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Permalink

Journal

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Publication Date

2024

DOI

Copyright Information

Peer reviewed

AMERICAN
ORTHOPAEDIC
ASSOCIATION
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1887

AOA Critical Issues in Education

Contemporary Trends in the Orthopaedic Surgery Residency Match and the Effects of COVID-19

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Objective: We aimed to elucidate associations between geographic location, size, and ranking of medical schools that orthopaedic surgery residents graduate from and the residencies that they match both pre–COVID-19 and post–COVID-19 pandemic by examining the 2017 to 2022 orthopaedic surgery residency cohorts.

Methods: Demographics were extracted using Doximity Residency Navigator platform, the 2021 US News and World Report, and program websites. Medical schools were classified as large if they had >613 medical students. Postgraduate year 1 (PGY-1) (2021 match) and PGY-2 (2022 match) residents were classified as the COVID-19 cohort. Location was categorized as Northeast, Midwest, South, and West. Chi-square tests, Cohen's H value, and descriptive statistics were used for analysis with statistical significance set at $p < 0.05$.

Results: Four thousand two hundred forty-three residents from 160 accredited US orthopaedic residency programs (78.4%) were included. Northeastern applicants were most likely to match in the same region ($p < 0.01$), and southern applicants were most likely to match at their home program ($p < 0.001$). Applicants affected by the COVID-19 pandemic did not differ from their predecessors with regards to matching to the same region ($p = 0.637$) or home program ($p = 0.489$). Applicants from public medical schools were more likely to match in the same region and at their home program ($p < 0.001$), whereas those from private medical schools were more likely to match at top-ranked residencies ($p < 0.001$). Students from both top 25- and top 50-ranked medical schools were more likely to match at their home program ($p < 0.01$) and attend top 20-ranked residency programs ($p < 0.0001$).

Conclusion: These results demonstrate significant associations between matched residencies and attended medical schools' geographic location, school type, and ranking. During the pandemic, geographic trends were overall unchanged, whereas residents from large or lower-ranked schools were more likely to match at home programs, and those from private or top-ranked schools were less likely to attend top residencies.

Introduction

Orthopaedic surgery is one of the most competitive fields to successfully match into across all medical specialties. In the midst of a steady rise in number of applicants since 2008, there has been little change in the number of US orthopaedic residency program spots, making this match process extremely

competitive[1]. Results from the recent 2022 Main Residency Match showed that only 60% of applicants successfully matched as a postgraduate year 1 (PGY-1) into an orthopaedics residency[2], despite an average of 72 program applications per applicant[3]. With increasingly selective match rates, it is important to understand current characteristics of a successful US orthopaedic surgery residency application.

Traditional factors impacting the match have included student metrics and evaluation systems (e.g., test scores, grades, honors, research publications, and letters of recommendation), program metrics (e.g., geography, ranking, size, and culture), and away rotations[4]. However, since 2020, the orthopaedic surgery residency match landscape has significantly changed. COVID-19 disrupted limited traditional in-person interactions between programs and applicants[5].

Because of the increasingly competitive match and the uncertainty of the current residency match climate, an investigation of current prematch and postmatch factors can be valuable for applicants and programs. A 2018 geographic trends analysis for orthopaedic residency programs found strong associations between the regions where residents lived, went to medical school, and matched for residency training, especially for those in the Pacific and Mid-Atlantic regions[6]. Similarly, another study found a significant relationship between the ranking of residents' medical schools and their matched orthopaedic programs[7]. Other studies found correlations between medical school prestige and location in neurosurgery[8] and otolaryngology program placement[9], respectively. To date, there are no studies that have investigated both the relationship between geographic location and ranking for medical schools and residency programs in the orthopaedics match.

In this cross-sectional study of the 2023 match cycle, we examined the effects of COVID-19 on the associations between geographic location, size, funding source, and ranking of the medical schools attended by current residents as well as the residency programs these current orthopaedic surgery residents are enrolled in.

