

Research Article

Research Productivity Trends Among Residents Applying for Orthopaedic Spine Fellowships in the United States: A Bibliometric Analysis

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Study Design

Retrospective bibliometric analysis

Objectives

The purpose of this study was to identify research trends and characterize the academic profiles of orthopaedic spine fellows from 2018 to 2023 in the United States (U.S.) during their residency training.

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[Conflicts of Interest Statement for Andrew Kim](#)

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d Veenadhari Kollipara is a third-year medical student at Pennsylvania State University College of Medicine. She graduated from the University of Pennsylvania with a summa cum laude in Health & Societies (Health Policy & Law Concentration) and a minor in Cinema and Media Studies. Her experiences as a Health Education Associate at the Netter Center for Community Partnerships, a volunteer at the Sayre Health Covid-19 Vaccine Distribution Center, and a Hoesley Digital Literacy Fellow have motivated Veenadhari to be passionate about both patient care and health policy/advocacy. In medical school, Veenadhari became involved in leadership as the President of the Neurosurgery Interest Group, President & Founder of the South Asian Student Association, Diversity Chair in Student Government, Grants & Research Chair of a mobile student-run free clinic, and the Health Policy Chair in PSUCOM's AMA. As she continues her medical school journey, Veenadhari hopes to make a real impact in the lives of her patients' communities.

[Visit Veenadhari Kollipara](#)

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Methods

The North American Spine Society (NASS) Fellowship Directory was used to identify orthopaedic spine fellowships in the U.S. Fellowships that listed graduating fellows from 2018 to 2023 were included for analysis. For each fellow, total number of publications, citation count, authorship, and fellowship program were compiled using Scopus and spine fellowship websites. Only publications and citations in years prior to the start of fellowship were collected. H-index was calculated using these totals to reflect pre-fellowship research output.

Results

Thirty-eight programs qualified with 181 fellows from 2018 to 2023. Fellows published an average of 7.9 ± 10.6 articles, with 112.6 ± 226.0 citations per fellow. Most publications involved middle authorship (65.8%) and 37.2% focused on spine surgery. Average number of publications per fellow (11.4 ± 9.1) and h-index (5.0 ± 3.1) were highest for fellows in programs located in the northeast region of the U.S. Fellows with a graduation date of 2023 had the highest average number of publications (10.6 ± 16.4), number of citations (136.5 ± 321.2), and h-index (4.3 ± 4.3).

Conclusions

There has been an increasing trend in the number of pre-fellowship publications, citations, and h-index among orthopaedic spine fellowship applicants. Research productivity was found to be the highest among spine fellows in programs in the northeast region.

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INTRODUCTION

Among all surgical specialties, orthopaedic surgery has the highest rate of trainees who plan on applying for a fellowship following residency, with over 90% expressing interest in pursuing a fellowship (Cotter, Polce, Lee, et al. 2021; Egol, Shields, Errico, et al. 2020). This trend is becoming universal as fellowship-trained orthopaedic surgeons have increased employment opportunities (Morrell, Mercer, and Moneim 2012), academic leadership appointments (Elkadi et al. 2022), and higher financial returns (Mead et al. 2020). Within orthopaedic fellowships, spine is among the most competitive, having one of the lowest applicant-matching success rates and a declining number of available positions (Ruddell, Eltorai, DePasse, et al. 2018).

Although there are no research benchmarks required to match into a spine fellowship, resident applicants routinely engage in research throughout their training. Spine program directors consider academic accomplishments and research experiences among the most important criteria when evaluating fellowship applicants (Bernatz et al. 2021;

Satin et al. 2023). However, the research productivity of residents successfully matching into spine fellowships has not yet been defined. The purpose of this study is to identify research trends and characterize the academic profiles of recent spine fellows in the United States (U.S.) during their residency training.

