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Strengthening Capacity in Radiotherapy Skills to Deliver High-Quality Treatments in Low- and Middle-Income Countries: A Qualitative Study

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Introduction

Radiation therapy is a core component of cancer treatment, used for both curative and palliative intent, alongside surgery and systemic therapies.[1] Over the last 2 decades, external beam radiation therapy technologies have progressed from 2-dimensional (2D) to more complex techniques such as 3-dimensional (3D) conformal radiation therapy, intensity-modulated radiation therapy (IMRT), and stereotactic radiation therapy. Improved accuracy of treatment delivery has brought considerable benefits to patients, such as reduced toxicities and improved long-term outcomes.[2,3]

However, globally there is a considerable gap between provision of radiation therapy and clinical need.[3,4] This gap is most marked in low-and middle-income countries (LMICs), where it is estimated that over 50% of patients who require radiation therapy are unable to access it.[4] A scarcity of radiation therapy equipment is a key factor contributing to this issue, with an estimated 1 megavoltage machine per 1.4 million population in LMICs falling far below that of the International Agency for Atomic Energy (IAEA) recommended 4 machines per 1 million population.[5,6] The high cost of initial investment in modern radiation therapy machines and software, ongoing maintenance, and establishment of specialized facilities are also considered barriers to expanding radiation therapy services in LMICs.[7] However, despite these costs, there is compelling evidence that radiation therapy is cost-effective and confers considerable economic value alongside health benefits.[3] A shortfall of trained workforce to deliver radiation therapy is a further barrier, with an estimated 0.04 radiation oncologists per 100,000

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population in LMICs, compared with 1.24 per 100,000 in high-income countries (HICs).[8]

Uptake of these newer radiation therapy technologies has been rapid and widespread in HICs, where adequate funding and resources, effective clinical and administrative leadership, and multidisciplinary, multicenter collaboration and support have been highlighted as key enablers to successful implementation of modern radiation therapy techniques.[9-11] However, the transition has been more gradual in LMICs,[2,4] where limited resources and prioritization within the health sector have impacted on procurement and implementation of such services.

Modern radiation therapy techniques require investment not only in machines and health infrastructure, but also in education and training of the workforce to deliver the treatment.[6] To safely prescribe treatment, radiation oncologists must acquire a comprehensive knowledge of anatomy, radiobiology, radiation physics, patterns of spread of cancer, and medical imaging.[12] In addition to theoretical knowledge, the delivery of modern radiation therapy requires technical competency. A key aspect of planning modern radiation therapy is delineating, or contouring, treatment targets, and other anatomic structures that represent organs at risk to create treatment plans. Contouring anatomic structures and organs at risk is a complex skill that requires dedicated time and training to master.[13,14] For example, the IAEA-recommend contouring skills are developed during a training program lasting at least 3 years at full time.[15] Failure to do so has been shown to impact outcomes in LMICs.[16]

Delivering high-quality training can be challenging. An in-depth qualitative study in a high-income setting found that a lack of feedback on contours and little protected time for teaching were major issues.[17] This was reflected in a global survey on oncology training, which additionally identified limited technical infrastructure and lack of functioning radiation therapy machines as barriers to radiation therapy training in resource-poor countries.[18] An evaluation of a course supporting clinicians in Sub-Saharan Africa to transition from 2D to 3D radiation therapy found that attendees felt empowered to advocate for newer technologies, but financial constraints and hierarchical management structure may ultimately limit their ability to implement new skills.[14]

To our knowledge, there has been no dedicated qualitative study designed to explore the views, perceptions, and experiences of training among radiation oncologists in LMICs. We believe the insights and experience of these clinicians are vital to inform educational initiatives and health partnerships aiming to strengthen radiation therapy treatment globally.

This study used in-depth semistructured interviews to explore the perceptions of radiation oncologists in LMICs into their training experience and educational needs, with a specific focus on the technical skills of modern radiation therapy, such as contouring. The perspectives of both trainees (a term that encompasses "residents" and "registrars") and trainers (consultants) were explored, because although trainees can offer contemporaneous perspectives, trainers can provide valuable historical context. Additionally, because radiation therapy training is frequently described as an "apprenticeship,"[19] with consultants as trainers,[20] their perspectives are essential to consider when examining training issues.

