Geographic Trends in the Ophthalmology Residency Match: Influence of Program and Applicant Characteristics

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Abstract

Introduction The ophthalmology residency match remains competitive. Several prior studies have examined various factors that contribute to a successful match into an ophthalmology residency program; however, the role of geographic location in the ophthalmology residency match process is unclear. The purpose of our study was to evaluate geographic trends in the ophthalmology residency match and to determine whether geographic trends vary based on program level factors such as program rank or funding source and/or applicant factors such as year of training, gender, and medical degree earned. Specifically, we assessed associations with residents training at the residency program affiliated with their medical school and/or within the same geographic region as their medical school, using data obtained through publicly available sources and residency program surveys.

Methods We used the American Medical Association's Fellowship and Residency Electronic Interactive Database database to identify accredited ophthalmology residency programs. Residency program Web sites and email inquiries were used to collect demographic and geographic information for residents in the graduating classes of 2021 to 2023. Statistical analysis included χ^2 testing and multivariate logistic regression.

Results In total, 1,378 residents were included from 110 ophthalmology residency programs and 218 medical schools. Residents who matched at the residency program affiliated with their medical school (18%) were evenly distributed among the Midwest, Northeast, South, and West regions ($p = 0.2236$). Residency programs in the West (31.7%) matched fewer regional medical students compared with programs in the South (61.2%), Midwest (57.4%), and Northeast (58.4%) ($p < 0.0001$). Attending a publicly funded medical school was associated with higher odds of matching into a regional residency program (odds ratio [OR], 1.45; 95% confidence interval [CI], 1.10–1.90; $p = 0.0001$) and attending a privately funded medical school was associated with higher odds of matching into a top-ranked residency program (OR, 1.53, 95% CI, 1.34–1.82; $p = 0.0002$).

Keywords
► geographic
► trends
► match
► residency
► ophthalmology

Conclusions   The majority of current ophthalmology residents trained at programs in the same geographic region as their medical schools, with nearly 20% of residents training at their medical school-affiliated program. Geographic differences in match results were observed based on resident gender, medical school characteristics, and residency program region.

The ophthalmology residency match process has become increasingly competitive in the past decade. Since 2011, the number of applications submitted per applicant has risen from 52 in 2011 to 80 in 2021.[1] Increased applications have led to greater financial and logistical burden for applicants and administrative burden for residency programs.[2] Furthermore, the steady rise in applications submitted per applicant has not yielded improved match outcomes, with the percentage of applicants matching at one of their top three ranked residency programs slightly declining in each of the past 3 years.[1]

There have been several studies that have examined the various factors that contribute to a successful match into an ophthalmology residency program. Attending an allopathic medical school, earning a high United States Medical Licensing Examination Step 1 score, strong clinical grades, and letters of recommendation from ophthalmologists have all been associated with a greater chance of matching into an ophthalmology residency program in the United States.[3] While these factors have been cited by ophthalmology residency program directors as important qualities affecting whether or not an applicant is offered an interview invitation, the role of geographic location in the ophthalmology residency match process is less clear.[4]

Geographic analyses of match outcomes in other specialties suggest that geographic location may play an important role in determining match outcomes. A study of the general surgery match indicated that nearly 25% of all general surgery residents matched at the institution affiliated with their former medical school.[5] Plastic surgery match analyses found that larger programs tended to have a higher proportion of residents matching at the program affiliated with their medical school compared with smaller programs.[6] Furthermore, geographic differences in residency match outcomes have been reported for both orthopaedic surgery and otolaryngology.[7,8]

The primary goal of our study is to evaluate geographic differences among matched ophthalmology residents based on resident and residency program characteristics—specifically to assess for associations with residents training at the residency program affiliated with their medical school and/or within the same geographic region as their medical school, using data obtained through publicly-available sources and residency program survey.

Methods

We collected data for this cross-sectional study in June 2021. We used the American Medical Association's Fellowship and Residency Electronic Interactive Database (FREIDA) database to identify all accredited ophthalmology residency programs.[9] The FREIDA database provides direct links to residency program Web sites for most programs listed. If FREIDA did not provide a direct link to an individual program Web site, a Google search was used with the parameters "[Name of Program] Ophthalmology Residency Program" to locate the appropriate residency program Web site. Residency program Web sites for all accredited ophthalmology residency programs were subsequently evaluated for residency rosters. If a residency program Web site did not list a current residency roster, programs were contacted via email by the study authors in an attempt to retrieve resident information. The approach was consistent with previously published methods.[8] The study was determined exempt by the Stanford University School of Medicine Institutional Review Board.

