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Research Article

Discrepancies in Publication Volume Per Matched-Applicant Between Sex, Geographic Regions and Program Affiliation in the 2023 Orthopaedic Surgery Residency Match

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Abstract

Objective: This study aims to examine potential gender-based publication disparities among 2023 orthopaedic surgery matched-applicants, investigate variations in research emphasis based on program affiliation and assess publication differences across different geographic regions.

Methods: Orthopaedic surgery residency programs participating in the 2023 NRMP with a publicly available incoming resident class were identified using the NRMP database. Each resident was searched using PubMed and ORCID identifiers for publications. Each program was designated as "university-based", "community-based", "community-based/university affiliated" or "other" using the American Medical Association's FRIEDA database.

Results: In total, 763 residents were identified with a mean and median number of publications of 6.1 (SD=10.0) and 3.0 (IQR=1.0-7.0) respectively. There was no significant difference in the median number of publications between males (2.0) and females (3.0, p=0.2315). Those who matched to "community-based/university affiliated" (median=2.0) programs had a lower median number of publications than those who matched to "university-based" (median=3.0, p<0.0001) or "other" (median=6.0, p=0.0006). Geographically, applicants in the West-South Central region (median=1.0) had the lowest publication median compared to those in the New England (median=4.0, p=0.0010) or Pacific (median=4.0, p=0.0015) regions.

Conclusion: There lies a perceived increase in significance of research publications for competitiveness in the orthopaedic surgery match. This largely follows the elimination of objective Step-1 scoring to help stratify potential applicants. Research remains an objective manner to stratify applicants; however, new data lacks on recent analysis of the 2023 match pool. There was not a significant difference in the number of publications between male vs female matched-applicants. The program category "other" and the New England and Pacific regions had the highest median number of publications.

Keywords: Orthopaedics; Medical Residency; Graduate Medical Education; Medical School; Residency Match; Orthopaedic Education; Orthopaedic Residency

Introduction

Orthopaedic surgery consistently has more applicants applying for residency training than available residency spots. Between 2013 and 2022, the percentage match rate for orthopaedic surgery was 80% for allopathic (MD) medical applicants and 70% for all medical graduates [1]. The transition of the United States Medical Licensing Examination (USMLE) Step 1 to pass/fail rather than numerical scores give students one less opportunity to objectively stratify themselves in the already competitive orthopaedic surgery residency match. This places a greater emphasis on other aspects of the application, such as research experience, letters

of recommendation, USMLE Step 2 scores and community involvement, among other factors. Additionally, a 2018 study reported a statistically significant difference in match rates between males and females (70.3% and 67.1% respectively, $p<0.0191$), prompting further evaluation of specific application discrepancies noted between an applicant's sex and/or gender [2].

While the National Resident Matching Program (NRMP) provides data on the mean number of research experiences orthopaedic surgery applicants report on their applications, there is limited information on how the research output of an applicant influences where they match. Previous studies have investigated how an applicant's number of publications may lead to matching at a program with a higher research productivity [3,4]. However, none have investigated the relationship between geographic regions, program affiliation types and males vs females.

The purpose of this study is to identify if a discrepancy exists in the quantity of publications between males and females matching into orthopaedic surgery, if programs closely affiliated to university medical centers match applicants with greater research experience and whether significant disparities exist in the quantity of publications between geographical regions. It is expected that males, programs more closely affiliated with universities and geographic regions with populated city concentrations would be associated with a greater number of publications.

Material and Methods

All orthopaedic surgery residency programs participating in the 2023 NRMP were identified using American Medical Association's Fellowship and Residency Electronic Interactive Database Access (AMA FRIEDA) [5]. Each program's website and social media pages were searched for a publicly available announcement of the incoming 2023 intern class, where photos and listed names associated with each incoming resident were used to determine their sex (male vs. female).

The individuals in each 2023 incoming class were searched using PubMed and Open Researcher and Contributor ID (ORCID) identifiers between June 2023 and July 2023. To be counted as a publication, the following criteria were met:

1. The project must have been published within the last 10 years
2. The individual must be listed as an author or contributor on the PubMed page
3. The published affiliation must match the graduate or undergraduate institution of the individual or be orthopaedics-focused in subject matter. The projects were not differentiated based on type of publication. Articles, abstracts, letters to the editor, responses to letters to the editor and any other works associated with a PubMed ID were included

Each program was designated as "university-based", "community-based", "community-based/university affiliated" or "other" using the American Medical Association's FRIEDA database [5]. Geographic regions were established using Centers for Disease Control and Prevention (CDC) guidelines.

