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The 2021 Neurosurgery Match: An Analysis of the Impact of Virtual Interviewing and Other COVID-19–Related Changes

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■ BACKGROUND: **Given the safety concerns during the COVID-19 (coronavirus disease 2019) pandemic, residency programs suspended away rotations in 2021, and the interview process was transitioned to a virtual video format. In the present study, we assessed the extent to which these changes had affected match outcomes and whether medical school ranking, international graduate status, or affiliation with a home neurosurgery program had affected these outcomes.**

■ METHODS: **A cross-sectional analysis of neurosurgery match data from 2016 to 2021 was performed, and the match outcomes were assessed by matched program geography and program research ranking. χ^2 tests were performed to identify significant differences between the 2021 and 2016–2020 match results.**

■ RESULTS: **A total of 1324 confirmed matched neurosurgery residents were identified from 2016 to 2021 (2016–2020, $n = 1113$; 2021, $n = 211$). No statistically significant differences were found in the rates of matching at a home program, within state, or within region between 2021 and 2016–2020 in the overall cohort. The proportions of international graduates and students without home programs among the matched applicants were unchanged in 2021. In 2021, students from the top 25 medical schools were less likely to match within their state or region ($P < 0.05$).**

■ CONCLUSIONS: **Our findings might reflect enhanced weighting given by programs to applicants from top medical schools in the absence of data from in-person rotations and interviews. These findings, coupled with the potential benefits of an increasingly virtual application process in improving equity and diversity among candidates from underrepresented communities, should be considered when determining permanent modifications to future residency application cycles.**

INTRODUCTION

The neurosurgery match is highly competitive, with 74.3% of U.S. medical applicants successfully matching into the specialty in 2020 compared with 89.8% in all specialties.[1,2] Matching into neurosurgery is more difficult for graduates from medical schools outside of the United States and for applicants from U.S. medical schools not affiliated with neurosurgical residency programs compared with their U.S. counterparts with home programs.[1,3] These existing inequities in the medical school system have exacerbated the difficulty of matching into neurosurgery and could potentially lead to a less diverse neurosurgery workforce, which would likely lead to worse patient care.[4,5]

Applicants have traditionally completed away rotations to gain exposure to the field, develop a mentorship network of faculty and

Key words
- COVID-19
- Diversity
- Equity
- Geography
- Match
- Residency

Abbreviations and Acronyms
AAMC: Association of American Medical Colleges
ACGME: Accreditation Council for Graduate Medical Education
COVID-19: Coronavirus disease 2019
IMG: International medical graduate
SNS: Society of Neurological Surgeons

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residents, and maximize their chances of matching. This is critical in neurosurgery, a specialty that receives little exposure in most medical school curricula. However, in response to safety and equity concerns during the coronavirus disease 2019 (COVID-19) pandemic and in compliance with the Association of American Medical Colleges (AAMC) directives, the Society of Neurological Surgeons (SNS), representing academic chairs and residency directors of Accreditation Council for Graduate Medical Education (ACGME)—accredited neurosurgery residencies, issued guidelines suspending external subinternship clinical rotations and recommended that students interested in neurological surgery complete two rotations at their home institution.[6] In addition, the SNS developed a national curriculum for subinternships to improve equity and assisted students without a neurosurgery program at their school to find a regional "adoptive" home neurosurgery program.[7]

In accordance with the AAMC guidance, the entire interview cycle transitioned to a virtual format, without in-person interviews or neurosurgery program visits. These recommendations were unanimously endorsed by representatives of the One Neurosurgery Summit of the SNS, American Board of Neurological Surgeons, American Academy of Neurological Surgery, ACGME Neurological Surgery Review Committee, American Association of Neurological Surgeons, Congress of Neurological Surgeons, and American Association of Neurological Surgeons-Congress of Neurological Surgeons Washington Committee.

