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Scientific Article

Characterization of Research Mentorship During Medical School for Future Radiation Oncology Trainees

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Purpose: Medical student access to radiation oncology (RO) research opportunities is important for stimulating interest in the specialty. The purpose of this study was to assess the publication record during medical school of students who ultimately matched in RO, to characterize the source(s) of their RO mentorship relative to other specialties.

Methods and Materials: We performed web-based searches to identify manuscripts published during medical school (defined as being published from January 2016 to December 2019) for all RO residents with postgraduate year 2 status in 2020 to 2021. Students with a PhD degree and international graduates were excluded. Characteristics of these publications, the student, and the primary mentor, were assessed.

Results: A total of 435 publications were authored by the 148 included residents. In total, 115 (78%) attended a medical school with an affiliated RO residency program. The median number of publications per student was 2 (interquartile range, 1-4), and students' median byline author position was 2 (interquartile range, 1-4). In total, 351 publications (80.7%) were on a cancer-related topic, with 234 (53.8%) published in oncology-oriented journal, and 96 (22.0%) published in RO-oriented journals. There were 294 unique mentors, with 70 mentors (24%) on 2 or more student publications. Most mentors (n = 187, 64%) shared the same institution as the student. Mentors were most commonly radiation oncologists/radiation biologists/medical physicists (n = 153, 52.6%), surgical subspecialists (n = 53, 21%), and medical oncologists (n = 18, 6.2%). Students working with primary RO mentors were more likely to publish in an oncology-oriented journal (79.1% vs 18.2%, $P < .01$) or RO-oriented journal (36.2% vs 2.2%, $P < .01$), compared with students working with non-RO mentors, respectively. A higher percentage of publications with RO mentors occurred in the last 2 years of medical school compared with the first 2 years (64.0% vs 40.9%, respectively, $P < .01$).

Conclusions: Approximately one-half of student publications among future RO residents are published in nononcology journals, and result from mentoring relationships with non-RO physicians.

Introduction

Medical student research productivity is an important component of career development and contributes to becoming a more competitive residency applicant for a variety of specialties.[1-4] Additionally, engaging students in

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mentored research projects can help enhance students' depth of understanding of a specialty and interest in pursuing a career in it.[5-8] Offering sufficient research opportunities to students may be particularly important to attract them to a specialty like radiation oncology (RO), which emphasizes innovation and evidence-based care and tends to attract students with an interest in science and technology[9-12] but offers few curricular opportunities for clinical exposure at most medical schools.[13-16]

Many radiation oncologists at academic medical centers conduct research; however, there is evidence that collaborating with medical students in that research is uncommon, with one recent study reporting that only approximately 6% of scientific publications in the 3 American Society for Radiation Oncology journals included a medical student author, with mentorship on those publications coming from only approximately 5% of all academic RO faculty at US MD-granting medical schools.[17] However, the extent to which medical students find research mentorship in RO relative to physicians in other specialties is unknown. Given the relatively small number of RO faculty compared with other specialties, and that students have little exposure to RO during medical school, our hypothesis is that medical students who ultimately pursue RO residency will have a high percentage of publications with non-RO mentors published in nononcology journals. Given the decrease in student interest in RO in recent years,[18] better characterizing gaps in RO research opportunities may be particularly useful to stimulate more interest in the specialty.

Methods and Materials

This study assessed the publication record during medical school of for all RO residents with postgraduate year 2 (PGY2) status in 2020 to 2021. Residents were excluded if they had a PhD degree, since these students are on a very different research track than MD candidates, who represent the vast majority of medical students. Residents were also excluded if they graduated from an international medical school or spent more than 1 year of graduate medical education training in a different specialty. This list of individuals was compiled in December 2021 using the websites of all 91 Accreditation Council for Graduate Medical Education—accredited RO residency programs. Six programs were excluded due to missing resident information on their respective websites, and another 2 programs were excluded for having no PGY2 residents in the 2020 to 2021 academic year. In the remaining 83 programs, 198 PGY2 residents were identified, 9 of whom were excluded for being international medical graduates, 2 for transferring to RO residencies after spending more than 1 year in a different specialty, and 39 for having a PhD degree.

For each of the remaining 148 residents, all peer-reviewed scientific publications initiated during medical school were assessed. Based on the aforementioned exclusion criteria, these residents would have graduated from medical school in 2019. Publications initiated during medical school were defined as those between the dates of January 1, 2016, and December 31, 2019, which reflects timing 6 months most postinitiation, and completion, of medical school, respectively. Publication data were obtained from Scopus and cross-referenced for accuracy using both PubMed and Google Scholar. Only publications that were categorized as original clinical, basic science, case report/series, or education/training were evaluated, whereas reviews, editorials, clinical guidelines, correspondence articles, and abstracts for scientific meetings were excluded.

