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Research training in radiation oncology: a scoping review of global pathways, barriers and enablers

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ABSTRACT

Background: There is a disparity between the importance of radiation oncology (RO) to cancer care and the research activity that underpins it. This may relate to inadequate availability of, or barriers within, residency research training. This scoping review sought to characterize the barriers and enablers to RO research training, and to summarize relevant training pathways.

Methods: Systematic Medline and Embase searches were conducted using “RO”, “research”, “training”, and related terms, to identify reports published between 2010 and 2025. Manuscripts were screened using predefined inclusion and exclusion criteria to select those describing research initiatives, and barriers and enablers to resident-level research. These features were extracted along with country of origin and study design parameters. **Results:** Of 1745 identified manuscripts, 54 were included. Most reports originated from North America (n = 24/54; 44.4%), Europe (n = 12/54; 22.2%) and Australasia (n = 8/54; 14.8%). A majority were survey-based studies (n = 27/54; 50.0%) or observational cohort analyses (n = 10/54; 18.5%). We identified seven countries with mandated resident-level research training and three regions/countries with RO-specific physician scientist training programs. These varied from integrated training schemes that include higher research degree completion, to short-interval initiatives. Five programs were supported by metrics detailing their impact. Reported enablers and barriers demonstrated a subtle geographic variation but included protected time and funding, mentorship and attainment of research skills.

Conclusion: There is global variation in research training during RO residency but numerous shared enablers and barriers. These data provide shared best practice and a scaffold on which national and international societies can build improved research training pathways to redress the radiation research deficit.

1. Introduction

There is growing evidence of a disparity between the role radiation oncology (RO) plays in cancer care and the research funding and activity apportioned to it. Radiation-based treatments are indicated in the management of up to 60% of all patients who have a diagnosis of cancer and contribute to 40% of all cures (Borras et al., 2015; Delaney et al., 2005). Despite this, RO accounted for only 5% of cancer-related randomized clinical trials between 2007 and 2017 and 31% of all cancer research publications in 2019 (Liu et al., 2018). This compares poorly

with the 49% of publications that focus on systemic anti-cancer therapies (Berger et al., 2021). This relative deficit in radiation-related research is also reflected by a lack of funding, with RO in receipt of only 4–6% of global public and philanthropic cancer research spend (McIntosh et al., 2023).

The causes of the radiation research shortfall are uncertain but there are multiple possible contributing factors, including neutral or negative public perceptions about radiation (Wawrzuta et al., 2024), reduced availability of industry-sourced funding (Liu et al., 2018), and a lack of a sufficiently research competent and motivated RO workforce (Jones and

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Spencer, 2021). The latter point applies to clinicians with a significant proportion of their working time dedicated to research (i.e. physician scientists and academic clinicians) as well as those who contribute to and undertake research but predominantly focus on clinical service delivery. Concerns have been raised about the sustainability of physician scientist training pipelines across a variety of specialties but the extent to which those who train in RO (i.e. resident-level physicians) can access high-quality training to undertake and lead research is uncertain, as is the degree to which there is global variation in the pathways for, and the barriers and enablers to, this training (Jones and Spencer, 2021; Kwan and Gross, 2023; O'Rahilly, 2023; Vassie et al., 2020).

Given these unknowns, we undertook a scoping review to characterize current literature relating to RO resident-level research training. Within this, we specifically sought to outline global variation in research training pathways, pipelines and initiatives for RO residents. We additionally sought to identify key barriers and enablers of high-quality resident-level research experience in both standard clinical training and dedicated clinical academic research training pathways.

2. Materials and methods

2.1. Search strategy

This study follows the methodological framework for conducting a scoping review by Arksey and O'Malley and is reported in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement for Scoping Reviews (PRISMA-ScR) guidelines (Tricco et al., 2018). It is registered with the Open Science Framework (osf.io/jbvs5).

A comprehensive search of the Medline and Embase databases was conducted using key search terms, including "radiation oncology", "research" and "training". Relevant studies published between 1st January 2010 and 1st January 2025 were identified. This period was selected to allow for an analysis of contemporary literature and to capture relevant trends in training approaches, barriers and enablers. Grey literature searches targeted the websites of national organizations with oversight of RO training to identify information on country-specific RO research training programs and requirements. An outline of the search strategy, including search terms and organization websites included, is provided in [Supplementary Material A1](#).

2.2. Study selection

We aimed to capture the full breadth of literature relating to barriers and enablers to clinical academic training in RO, current research training pathways in RO, and descriptions of current or previous cohorts enrolled in research training in RO. We included review articles, editorials, commentaries and original research articles. Studies and articles presented in abstract form or as a letter, those not available as full-text and those not in English were excluded. Full details of these criteria are provided in [Supplementary Material A2](#).

The identified studies were initially screened for inclusion based on title/abstract by two independent authors (J.K., A.I.). Any conflicts were resolved by two other independent investigators (G.M.W., C.M.J.) based on the article full text.