The FREIDA database provided a list of 123 ophthalmology residency programs.[9] Of these, 110 were included in this study based on inclusion criteria (1) availability of a roster of ophthalmology residents from the graduating classes of 2021, 2022, and 2023 (obtained from the program Web site or email inquiry to the residency program) and (2) available data on residents' medical school attended and medical degree earned. If a listing of medical schools attended was unavailable or incomplete on a residency program Web site, Google searches and social media accounts (Doximity, Twitter, and Instagram) were used to identify a given resident's medical school attended. Four military-based programs, one international residency program, and three programs without a functional Web site or active contact information were excluded from the study. Of the remaining five programs, three were new programs that did not have residents during all years included in our study and two programs neither listed a resident roster on their program Web site nor replied to the authors' email inquiries for a resident roster.

The medical school affiliation for each residency program and residency program size were obtained through the FREIDA database or from department Web sites. Medical school ranking (top 25 vs. others) and funding source (private vs. public) were classified according to the 2022 U.S. News and World Report (USNWR) rankings.[10] Residency program ranking (top 25 vs. others) was determined by the Doximity reputation rating, a metric deemed important by nearly 80% of residency applicants.[11,12] Residency programs and medical schools were categorized into four U.S. regions according to the U.S. Census Bureau: Midwest, Northeast, South, and West.[13]

In addition to medical school attended, other information gathered from program Web sites (or email inquiries) on all residents included year of training, perceived gender, and medical degree earned (Doctor of Medicine [MD] vs. Doctor of Osteopathy [DO]). Perceived gender was determined through photographs on residency program Web sites or, if photographs were not provided, through searches of resident social media accounts such as Doximity, Twitter, and Instagram. In addition to photographs, we used knowledge of commonly assigned names by gender to classify the perceived gender of residents. For example, "Robert" would be considered male gender, whereas "Mary" would be considered female gender. This methodology for classifying the perceived gender of residents is consistent with the previous literature.[14,15] Residency programs were contacted if the gender of the individual could not be identified.

All statistical analyses were performed using RStudio version 2021.09.0. Variables are presented descriptively with percentages and standard deviations. All categorical variables were compared via chi-square tests and post hoc Fisher exact tests. Two multivariable logistic models were used to estimate the effects of previously identified covariates on an applicant's odds of matching into an ophthalmology residency program (1) at their medical school-affiliated residency programs and (2) in the same region as their medical schools. The following covariates were included: residency program size, residency class year (postgraduate year PGY 2–4), medical school funding source (public or private), gender (male or female), type of medical degree (MD vs. DO), medical school region, residency program region, matriculation at a top-25 USNWR medical school (yes vs. no), and matriculation at a top-25 Doximity residency program (yes vs. no). A multivariable logistic model was also generated to estimate the effects of previously identified covariates on an applicant's odds of matching into a top-25 Doximity residency program. The following covariates were included: residency class year (postgraduate year PGY 2–4), gender (male or female), medical school funding source (public or private), type of medical degree (MD vs. DO), medical school region, and matriculation at a top-25 USNWR medical school (yes vs. no). A p-value <0.05 was considered statistically significant for all analyses.

Results

Resident and Residency Program Characteristics

Of the 123 ophthalmology residency programs included in the FREIDA database, 110 (89%) met inclusion criteria for this study and contained information on approximately 1,378 total residents in the classes of 2021, 2022, and 2023. Our final cohort included 96.8, 98.3, and 95.9% of all residents in the classes of 2021, 2022, and 2023, respectively, according to the annual Ophthalmology Residency Match Summary Report (►**Table 1**).[16] Residents from the 110 programs studied attended 218 different medical schools. ►**Table 2** displays the 20 allopathic medical schools and seven osteopathic medical schools that produced the greatest proportion of ophthalmologists among their graduates for the years

Table 1 Total match positions filled and resident information collected, graduating classes of 2021 to 2023

Year	Total match positions filled	Resident information collected	Yield
Class of 2021	462	447	96.8%
Class of 2022	475	467	98.3%
Class of 2023	484	464	95.9%

studied. More than 95% of residents earned an MD degree, while less than 5% earned a DO degree prior to residency.

Ophthalmology residents who attended USNWR top-25 medical schools were disproportionately overrepresented in our study, comprising 22.5% (310/1,378) of all ophthalmology residents despite attending only 14.5% of the 172 total allopathic medical schools in the United States.

Geographic Differences in Medical School and Residency Program Characteristics

At the medical school level, the geographic region graduating the largest proportion of ophthalmology residents was the South (33.0%), followed by the Northeast (28.4%), Midwest (25.7%), and West (12.9%). There were significant differences in the proportion of medical students from each respective region who ultimately matched into ophthalmology. Graduates of medical schools in the South (6.1%), Midwest (6.5%), and Northeast (6.2%) matched into ophthalmology at a greater frequency than medical students from the West (4.3%) ($p = 0.0003$).