Collected data relating to each students' publications included article type, journal name, publication date, total number of authors, name and affiliation the of first and last author, student's author position, and student's institutional affiliation. The primary mentor was defined as the senior (last) author, unless he/she was a trainee and the first author an attending physician, in which case the first author was considered the primary mentor (n = 45). Additional demographic data were collected for each student and primary mentor using ResearchGate, LinkedIn, and Doximity. For the students, these data included their sex, medical school attended, and whether there was an affiliated on-site RO residency program at their medical school. Demographic data collected for each primary mentor included sex, institutional affiliation, degree(s), academic rank, and medical specialty. All data collected were cross-checked across multiple web-based sources whenever possible to confirm the identity, affiliations, and publication record of the individuals included in this study. Descriptive statistics were used to report the characteristics of each of the students, mentors, and publications. χ^2 tests were used for subgroup analyses comparing RO-mentors versus non-RO mentors. The study was considered exempt by the local institutional review board.

Results

A total of 435 publications from scientific research projects initiated during medical school for the 148 PGY2 RO residents were identified. Table 1 shows demographic information for the students and primary mentors. The students were predominantly male (n = 96, 64.9%) and from a medical school with an affiliated RO residency program (n = 115, 77.7%). There were 291 unique primary mentors, among whom 70 (24.1%) served as the primary mentor for 2 or more student publications. The primary mentors were most commonly radiation oncologists (n = 142, 48.8%), medical oncologists (n = 18, 6.2%), and neurosurgeons (n = 16, 5.5%). The primary mentor

Table 1 Demographics of medical students and mentors

	Medical students (n = 148)	Mentors (n = 291)
Sex		
Male	96 (64.9%)	209 (71.8%)
Female	52 (35.1%)	82 (28.2%)
Attended medical school with an affiliated RO residency program		
Yes	115 (77.7%)	—
No	33 (22.3%)	—
Degree		
MD or MBBS	In progress	253 (86.94%)
PhD	—	88 (30.2%)
Masters	5 (3.4%)	39 (13.4%)
Academic rank		
Professor	—	113 (38.8%)
Associate professor	—	89 (30.6%)
Assistant professor	—	68 (23.4%)
Nonacademic clinician	—	16 (5.5%)
Physician trainee	—	4 (1.4%)
Postdoctoral trainee	—	1 (0.3%)
Mentor specialty		
Radiation oncology	—	141 (48.5%)
Medical oncology	—	18 (6.2%)
Neurosurgery	—	16 (5.5%)
Radiation biologists/medical physicists	—	12 (4.1%)
Radiology	—	8 (2.7%)
Otolaryngology	—	7 (2.4%)
General surgery	—	5 (1.7%)
Neurology	—	5 (1.7%)
Ophthalmology	—	5 (1.7%)
Interventional radiology	—	4 (1.4%)
Orthopedic surgery	—	4 (1.4%)
Pathology	—	3 (1.0%)
Plastic surgery	—	3 (1.0%)
Urology	—	3 (1.0%)
Other clinical specialties	—	31 (10.7%)
Other nonclinicians	—	26 (8.9%)

was affiliated with the same medical school institution as the student for 283 publications (65.1%). Including radiation oncologists, radiation biologists, and medical physicists, the total number of RO primary mentors was 153 (52.6%). The RO primary mentors were affiliated with a total of 65 unique institutions, and 108 (70.6%) were male and 45 (29.4%) female.

The median number of publications per student was 2 (interquartile range [IQR], 1-4). Students' median author position in the byline was 2 (IQR, 1-4), including first author for 157 (36.1%) publications, second author in 92 (21.2%) publications, and third author in 47 (10.8%) publications. Categories of publications included 335 clinical (77.0%), 50 basic science (11.5%), 38 case reports/series (8.7%), and 12 education/training (2.8%). Based on the title of each publication, 351 (80.7%) were related to oncology. Manuscripts were published in a wide variety of journals, with 234 (53.8%) published in 79 different

Table 2 Most common institutions of radiation oncology (RO) mentors who published with students in this study

Institution	Number of unique RO mentors	Number of publications from the RO mentors at this institution
Harvard University	12	17
University of Texas/ MD Anderson	10	19
University of California-San Diego	7	15
Washington University-St Louis	7	12
Memorial Sloan Kettering Cancer Center	7	10
Stanford University	5	8
University of Pittsburgh Medical Center	5	8
Rutgers University	4	10
Columbia University	4	6
University of California-Los Angeles	4	6
Total	65	111

oncology-oriented journals, and 96 (22.0%) in 16 different RO-oriented journals. Fifty-five manuscripts were published in the 3 American Society for Radiation Oncology journals: *International Journal of Radiation Oncology, Biology, Physics* (IJROBP) (n = 26, 6.0%), *Practical Radiation Oncology* (PRO), (n = 15, 3.4%), and *Advances in Radiation Oncology* (ARO) (n = 14, 3.2%). Ninety-two (95.8%) of the publications in RO journals had a RO primary mentor.