Methods

Approval from the University of California, Irvine Institutional Review Board was not required because of lack of patient involvement and public accessibility of requisite data. All data were obtained from April 2022 to May 2022 except the 2022 to 2023 cohort, which was obtained in October 2023. A list of accredited US orthopaedic surgery residency programs was obtained from the American Medical Association Fellowship and Residency Electronic Interactive Database[10]. Data were collected for a total of 4,243 residents from accredited US orthopaedic surgery programs. Using program websites and residency rosters listed online, we recorded each resident's program name, program location, program size, current year of training, and the medical school that they attended and categorized the collected demographics based on research ranking, program size, and region.

Residency program research rankings were extracted from the Doximity Residency Navigator platform[11], and programs were sorted into 2 categories: "top 20" and "others." Medical school size, funding source, and research rankings were based on the 2023 US News and World Report (USNWR)[12]. As with residency programs, medical schools were separated into "top 25" vs. "other" and "top 50" vs. "other." The median medical school size was determined to be 613 students, and schools were additionally classified as large (>613) or small (≤613). PGY-1 and PGY-2 residents in the 2021 to 2022/2022 to 2023 cohorts were classified as the COVID-19 cohort, meaning that the pandemic potentially altered the match process for these residents when they were applying for orthopaedic surgery residency. The locations of residency programs and medical schools were categorized into 4 regions defined by the US Census Bureau: Northeast, Midwest, South, and West[13].

Our exclusion criteria included residents/programs missing data and international students. Chi-square tests, Cohen's H, and descriptive statistics were used for analysis with a statistical significance set at $p < 0.05$.

Results

Overview

Overall, 160 of 204 accredited US orthopaedic residency programs and the 4,243 residents from those programs were included in this study. There were 72 international medical graduates excluded.

Overall Geographic Trends

Of the 4,243 residents in the study, 1,153 (27%) attended medical school in the Midwest, 1,337 (32%) in the Northeast, 1,202 (28%) in the South, and 551 (13%) in the West. Those from the Northeast were the most likely to match in the same region as their medical school at a rate of 68% ($p < 0.01$, Table I). Medical students in the Midwest and South were also likely to match in their medical school's region, although at a lower rate than those from the Northeast ($p < 0.01$, Table I), with rates of 63% and 61%, respectively ($p < 0.01$, Table I). Significantly fewer students from the West matched into residencies in the West with a rate of 53% ($p < 0.01$, Table I).

In addition, those from the South were significantly more likely to match at their home program with a rate of 24% ($p < 0.001$, Table I), whereas students from the Midwest, Northeast, and West were equally likely to match at their school's home program, with an average rate of ~18% ($p > 0.50$, Table I).

These geographic associations were not significantly different between the pre–COVID-19 cohort and the COVID-19 cohort ($p = 0.634$).

Overall Associations Between Residencies and Medical School Characteristics

Of the included residents, 1,768 (41%) attended a private medical school, and 2,475 (59%) attended a public medical school. Residents from public medical schools were significantly more likely to match in the same region ($p < 0.001$, Table II) and at their home program ($p < 0.001$, Table II). In comparison, graduates from private medical schools were more likely to match at top-ranked residencies ($p < 0.001$, Table II).

TABLE I Geographic Associations Between Medical School and Residency Program				
	Residency Program Region			
Medical School Region	Midwest	Northeast	South	West
Midwest (n = 1,151)	692 (60%)	159 (14%)	221 (19%)	79 (7%)
Northeast (n = 1,337)	169 (13%)	871 (65%)	209 (16%)	88 (7%)
South (n = 1,202)	159 (13%)	139 (12%)	860 (72%)	44 (4%)
West (n = 553)	102 (18%)	113 (20%)	103 (19%)	235 (43%)
Same Medical School	215 (19%)	242 (18%)	290 (24%)	98 (18%)
Not same medical school	936 (81%)	1,095 (82%)	912 (76%)	455 (82%)

Two thousand eight hundred forty-three (67%) of the residents came from large medical schools, and 1,400 (33%) came from small medical schools (large >613 students or small ≤613 students). Residents from large medical schools matched more frequently at their home program (21% vs. 17%, p <0.001). Medical school size was not found to be significantly associated with matching in the same region or matching at a top-ranked residency (p >0.05).