At the residency program level, regional distribution of ophthalmology residents indicated a total of 421 (30.6%) residents at programs in the Northeast, 343 (24.9%) in the Midwest, 428 (31.1%) in the South, and 186 in the West (13.5%). Overall, a slight majority of residents (58.7%) were male; however, there were regional differences in the gender of residents, with Southern residency programs training fewer females (37.1%) when compared with programs in the Northeast (44.7%), Midwest (44.3%), and West (41.4%), ($p = 0.0273$) (►**Table 3**). Residency programs in the West matched a greater proportion of residents from USNWR top-25 medical schools (37.6%) when compared with residency programs in the Midwest (21.0%), Northeast (24.0%), and South (15.7%) ($p < 0.0001$). Furthermore, residency programs in the Northeast (63.4%) and the West (60.8%) trained a significantly greater proportion of residents from privately funded medical schools than programs in the Midwest (43.4%) and South (33.9%) ($p < 0.0001$) (►**Table 3**).

There were also significant regional geographic associations between residents' medical school attended and residency program attended (►**Table 4**). Residency programs in the South (61.2%), Midwest (57.4%), and Northeast (58.4%) had a similar frequency of training medical students from schools in the same region ($p = 0.4421$), but all had significantly higher frequency compared with the West (31.7%) ($p < 0.0001$) (►**Table 4**).

Table 2 Allopathic (MD) and osteopathic (DO) medical schools producing the most ophthalmology residents, residency classes of 2021 to 2023

Rank	Name of program	Total residents class of 2021–2023	Percentage of total graduates
MD programs			
1	University of Pennsylvania	27	5.8
2	Baylor	27	4.8
3	University of South Dakota Sanford	10	4.8
4	Columbia University, Vagelos College of Physicians and Surgeons	20	4.8
5	Case Western Reserve	29	4.5
6	University of California, Irvine	14	4.5
7	Yale University	13	4.3
8	Johns Hopkins University	15	4.1
9	New York University	12	3.9
10	Duke University	14	3.9
11	University of Miami	23	3.8
12	University of Texas Houston McGovern	27	3.8
13	Oakland University William Beaumont	14	3.7
14	University of South Alabama	8	3.6
15	Northwestern University	17	3.5
16	Emory University	14	3.4
17	University of Michigan	17	3.4
18	Rutgers New Jersey	18	3.4
19	University of Texas Southwestern	23	3.4
20	University of Pittsburgh	15	3.4
DO programs			
1	Michigan State University College of Osteopathic Medicine	5	1.7
2	Touro University College of Osteopathic Medicine	4	1.0
3	Nova Southeastern University College of Osteopathic Medicine	5	0.9
4	University of North Texas College of Osteopathic Medicine	4	0.6
5	Western University of Health Sciences College of Osteopathic Medicine	4	0.4
6	Lake Erie College of Osteopathic Medicine	5	0.3
7	Edward Via College of Osteopathic Medicine	5	0.2

Abbreviations: DO, Doctor of Osteopathy; MD, Doctor of Medicine.

Resident and Residency Program Associations with Residents Training at their Home Program

Ophthalmology residency programs with an affiliated medical school trained an average of 18.0% (standard deviation 15.2%) of their residents from their "home" residency program-affiliated medical school. The University of Kansas ophthalmology residency trained the greatest percentage of home residents, with 55.6% of residents having attended the affiliated medical school. The residency programs with the highest percentage of residents from their affiliated medical school are reported in ►**Table 5**. No correlation was found between residency program size and the percentage of residents who graduated from the program's affiliated medical school ($R^2 = 0.040$). Top-25 ophthalmology residency programs (according to Doximity reputation rankings) matched residents from their affiliated medical schools at the similar frequency as non-top-25 programs (18.5 vs. 17.7%, $p = 0.7573$) (►**Table 4**).