METHODS

FELLOWSHIP REVIEW

The North American Spine Society (NASS) Fellowship Directory was used to identify all orthopaedic spine fellowship programs in the U.S. This yielded 78 spine fellowship programs. Each program was reviewed for adherence to inclusion criteria for the study, which were (1) fellow(s) listed on the fellowship website, (2) program located in the U.S., and (3) the program was not limited to neurosurgery residents. A total of 38 programs met the inclusion criteria. Remaining programs were then organized by geographic region within the U.S. ("United States Regions" 2022).

The fellowship websites were used to compile a list of current and former spine fellows over the last five fellowship cycles (2018-2023). This yielded 222 spine fellows. An exclusion criterion was any fellow whose research or academic profiles were not publicly available. A total of 181 fellows remained after the exclusion criteria.

DATA COLLECTION

Each fellow's name was manually searched in Scopus, a publicly available abstract and indexing database, to obtain their academic and bibliometric profiles. Fellow profiles were confirmed by cross-referencing their name, residency program, medical school, and geographic location with publicly available information from departmental websites, LinkedIn®, and Doximity, Inc. profiles. Additional information collected for each fellow included fellowship year and sex. Fellows were excluded if their information could not be confirmed.

After confirmation, the total number of publications published or accepted up to December 31st of the year prior to the applicant's match year were included in the analysis to reflect the resident's research profile during their fellowship application cycle. Research experiences such as abstracts, presentations, letters, and posters were excluded from the analysis. The number of citations from each publication was likewise totaled to include only those within the date parameters.

Each publication was examined to determine authorship position and focus of the publication. Total number of publications, citations, and fellows and mean number of publications, citations, and *h*-index per fellow were calculated by program region, fellowship year, and fellow sex. The *h*-index is a metric used to quantify an individual's scientific research output. This was calculated as the number of publications (*n*) that have been cited at least *n* times (Hirsch 2005) using the fellow's total number of publications and citations prior to December 31st of their match year.

RESULTS

A total of 181 spine fellows from 2018 to 2023 were identified and included in this study. Overall, there were 1,403 total publications and 20,048 citations (Table 1). Each fellow had a mean of 7.9 ± 10.6 publications and 112.6 ± 226.0 citations. The mean *h*-index per fellow was 3.9 ± 3.7 . Fellows were listed as first author in 31.5% (442/1,403) and middle author in 65.8% (923/1,403) of publications. Of the total publications, 37.2% (522/1,403) were focused on spine.

When examining research productivity trends with respect to fellowship program region, the northeast had the highest mean number of publications (11.4 ± 9.1), citations (134.3 ± 127.2), and *h*-index (5.0 ± 3.1) per fellow (Table 2). Programs in the southwest had the lowest mean number of publications (4.3 ± 2.8) and *h*-index (2.7 ± 1.2) per fellow, however, only 6 fellows were included from that region. The lowest mean number of citations per fellow (98.6 ± 148.1) was found in programs in the west.

Since 2018, there has been an increasing trend in the mean number of publications and *h*-index per fellow each year (Table 2). The mean number of publications (10.6 ± 16.4), citations (136.5 ± 321.2), and *h*-index (4.3 ± 4.3) was highest among spine fellows in the 2022-2023 match year. The total number of publications (528) and citations (6,826) was also highest among this cohort. Fellows from the 2018-2019 match year had the lowest mean number of publications (6.2 ± 8.4) and *h*-index (3.6 ± 4.5) per fellow. Although male spine fellows had a higher mean number of publications (8.2 ± 11.0), citations (116.3 ± 236.4), and *h*-index (4.0 ± 3.8) when compared to female spine fellows, only 9.4% (17/181) female spine fellows were included for analysis.

DISCUSSION

Spine fellowship is considered among the most competitive within the orthopaedic subspecialties (Ruddell, Eltorai, DePasse, et al. 2018). Although academic achievement and research are important criteria fellowship directors consider when interviewing applicants (Bernatz et al. 2021; Satin et al. 2023), quantifying standards for research productivity remain unknown. Our study analyzed research trends of recent orthopaedic spine fellows during their residency training. The number of publications, citations, and *h*-index were shown to have increased annually, both cumulatively and per fellow, over the last five years. Residents who matched into spine fellowship programs in the northeast region had the highest mean number of publications, citations, and *h*-index per fellow, whereas residents matching into spine fellowship programs in the southwest had the lowest mean number of publications and *h*-index per fellow. To our knowledge, this is the first study to investigate research trends among spine fellowship applicants.