All statistical analyses were performed using SAS 9.4. Descriptive statistics on all variables were determined. Statistical significance was assessed using an alpha level of 0.05. For the number of PubMed publications, descriptive statistics [mean, standard deviation, median and Interquartile Range (IQR)] were determined by sex, institution type and region. Due to the skewed and ordinal nature of the number of publications, nonparametric methods were used. To examine differences in PubMed publications by sex, institution type and region, Kruskal-Wallis tests were used with post hoc pairwise comparisons performed using the Dwass-Steel-Critchlow-Fligner method. To examine whether there was sex by region differences in the number of PubMed publications, a two-factor analysis of variance on the ranks of the number of PubMed publications was performed. A Tukey-Kramer multiple comparison procedure was used to examine differences by sex within different regions.

Results

In total, 763 of 899 (85%) residents were identified with a mean number of publications of 6.1 (SD=10.0) and a median of 3.0 (IQR=1.0-7.0). We were unable to identify the remaining 15% of residents due to the absence of publicly available match announcements for their respective programs. Of the 763 residents, 26% of the individuals were female, 69% matched to a "university-based" hospital and the Middle Atlantic (24%), South Atlantic (16%) and East North Central (15%) regions had the highest percentages of matched residents (Table 1).

There was no significant difference in the median number of publications between males (2.0) and females (3.0, p=0.2315). Those who matched to "community-based/university affiliated" programs (median=2.0) had a significantly lower median number of publications than those who matched to a "university-based" (median=3.0, p<0.0001) or "other" program (median=6.0, p=0.0006). Similarly, those who matched to a "community-based" program (median=2.0) had a significantly lower median number of PubMed publications than those who matched to a "university-based" (p=0.0009) or "other" (p=0.0004) program. In regard to regional differences, applicants who matched in the West South-Central region (median=1.0) had a significantly lower median number of publications than those who matched in the New England (median=4.0, p=0.0010) or Pacific (median=4.0, p=0.0015) regions. Those who matched in the East South-Central region (median=2.0) had a significantly lower number of PubMed publications compared to the New England region (p=0.0207) (Table 2). There was no statistically significant correlation between region and sex. Additionally, there were no statistically significant differences between males and females when stratified by region (Table 3).

Variable	Level	Matched Applicants
Sex - n (%)	Female	202 (26.5)
	Male	561 (73.5)
Institution Type - n (%)	University Based	523 (68.6)
	Community Based with University Affiliation	176 (23.1)
	Community Based	49 (6.4)
	Other	15 (2.0)
Region - n (%)	New England	49 (6.4)
	Pacific	84 (11.0)
	Mountain	29 (3.8)
	West South Central	87 (11.4)
	East South Central	35 (4.6)
	South Atlantic	123 (16.1)
	Middle Atlantic	181 (23.7)
	East North Central	118 (15.5)
	West North Central	57 (7.5)
Number of PubMed Publications - mean (SD), Median (Q1-Q3)		6.1 (10.0) 3.0 (1.0-7.0)

Table 1: Descriptive statistics on all variables.

Variable	Level of Variable	Number of Publications		c2 statistic	p-value
		Median	Q1-Q3		
Sex	Female	3.0	1.0-7.0	1.43	0.2315
	Male	2.0	1.0-7.0		
Institution Type	University	3.0	1.0-8.0	44.80	<0.0001
	Community with University Affiliation	2.0	0.0-4.0		
	Community	2.0	0.0-3.0		
	Other	6.0	3.0-10.0		
Region	New England	4.0	2.0-9.0	31.40	0.0001
	Pacific	4.0	1.0-12.0		
	Mountain	2.0	1.0-8.0		
	West South Central	1.0	0.0-4.0		
	East South Central	2.0	1.0-4.0		

	South Atlantic	2.0	1.0-6.0		
	Middle Atlantic	3.0	1.0-9.0		
	East North Central	3.0	1.0-5.0		
	WestNorth Central	3.0	1.0-6.0		

Table 2: Kruskal-Wallis tests for differences in PubMed publications by sex, institution type and region.