When examining regional variation, there was no significant difference in the proportion of residents who also attended their residency program's affiliated medical school, with programs in the South (20.1%), Midwest (19.5%), Northeast (16.6%), and West (14.0%) training similar percentages of home residents ($p = 0.2236$) (►**Table 4**). Males (18.7%) and females (17.2%) attended their home residency programs at similar rates ($p = 0.4934$). Residents who earned an

Table 3 Breakdown of resident characteristics by residency program geographic region

Resident characteristics	Residency program region					*p*-Value
	Midwest *N* (%)	Northeast *N* (%)	South *N* (%)	West *N* (%)	Total	
Gender						
Female	152 (44.3)	188 (44.7)	152 (37.1)	77 (41.4)	569	**0.0273**
Male	191 (55.7)	233 (55.3)	276 (62.9)	109 (58.6)	809	
Medical school region						
Midwest	197 (54.0)	58 (15.9)	66 (18.1)	44 (12.1)	343	**<0.0001**
Northeast	47 (12.2)	246 (64.1)	45 (11.7)	46 (12.0)	421	
South	72 (16.4)	66 (15.0)	270 (61.5)	31 (7.1)	428	
West	14 (11.7)	19 (15.8)	28 (23.3)	59 (49.2)	186	
International	13 (18.6)	32 (45.7)	19 (27.1)	6 (8.6)	70	
Attend residency—affiliated medical school	67 (19.5)	70 (16.6)	86 (20.1)	26 (14.0)	249	0.2236
Top-25 USNWR medical school	72 (21.0)	101 (24.0)	67 (15.7)	70 (37.6)	310	**<0.0001**
Medical school funding						
Private	149 (43.4)	267 (63.4)	145 (33.9)	113 (60.8)	674	**<0.0001**
Public	194 (56.6)	154 (36.6)	283 (66.1)	73 (39.2)	704	
Medical degree						
MD	322 (93.9)	411 (97.6)	403 (94.2)	185 (99.5)	1321	**0.0011**
DO	21 (6.1)	10 (2.4)	25 (5.8)	1 (0.5)	57	
Residency graduation year						
2021	114 (25.5)	133 (29.8)	140 (31.3)	60 (13.4)	447	0.9979
2022	117 (25.1)	145 (31.0)	144 (30.8)	61 (13.1)	467	
2023	112 (24.1)	143 (30.8)	144 (31.0)	65 (14.0)	464	

Abbreviations: DO, Doctor of Osteopathy; MD, Doctor of Medicine; USNWR, U.S. News and World Report.

MD degree stayed at their home residency program significantly more (19.0%) than residents who earned a DO degree (1.8%) ($p < 0.0001$) (►**Table 4**). There were no significant differences in the percentage of residents staying at their home residency program when comparing the graduating class of 2021 (18.6%), class of 2022 (16.7%), and class of 2023 (18.5%) ($p = 0.6990$) (►**Table 4**).

Residents from USNWR top-25 medical schools trained at their home affiliated residency program at the similar frequency as non-top-25 medical school peers (19.7 vs. 17.6%, $p = 0.4030$) (►**Table 4**). Ophthalmology residents from publicly funded and privately funded medical schools had the similar frequency of remaining at their home residency program (19.9 vs. 18.1%, $p = 0.4375$) (►**Table 4**).

In adjusted regression analysis, factors associated with higher odds of applicants matching into their "home" residency program included a larger residency program (odds ratio [OR], 1.13; 95% confidence interval [CI], 1.03–1.25; $p = 0.0142$) and attending an allopathic rather than osteopathic medical school (OR, 14.1; 95% CI, 2.96–251.7; $p = 0.0002$). Applicants who matched into a residency program in the West were less likely to have attended their residency-affiliated medical school (OR, 0.51; 95% CI, 0.29–0.87; $p = 0.0163$) (►**Table 6**).

Resident and Residency Program Associations with Matches in the Same Geographic Region

Ophthalmology residency programs averaged 55.7% (standard deviation 21.4%) of residents from medical schools within their home region. Three residency programs (University of Arkansas for Medical Sciences, University of Mississippi, and Texas A&M College of Medicine) selected 100% of residents from their home region. ►**Table 7** shows the residency programs with the highest percentage of residents from their home region in the graduating classes of 2021 to 2023. Top-25 ophthalmology residency programs matched residents from their home region at similar rates as non-top-25 programs (52.1 vs. 57.2%, $p = 0.0945$) (►**Table 4**).

Males (56.1%) and females (54.8%) attended residency programs in the same region as their medical school at similar rates ($p = 0.6363$) (►**Table 4**). There were no differences in the proportion of residents who attended residency programs in the same region as their medical school when comparing residents with an MD degree (53.7%) versus DO degree (42.1%) ($p = 0.0863$) or when comparing residents in the graduating class of 2021 (55.9%), class of 2022 (51.8%), and class of 2023 (58.2%) ($p = 0.1416$) (►**Table 4**). Residents from top-25 medical schools trained at residency programs in the same region as their medical school at similar rates as

Table 4 Frequency of residents matching at regional and medical school-affiliated residency programs by resident and applicant characteristics, 2021 to 2023 resident classes