Methods and Materials

Study design

As this study aims to understand the experiences and perspectives of radiation oncologists, a qualitative approach using modified grounded theory[21] was used.

Participant selection

Radiation oncologists with experience of training in LMICs were identified through the professional network of the authors and participants and invited to participate by email. A "snowball" sampling[22] strategy was used to identify additional participants. The aim was to include oncologists from LMICs in each of the World Health Organization (WHO) regions. Recruitment continued until theoretical data saturation was achieved.[21] A total of 20 clinicians were approached to participate. In all, 12 undertook full interviews. Non-participation was due to lack of clinician availability (n = 6), insufficient internet bandwidth preventing the interview (n = 1), and not responding to the invitation (n = 1).

Setting

Participants took part in a semistructured interview via video link with T.H.-J. at a time suitable for them, outside of clinical commitments between September 2022 and May 2023. Only the researcher and participant were present during the interview.

Data collection

A semistructured interview was chosen as the method of data collection, to facilitate exploration of predetermined topics and to allow for expansion of participants' responses to provide depth to the data. The topic guide, detailed in Appendix 1, was pilot tested with a radiation oncologist from Zambia and amended accordingly. The interviews lasted an average of 21 minutes, ranging from 13 to 34 minutes and were conducted in English. There were no repeat interviews. Audio recordings were transcribed by [Anonymized for review] and supplemented by written notes made by the researcher during the interview. The transcripts were not returned to the participants, because this exercise can be time consuming for the participants and is not considered a prerequisite for validating qualitative results.[23,24]

The choice of semistructured interview questions and topics were informed by previous research into the experience of clinical oncology trainees in a high-income setting[19] and radiation therapy education initiatives in LMICs.[25,26] One participant provided written responses, clarified and expanded where appropriate, due to their preference not to take part in a video interview.

Analysis

Data were analyzed using a modified grounded theory approach[21] by T.H.-J. and A.A., following the principles outlined by Corbin and Strauss.[27] Alongside data collection, iterative codes were identified and were subsequently grouped into themes. Review and revision of codes and themes occurred throughout the data collection and analysis, because the body of data grew and with discussion between authors. Microsoft Excel was used to manage the data. The findings are presented following the Consolidated Criteria for Reporting Qualitative Research.[28]

Ethics

Ethical approval for the study was granted by King's College London, Ref No. MR 21/22.33657. Participants were provided with a study information sheet before the interview and gave written consent to participate.

Results

Participant characteristics

Oncologists (n = 12) from 5 of the 6 WHO regions participated. No participants were recruited from the WHO Eastern Mediterranean countries, because none were identified through snowball sampling. Table 1 details the participant characteristics. The year the consultants had commenced training ranged from 2000 to the latest starting their training in 2015 and completing in 2019. The starting year for trainees ranged from 2011 to 2019 and they were all in a training role, including overseas fellowships, at the time of interview. Six themes emerged during the analysis.

Table 1 Participant characteristics

Participant	Role	Country of relevant experience	Method of selection
1	Consultant	Tanzania	Professional network
2	Trainee	India	Professional network
3	Trainee	India	Professional network
4	Trainee	Malaysia	Professional network
5	Consultant	Madagascar	Professional network
6	Consultant	Nigeria	Snowballing
7	Consultant	Costa Rica	Snowballing
8	Consultant	Philippines	Snowballing
9	Consultant	Azerbaijan	Snowballing
10	Consultant	Ghana	Professional network
11	Trainee	Nigeria	Snowballing
12	Consultant	Zambia	Professional network

Theme 1: The value of experiential learning and understanding the basics

Practical, hands-on experience was considered integral to learning radiation therapy techniques; the skills are learned through doing them. This view was shared by trainees and consultants. Several participants also discussed their experience of transitioning from 2D to 3D techniques, because their institutions acquired newer radiation therapy machines. Generally, this transition was viewed as challenging, requiring a paradigm shift in their understanding of anatomy and radiation therapy delivery.

"It's very difficult to switch from 2D thinking to 3D... And I had nobody who could train me." Consultant 9.

However, understanding the progression from 2D to 3D was also considered by some who had experienced the transition to be beneficial to modern practice, providing historical context and a knowledge of anatomical landmarks.