There were 670 (15%) residents who obtained their medical degree from a top 25 medical school and 1,463 (35%) from a top 50 medical school. Students from the top 25 medical schools were more likely to match at their home program (p <0.01, Table II), whereas those from the top 50 were more likely to match at their home program and at their home region (p <0.05, Table II). In addition, those who attended top 25 or top 50 medical schools were significantly more likely to attend residency programs ranked in the top 20 (p <0.0001, Table II).

Most notably, more than 40% of residents in the top 20 residency programs were from the top 25 medical schools.

Associations Before and After the COVID-19 Pandemic

There were 2,884 (68%) residents in the pre–COVID-19 cohort and 1,359 (32%) residents in the COVID-19 cohort. Residents in the COVID-19 cohort matched to their home region 62% of the time and home medical school 19% of the time. This was not significantly different from the overall rate of their predecessors who matched 63% of the time in the same region (p = 0.637, Table II) and 20% of the time to their home program (p = 0.489, Table II). Associations between residencies and medical school characteristics were broken down by cohort in Table III. During the COVID-19 pandemic, residents from large programs were more likely to match in their home region (70% vs. 60%, p <0.001). The COVID-19 cohort who attended private schools were less likely to match at their home program (15% vs. 25%

TABLE II Overall: Associations Between Residency Program and Characteristics of Medical Schools			
Medical School Characteristics	Same Region	Home Medical School	Top Residency
Private	1,013 (57%)	270 (15%)	388 (22%)
Public	1,626 (66%)	575 (23%)	297 (12%)
p	**<0.001**	**<0.001**	**<0.001**
Large	1794 (63%)	608 (21%)	495 (16%)
Intermediate	858 (61%)	237 (17%)	190 (16%)
p	0.250	**<0.001**	0.778
Top 25	385 (59%)	154 (24%)	270 (42%)
Not top 25	2,263 (63%)	691 (19%)	415 (12%)
p	0.076	**0.008**	**<0.001**
Top 50	882 (60%)	371 (25%)	359 (24%)
Not top 50	1,766 (64%)	474 (17%)	326 (12%)
p	**0.030**	**<0.001**	**<0.001**
COVID	842 (62%)	253 (19%)	—
pre-COVID	1806 (63%)	562 (20%)	—
p	0.637	0.489	—
Bold text indicates statistical significance.			

p < 0.001). Those who attended large schools (24% vs. 18% p <0.01) or those outside the top 25 (21% vs. 18% p = 0.037) were more likely to match at their home program. In the COVID-19 cohort, attending a private school (18% vs. 23%, p = 0.017), small school (16% vs. 25%, p = 0.011), top-25 school (33% vs. 46%, p = 0.002), and top-50 school (22% vs. 30%, p = 0.002) were less associated with matching at top residency than pre–COVID-19. All effect sizes from direct comparisons and associated p values are displayed in Table IV.

Discussion

Medical students and residency programs alike are facing unique challenges when it comes to "the match" process. The past 3 years have seen significant changes to the application landscape including the COVID-19 pandemic. Traditional parameters for the applicant screening process have focused on student evaluation, program metrics, and away rotation performance[14].

The COVID-19 pandemic caused many programs to interview virtually, and currently, there are no recommendations to return to in-person interviews[15]. Although this may be convenient and equitable by alleviating financial pressures associated with interviews, it could also reduce the ability of programs to gauge each candidate's "soft-skills." Furthermore, the applicants with higher objective metrics may attend a greater number of interviews in the virtual format, which may afford fewer interview opportunities for others[15].