2.3. Data extraction

Extracted data items included bibliographic details for each manuscript, study design and methodology, time-period in focus, population or intervention under study, outcome measures and key findings. Data extraction was performed using a pre-piloted, structured Microsoft Excel template by two independent investigators (J.K., A.I.).

2.4. Study quality assessment

A standardized approach to analyzing and comparing study quality was not possible given the significant heterogeneity in study design among eligible reports captured within this scoping review, which included narrative reviews and editorials in addition to articles containing original data and grey literature.

3. Results

3.1. Study characteristics

In total, 1745 manuscripts were identified, of which 54 met the eligibility criteria for inclusion ([Fig. 1](#)). A majority were survey-based studies ($n = 27/54$; 50.0%) or observational cohort analyses ($n = 10/54$; 18.5%) originating from North America ($n = 24/54$; 44.4%), Europe ($n = 12/54$; 22.2%) or Australasia ($n = 8/54$; 14.8%). Some studies included more than one methodological approach ($n = 6/54$, 11.1%). As outlined in [Table 1](#), 21/54 (38.9%) of the reports primarily focused on barriers to research, 15/54 (27.8%) outlined physician scientist pathways and other research training pathways, and 16/54 (29.6%) discussed enablers to research unrelated to formal research training pathways (henceforth referred to as "supplementary pathway enablers"). Most survey-based reports focused on barriers ($n = 17/27$, 63.0%) and on supplementary pathway enablers ($n = 9/27$, 33.3%). The response rates (range 9–100%) and aims of the surveys and qualitative interview studies are summarized in [Supplementary Table B1](#). Observational cohort analyses predominantly focused on supplementary pathway enablers ($n = 4/10$, 40.0%), barriers ($n = 3/10$, 30.0%), and physician scientist pathways and other research training pathways ($n = 3/10$, 30.0%). By contrast, the editorials and letters mostly outlined clinical training program metrics related to research outputs and research experiences of residents ($n = 3/5$, 60.0%). There was no clear correlation between the type or focus of the publications and their country of origin. An additional 12 webpages that related to national RO resident-level research training pathways and programs were identified ([Supplementary Table B2](#)). In total, 16 manuscripts not in English language were identified and excluded. Of these, three would have likely been relevant based on abstract screen, as translated in Medline ([Hilmi et al., 2022](#); [Koizumi, 2022](#); [Seufferlein and Adler, 2010](#)).

3.2. Research training activity for RO residents

To contextualize evidence for research training enablers and barriers, we first sought to explore the characteristics of current RO clinical training programs and to define the extent to which their research requirements vary. As summarized in [Supplementary Table B2](#), information relating to the presence or absence of a requirement for residents to participate in research was identified for RO training programs in 13 countries. Of these, seven (53.8%) countries incorporated mandatory research experience within residency programs. This group included the United States of America (USA), Canada, United Kingdom (UK), Germany, Switzerland, Australia and New Zealand, and the Philippines. Training bodies from the remaining six included countries (France, India, Tanzania, Ghana, Zambia, and Zimbabwe) reported that they encourage research involvement throughout training but do not mandate it. In addition to the research components of RO clinical training programs, nine dedicated research training pathways for RO residents were described across 15/54 (27.8%) published manuscripts from seven regions/countries. As summarized in [Fig. 2](#), these varied markedly by country with the USA, Canada, UK, Australia and New Zealand also offering specific pathways for residents on a physician scientist training track. The structure and research outputs of these posts, if reported, are outlined in [Supplementary Table B3](#).

RO residents are required by the American Council for Graduate Medical Education (USA) and the Royal College of Physicians and