Effect	Level of Region	Sex	Median	Q1-Q3	F Statistic	p-value
Region x Sex	New England	Male	4.0	2.0-8.0	1.09	0.3666
		Female	5.0	3.0-23.0		
	Pacific	Male	3.0	1.0-10.0		
		Female	6.0	3.0-18.5		
	Mountain	Male	2.0	1.0-10.5		
		Female	5.0	0.0-5.0		
	West South Central	Male	2.0	0.0-3.0		
		Female	1.0	1.0-5.0		
	East South Central	Male	2.0	1.0-4.0		
		Female	2.0	1.0-2.0		
	South Atlantic	Male	2.0	1.0-7.0		
		Female	3.0	1.0-5.0		
	Middle Atlantic	Male	3.0	1.0-9.0		
		Female	3.0	0.0-8.0		
	East North Central	Male	3.0	1.0-6.0		
		Female	3.0	1.0-5.0		
	West North Central	Male	3.0	1.0-6.0		
		Female	5.0	2.5-7.0		

Table 3: GLM* on ranks of number of PubMed publications by region and sex.

Discussion

Orthopaedic surgery remains one of the most competitive residency specialties. A 2022 study by Martinez, et al., found that orthopaedic surgery applicants ranked 35% higher on a normalized competitive index than the average applicant for the 2022 match, with an upward trend between 2013 and 2022 [1]. This trend of increasing competitiveness for matching into orthopaedics is also evident by the declining match rates in recent years [6]. As more qualified orthopaedic applicants continue to fail to match in recent years, the necessity of objective measurements of potential applicants has increased. Research output, reported on the NRMP application, includes publications, abstracts and posters. Between 2007 and 2021 the research output of orthopaedic surgery applicants has reportedly quadrupled [1]. Even comparing 2018 to 2022, there is an upward trend in the number of reported projects from 11.5 in 2018, to 14.3 in 2020 and further increasing to 16.5 in 2022 [7]. It is important to note that while these numbers are high, they are self-reported and a wide variety of projects regarded as "research" leaves room for misrepresentation [8].

Further investigation of the published research output of applicants was performed for the 2017 orthopaedic surgery match, which found the average number of published works to be 1.6 [3]. The study additionally examined how research output correlated between applicants and residency programs, where residency programs with greater research output matched applicants with higher numbers of published works [3]. This is consistent with the findings of our study, as we observed programs classified as "other" (median=6.0) or "university-based" (median=3.0) matched applicants with significantly higher median numbers of publications than "community-based" (median=2.0) or "community-based/university-affiliated" (median=2.0) programs.

No prior literature exists on how research productivity differs between applicants matching into orthopaedic residency programs of different geographic regions. Our study found that the New England and Pacific regions had the highest median number of publications (New England & Pacific median=4.0). Both regions had a higher median number of publications than the West South-Central region (median=1.0, vs New England p=0.0010, vs Pacific p=0.0015). Further investigation was conducted to determine if "university-based" or "other" type programs constituted a higher proportion in these regions. We found that while New England had the highest fraction of "university-based" programs (100%), the Pacific region had the lowest fraction (47%) of all regions. While this may suggest that the increased median number of publications in New England is to be attributed to the higher concentration of university-based programs, this does not hold true for the Pacific region, as it had the lowest rate of "University-based" programs, but had the highest number of median publications.

Orthopaedic surgery remains a specialty with notably low female representation, comprising only 18.3% of active orthopaedic surgery residents as reported by the AAMC for the 2021-22 year [9]. One study published by the American Academy of Orthopaedic Surgeons investigated 12 prominent orthopaedic journals, revealing an upward trend in female authorship between 2011 and 2020 for female first authors [10]. However, this increase was not observed among female last authors or in the overall total number of authors, maintaining a persistently imbalanced ratio.

Acknowledging female underrepresentation with fewer opportunities historically available to females, one may suggest that this gender disparity could influence opportunities for research experience. To assess this, the study examined the variation in the number of publications among orthopaedic surgery applicants based on their sex, assuming that males would possess a higher volume of publications. The study's identified residents were 26.5% female and 73.5% male and notably, there was no significant disparity in the median number of publications based solely on sex. The interquartile ranges revealed that both females and males exhibited similar values, ranging between 1 and 7 publications (Fig. 1).

An additional finding of this study indicated that there is no statistically significant difference in the median number of research publications based on the stratification between region and sex. When examining each region individually, there were no statistically significant discrepancies between male and female median numbers of publications, suggesting a consistent pattern across different regions. Two out of nine regions, Pacific and New England, stood out due to their relatively wide interquartile ranges within the female category, spanning from 3 to 18.5 and 3 to 23, respectively, suggesting greater variability in the number of publications for incoming residents of these regions.