Table 2 shows the most commonly represented institutions of the RO mentors who published with this cohort of students. Each of the top 10 institutions was a National Cancer Institute—designated comprehensive cancer center. Table 3 shows the types of journals publishing articles from RO versus non-RO primary mentors, demonstrating that students working with primary RO mentors were more likely to publish research in an oncology-oriented journal (79.1% versus 18.2%, $P < .01$) or RO-oriented journal (36.2% versus 2.2%, $P < .01$), compared with students working with non-RO mentors, respectively. Figure 1 shows the number publications during each evaluated calendar year from RO mentors versus non-RO mentors, demonstrating that publications with RO mentors increased markedly in the latter years of medical school. A greater percentage of publications with RO mentors occurred in the last 2 years of medical school compared with the first 2 years (64.0% versus 40.9%, respectively, $P < .01$).

Discussion

RO is a small field, with radiation oncologists comprising only approximately 0.5% of the U.S. physician workforce.[19] RO is also a highly specialized field, with minimal curricular attention at most medical schools.[13-16] Offering medical students research in RO can help overcome these barriers to access and, by raising awareness of the specialty, provide a pathway for in-depth exposure to it. This study has demonstrated that among radiation oncology residents, only approximately 50% published a research study with a RO primary mentor during medical school. Among all manuscripts, 81% focused on a cancer-related topic, 54% were published in an oncology-oriented journals and 22% were published in a radiation oncology-oriented journal. Students with primary RO mentors were more likely to publish research in an oncology-oriented, or RO-oriented journal.

An important challenge in interpreting these findings is a lack of similar data from other medical specialties describing the percentage of medical student research mentorship coming from within a given specialty versus

Table 3 Characteristics of publications from radiation oncology (RO) mentors (including radiation oncologists, radiation biologists, and medical physicists) versus all other mentors

	RO mentors (n = 153)	Non-RO mentors (n = 138)	*P* value
Total no. publications	254	181	
Total no. (%) publications in oncology-oriented journals	201 (79.1%)	33 (18.2%)	<.01
Total no. (%) publications in radiation oncology-oriented journals	92 (36.2%)	4 (2.2%)	<.01