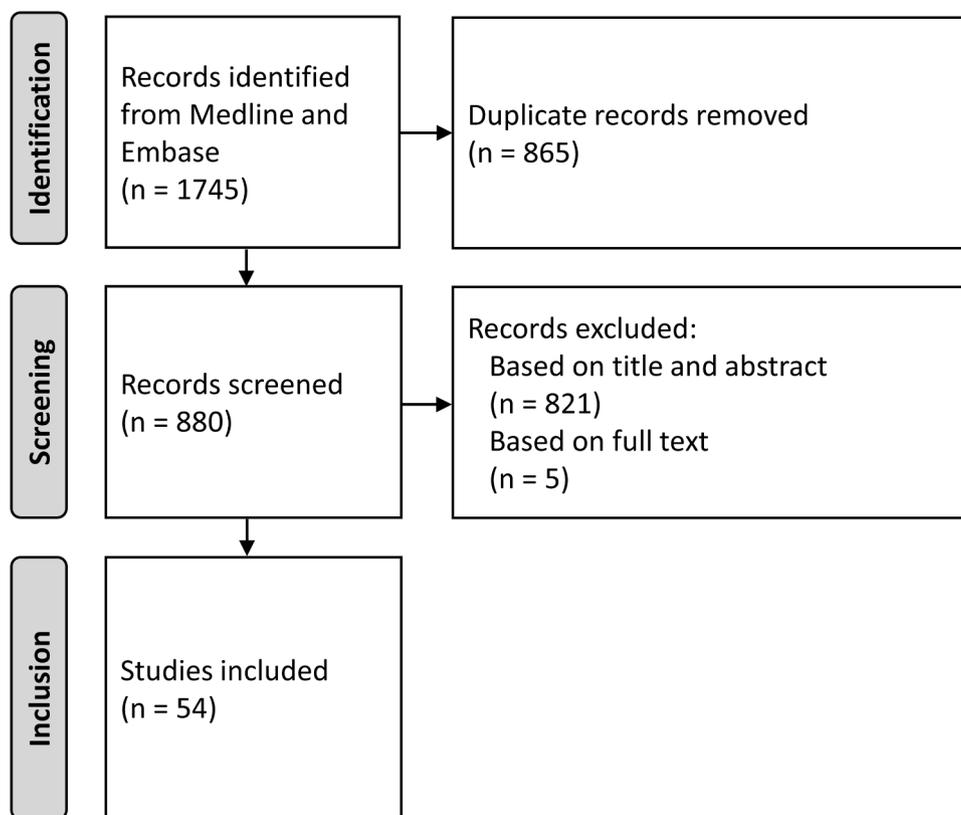


Fig. 1. A flow diagram demonstrating the scoping review screening and manuscript selection process.

Surgeons of Canada to complete at least one scholarly project during residency, although it is unclear whether this is mandated by a minimum time requirement (Dahn et al., 2020; Verma et al., 2016). In addition to the mainstream clinical residency programs, two USA-based integrated research training programs were identified; The American Board of Radiology Holman Research Pathway (HRP) and The Duke Radiation Oncology Research Scholar (RORS) program (Salama et al., 2021; Sindhu et al., 2021). These are focused on physicians planning a career with a significant discovery science, translational, or clinical research focus. HRP residents complete four years of RO training, consisting of 27 months of clinical training and at least 18 months of research (Sindhu et al., 2021). The RORS program integrates an additional two-year postgraduate position with 80 % research effort, providing residents with a total of 45 months of research time (Salama et al., 2021). Residents in Canada may enroll in the Strategic Training in Transdisciplinary Radiation Science for the 21st Century (STARS21) program, which is also open to international fellows (Patel et al., 2021). STARS21 provides interdisciplinary RO research education, projects and networking, and is composed of 13 biweekly 1.5-hour interactive “brainstorm” workshops, a career development and networking event, two group projects, and a Research Day symposium (P'ng et al., 2012; Patel et al., 2021).

In the UK, RO is delivered by clinical oncologists, who also undertake training in internal medicine and the administration of systemic therapies. Standard clinical oncology training in the UK incorporates basic research training, such as statistics and basic clinical trial methodology. All residents must obtain certification in Good Clinical Practice, which is a set of internationally recognized ethical and scientific quality requirements for clinical trial staff. For aspiring physician scientists, the National Institute for Health and Care Research (NIHR) offers pre-doctoral Academic Clinical Fellowships, which comprise 25 % protected research time with a view to securing a doctoral training position, and post-doctoral Clinical Lectureships, which offer 50 % protected research time (Jones et al., 2024; Jones and Spencer, 2021; Lei et al., 2012). Residents across the UK may also undertake out-of-program

experience (OOPE), which may be taken for research purposes. These include undertaking a higher research degree or other short-term research fellowships (Benstead et al., 2012; Lei et al., 2012; Said et al., 2014).

RO residents are required by The Royal Australian and New Zealand College of Radiologists to undertake a piece of original research during their training and to have original research work published or under peer-review in one of five RO journals (Foley and Roos, 2020; Roos et al., 2019). In addition to this broad research requirement, a physician scientist training pathway that integrates a higher research degree with training was established for RO residents in 2013 (Ong et al., 2020; Roos et al., 2019). Published information for this pathway is limited but the authors understand from grey literature that a formal Clinician-Scientist pathway was discontinued in 2022 due to changes towards competency-based medical specialist training, though it is still accommodated for individuals via flexibility in training policies.

As summarized in Fig. 2 and described in detail in Supplementary Table B3, four pathways from Europe and Africa offer short-term posts in research training for residents. The European School of Oncology Clinical Training Centers (ESO CTCs) program enables a period of three to six months at a center of excellence across different European countries. The fellowship primarily offers clinical training, but fellows can also undertake experimental, translational and clinical research (Pavlidis et al., 2020). In Tanzania, the three-year Master of Medicine (MMed) in Clinical Oncology program requires residents to complete a research dissertation, and provides training in radiation and medical oncology incorporating epidemiology, biostatistics, and medical ethics (Rubagumya et al., 2019). The Clinical Research Mentorship Program (CRMP), a collaborative partnership between Ghana, Zimbabwe and Canada, is a one-year program that consists of a call for research proposals, a ten-week research skills seminar series, a joint project mentorship, and provision of funding to conduct research and to travel to a conference to present results (Wong et al., 2021). Similarly, the MD Anderson and Zambia Virtual Clinical Research Training Program

Table 1
Overview of included studies by region, methodology and focus.