Theme 2: Educational resources

Trial protocols and anatomy atlases were considered essential tools when learning to contour; however, participants often faced barriers to accessing these resources in LMICs. Although some institutions assisted clinicians in accessing educational materials, for example, providing an offline library at contouring workstations, others were required to self-fund access to academic resources.

"Unlike my experience in [a HIC] where the institution gives you access to publications and literature... here you have to find it yourself, pay for it yourself." Consultant 10.

Where clinicians had access to resources, there remained concerns that the content is not appropriate for an LMIC setting, because of the vast majority originating from HICs. One clinician described how resources are not reflective of the types of cancers, or advanced stage that they treat, desiring more context-specific tools.

"So, if we could have an econtour for African cases, which will be more relatable for us, I think that will be an improvement." Trainee 11.

Others described how educational resources are not appropriate for the imaging modalities available in LMICs, such as magnetic resonance imaging (MRI).

"All the atlases and all the conferences teach you ideal things, based on MRI-based planning. There is no way in your practice you have that for all the patients. Because there is no resource for doing an MRI. So, I think that's the hard bit, because you learn the ideal thing, but in practice that is not what you are doing." Trainee 2.

Digital resources were generally considered useful, particularly when used for hands-on practice, receiving feedback, and educational partnerships. Conversely, digital resources were occasionally deemed inferior to in-person education, due to poor internet connectivity limiting their use, unfamiliarity with using digital resources and ability to be easily distracted when teaching is online.

A lack of a consistent approach to utilizing educational resources was also apparent. Trainees described gathering all the resources they could access to teach themselves contouring skills, but it was not clear how best this should be sequenced or integrated with traditional hands-on teaching, especially when senior support was lacking.

Theme 3: Knowledge acquisition

Learning from colleagues, particularly through feedback, was a highly valued method of learning technical radiation therapy skills. However, there was great variation described between the frequency, format, and quality of the feedback received. Although some centers had established regular formal feedback sessions, many described how feedback was opportunistic and informal. Lack of dedicated time was cited as a key barrier to gaining feedback.

A variation in the skills of the consultants delivering the training and lack of institutional oversight of the quality of training were highlighted as issues with learning from consultants in LMICs.

"Sometimes even these supervisors, they themselves, they need some feedback. This is a problem, the supervisors' level should also be checked." Consultant 9.

Departmental peer-review meetings, when practiced, were seen as an important educational opportunity to improve the skills of both trainees and consultants, in addition to providing quality assurance.

Regarding the feedback specifically, tailored, qualitative feedback on completed contours was considered highly valuable. It formed an important part of a cycle of learning, after the trainee has attempted the contours independently. Learning from non-medical colleagues, such as dosimetrists and physicists, was commonly described and valued.

"What really helped me learn was the reviews of the plans that I attended with my consultant. Because what I like to do, for learning for myself, is I like to challenge myself. Try something, if I don't get it right, I go back. And so, I think going back to them and then showing me those intricacies, those little areas where you just didn't get this right, "we'll do this this way" and "do this that way" really for me is really the turning point." Trainee 11.

Theme 4: Resource constraints

The negative impact of resource constraints on training in LMICs was a consistent theme. Participants described the challenge of learning about modern radiation therapy yet having few machines capable of delivering newer techniques and thus little opportunity for hands-on experience. Others described the impact on educational initiatives, for instance through lack of facilities to deliver training.

One common method to tackle these issues was via overseas "observerships" or fellowships, where trainees would travel to an HIC to learn about the newer radiation therapy techniques. Observerships were frequently described; virtually all participants either had undertaken one personally or had been trained by colleagues that had.

Although being viewed as an important component of training in LMICs, in some settings, the responsibility fell on the individual to arrange and fund the observership.

"They just gave me the leave, the permission to go without losing your job. That's all the support I got from my institution. . . one has to personally be proactive in searching for opportunities to gain further knowledge or expertise." Consultant 10.

When discussing overseas observerships, an interesting paradox emerged. Clinicians would travel abroad to be trained in newer techniques, although sometimes found themselves unable to put this learning into practice once they returned.