Despite the combined simultaneous uncertainty of a global pandemic and changes in standardized examination scoring system, both the geographic location of the resident's medical school education and the ranking of their school are important factors in determining where they will match. Although it is difficult to estimate the importance of the personality characteristics and social competency of a student's residency application, comparable metrics such as US Medical Licensing Examination Step 2, clerkship scores, and research profiles may be increasingly important in the post-pandemic residency match landscape. The current analysis

	TABLE III COVID-19 and Pre–COVID-19 Cohort Breakdowns: Associations Between Residency Program and Characteristics of Medical Schools			
Cohort	Medical School Characteristics	Same Region	Home Medical School	Top Residency
COVID-19	Private	340 (57%)	92 (15%)	110 (18%)
	Public	502 (66%)	191 (25%)	77 (10%)
	p	**p = 0.001**	**p < 0.001**	**p < 0.001**
	Large	403 (70%)	137 (24%)	34 (6%)
	Not large	124 (68%)	30 (16%)	29 (16%)
	p	p = 0.593	**p = 0.043**	**p < 0.001**
	Top 25	128 (57%)	46 (21%)	73 (33%)
	Not top 25	714 (63%)	237 (21%)	114 (10%)
	p	p = 0.145	p = 1	**p < 0.001**
	Top 50	291 (60%)	126 (26%)	106 (22%)
	Not top 50	551 (63%)	157 (18%)	81 (9%)
	p	p = 0.329	**p < 0.001**	**p < 0.001**
Pre–COVID-19	Private	673 (57%)	178 (25%)	278 (23%)
	Public	1,133 (66%)	384 (22%)	220 (12%)
	p	**p < 0.001**	**p < 0.001**	**p < 0.001**
	Large	570 (60%)	175 (18%)	2 (0%)
	Not large	673 (63%)	178 (19%)	278 (25%)
	p	p = 0.160	p = 0.461	**p < 0.001**
	Top 25	257 (60%)	108 (25%)	197 (46%)
	Not top 25	1,549 (63%)	454 (18%)	301 (12%)
	p	p = 0.296	**p = 0.001**	**p < 0.001**
	Top 50	591 (60%)	245 (25%)	294 (30%)
	Not top 50	1,215 (63%)	317 (16%)	204 (10%)
	p	p = 0.068	**p < 0.001**	**p < 0.001**

Bold text indicates statistical significance.

TABLE IV Direct Comparison of Association Effect Sizes (Cohen's H) Between Pre–COVID-19 and COVID-19 Cohorts			
Group	Same Region (p)	Home Medical School (p)	Top Residency (p)
Private	0.001 (1)	**0.252 (<0.001)**	**0.124 (0.017)**
Public	0 (1)	0.071 (0.112)	0.064 (0.162)
Large	**0.209 (<0.001)**	**0.147 (<0.01)**	N/A (N/A)
Not large	0.108 (0.214)	0.080 (0.381)	**0.224 (0.011)**
Top 25	0.064 (0.487)	0.095 (0.300)	**0.267 (0.002)**
Not top 25	0 (1)	**0.076 (0.037)**	0.064 (0.088)
Top 50	0 (1)	0.023 (0.732)	**0.183 (0.002)**
Not top 25	0 (1)	0.053 (0.204)	0.034 (0.437)

Bold text indicates statistical significance.

examines how geography, the COVID-19 pandemic, medical school funding source, school size, and school ranking have affected the orthopaedic surgery residency match.

Geographic Region

In this 2023 cross-sectional study of 4,243 US orthopaedic surgery residents, geographic associations were found between medical school attended and current residency training program. Historically, applicants have generally matched into residency programs within the same US census division as their medical school[15]. The percentage of medical students matching to their home program and/or home region for orthopaedic surgery residency remained relatively unaffected by the COVID-19 pandemic.

Notably, the proportion of applicants who matched into their home region was significantly lower for medical students in the West. We hypothesize that a possible explanation of this trend is differences in inherent class attributes of medical schools in various geographical regions. Medical schools differ in acceptance rates of out of state applicants, and, for example in the south where the highest percentage of students match in the same region, Texas state schools are required to accept 90%+ of in-state applicants[16,17]. Thus, future studies must assess medical school class attributes as a possible explanation of residency match trends.

Completing away rotations and networking with program faculty are important during the match process[18]. Many candidates complete away rotations in areas where they wish to signal their geographic interest such as their hometown. Away rotations can increase the applicant's chances of getting into their desired residency program, especially if the applicant shows that they are a good fit clinically and personally within the existing group of residents. Given the decreases in away rotations because of pandemic related restrictions, one might expect an increase in home program match rates. Regionally, the pandemic era "home program" match rate of 23% (for current PGY-1 and PGY-2 residents) is higher trend than the prepandemic "home program" match rate of 18% in the Midwest, Northeast, and West (p > 0.05). Although we did

not find this statistically significant, it indicates the potential impact of the away rotation in the match process and the power that applicant familiarity has on program directors and resident selection committees through intangibles such as soft skills[5,18].