Region	Study	Methodology						Clinical program metrics		Research training pathways			Enablers and barriers	
		Survey	Observational cohort analysis	Letter or editorial	Program description	Qualitative interview	Other	Objective research outputs	Subjective experiences of research	Physician scientist pathway	Other research training pathway	Pre-residency initiative	Supplementary pathway enablers	Barriers
North America	Aboytes et al., 2024	•	•									•		
	Bono et al., 2024		•										•	
	Dahn et al., 2020	•												•
	Doke et al., 2019	•							•					
	Gondi et al., 2012	•						•						
	Holliday et al., 2014	•											•	
	Hsieh et al., 2025		•										•	
	Huang et al., 2023		•										•	
	Jones et al., 2023		•											•
	Lalani et al., 2018	•											•	•
	Liberman et al., 2023	•	•									•		•
	Mulherkar et al., 2024						•	•						
	Paracha et al., 2018		•										•	
	Parekh et al., 2020	•						•						•
	Patel et al., 2021	•	•			•					•	•		
	P'ng et al., 2012	•	•			•					•	•		
	Salama et al., 2021				•						•			
	Sidiqi et al., 2019	•											•	•
	Sindhu et al., 2021		•								•			
	Vayani et al., 2023	•				•						•		
Verma et al., 2016		•					•						•	
Wallner et al., 2013		•								•				
Wang et al., 2022	•						•							
Yorke et al., 2023				•									•	
Europe	Benstead et al., 2012	•						•					•	
	Casswell et al., 2018	•											•	
	Dickson et al., 2017	•											•	
	Goranov et al., 2013			•				•						•
	Hilmi et al., 2020	•												•
	Jones et al., 2024	•								•			•	•
	Jones and Spencer, 2021			•								•	•	
	Kosmin et al., 2016	•								•				•
	Krug et al., 2016	•								•				•
	Lei et al., 2012			•						•				
Australasia	Pavlidis et al., 2020	•									•			
	Said et al., 2014	•												•
	Christie and Barton, 2020			•					•					
	Foley and Roos, 2020	•												•

(continued on next page)

Table 1 (continued)

Region	Study	Methodology	Enablers and barriers	Research training pathways	Clinical program metrics
Africa	Hanlon et al., 2018				
	Ong et al., 2020				
	Quinn et al., 2024				
	Roos et al., 2019				
	Thiruthaneeswaran et al., 2014				
	Turner et al., 2016				
	Bhatia et al., 2020				
	Chopra et al., 2023				
	Grover et al., 2015				
	Jacomina et al., 2024				
Asia	Rubagumya et al., 2019				
	Diao et al., 2022				
Global	Diao et al., 2021				
	Jalan et al., 2020				
	Vulpe et al., 2020				
	Wong et al., 2021				

(MOZART) is a one-year virtual collaborative program between Zambia and the USA, which enables residents to enter a period of longitudinal research mentorship and offers a 14-week lecture series on research methodologies (Diao et al., 2021).

The extent to which these programs translate to resident-level research outputs and progression to post-residency research participation or leadership is only captured for five (HRP, STARS21, NIHR Integrated Academic Training, CRMP and MOZART) of the nine pathways. As outlined in Supplementary Table B3, the outputs for these programs are generally positive in terms of acquisition of research skills, better publication metrics, and increased progression to employment in research posts.

Data on the research productivity for the remaining programs was limited. However, as highlighted in Table 1, 11/54 (20.4 %) manuscripts from six regions/countries reported on RO resident-level research outputs in general. These are described in detail in Supplementary Table B2. The reporting criteria here vary substantially, which challenges data synthesis. Nevertheless, there is clear variation with, for example, 27 % of RO residents in the Philippines and 71 % of RO residents in Australia obtaining a publication during training (Jacomina et al., 2024; Thiruthaneeswaran et al., 2014). Furthermore, 11/54 (20.4 %) manuscripts from six regions/countries described the RO residents' subjective experiences of research within their clinical programs. As described in Supplementary Table B2, the reported attitudes towards research vary but are generally negative.

Of note, the literature search also revealed five initiatives that enable pre-medical and medical students to undertake RO research (Aboytes et al., 2024; Jones and Spencer, 2021; Liberman et al., 2023; Patel et al., 2021; Vayani et al., 2023). These are listed in Table 1 and summarized in Supplementary Table B4. Examples include the UK Royal College of Radiologists Summer Undergraduate Research Fellowship (RCR SURF) program, which provides funding for undergraduate medical students to undertake radiation-related research for up to eight weeks, and The Assistant Clinical Research Coordinator (ACRC) Program in the USA, which involves hiring a pre-medical college graduate to provide administrative and research support for RO faculty members (Aboytes et al., 2024; Jones and Spencer, 2021).