Given the lack of rotation contact with students from other medical schools and the limitations of the virtual interview format, we hypothesized that the proportion of neurosurgical residencies matching home program applicants would increase in the 2021 match. Even before the COVID-19 pandemic, surgical specialties had demonstrated a bias toward home program applicants.[8] Likewise, without visiting other programs and regions, applicants were expected to display a preference for their home program, state, and geographic region. Finally, applicants graduating from highly ranked schools were presumed to benefit from national name recognition and a robust network of alumni,[1,9] which could, in turn, disproportionately disadvantage U.S. students without home neurosurgery programs, international medical graduates (IMGs), and medical students from lower ranked medical schools in the match.

The objective of the present study was tripartite. First, we quantified the extent to which virtual interviews and the elimination of away rotations affected the proportion of applicants matching at their home program, state, or geographic region in the 2021 neurosurgery match. Second, we compared the proportion of U.S. students at medical schools not affiliated with an ACGME-accredited neurosurgery residency program and IMGs who had successfully matched in 2021 to that of the preceding 5 years. Third, we assessed the effects of the applicants' medical school ranking on the rank of the residency program to which they had matched.

METHODS

A cross-sectional analysis of match data from 2016 to 2021 was performed. A total of 115 neurosurgical residency programs participating in the 2021 match cycle were identified through the electronic residency application service.[10] Using official program website rosters, publicly available social media, and online forum postings, the neurosurgery match data from 2021 and from the preceding 5 years (2016—2020) were compiled. These data included the trainee's name, home institution, and matched institution. The match data for the programs that had previously participated in the match but were no longer accredited were collected via internet archive websites (e.g., the Wayback Machine[11]).

For each matched applicant, we determined whether the applicant had matched at their home institution or had matched within the state or geographic region of their home medical school. The 4 geographic regions used were the West, Midwest, Northeast, and South, as defined by the U.S. Census Bureau.[12] We then identified the matched applicants who had attended a medical school outside of the United States or had attended medical schools not affiliated with a neurosurgery residency program. Finally, for the assessment of impact of school ranking on the match outcomes, we stratified the applicants who had attended the top 25 ranked medical schools (based on the 2021 U.S. News and World Report rankings in research[13]) from those who had not and stratified the matched programs by those ranked in the top 25 (using the 2021 Doximity reputation ranking for neurosurgical residency[14]) from those ranked lower.

The χ^2 test was performed first to determine whether any differences existed between the categorical variables within each period of 2021 and 2016—2020 and then to compare the variables between 2021 and 2016—2020. A P value of <0.05 was considered statistically significant. All analyses were undertaken using R, version 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

A total of 1324 matched neurosurgery applicants were identified from 2016 to 2020 ($n = 1113$ for 2016—2020 [99.1% of all matches]; $n = 211$ for 2021 [90.2% of all matches]). Of the cohort of matched applicants from 2016 to 2020, 27.9% had attended a top 25 ranked medical school, 6.2% had graduated from a medical school outside of the United States, and 17.8% had attended a medical school that was not affiliated with a neurosurgery residency program. These proportions were similar to those of the 2021 cohort, of whom 32.2% had attended a top 25 ranked medical school ($P = 0.225$), 7.1% had graduated from a medical school outside of the United States ($P = 0.792$), and 18.5% had attended a medical school that was not affiliated with a neurosurgery residency program ($P = 0.891$).