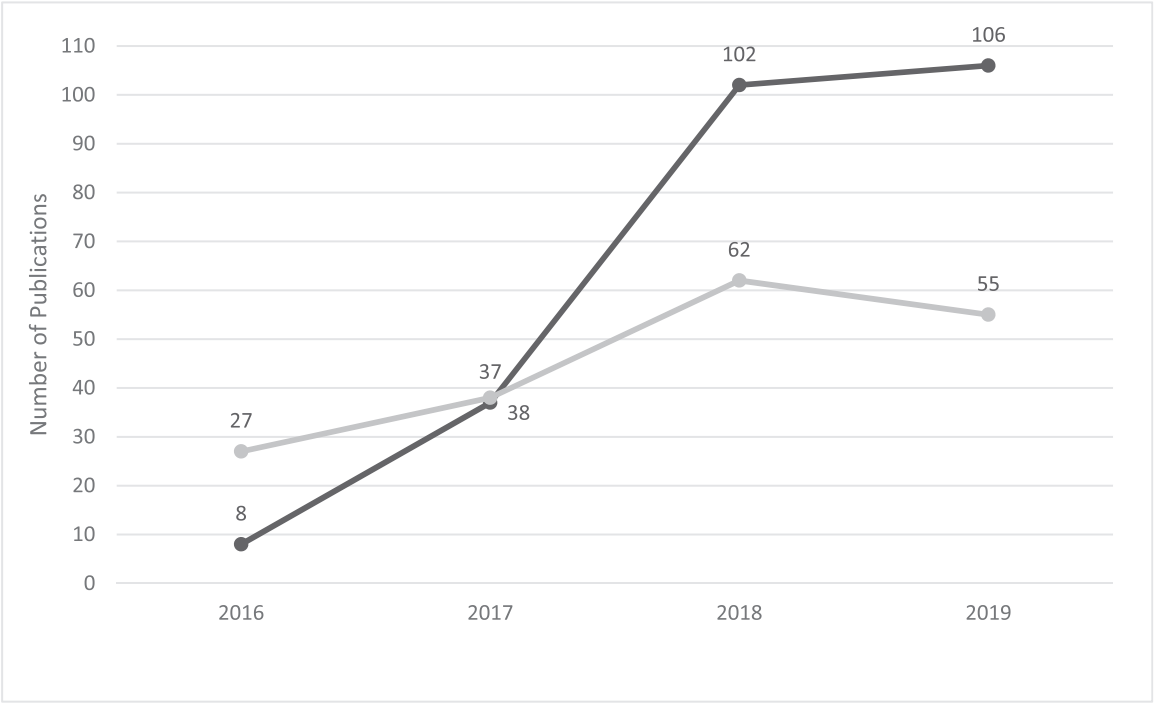

Figure 1 Number of student publications during each evaluated year from RO mentors (black) versus non-RO mentors (gray). The observed differences in 2016, 2018, and 2019 were all statistically significant ($P < .01$).

outside of it. However, the journal in which students in other professions publish during medical school is a useful surrogate. For example, it has been reported that 78% of publications during medical school for neurosurgical residents were in neurosurgery journals,[20] and 56% of publications during medical school for otolaryngology residents were in otolaryngology journals.[21] Similar data have been reported in the fields of dermatology (72%),[22] orthopedic surgery (52%),[23] and plastic surgery (42%).[24] Our data showed that although 54% of manuscripts were published in oncology-oriented journals, only 22% were published specifically in radiation-focused oncology journals. This discrepancy related to RO journals compared with other specialties may derive from the relative lack of exposure to RO early in medical school, that radiation oncologists frequently publish in non-RO journals, that RO may be more multidisciplinary than many other specialties, or that RO is smaller and thus has fewer potential mentors than most other specialties.

Approximately three-fourths of medical students change their specialty preference during medical school,[25] so it is expected that many students would pursue research mentorship with physicians in specialties outside of the one they ultimately pursue. However, there is also substantial evidence from a variety of specialties (including RO) that early research mentorship does increase the probability of a student matching in that specialty.[5-8,26–30] Interestingly, most of the non-RO mentors in our study were from specialties with whom radiation oncologists work closely clinically (eg, medical oncology, neurosurgery, radiology, otolaryngology), perhaps suggesting other fields that students who ultimately pursue RO consider before their preferences change. Our finding that publications with RO mentors increased to a greater extent during the latter years of medical school compared with publications with non-RO mentors, also suggests that most students are finding RO mentors *after* developing their interest in pursuing residency in RO. Along these lines, there may be insufficient research opportunities in RO for students in the early years of medical school when they are still deciding on a career path. This may in part be related to new opportunities for research that arise during away rotations, which often take place at larger academic centers, including some that lack an official medical school affiliation (eg, MD Anderson or Memorial Sloan Kettering).

There are a variety of feasible approaches to increase RO research mentorship.[12] From a cultural standpoint, it should be part of the academic mission of any RO department affiliated with a medical school to purposefully and proactively encourage their faculty and residents to offer research opportunities to medical students. Mentoring students requires effort and should be a shared responsibility, with adequate time and resources provided. Organization of research efforts through dedicated leadership is likely to be worthwhile in facilitating proactive approaches that departments might take, for instance: Advertising available RO projects to the many students seeking research during the summer between their first and second year, informing

students of national opportunities for funded oncology research, providing departmental funding for student research or meeting presentations, or ensuring that radiation oncologists participate in a medical school's didactics in research methodology.

There are several important limitations of this study. First, the cohort of students evaluated were from a single year, and a degree of variability in research mentorship and publications is likely from 1 year to the next. Along these lines, variations in the competitiveness of matching into a RO residency position is likely to affect the publication record of those who match into the specialty. An additional limitation of our methods is that it is likely that some publications initiated during medical school, but completed afterward, were not captured due to a lag in manuscript completion, the peer review process, or journal publication. It is also possible that a few of the primary mentors were miscategorized by our approach. Our methods also could not capture all student-mentor partnerships so much as those that culminated in a publication, which has been reported to occur for the minority of medical student research experiences across a variety of institutions and medical specialties.[4,26,27]

Conclusions

Approximately one-half of medical student publications among future RO residents are published in non-RO journals and result from mentoring relationships with physicians in other specialties. Furthermore, most RO research mentorship appears to occur later in medical school, after interest in the specialty has already been established. Our future work will evaluate the underlying reasons for these findings, and potential avenues for radiation oncologists to better engage students exploring a career in oncology. Furthermore, additional research on this topic that compares multiple years of residents would be valuable in identifying trends in mentorship over time, and may help identify further gaps for the radiation oncology community to address.

Disclosures

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