3.3. Enablers & barriers to resident-level research in RO

We next sought to identify enablers and barriers to RO resident-level research activity. Reported enablers are summarized in Supplementary Table B5 and Fig. 2. Of 16/54 (29.6 %) manuscripts that reported on supplementary pathway enablers, 7/16 (43.8 %) reported availability of dedicated research time that is separate to clinical training as an enabler (Benstead et al., 2012; Casswell et al., 2018; Dickson et al., 2017; Jones et al., 2024; Lei et al., 2012; Said et al., 2014; Sidiqi et al., 2019), 4/16 (25.0 %) reported on mentorship (Holliday et al., 2014; Hsieh et al., 2025; Jones et al., 2024; Lalani et al., 2018), 2/16 (12.5 %) reported multicenter collaborative projects (Chopra et al., 2023; Jones and Spencer, 2021), and the remainder focused on research support, courses and student authorship as additional enablers (Bono et al., 2024; Hanlon et al., 2018; Huang et al., 2023; Paracha et al., 2018; Turner et al., 2016; Yorke et al., 2023). Manuscripts with a focus on supplementary pathway research enablers originated from the USA, the UK, Australia and an Asian collaborative group.

Outcomes from 21/54 (38.9 %) studies reporting research barriers are outlined in Supplementary Table B6 and Fig. 3. A lack of protected research time was reported in 9/21 (42.9 %) studies across all continents identified in the search. Other barriers reported in individual regions/countries included poor funding (n = 6/21; 28.6 %), poor mentorship (n = 6/21; 28.6 %), lack of research skills (n = 5/21; 23.8 %), gender inequalities (n = 4/21; 19.0 %), minimal exposure to research (n = 4/21; 19.0 %), poor research support (n = 3/21; 14.3 %), inequality of low- and middle-income country (n = 3/21; 14.3 %), lack of opportunities within the area of interest (n = 2/21; 9.5 %), and the