An analysis of the geographic matching trends in 2016—2020 compared with 2021 is presented in **Table 1**. No statistically significant difference was found between the rates at which the overall 2021 cohort compared with the 2016—2020 cohort had matched at their home program (19.3% vs. 19.8%; $P = 0.94$), within the same state (23.6% vs. 27.0%; $P = 0.35$), or within the same region (42.5% vs. 49.2%; $P = 0.11$). When stratified by medical school ranking, the students graduating from the top 25 ranked schools had matched within the same region (2016—2020 cohort, 50.7%; vs. 2021 cohort, 32.8%; $P = 0.013$) and within the same state (2016—2020 cohort, 37.3%; vs. 2021 cohort,

Table 1. Geographic Comparison of Matching Outcomes Between 2021 and 2016–2020

Variable	2021 (%)	2016–2020 (%)	*P* Value
Overall			
Home program	19.34	19.78	0.943
Same state	23.58	27.00	0.353
Same region	42.45	49.19	0.107
Top 25 medical schools			
Home program	19.40	31.70	0.06
Same state	23.90	37.30	0.0499*
Same region	32.80	50.70	0.013*
Non-top 25 medical schools			
Home program	19.40	15.50	0.291
Same state	23.60	23.30	1.000
Same region	47.20	48.50	0.864

*Statistically significant.

23.9%; P = 0.05) at significantly lower frequencies in 2021. For the top 25 school graduate cohort, the home program match rates showed a trend toward significance, with fewer students matching at their home programs in 2021 than in previous years (2016–2020, 31.7%; vs. 2021, 19.4%; P = 0.06). No such differences were found when comparing the non-top 25 medical school cohort from 2016 to 2020 to the non-top 25 medical school cohort from 2021 (home program, 15.5% vs. 19.4% [P = 0.29]; within state, 23.3% vs. 23.6% [P = 1.000]; within region, 48.5% vs. 47.2% [P = 0.864]).

In the 2016–2020 application cycles, significantly more students statistically from the top 25 medical schools had matched at home programs (31.70%) and programs within the same state (37.30%) than had students from the non-top 25 medical schools (15.50% [P ≤ 0.001] and 23.30% [P ≤ 0.001], respectively; Table 2). In the 2021 application cycle, the differences in these same comparisons were not statistically significant (Table 3). In neither the 2016–2020 cohort nor the 2021 cohort was a statistically significant difference found for students matching in the same overall geographic region.

No statistically significant difference was found in the rates at which the medical students who had graduated from the top 25 medical schools had matched at the top 25 ranked neurosurgery residency programs between the 2016–2020 and 2021 cohorts (65.2% vs. 66.2%; P = 0.99; Table 4). Similarly, no statistically significant difference was found in the rates at which the medical students who had graduated from the non-top 25 medical schools had matched at the top 25 ranked neurosurgery residency programs between the 2016–2020 and 2021 cohorts (21.8% vs. 21.0%; P = 0.92).

DISCUSSION

Fundamental changes to the 2021 application cycle occurred as a result of the COVID-19 pandemic, with the vast majority of interviewing and networking occurring virtually. Significant concerns arose regarding the disproportionately detrimental effects these changes could have had on some medical students,[15] specifically those from lower ranked medical schools, students without home residency programs, and IMGs (SNS virtual recruitment survey, unpublished data, 2021). The results we have presented demonstrated no statistically significant changes to the results of the match in the 2021 cycle compared with the 2016–2020 cycles. Although we cannot extrapolate either the programs' or the applicants' individual preferences from the available data and because the rates of attrition resulting from a

Table 2. Geographic Comparison of Matching Outcomes Between Top 25 and Non-Top 25 Schools From 2016 to 2020

Variable	2016–2020 Top 25 (%)	2016–2020 Non-Top 25 (%)	*P* Value
Home program	31.70	15.50	<0.001*
Same state	37.30	23.30	<0.001*
Same region	50.70	48.50	0.58

*Statistically significant.