"I had the added advantage of having to go to [a HIC] to train, where I saw different techniques. So, I have expertise in those areas. . . but sometimes you are limited in applying it back here because in terms of infrastructure we are a bit limited. So, sometimes you have the knowledge, but you are not able to put it into practice, because you don't have the resources to use them." Consultant 10.

Yet despite the limited availability of these technologies in practice, it was still considered important to educate oncology trainees on the concepts. Educating the trainees on these topics was seen as a way to develop the capability of the department and keep colleagues informed on global advances.

Institutional mentoring was described by only 1 participant, who had developed a remote institutional mentoring program to establish a local IMRT service, following their overseas fellowship in an HIC.

"When I came back from [a HIC] there was a program that we used to run, where we got support from their planning team. . . we had sessions on contouring, treatment planning for some of our cases" Consultant 10.

Theme 5: Balancing clinical duties and training

A high clinical workload, with large numbers of patients per clinician, was frequently described as an obstacle to training by both consultants and trainees. Trainees often reported having a lack of protected time allocated for radiation therapy planning and would regularly stay after working hours to contour volumes. They also reported little protected time for receiving feedback on their work.

"We never had specific planning time, or training... That could have helped us... If we had a protected time for getting feedback for the volume we have done and ways that we can improve our voluming and quality of our contours. I think that would have been helpful." Trainee 3.

However, some acknowledged that the high volume of patients to be treated meant increased opportunity to practice contouring and thus develop their skills.

"I think we eventually learned because of the numbers that were there. In a week, at least 4 or 5 patients would be scanned." Trainee 3.

Theme 6: Future directions

Participants described a growing number of digital education resources that were generally predicted to have a positive impact on training in radiation therapy. Some participants noted that there was an opportunity for the development of digital training datasets that were relevant to their setting and for digital feedback to compensate for the lack of in-person feedback.

The advancement of artificial intelligence (AI) within radiation therapy contouring was expected to improve training, through easing workload on clinicians. No concerns were expressed on the potential impact of AI in contouring and planning on their training.

Participants believed that overseas collaboration and fellowships would remain an important component of radiation therapy training in LMICs, albeit with greater focus on bidirectional learning.

"Short fellowships in other centers abroad, to compare and collaborate to do research, that would be vital in improving the care of our patients. And most importantly for us really in Africa for us... to put out there to the world the kind of tumors that we see." Trainee 11.

Discussion

To our knowledge, this is the first study to investigate in detail the experiences and educational needs of radiation oncologists when learning the complex technical skills required to deliver modern radiation therapy techniques in resource-limited settings. The themes identified include the challenge of transitioning to newer technologies, with training that is largely self-directed and undertaken in the context of a high clinical workload. The impact of resource constraints featured prominently; although e-learning resources are available, they are either too costly to access or do not represent the cases typically treated in the practitioners setting. Lack of infrastructure and technology also limited learning opportunities during training.

Similar barriers to training in technical skills in LMICs have been identified in surgery where, analogous to radiation therapy, procedural competency is vital to providing high-quality cancer care. Wilkinson et al[29] reported that a lack of resources, experienced trainers, and clinical supervision were key barriers to acquiring skills in laparoscopic surgery in LMICs. They also described the common pursuit of overseas learning opportunities and the subsequent threat to staff retention and discussed how training guidelines designed for high-income settings can be inappropriate for use in LMICs.

The IAEA global syllabus recommends that training programs ensure that clinical commitments are balanced with training opportunities.[15] Recommended strategies to implement this in practice, albeit in high-income settings, include limiting patient case numbers treated by trainees,[30] or by creating protected time for radiation therapy planning when clinical duties are covered by colleagues.[31] Competency-based radiation therapy training, using structured workplace-based assessments and feedback tools, has been reported to facilitate educational trainee-trainer interactions.[32] Additionally, logbooks have been recommended to record progression through training.[33,34] Rosenblatt et al[35] advocate for the implementation of such tools within competency-based programs in LMICs, with adaptation to the local setting.