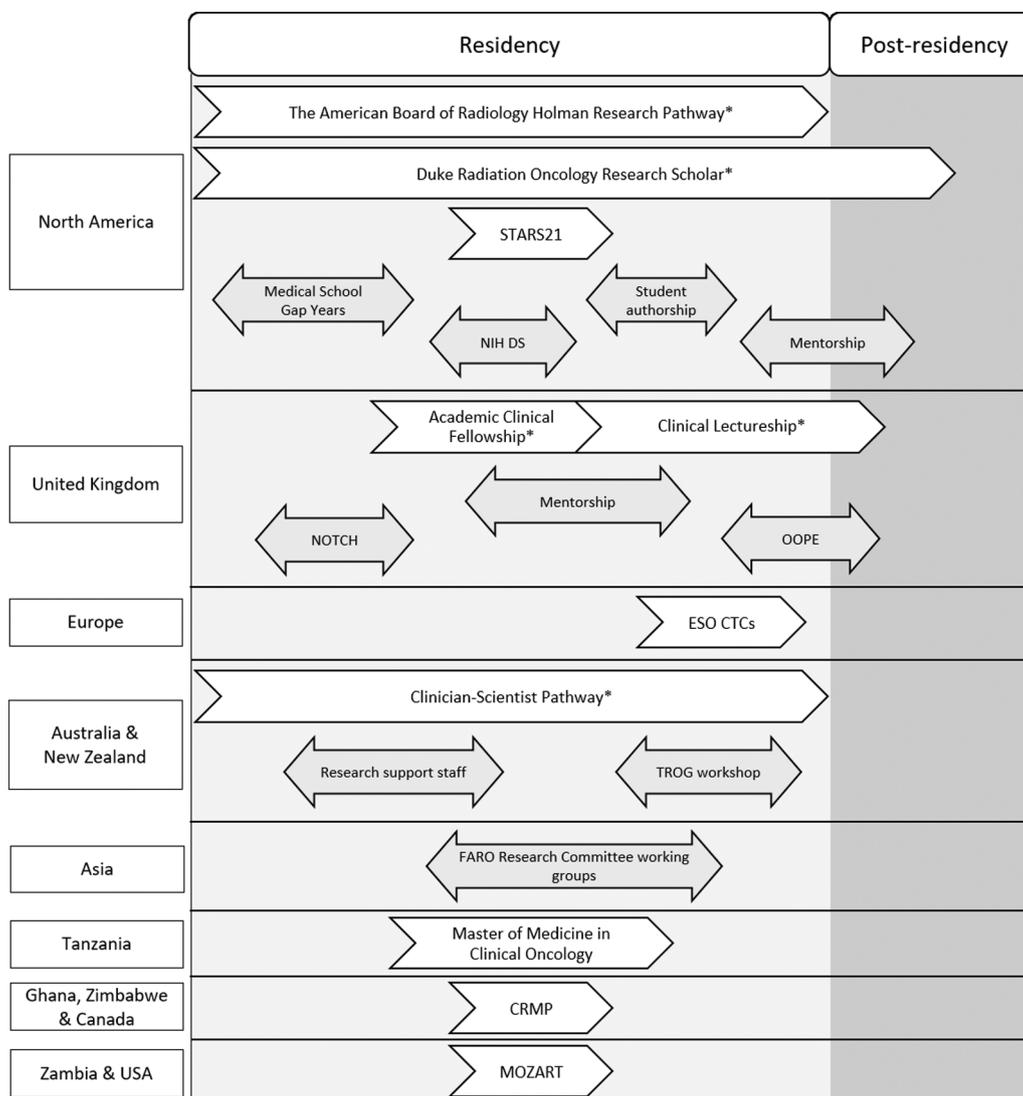


Fig. 2. An overview of reported academic residency and post-residency training pathways by country.

*Physician Scientist pathways.

White shapes represent formal research training programs. Grey shapes reflect other initiatives reported within the literature.

CRMP: Clinical Research Mentorship Program; ESO CTCs: European School of Oncology Clinical Training Centers program; FARO: Federation of Asian Organizations for Radiation Oncology; MOZART: MD Anderson and Zambia Virtual Clinical Research Training Program; NIH DS: National Institute of Health Diversity Supplement; NOTCH: National Oncology Trainees Collaborative for Healthcare Research; OPE: out-of-program experience; STARS21: Strategic Training in Transdisciplinary Radiation Science for the 21st Century; TROG: Trans-Tasman Radiation Oncology Group.

impacts of the COVID-19 pandemic (n = 2/21; 9.5 %). Gender inequalities, lack of opportunities within a resident's area of research interest and impacts of COVID-19 were only reported in studies originating from the USA, Europe and Australia.

4. Discussion

There is relative paucity of RO research activity when compared to the proportion of patients who receive, and benefit from, radiotherapy. The reasons for this RO research deficit are uncertain and likely to be multifactorial, yet a fundamental requirement for research activity is a workforce equipped and trained to undertake it. Effective training pathways are key to developing this, yet this scoping review reveals a limited evidence base on which to build new training programs, and inconsistent reporting of outcomes from published RO residency research training initiatives. Nevertheless, the limited number of studies that reported the outcomes of research training initiatives found those to be positive in terms of objectively increasing high impact research in

RO.

There was evidence from the identified manuscripts of global similarities in reported barriers and enablers to research training. Key amongst these was the availability of dedicated research training initiatives that feature protected research time away from clinical responsibilities (Jones et al., 2024; Sindhu et al., 2021). Other enablers to resident-level research in RO were unrelated to formal training programs and were more diverse, including opportunities to receive mentorship, to participate in multicenter collaborative groups, to obtain direct research support and to undertake research training courses. Importantly, the identified manuscripts also suggest that early exposure to RO research leads to retention of research-active individuals, which lends support to schemes targeted at undergraduates such as the RCR SURF program or the ACRC program (Aboytes et al., 2024; Jones and Spencer, 2021).

The inaccessibility of many of the identified enablers was reflected across the identified barriers. Protected research time from clinical work is guaranteed on dedicated research training pathways, so it was

unsurprising that the lack of separation between research and clinical workload was the most commonly reported barrier to resident-level research in RO. Similarly, addressing poor funding, poor mentorship, poor research support and lack of research skills were reflected in enablers that tackle those barriers, for example, through funding supplements, mentoring schemes, research support staff and research courses.

These enablers and barriers are not unique to RO and an important outcome of our work is highlighting the relative absence of more RO-specific influences on research training (O'Rahilly, 2023). A notable exception to this is a consistent perception of a lack of opportunities to undertake protected research programs during training. This may be a consequence of a relative lack of funding for RO research combined with a relatively small pool of RO research supervisors and is of importance

given the risk of a self-perpetuating cycle in which fewer training opportunities result in fewer research programs and less attached funding with which to establish new training opportunities. Furthermore, the emphasis of some training programs requiring residents to publish research is not always accompanied by adequate support and may fail to produce high-quality outputs (Stehlik et al., 2025).

Taken together, these data suggest that best practice for engaging and retaining RO residents in high-quality research requires supported pre-residency exposure followed by an ability to undertake dedicated research training posts. Additionally, the careers of research-active RO residents should be complemented with strong mentorship, availability of research support (funding, staff and resources), attendance at relevant courses and opportunities for multicenter collaborations. To achieve