Table 3. Geographic Comparison of Matching Outcomes Between Top 25 and Non-Top 25 Schools in 2021

Variable	2021 Top 25 (%)	2021 Non-Top 25 (%)	*P* Value
Home program	19.40	19.40	1.000
Same state	23.90	23.60	1.000
Same region	32.80	47.20	0.069

"poor fit" will not be known for another 2–3 years, these results reflect a preliminarily neutral outcome from the COVID-19–related changes to the virtual 2021 application cycle. Thus, our findings have largely negated the fears that the COVID-19–related changes to the 2021 electronic residency application service cycle would geographically limit applicants. However, they are aligned with previous reports stating differential outcomes according to applicant medical school rankings.[1,9]

The applicants from the top 25 ranked medical schools were more likely to match away from home, out of state, and out of their U.S. geographic region in 2021 than during the preceding 5 years. This single statistically significant alteration in 2021 might suggest that studying at a top 25 medical school was more highly valued by residency programs in the absence of additional in-depth data derived from in-person rotations and interviews. Another possible explanation for this finding could be that higher ranked schools draw broader geographic applicant pools and, subsequently, more geographically diverse students, who might wish to return closer to home for residency. Although diversity at the top 25 U.S. medical schools has substantially improved in recent years,[16] further study is necessary to understand whether this factor affected either financial- and/or diversity-related equity in the 2021 match. In addition to the recent trends of many medical schools' recent transition of the preclinical curriculum to pass/fail grading, the transition of the U.S. Medical Licensing Examination step 1 score reporting to pass/fail will further limit the breadth of information available about individual residency applicants and might result in further emphasis on the school of origin or other factors.[17] Other institutional benefits such as access to more nationally recognized faculty for letters of recommendation and perceived school prestige could become more influential in the residency selection process. The effects of these changes on the promotion of diversity in neurosurgical training should be studied further.

The elimination of away rotations and in-person interviewing was previously suspected to have negative effects on applicants from lower ranked medical schools. Graduates from lower ranked medical schools benefit less from national name recognition or robust networks of alumni and resources, which could have resulted in lower match rates or greater difficulty matching at prestigious programs for these individuals in 2021. However, the results from the present study demonstrated no significant changes in the proportion of matched applicants from non-top 25 ranked medical schools. Furthermore, the applicants from this group had matched at the top 25 ranked residency programs at a similar rate in 2021 compared with previous years. This suggests that the changes made to the 2021 cycle did not disproportionately affect the applicants from the non-top 25 ranked medical schools. However, the neurosurgery residents from the top 25 medical schools still greatly outnumbered the neurosurgery residents from the other 130 AAMC-accredited allopathic institutions. In the United States, the top 25 medical schools account for only 16.1% of all medical schools.[18] In contrast, the applicants from these institutions accounted for 27.9% and 32.2% of the matched applicants in the 2016–2020 and 2021 cycles, respectively. These findings further emphasize the need for additional studies to establish the equity of the neurosurgery match.

In addition to the results from the present study, other important aspects of the residency interview process should be considered when determining permanent changes to residency application cycles. Cancellation of away rotations eliminated the cost of short-term living in a different city, and the changes to the 2021 interview cycle were associated with significant reductions in costs for the applicants, as previous studies had quantified the

Table 4. Residency Outcome Comparison of Applicants Matching at Top 25 Ranked Neurosurgery Residency Programs in 2016–2020 Period Compared with 2020

Variable	2016–2020 Matched at Top 25 Residency Programs (%)	2021 Matched at Top 25 Residency Programs (%)	*P* Value
Top 25 medical schools	65.16	66.18	0.985
Non-top 25 medical schools	21.77	20.98	0.92
IMGs	26.00	40.00	0.444
No home program	23.73	23.07	1.000

IMGs, international medical graduates.

application cycle expenses (including interviews) to be, on average, $10,255.[19] In addition to the benefits of the cost reduction, the transition to virtual interviewing considerably reduced scheduling conflicts experienced by applicants, providing more opportunities to interview at distant institutions with fewer scheduling and financial restrictions.[20] Programs reported ~30 more applications received per program and ~5 more applicants interviewed for a mean of 315 applications reviewed and 45 applicants interviewed per program in the 2020–2021 cycle (SNS virtual recruitment survey, unpublished data, 2021).