Peer-review meetings are a recommended component of quality assurance in radiation therapy.[36-38] In HICs, radiation therapy peer-review has been found to improve compliance with accepted contouring standards,[39] resulting in improved patient outcomes[40,41] and changes in clinical care.[42,43] The subsequent impacts of such initiatives on patient outcomes in low-resourced settings are being studied currently.[16] The educational value of peer-review, in addition to quality assurance, was highlighted by participants in our study. This supports existing recommendations on peer-review that emphasize the educational value of these meetings[44] and predict their inclusion in future training curricula.[35]

Educational resources for radiation therapy learning are clearly vital in resource-limited settings. However, there should be greater affordable access to educational material, development of content that is relevant for the pathology, and technical resources, with guidance on how to strategically utilize the abundance of material. Digital resources and feedback tools could play an important role in LMICs, provided they are purposefully designed for use in these settings.

For example, Abugideiri et al[25] found that an offline digital training module, comprising a lecture and contour practice with comparison with gold standard contours as feedback, improved self-reported confidence and reduced deviation from the gold standard among oncology residents in Ethiopia. However, there was no facility for this program to

provide tailored, qualitative feedback, which our study indicates is likely to be of greatest educational value. A cloud-based tool, described by Lewis et al,[26] to enable remote peer-review and training within oncology centers in LMICs was designed to provide qualitative feedback, but they found poor internet connectivity prevented its implementation.

Two further concepts explored in this study are important to consider as radiation therapy technologies rapidly advance; that radiation therapy skills are best learned by practicing first-hand and understanding the evolution of radiation therapy benefits clinicians' practice. This is particularly relevant with the advent of AI. The ARCHERY study, a prospective observational study of artificial intelligence based radiotherapy treatment planning for cervical, head and neck and prostate cancer, is currently investigating whether AI can match the skill of trained oncologists worldwide in planning radiation therapy, yet with greater time and cost efficiency.[45] If proved effective, AI could increase treatment capacity while easing clinicians' workloads, invaluable benefits in low-resourced countries.

However, although reducing workloads may facilitate time for education and training, conversely, it could reduce opportunities for trainees to have first-hand practice and thus limit their skill development. Indeed, Hindocha et al[46] reported concern among clinical oncologists that reliance on auto-contouring AI could result in future oncologists lacking the skills to evaluate and revise AI-derived contours and ensure patient-specific adjustments were made. Those leading oncology training programs globally should be mindful that although AI could improve clinical workflow efficiency, this should be balanced with ensuring oncologists of the future are equipped to review and amend AI-generated contours and plans.

Although overseas observerships remain a prominent and popular component of training in LMICs, their tendency to be expensive, impact on staffing levels[47] and workforce retention[35] limit their sustainability. The appropriate timing, format, and location of observerships should be considered. For example, observerships should address specific learning needs, focus on helping the observer to develop capacity in their home institution, and provide an opportunity for bidirectional learning. The development of an IMRT service to treat cervical cancer in Ghana is one example of how focused observerships can support service development.[48] Developing South-South, or triangular partnerships,[49] such as the Access to Care Cape Town programme,[14] rather than the traditional LMIC-HIC observerships could enable this.

Limitations

Because snowball sampling was used, participants were likely to have a professional interest in global oncology or training development; therefore, selection bias was inevitable in this study. Such participants were not excluded, because they provided rich and detailed perspectives on training in LMICs that the researchers considered valuable to include. Consultants made up a greater proportion of participants than trainees, because fewer trainees responded to the invitation to participate. Because past experiences alongside current practices were discussed, there is a risk of recall bias affecting responses. For all participants, English was a second language; therefore, miscommunication could affect the nature of their responses and limit the depth of detail provided.

The researchers endeavored to remain reflexive during data collection and analysis to avoid introducing bias from their own views. To increase generalizability, the study was designed to explore a specific aspect of radiation therapy training, namely the technical skills, across several LMICs. However, despite recruitment stopping once saturation of data was achieved, the sample size was relatively small, with only 10 countries represented. We have not explored the theoretical education in radiation therapy, therefore welcome further research into the training needs in this area.

Conclusions

Learning the practical skills to deliver modern radiation therapy in LMICs is challenging. Significant barriers to training include a lack of dedicated time for supervision and training, resource constraints necessitating overseas or remote training, and variable access to heterogenous educational materials that are not context-specific. Opportunities for improvement include regular high-quality qualitative feedback from trainers, digital tools that are accessible, and relevant limited-resource settings and strategic training partnerships.

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