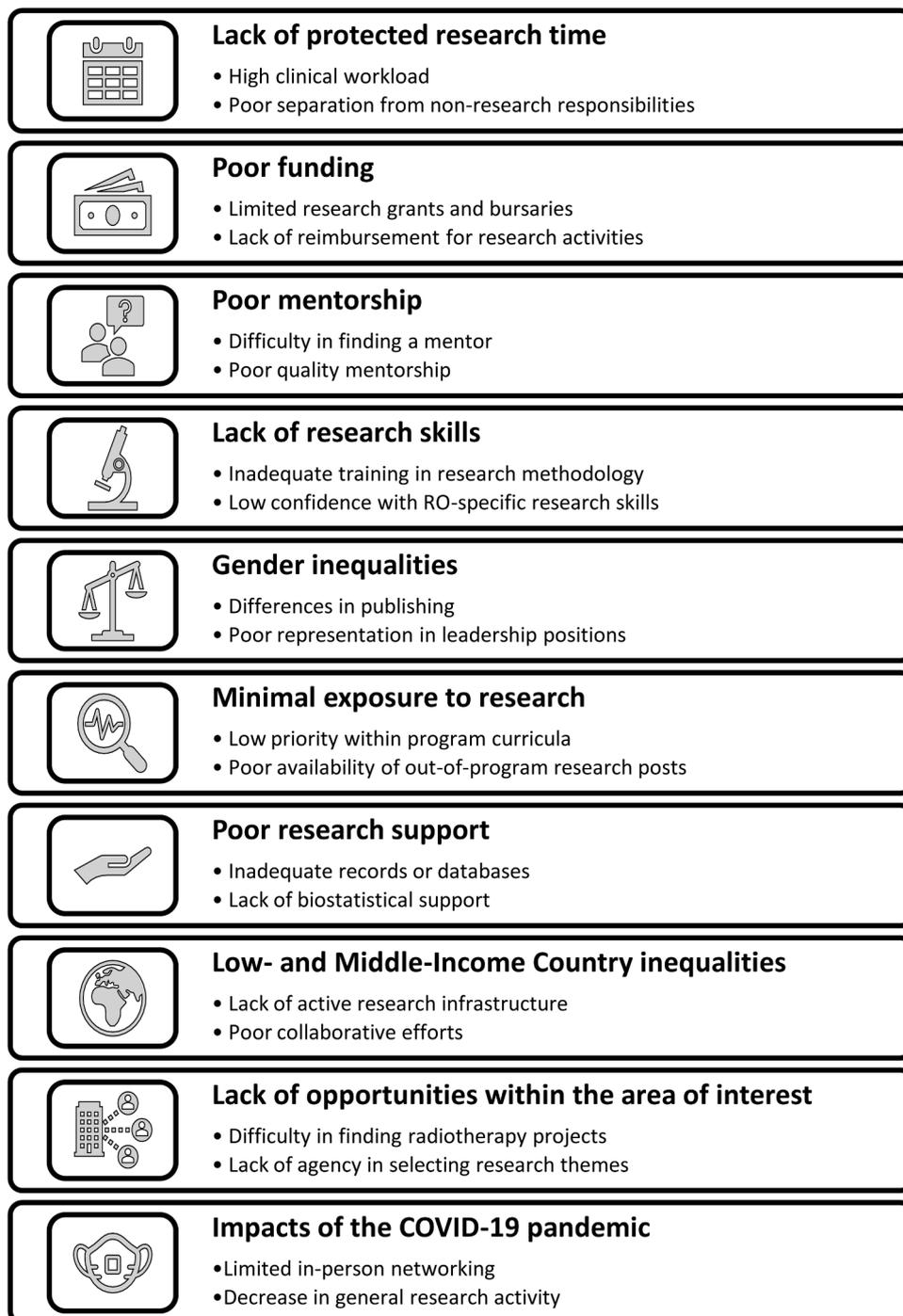


Fig. 3. A summary of reported barriers to research training during residency in radiation oncology.

this, there is a need for national and international organizations to use the evidence provided here to lobby for funding for, and to prioritize, research training initiatives for RO residents. Best practice for these initiatives should be shared and the short- and long-term outcomes of RO research training pathways should be routinely audited to ensure the most effective allocation of limited resources. Suggested recommendations for training and retaining a research active RO workforce are summarized in Table 2.

The work presented here also serves to highlight major gaps within the current evidence base regarding RO research training. There was, for instance, an absence of data describing RO residency research training post availability for each country, nor the related competition ratios and associated research outputs of the residents in those nations. In addition, though guidelines for RO education and clinical training are widely available, published statements on training standards specific to research are lacking. Finally, there is also a shortage of high-quality qualitative research on resident and faculty perceptions of research training in RO. Further work in these areas would be beneficial to identify enablers and areas for improvement more comprehensively.