	Medical school/ residency in the same region N(%)	p-Value	Medical school/ residency at the same institution N(%)	p-Value
Resident characteristics				
Female gender	313 (54.8)	0.6363	98 (17.2)	0.4934
Medical school region		**0.0031**		0.8259
Midwest	197 (54.0)		67 (18.4)	
Northeast	246 (64.1)		70 (18.2)	
South	270 (61.5)		86 (19.6)	
West	59 (49.2)		26 (21.7)	
Top-25 USNWR medical school	167 (53.9)	0.4360	61 (19.7)	0.4030
Medical school funding		**0.0030**		0.4375
Private	322 (53.6)		109 (18.1)	
Public	447 (63.5)		140 (19.9)	
Medical degree		0.0863		**<0.0001**
MD	714 (53.7)		251 (19.0)	
DO	24 (42.1)		1 (1.8)	
Residency graduation year		0.1416		0.6990
2021	250 (55.9)		83 (18.6)	
2022	242 (51.8)		78 (16.7)	
2023	270 (58.2)		86 (18.5)	
Residency program characteristics				
Program Region		**<0.0001**		0.2236
Midwest	197 (57.4)		67 (19.5)	
Northeast	246 (58.4)		70 (16.6)	
South	270 (61.2)		86 (20.1)	
West	59 (31.7)		26 (14.0)	
Top-25 residency program by Doximity Rankings	208 (52.1)	0.0945	74 (18.5)	0.7573

Abbreviations: DO, Doctor of Osteopathy; MD, Doctor of Medicine; USNWR, U.S. News and World Report.

non-top-25 medical school peers (53.9 vs. 56.7%, $p = 0.4360$) (►**Table 4**).

Residents from publicly funded medical schools remained in the same region for residency training significantly more often when compared with counterparts from privately funded medical schools (63.5 vs. 53.6%, $p = 0.0030$) (►**Table 4**).

In adjusted regression, factors associated with higher odds of matching into a regional residency program included attending a publicly funded medical school (OR, 1.45; 95% CI, 1.10–1.90; $p = 0.0001$) and attending a medical school in the Northeast region (OR, 1.87; 95% CI, 1.32–2.66; $p < 0.0001$). Residency programs in the West were significantly less likely to train regional medical students (OR, 0.30; 95% CI, 0.19–0.45; $p < 0.0001$) (►**Table 6**).

Resident Associations with Matches at a Top-25 Doximity Residency Program
In adjusted regression, factors associated with higher odds of matching into a top-25 Doximity residency program includ-

ed attending medical school in the Northeast (OR, 1.44, 95% CI, 1.01–2.04; $p = 0.0433$) or West (OR, 2.38, 95% CI, 1.48–3.83; $p = 0.0003$) regions, earning an MD (rather than DO) degree (OR, 10.23, 95% CI, 3.08 - 65.51; $p = 0.0018$), and attending a USNWR top-25 medical school (OR, 3.98, 95% CI, 2.93–5.43); $p < 0.0001$) (►**Table 6**). Medical students attending private schools were also significantly more likely to match into a top-25 residency program than medical students attending public schools (OR, 1.53, 95% CI, 1.34–1.82; $p = 0.0002$).

Discussion

Ophthalmology remains a competitive specialty, with an increase in the number of applicants as well as applications submitted per applicant over the past decade.[17,18] To maximize chances of matching successfully, students often apply to high numbers of programs, beyond the number at which it

Table 5 Proportion of matched residents who graduated from their residency-affiliated medical school, by residency program, resident classes of 2021 to 2023

Rank	Name of residency program	Total residents, 2021–2023 graduating classes	Percentage of residents from affiliated medical school
1	University of Kansas	9	55.6
2	University of Tennessee	15	53.3
3	Detroit Medical Center/ Wayne State University	21	52.4
4	Loma Linda University	14	50
5	McGaw Medical Center of Northwestern University	12	50
6	LSU Shreveport	12	50
7	University of Maryland	12	50
8	University of Pennsylvania	15	46.7
9	Indiana University	18	44.4
10	Pennsylvania State Milton Hershey	9	44.4
11	Rutgers Health/New Jersey Medical School	15	40
12	University of Texas Southwestern	26	38.5
13	University of Mississippi	11	36.4
14	University of South Florida	12	33.3
14	Boston University	12	33.3
14	Johns Hopkins University	15	33.3
14	University of Nebraska Medical Center	6	33.3
14	New York Presbyterian Columbia	12	33.3
14	Albany Medical College	9	33.3
14	Philadelphia College of Osteopathic Medicine	3	33.3
14	Texas A&M College of Medicine	9	33.3
14	Baylor College of Medicine	18	33.3
14			