In addition to research productivity, letters of recommendation (LORs) are considered the most important criterion in obtaining an interview for orthopaedic fellowship (Bernatz et al. 2021; Satin et al. 2023; Grabowski and Walker 2013). While these letters include subjective metrics about an applicant's skillsets, qualifications, and characteristics, they also contain objective metrics such as exam scores and research publications (Jodeh, Miller-Ocuin, Ginesi, et al. 2023). Given the increasing difficulty in matching into spine fellowship, residents may be engaging in more academic research to strengthen their LOR, accounting for the steadily increasing number of publications per fellow each match year. The inclusion of elective research years and implementation of research curricula during orthopaedic residency may also be contributing to this trend (Williams, Agel, and Van Heest 2017; Segal et al. 2006). Additionally, the rising number of research fellowships and medical students pursuing research gap years may explain why publication output is the highest in recent years, as students are engaging in research earlier in their academic careers (Cotter, Polce, Lee, et al. 2021; Bram et al. 2020; Cotter et al. 2022). Further research is needed to determine if the increasing research productivity observed in our

Table 1. Research productivity among all spine fellows

	n (%)
Total of All Fellows	
Number of Publications*	1,403
Number of 1 st Authorship Articles	442 (31.5%)
Number of Middle Authorship Articles	923 (65.8%)
Number of Articles with Spine Focus	522 (37.2%)
Number of Citations	20,048
Means Per Fellow	
Number of Publications*	7.9 ± 10.6
Number of 1 st Authorship Articles	2.5 ± 4.5
Number of Middle Authorship Articles	5.2 ± 6.9
Number of Articles with Spine Focus	2.9 ± 5.6
Number of Citations	112.6 ± 226.0
H-index	3.9 ± 3.7

*Number of publications and citations represents a fellow's research output prior to the start of their fellowship.

Table 2. Association of research productivity with fellowship program region, fellow sex, and fellowship year

	Number of Publications [n (%)]*	Number of Citations [n (%)]	Number of Fellows	Mean Publications per Fellow	Mean Citations per Fellow	h-index per Fellow
Fellowship Program Region						
Northeast	297 (21.2%)	3,493 (17.4%)	26	11.4 ± 9.1	134.3 ± 127.2	5.0 ± 3.1
Midwest	344 (24.5%)	4,999 (24.9%)	49	7.0 ± 6.4	102.0 ± 208.7	3.9 ± 3.8
Southeast	265 (18.9%)	4,275 (21.3%)	30	8.8 ± 20.0	142.5 ± 416.1	3.6 ± 5.3
Southwest	26 (1.9%)	673 (3.4%)	6	4.3 ± 2.8	112.2 ± 116.9	2.7 ± 1.2
West	471 (33.6%)	6,608 (33.0%)	70	7.0 ± 7.5	98.6 ± 148.1	3.8 ± 3.0
Fellowship Year						
2022-2023	528 (37.6%)	6,826 (34.0%)	50	10.6 ± 16.4	136.5 ± 321.2	4.3 ± 4.3
2021-2022	239 (17.0%)	2,464 (12.3%)	33	7.2 ± 5.7	74.7 ± 80.7	4.0 ± 2.8
2020-2021	215 (15.3%)	3,108 (15.5%)	30	7.2 ± 7.1	103.6 ± 134.7	3.9 ± 2.9
2019-2020	240 (17.1%)	4,225 (21.1%)	37	6.7 ± 7.1	117.4 ± 186.7	3.8 ± 3.7
2018-2019	181 (12.9%)	3,425 (17.1%)	31	6.2 ± 8.4	118.1 ± 267.1	3.6 ± 4.5
Fellow Sex						
Male	1,314 (93.7%)	18,730 (93.4%)	164	8.2 ± 11.0	116.3 ± 236.4	4.0 ± 3.8
Female	89 (6.3%)	1,318 (6.6%)	17	5.2 ± 4.3	77.5 ± 88.6	3.4 ± 2.6

*Number of publications and citations represents a fellow's research output prior to the start of their fellowship.

study is a consequence of increasing competitiveness of the spine fellowship application process.