However, several negative aspects of virtual interviewing should be acknowledged. Online formats can lead to de-individualization of applicants, and applicants could miss important opportunities to interact with the current resident cohort and gain direct insight into the clinical and educational resources and culture of a program. The ability to assess "personality" was noted to be worse than with in-person interviews by 74.8% of the program leadership and assessment of "program culture" was reported to be much worse by 78.2% of the applicants (SNS virtual recruitment survey, unpublished data, 2021). Additionally, a small degree of interview "hoarding," in which the most competitive applicants are offered and attend a higher number of interviews than necessary to match (and less competitive applicants receive few or no interviews) was observed in the 2021 match.[21] Of the applicants, 9% had received >40 interview invitations, and 34.7% had completed >20 interviews (SNS virtual recruitment survey, unpublished data, 2021). Despite these concerns, the results from the present study have shown that virtual interviewing did not significantly harm any group studied, because the proportions of matched applicants who were IMGs or from medical schools without home programs were unchanged in 2021.

The present study had several limitations. First, although a vast number of programs had indicated support for, and/or compliance with, the SNS and AAMC guidelines, a small number did not. We had no specific method available to assess compliance by the individual programs. Second, both the U.S. News and World Report rankings and the Doximity rankings have capricious scales for evaluating match outcomes, and neither metric can fully capture applicant or program success. The usage of a ranking system based on a single year's rank results for a longitudinal study is inherently imperfect because the rankings can shift annually according to reputation, research productivity, and research endowment. However, it is likely that any shift in ranking would affect all populations equally and, thus, would not change the results of our study significantly. Given the existence of multiple ranking bodies and the methods for ranking, the results of the present study might differ according to the ranking system used. Additionally, demographic information on the applicants was not available. Subsequently, it was not possible to determine the results of the 2021 match for underrepresented groups in neurosurgery or correct for multiple comparisons. This is a much-needed area of research, and future studies should aim to evaluate whether and to what extent these groups were affected by the elimination of away rotations and the transition to virtual interviewing. Finally, our study only assessed the effects of the COVID-19 pandemic on the U.S. neurosurgical match process. Because COVID-19 is a global pandemic with wide-reaching effects across countries, it is important for future research to evaluate the global consequences of the COVID-19 pandemic on medical training and education.

CONCLUSIONS

The 2020–2021 neurosurgery residency application cycle underwent many changes in response to the COVID-19 pandemic. Virtual interviews decreased the time limitations and financial burden for applicants; however, the applicants reported that their ability to assess the program culture and location was significantly limited. Also, the elimination of away rotations raised the risk of limiting the match opportunities for applicants, especially those already at a disadvantage in matching with a neurosurgery residency program. Despite these potential disadvantages, we found no statistically significant evidence of geographic limitations or changes in the proportion of applicants matching at a top 25 residency for any applicant group. We also did not find a change in the proportions of matched IMGs or applicants from schools without affiliated residency programs in 2021. The one significant alteration in the 2021 match patterns was an increase in the proportion of students from the U.S. top 25 medical schools who had matched out of the region from their home program, perhaps reflecting the increased importance of medical school origin to programs, given the limitations on data from in-person rotations and interviews. These findings, coupled with the financial and scheduling benefits of virtual interviewing and the potential improvements in equity for candidates from underrepresented in medicine communities, should be considered when determining modifications to future residency application cycles to ensure equitable opportunities for neurosurgical training and to establish a future neurosurgery workforce of diverse backgrounds and perspectives.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Kathleen M. Mulligan: Investigation, Writing – original draft. **Xuankang Pan:** Investigation, Writing – original draft. **Christina Gerges:** Conceptualization, Writing – review & editing. **Nicholas M. Rabah:** Formal analysis, Writing – review & editing. **Nathan R. Selden:** Writing – review & editing. **Stacey Q. Wolfe:** Writing – review & editing. **Christina Huang Wright:** Writing – review & editing. **James M. Wright:** Conceptualization, Writing – review & editing.

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