is feasible to interview. This broad-based approach to the application cycle is extremely costly to applicants, with a recent analysis indicating that the average cost of the application cycle for an ophthalmology applicant is approximately $7,000.[2] The increased volume of applications also makes it difficult for ophthalmology residency programs to decide which candidates to extend an interview invitation. Once programs sift through candidate applications, hosting interviews is also expensive for residency programs, with one program estimating costs for the 2017 to 2018 residency application cycle to be nearly $180,000 when accounting for meals, supplies, losses in faculty clinical productivity, and losses in clinic fixed costs.[2] As such, there is a need for information that will allow both ophthalmology applicants and residency programs to become more efficient and to better allocate resources during the match process.

In 2017, the National Resident Matching Program conducted a survey of approximately 15,000 residency applicants across more than 20 specialties and "desired geographic location" was cited as the most important factor by applicants when deciding whether or not to apply to a given residency program.[19] Our study revealed geographic preferences in the ophthalmology residency match. At the applicant level, a plurality of medical students from all four regions matched into residency programs in the same region as their medical school; however, we did observe regional variation, as medical students from the West were less likely to choose ophthalmology as their specialty and those who did choose ophthalmology were less likely to remain in the region for residency when compared with medical students from the Northeast, South, and Midwest. At the program level, Southern, Northeastern, and Midwestern residency programs matched more regional medical students than Western programs (►**Table 4**). These findings align with a previous study of geographical trends in the otolaryngology residency match, where residency programs in the West matched more geographically diverse applicants than programs in other regions.[8] Both familial and financial obligations have been reported as significant sources of stress for medical students, and matching into a regional residency program may help to alleviate these stressors by reducing moving costs and by maintaining close proximity to family.[20,21] Furthermore, interestingly, although the top-three programs matching 100% of their residents from the same

Table 6 Multivariable logistic regression analysis of factors associated with ophthalmology residency match results, resident classes of 2021 to 2023

Applicant and program characteristics	Resident match at "Home" medical school-affiliated residency program		Resident match at residency program in the same geographic region		Resident match at Doximity top-25 residency program	
	Odds ratio (95% CI)	p-Value	Odds ratio (95% CI)	p-Value	Odds ratio (95% CI)	p-Value
Resident characteristics						
Current PGY class[a]						
PGY-3	0.92 (0.65–1.29)	0.6193	0.79 (0.60–1.05)	0.0964	0.97 (0.72–1.34)	0.7335
PGY-4	1.03 (0.73–1.44)	0.8802	0.92 (0.69–1.22)	0.5432	1.01 (0.75–1.40)	0.8432
Gender[b]						
Male	1.09 (0.82–1.47)	0.5445	1.04 (0.82–1.32)	0.7272	0.79 (0.61–1.03)	0.0865
Medical school funding[c]						
Public	0.93 (0.66–1.31)	0.6781	1.45 (1.10–1.90)	**0.0001**	0.65 (0.48–0.88)	**0.0061**
MD/DO[d]						
MD	14.1 (2.96–251.7)	**0.0002**	1.75 (0.98–1.34)	0.0594	10.23 (3.08–65.51)	**0.0018**
Medical school region[e]						
Northeast	1.05 (0.68–1.63)	0.8173	1.87 (1.32–2.66)	**<0.0001**	1.44 (1.01–2.04)	**0.0433**
South	1.07 (0.71–1.60)	0.7442	1.19 (0.87–1.65)	0.2794	1.38 (0.97–1.95)	0.0711
West	1.69 (0.95–2.97)	0.0706	1.35 (0.85–2.17)	0.2103	2.38 (1.48–3.83)	**0.0003**
Top-25 USNWR medical school[f]						
Yes	1.01 (0.69–1.47)	0.9755	1.01 (0.74–1.39)	0.9265	3.98 (2.93–5.43)	**<0.0001**
Residency program characteristics						
Residency region[e]						N/A
Northeast	0.78 (0.51–1.20)	0.2623	0.91 (0.64–1.28)	0.5735	N/A	
South	0.95 (0.63–1.43)	0.7926	1.16 (0.83–1.63)	0.3814		
West	0.51 (0.29–0.87)	**0.0163**	0.30 (0.19–0.45)	**<0.0001**		
Program size—# of residents	1.13 (1.03–1.25)	**0.0142**	1.05 (0.96–1.14)	0.2802	N/A	N/A
Top-25 Doximity residency[f]						
Yes	0.76 (0.52–1.12)	0.1725	0.79 (0.58–1.08)	0.1434	N/A	N/A

Abbreviations: CI, confidence interval; DO, Doctor of Osteopathy; PGY, postgraduate year; USNWR, U.S. News and World Report.
[a]Reference is PGY-2.
[b]Reference is female.
[c]Reference is private.
[d]Reference is DO.
[e]Reference is midwest.
[f]Reference is No.

