant with a suggestion that clinical specialist or advanced practice radiographers would need a higher level of education. There was agreement that collaboration on a set of competencies was required so that a 'passport' system could be put in place to transfer knowledge and skills across organisations. A preference was expressed for a blended approach to learning combining face to face learning with some on line elements and an emphasis that it must have a practical element with theoretical training alone not being sufficient. Time and funding were identified as the main barriers to accessing education to new technologies, with a feeling that training for new radiotherapy technologies is often rushed and reactive.

Virtual environments were thought to be a powerful learning tool by participants providing they are clinically relevant, incorporating real-life case studies and verification images. It was thought that virtual training packages could alleviate pressures in the clinical setting, allowing TRs to gain capability in a safe and efficient way. Simulation sessions have been highlighted as essential for training and familiarising radiographers with oART tools and workflows.^{5,6}

Strengths and limitations

This research utilised a mixed-method approach, with the triangulation of data providing a thorough exploration of the regional needs. The qualitative interviews and focus groups provided additional insights into the quantitative results, providing further explanations. The main limitation of this study relates to the small number of participants that completed the survey. The interviewer had a prior relationship with the participants and there is a potential for power imbalances and positive response bias, which may have influenced the participants' willingness to disclose information or respond candidly. Further, no participants had a work base in dosimetry or treatment planning and this study looked at regional needs, which may mean findings are not generalisable to the wider TR workforce.

Conclusion

This study identified that TR oART educational needs exist within the region. A key area with a lack of confidence is the clinical judgement surrounding oART decision making. Interdisciplinary collaborations were identified as being essential in addressing these. A preference was expressed for adopting a blended approach to learning within short CPD courses or MSc

modules depending on individual roles within oART implementation. The academic underpinning of oART was seen as crucial at a pre and post registration level with educational courses and associated institutions having to address the challenge of rapidly evolving technologies and roles within radiotherapy. Incorporating virtual learning environments in TR training was identified as a useful tool to acquire and enhance oART knowledge and skills. There was a consensus that a regional, inter-organisational approach to addressing educational needs is warranted to ensure efficiency and sustainability of clinical oART implementation. A national initiative that incorporates educational needs of all radiotherapy staffing groups and roles would further improve oART efficacy. A proactive, robust multi-disciplinary program of oART education will streamline the rapid uptake of oART and efficiently harness the associated clinical benefits.

Ethics approval and consent to participate

Ethical approval for this study was obtained from Health Sciences University ethics committee (APPROVAL NUMBER/ID: HRS-2024-UgowO).

Written informed consent was obtained for anonymised patient information to be published in this article.

Availability of data

Data required for this study may be made available by the author(s) upon reasonable request.

Author contributions

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CD: Data curation, Writing- Original Draft preparation.

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KL: Writing- Reviewing and Editing.

Generative AI use

Not applicable.

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Conflict of interest statement

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.radi.2025.103093>.

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