Our study also identified key differences in publication output by U.S. region, with spine fellowship programs in the northeast having the highest and programs in the

southwest having the lowest mean number of publications per fellow. According to the Blue Ridge Institute for Medical Research, among the top 25 NIH funded medical schools, most programs were located in the northeast region, with only one program located in the southwest region ("BRIMR Rankings of NIH Funding in 2022" 2022). Previous research in academic medicine has highlighted the importance of National Institutes of Health (NIH) funding and research productivity (Colaco et al. 2013; Svider et al. 2013; Itagaki and Pile-Spellman 2005). Within orthopaedic surgery, Campbell et al. analyzed publication rate by institution and found that programs affiliated with departments in the top 25 for NIH funding had the greatest number of publications (Campbell, Gupta, and Avedian 2016). Similarly, DeFroda et al. found that orthopaedic sports medicine fellows from programs located in the northeast region had the highest mean number of publications (DeFroda et al. 2018). In addition to NIH funding, other factors such as the distribution of academic institutions in the U.S., research productivity of orthopaedic faculty, and the presence of research fellows should also be considered as potential contributors to regionality differences in publication output. Additionally, our study found that females comprised 9.4% of our cohort. Although Bratescu et al. found that only 4% of orthopaedic spine surgeons are women (Bratescu, Härtl, and Berger 2024), this difference may be accounted for by recent programs, such as the Perry Initiative, to increase female representation among orthopaedic surgeons (Scerpella et al. 2022; Buckley, Dearolf, and Lattanza 2022).

Our study is subject to the limitations characteristic of all bibliometric retrospective analyses. The data collected in this study is restricted to the information publicly available on the spine fellowship websites. Fellows absent from the fellowship websites or those whose academic profiles could not be confirmed were omitted from the analysis, impacting our overall sample size. Moreover, websites with available fellow names may only represent the most competitive or prestigious institutions that place greater emphasis on research activities. Second, although the data was collected in accordance with specific date parameters to best reflect the research profile of a spine fellow during

their residency training, discrepancies in time to publication between journals may misclassify publications as those being completed during fellowship rather than residency. Third, the greatest increase in academic productivity was observed from 2020 to 2022, which may have been a result of the COVID-19 pandemic halting elective procedures and encouraging academic productivity, rather than due to broader longitudinal trends. Additionally, this study did not account for differences in length of training or time spent during research years. Finally, the Scopus database only lists research published within their registry of indexed journals, potentiating the risk of uncaptured publications. Numerous studies, however, have utilized the Scopus database to provide complete bibliometric profiles for analysis of research trends within orthopaedic surgery (Vishwanathan et al. 2021; Lieber et al. 2019; Lefaiivre, Shadgan, and O'Brien 2011; Siegel et al. 2020). Despite these limitations, this study is valuable in that it is the first to quantify and characterize research trends among residents applying into orthopaedic spine fellowships in the United States.

The overall number of publications of residents applying into orthopaedic spine fellowship has been steadily increasing in recent years. Spine fellows in programs located in the northeast region of the United States had the highest mean number of publications, citations, and *h*-index per fellow, and fellows in the southwest region having the lowest. Understanding these research trends can help residents gauge their competitiveness in applying for orthopaedic spine fellowships in certain U.S. regions. Institutional efforts should continue to be made to increase transparency of admissions criterion needed to successfully match into spine fellowship programs.

DECLARATION OF CONFLICTING INTERESTS

The Authors declare that there is no conflict of interest.

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