Table 7 Residency programs with the highest percent of residents who attended medical school in their home region, resident classes of 2021 to 2023

Rank	Name of program	Total residents 2021–2023	Percentage from the same region
1	University of Arkansas for Medical Sciences	10	100
2	University of Mississippi	11	100
3	Texas A&M College of Medicine	9	100
4	University of Minnesota	15	93.3
5	New York University	12	91.7
6	Medical College of Georgia	9	88.9
7	Indiana University	18	88.9
8	University of Florida	15	86.7
9	Hofstra/Northwell	13	84.6
10	University of South Florida	12	83.3
11	LSU Shreveport	12	83.3
12	Texas Tech University	12	83.3
13	Icahn School of Medicine	11	81.8
14	University of Alabama	14	78.6
15	University of Kansas	9	77.8
16	Beaumont Health (Royal Oak)	9	77.8
17	Temple University Hospital	9	77.8
18	University of Wisconsin	9	77.8
19	University of Texas Southwestern	26	76.9
20	New York Presbyterian Columbia	12	75.0

region were located in the South, and Southern residency programs matched the highest percentage of residents from the same region, in adjusted regression analysis we did not observe a significant difference in odds of the same-region match for applicants from Southern medical schools.

Slightly more than 18% of ophthalmology residency applicants attended their "home" program—the residency program that was affiliated with the medical school they attended. This number is slightly lower than the proportion of residents matching at their home residency program in general surgery (24.6%),[5] orthopaedics (21%),[7] and otolaryngology (20.9%)[8] but slightly higher than the proportion observed in the plastic surgery residency match (15.5%).[15] Applicants may have personal connections such as established relationships with faculty or current residents at their home program that could improve their likelihood of matching and may also have personal or logistical regions for desiring to remain at the same location. Interestingly, attending a top-25 ranked medical school did not improve an applicant's chances of matching into their home residency program, which is in contrast to a recent study of the otolaryngology match, where applicants from USNWR top-25 medical schools had a significantly higher likelihood of matching at their home residency program.[22]

When examining geographic trends in the ophthalmology match by perceived gender, our results indicate that South-

ern residency programs had a significantly lower percentage of female residents than programs in the Midwest, Northeast, and West, respectively (►**Table 3**). This finding aligns with a similar study that found Southern orthopaedic surgery residency programs also had the lowest female representation when compared with programs in other regions.[23] Without further data regarding applicant preferences, we cannot determine whether regional differences in female representation among ophthalmology residents are primarily caused by applicant-related factors (female candidates are less interested in Southern programs) or program-related factors (Southern programs give less consideration to female applicants). However, previous studies indicate that female applicants and medical students from backgrounds that are underrepresented in medicine (URiM) particularly value program diversity when considering where to apply to residency.[24–27] As such, residency programs who wish to better recruit female and URiM applicants may benefit from emphasizing diversity and inclusion initiatives to prospective residents.

Our study did not identify significant gender differences in the percentage of residency applicants matching into programs affiliated with their medical school or in the same home region as their medical school, which is consistent with trends observed in the otolaryngology match.[28] However, these results contrast with a recent study

examining outcomes of the dermatology residency match, where female applicants were more likely to match in their home program or within their home region.[29] The knowledge of similar geographic match outcomes for both male and female applicants may be useful for applicants deciding where to apply and residency programs considering applicants' likelihood of matching with them.

Prior reports suggest that medical school applicants have already formed strong opinions for and against medical specialties, and our study results provide valuable insight to prospective medical students interested in pursuing ophthalmology in their future careers.[30–33] When deciding which medical school to attend, prospective medical students have to balance many factors such as program reputation, geographic location, cost, and match outcomes of previous graduates.[34,35] Our data suggest that attending a USNWR top-25 ranked medical school may be beneficial for applicants, as students from these medical schools comprise a disproportionate number of ophthalmology residents. Residency programs in the West also matched a much higher proportion of residents from top-25 medical schools compared with programs in other regions (37.6 vs. 15.7–24%), potentially reflecting fewer programs in the West compared with the number of applicants. Medical students from these top-25 schools were also approximately four times more likely to match at a top-ranked residency program when compared with medical students from non-top-25 schools. Additionally, medical students from privately funded rather than publicly funded medical schools were 53% more likely to match into a top-ranked residency program ($p = 0.0001$); however, our data indicate that approximately 20% of residency spots are filled by medical students from the program's affiliated medical school and nearly 60% of top-ranked residency programs are affiliated with medical schools that are privately rather than publicly funded, which could explain this finding.