Medical School Attributes

Residents from private medical schools are more likely to match at large residencies and top-ranked programs, whereas residents graduating from public medical schools are significantly more likely to stay in the same region as their medical school and match to their home program. As the match process is highly self-selective, personal factors such as hometown, whether one resonates with the mission statements of the residency program, and finances strongly impact the preferences of an applicant.

There were no significant findings correlating medical school size and matching in the same region, matching at a home program, matching at a large residency, or matching at a top-ranked residency. Medical school ranking was not associated with an applicant matching in the same or different geographic region, but it did show that students from both top 25- and top 50-ranked medical school programs are more likely to match at their home program and match to residency programs ranked in the top 20. These findings suggest students from a "top tier" medical school may be favored over applicants from lower tier schools. One explanation is that medical students from the highly ranked programs—which receive the highest amounts of NIH funding—can leverage greater availability of research opportunities[19-22]. This could be yet another reason why these students have better success in the match process when compared with their peers from lower ranking schools.

The Effects of COVID-19

Our study suggests that the pandemic has had nuanced effects on residency matching patterns. Although the overall rates of matching to home programs and regions remained stable, subtle yet significant differences emerged within specific categories. For instance, residents from large programs during

the COVID-19 era were more likely to match in their home region, possibly reflecting a shift toward larger, potentially better-equipped or better-funded institutions during a time of healthcare crisis.

On the other hand, residents attending private schools in the COVID-19 cohort were less likely to match at their home programs. Interestingly, residents from large schools or those outside of the top 25 rankings were more likely to match at their home programs. This could indicate a changing landscape where traditional predictors such as school ranking become less influential, perhaps because of a heightened focus on familiar opportunities in uncertain times for both applicants and programs.

Moreover, residents from top-ranked or private schools were less likely to match into top residencies during COVID-19. This could indicate a changing landscape in what is considered a "top" candidate in these unique times. These shifts could be influenced by pandemic-related constraints on away rotations and networking, warranting further study to fully grasp the pandemic's long-term effects on the match process.

Limitations

It is important to acknowledge that USNWR and Doximity are imperfect measures when it comes to analysis of school prestige. USNWR bases their ranking on subjective and pre-medical metrics that do not necessarily reflect the strength of a student's medical school education or their performance in medical school[12]. For example, USNWR's ranking includes a numerical rating by the deans of other medical schools and undergraduate grade point average. These metrics do not provide an accurate account of a medical student's performance or potential to succeed as a resident[23].

Although this study addresses several variables, it does not directly speak to the importance of applicant traits such as academic excellence, publication number, personality characteristics, personal connections, or interview success. The intangible factors not mentioned in this article such as personality and interview success likely play a crucial role in the decision-making process for selection committees. Medical education's greatest attempt to standardize applicants through measures such as Step scores or number of publications may add some predictability to the match process that is not incorporated into this analysis,

although these do not fully eliminate uncertainties in the match process. Ultimately, this is an evaluation of the residency application cycle in a dynamic and changing time. The past trends of past matches may not be strongly predictive of the coming cycles and only time will tell.

Conclusion

This study investigates the effects COVID-19 had on associations between geographic and medical school characteristics on the orthopaedic surgery match. Overall, students from top-ranked schools have a clear advantage in securing top and large residency programs as well as home program matches. Graduates from public medical schools are more likely to match in their home regions, whereas those from private schools tend to match at top-ranked residencies. Residents in the COVID-19 cohort from large or lower-ranked schools were more likely to match at home programs during the pandemic, whereas those from private or top-ranked schools were less likely to match at top residencies. These findings suggest that although traditional match factors remain influential, the pandemic introduced subtle but noteworthy changes that may have long-term implications for residency matching. ∎

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