This scoping review had several limitations, largely due to the mixed range of quality of the studies available. The heterogeneity of the literature did not allow for a feasible quality assessment of the evaluated studies. Most evidence originated from survey-based studies with varying response rates, some as low as 18 %. Survey data are open to survivor bias, especially in the context of academic success. Some studies surveyed more senior oncologists regarding their time as a resident, which posed a risk of recall bias. Data from older studies or studies surveying former residents may also no longer be accurate, though we tried to mitigate this through exclusion of literature published before 2010. As a scoping review, we tried to moderate these limitations by contextualizing the findings from survey-based studies against the descriptive literature of existing research pathways and initiatives. Many identified manuscripts did not assess objective research productivity of the described programs, as defined by publication outputs and research grant funding, and instead examined subjective views of the residents. Similarly, some identified programs or initiatives were not formally evaluated, and their impact was only discussed using the authors' own opinions. Some manuscripts were related to early career research in radiation or oncology as a multidisciplinary field, making it unclear whether the findings can be fully generalizable to RO clinical residents. Further, we analyzed only those manuscripts published in English and may therefore have missed studies relevant to RO research-active non-English speaking countries. To contextualise this, based on an abstract screen, we consider that three non-English language studies would have likely been relevant. Given this, it is important that any absence of evidence for RO resident research barriers, enablers or pathways here is not seen as their definitive absence. It is also possible that other programs exist but are not publicized on websites or in journals. This publication bias is an unavoidable inherent limitation of research in this field. Our aspiration is that by highlighting the considerable gap in evidence, we will encourage groups to study and share both positive and negative research experiences and initiatives, in order to refine best practice.

5. Conclusions

A research competent RO workforce is vital to redressing the relative deficit between the importance of RO to cancer care and the research activity underpinning its development. In this scoping review, we described the global variation in research training in RO and identified the shared enablers and barriers. We summarized the extent of our current knowledge of best practice for research training and emphasized the importance of early exposure to RO research followed by the availability of dedicated research training pathways. There is a need for national and international RO organizations to lobby for the funding and prioritization of these, as well as to rigorously collate their related

outcomes to influence the optimal allocation of finite resources.

Critical view

We provide the first overview of residency-level research and academic training in radiation oncology globally. There is evidence for lower levels of funding for radiation oncology research compared to that provided for research related to medical oncology. This research deficit poses a risk of radiation-based treatments falling behind that of systemic treatments, challenging the role of radiotherapy in cancer care. The underlying cause for this trend is likely to be multifactorial, but the increase in radiation oncology research activity is contingent on the training and availability of a research competent and active workforce, including physician scientists and research-active clinicians who are vital to maintaining research activity. There is a longstanding recognition of barriers to physician scientist and broader residency-level research training across several specialties. The extent to which these apply to radiation oncology academic training pathways and the extent to which residency-level research opportunities differ across the globe is underexplored, yet this information is vital to identify steps through which a research-active radiation oncology workforce can be maintained. Given this, our scoping review identified shared and disparate barriers and enablers for residency-level research training, in addition to outlining key research training initiatives that may be shared globally to enhance the research skills of the broader radiation oncology workforce. These data provide shared best practice and a framework on which policy makers and national and international societies can build improved research training pathways to address the gap in radiation oncology research.

Table 2
Recommendations for training a research active workforce in RO.

Level	Recommendations
International	<ul style="list-style-type: none"> Greater endorsement of and advocacy for RO research training by international societies. Development and publication of research curriculum guidelines highlighting priorities for enabling academic workforce expansion. Opportunities for international research exchange programs and courses.
National	<ul style="list-style-type: none"> Regular audit of short- and long-term outcomes of national research training pathways. Urgent action to address bottlenecks in career pathways of research-active RO clinicians. Promotion of opportunities for professional growth, e.g. mentoring and sponsorship. Funding of early-medium career development supplements and grants for local research groups and individuals. Support for and recognition of trainee-led multicenter collaborative groups. Support creation of research-focused programs and 'taster weeks' for medical students and pre-residency doctors interested in RO research.
Regional	<ul style="list-style-type: none"> Regular audit of research outputs among local academic and non-academic RO trainees. Support for trainees to join national trial and research committees. Use of funds for research support staff roles to make RO research more efficient. Facilitation of high-quality qualitative research related to perceptions of research training in RO. Engagement and encouragement of medical students and pre-residency doctors in RO research in the local departments, including building and IT access.
Individual	<ul style="list-style-type: none"> Instigate project ideas that are SMART and see through to completion including presentation and publication. Seek out formal and informal research-focused mentorship opportunities. Participate in educational initiatives, such as research courses, workshops and conferences. Join and participate in academic committees.

SMART: specific, measurable, attainable, relevant, timely.

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Joanna Kucharczak: Methodology, Formal analysis, Investigation, Resources, Data Curation, Writing – Original Draft, Writing – Review & Editing, Visualization, Project administration. **Anushka Irodi:** Methodology, Formal analysis, Investigation, Resources, Data Curation, Writing – Review & Editing, Project administration. **Katie Spencer:** Methodology, Formal analysis, Writing – Review & Editing, Supervision. **Gerard Walls:** Methodology, Formal analysis, Writing – Review & Editing, Supervision. **Christopher Jones:** Conceptualisation, Methodology, Formal analysis, Investigation, Resources, Data Curation, Writing – Review & Editing, Visualization.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: An author reports a relationship with Candesic that includes: consulting or advisory. This is outside of the scope of the work presented here. Other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendices A and B. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.critrevonc.2026.105162.

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