Residents from publicly funded medical schools were nearly 50% more likely to remain in the same region for both medical school and residency training, when compared with residents from privately funded schools. Additionally, applicants from publicly funded medical schools graduate with less debt than those from privately funded schools.[36] If a prospective medical student interested in ophthalmology hopes to remain in the same geographic region for the entirety of graduate medical education training, a publicly funded medical school that produces high numbers of ophthalmology residents (e.g., ►Table 2) could be a cost-efficient option. Interestingly, the proportion of residents from privately funded medical schools was higher at coastal (West and Northeast) programs compared with South and Midwest.

Our study also provides insight into the current landscape of residents who graduated from international medical schools as well as residents who graduated with a DO degree. It has been shown to be difficult for applicants from international medical schools and DO schools to match into ophthalmology.[17,18] International medical school graduates accounted for the greatest proportion of residents in the Northeast (7.6%), followed by the South (4.4%), Midwest (3.8%), and West (3.2%). Additionally, while producing ophthalmology residents at a lower rate than allopathic medical schools, there were seven osteopathic medical schools that produced at least four ophthalmology residents throughout the 3 years included in our study (►Table 2). Applicants from allopathic medical schools were over 14-fold more likely to match at their home residency program compared with osteopathic applicants, likely reflecting the few osteopathic medical schools with an affiliated ophthalmology residency program. This information may be useful to current ophthalmology residency applicants as well as to prospective medical students deciding on the location and the type of medical school they wish to apply to or attend.

The shift to virtual residency interviews due to the coronavirus disease 2019 pandemic has the potential to drastically alter the recruitment process and, as such, may influence the geographic trends observed in this study. In fact, an analysis of the 2020 to 2021 ophthalmology application cycle (the first to consist of entirely virtual interviews) revealed that there was a higher likelihood of applicants matching at the residency program affiliated with their home medical school than in previous cycles. However, there was not a significant difference in the likelihood of applicants attending a residency program in the same region as their home medical school or attending a residency program in the same state as their home medical school.[37] A survey of applicants who endured a completely virtual residency application cycle indicated that the geographical location of the residency program remained their most important factor considered when generating their rank lists.[38] Furthermore, applicants cited cost savings and the ability to interview at more programs as the biggest strengths of virtual interviews, whereas the inability to experience the program's culture was ranked as the biggest limitation of virtual interviews.[38] Decisions regarding whether to continue with virtual interviews in future applicant cycles must weigh the benefits of cost savings to both applicants and residency programs with the limitations of virtual interviews, which may feel less personal to applicants and could potentially limit the ability of residency programs to evaluate candidates.

There are several limitations to our study. First, residency program Web sites were the primary source of information used to gain information about current residents and not all residency programs maintained an updated roster of current residents or replied to email requests from the authors for program-specific information. As such, not all residents in the graduating classes of 2021, 2022, and 2023 are included in this analysis; however, we did capture information regarding medical school attended for between 95 and 99% of residents, so additional information likely would not have altered our main conclusions. Second, although our findings suggest geographic differences in the residency match, we are unable to assess underlying causes, such as candidates preferring to apply and interview at more residency programs in their home region and/or programs being more likely to offer interview invitations to candidates who

attended medical school in the same region. We were also unable to ascertain the relative importance of factors that applicants consider, such as balancing a desire to stay close to family and considering geographic career opportunities for a spouse or significant other (e.g., programs at larger medical centers and/or in larger cities may offer more work or training opportunities). Future survey studies of ophthalmology residency applicants may better investigate these factors. In addition, the Doximity residency program reputation rankings and USNWR medical school rankings used to identify top-ranked residency programs and medical schools are subject to limitations.[11,39] However, these metrics have been used in previous geographic residency analyses as a tool to separate medical schools and residency programs and these rankings continue to be used by both medical school and residency applicants.[11,22,40,41] Finally, we were not able to access data on the race/ethnicity of the trainees included in this study. The impact of race/ethnicity on match trends warrants future research. Despite these limitations, our study provides important insights into the ophthalmology residency match process.

In summary, this study revealed unique geographic and demographic trends in the ophthalmology residency match. This information may be useful to both residency applicants and residency programs to inform decisions made throughout the match process, with the ultimate goal of making the application cycle more efficient and cost-effective while simultaneously yielding optimal match outcomes. Furthermore, data presented in our study can be used by prospective medical students interested in ophthalmology to inform decisions regarding the type and location of medical school they choose to attend as they prepare for future careers in ophthalmology.

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