A limitation of this study is the absence of a definitive means to accurately ascertain the subjects' gender. This study does not address the complex differences between gender and sex, highlighting the importance of future research adopting a more comprehensive approach to account for these nuanced factors. While imperfect, our method of discerning sex based on photos and names has been utilized in previous studies examining trends of females entering the field of orthopaedics [11,12]. Additionally, not all programs had publicly available incoming resident classes. Of the 208 noted orthopaedic surgery residency programs, 34 presented with no information of their 2028 class; however, our data represents 85% of the incoming orthopaedic surgery residents, allowing us to still draw credible conclusions. Another consideration is that programs were classified based on FRIEDA's "program type" descriptions which did not delineate military and osteopathic recognition programs but rather focused on institutional affiliations. Further limitations include the use of name variations (nicknames) in residency class announcements. In order to account for this discrepancy, we constructed a protocol using publication year, institutional affiliation and ORCID identifiers to ensure works accurately belonged to the individuals in each class. Moreover, the research type and quality were not analyzed. While all of the projects were required to be on PubMed and have the individual listed as an author or contributor, the impact factor of the journal within which the work was published was not reviewed. Additionally, individuals who took one or more gap years to participate in research-focused work created outliers in the data set, prompting the use of non-parametric statistical analysis. Future research should examine other factors, aside from simply the median number of articles published, to determine if differences in gender exist.

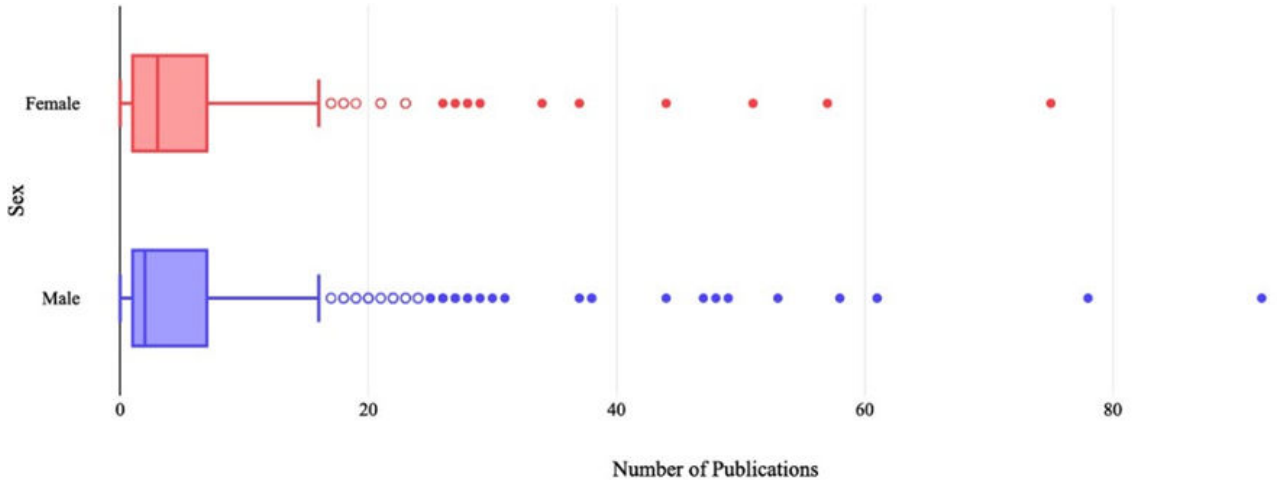

Figure 1: Sex-based distribution of PubMed publications among 2023 matched orthopaedic surgery applicants. [Females: n=202, min=0, Q1=1, median=3, Q3=7, max=75. Males: n=561, min=0, Q1=1, median=2, Q3=7, max=92].

Conclusion

Overall, our study found that of 763 matched orthopaedic surgery residents in 2023, the average number of published works on PubMed is 6.1. There was not a significant difference in the number of publications between male vs female matched-applicants. Programs classified as "university-based" or "other" had the highest median number of publications compared with "community-based" programs. The New England and Pacific regions had the highest median number of publications per matched applicant and the West South-Central region had a significantly lower median number.

Conflict of Interests

The author has no conflict of interest to declare.

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