Impact of the COVID-19 Pandemic on Identifying Exceptional Neurosurgical Residency Candidates

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Abstract

Objective

A specialty with high value on reliability and accountability, aspiring neurosurgical residents have classically excelled in demonstrating these attributes through in-person engagements. Sub-internship rotations, leadership in extracurriculars, and longitudinal research endeavors have traditionally shed light on uniquely responsible and self-driven candidates. As the COVID-19 pandemic altered the paradigm for medical student engagements, our team investigated whether neurosurgical residency programs would be able to gauge candidates' favorable attributes with the same accuracy as prior to the pandemic.

Design/Setting/Participants:

The PubMed/MEDLINE database was queried from inception to 2021 to determine the factors that contribute to a successful American neurosurgery residency match. Inclusion and exclusion criteria were predetermined to ensure comprehensiveness and relevance. Data from the National Residency Matching Program were also reviewed to determine significant trends in the American neurosurgery residency match. These data were then interpreted in the context of the COVID-19 pandemic to gain insight into the present-day neurosurgery match experience.

Results

A total of 32 studies were included in the review. Factors relevant to current neurosurgery residency match rates include the number of applicants to neurosurgery programs, quantity of research publications, quality of mentorship, interviews, letters of recommendation, standardized academic metrics, and residency program outreach. While current neurosurgery residency program directors are generally satisfied with recent match cycles, survey respondents expressed support for a more objective application review process. The transition to virtual interviews and suspension of away rotations required by the COVID-19 pandemic has raised significant student concerns related to the pandemic's impact on the current residency recruitment process.

Conclusion

The neurosurgery match is influenced by multiple dynamic, varied factors that are currently impacted dramatically by the COVID-19 pandemic. While more studies focusing on refining applicant selection processes are warranted, it is imperative for neurosurgical programs to seek new surrogates for assessing favorable neurosurgery residency applicant attributes.

Introduction

Neurosurgeons must be nimble in performance, profoundly curious in their thinking, and resilient in all aspects of their lives. Identifying physicians with exceptional work ethics, endurance, and inquisitively at the early stage of the fourth medical school year takes intense investigation. Though interviewing residents allows for elucidation of the extent to which an applicant embodies important qualities, time is of the essence for program directors, most of whom actively practice neurosurgery. Furthermore, with nearly every neurosurgical residency candidate applying to every residency program in the nation, the application serves to be the only realistic mechanism for evaluating each student to determine who may receive one of a limited number of interview spots within the timeframe of an application cycle.

Consequently, matching into an American neurosurgery residency program is a highly competitive process, reflective of the need for identifying highly self-motivated, balanced, intellectually curious neurosurgical residents [1, 2]. Currently, the Electronic Residency Application Service (ERAS) ranks neurosurgery among the top five most competitive specialties for residency [3]. Neurosurgical residency match rates have remained relatively consistent over the last thirty years, around 64%, despite the addition of 16 new programs in the United States over the past 10 years [4]. This may be attributed to a need for scrutiny in applicant evaluation to ensure residents are as prepared as possible for the immense privileges and rigors of neurosurgical residency.

The factors responsible for the high degree of competition for residency positions in neurosurgery are themselves worthy of study. Additionally, it is imperative that today's applicants take into consideration their individual chances of success in matching. Given the structure of residency applications in the U.S., applicants are faced with the unenviable task of attempting to distinguish themselves from their colleagues through rather limited metrics; these include standardized examinations - the United States Medical Licensing Exam (USMLE) Step 1 and Step 2 Clinical Knowledge (CK), clerkship grades and subjective performance evaluations during the third year of medical school, letters of recommendation, research involvement and productivity, extracurricular responsibilities, evaluations from sub-internship rotations, both at home and away institutions, and in-person interview performance [5]. Several studies have examined these factors as they relate to matching into other specialties or in other countries [6–8], though few have focused on neurosurgery specifically. As the neurosurgical match remains undeniably competitive, this literature review aims in part to summarize and discuss the extent to which these factors contribute to a successful match. However, more specifically, the authors aim to convey the COVID-19 pandemic's impact on neurosurgical residency candidate assessment. With many opportunities classically acted on by medical students eliminated during the timeframe of the national lockdown, we strive to understand how successful applicant criteria may be redefined by program directors.

Materials And Methods

Database Search

We comprehensively queried the literature through a search of published English research articles via the PubMed/MEDLINE database using the search algorithm: ((neurosurgery OR neurological surgery) AND

(medical student OR resident OR residency) AND (selection OR match)) from database inception. Titles and abstracts for each article were reviewed for relevance and otherwise were excluded. The remaining articles were reviewed in full based on our inclusion and exclusion criteria. Bibliographies of articles were also reviewed for relevant studies. Due to the public use of these databases and accessibility of publicly available literature, this study was exempt from Institutional Review Board approval. Patient consent was not required.

Inclusion and Exclusion Criteria

Articles were included if they 1) were written in or translated to English 2) were original articles with full text available 3) described surveys or data analysis pertaining to the recruitment of future neurosurgeons and the applicant selection processes of neurosurgical programs or 4) reported preliminary data, were case studies, letters to the editor, commentaries, or editorials/opinions. Further, studies describing factors influencing academic neurosurgery faculty positions, outcomes following completion of neurosurgery residency, match outcomes for specialties other than neurosurgery, or non-US residency programs were excluded.

Search Results

In total, our search yielded 128 unique results. Reference lists were thoroughly examined for any studies that might have been missed during the initial search. This process resulted in inclusion of one additional publication, for a total of 129 unique references. Following the application of inclusion and exclusion criteria, 32 studies remained in the final analysis. Outcomes relating to the neurosurgical match, including average USMLE Step 1 scores, number of research experiences per applicant, number of publications, abstracts, and presentations per applicant, and percentage of applicants achieving Alpha Omega Alpha (AOA) honor society induction, were extracted.

Analysis of ERAS Data

We reviewed and extracted data from the National Residency Matching Program's (NRMP) "Charting Outcomes in the Match" (ChOM) document to determine trends in the neurosurgery match during the years for which data is available (2009, 2011, 2014, 2016, 2018, 2020). Outcomes of interest included the number of neurosurgery applicants per cycle, the percentage of AOA members amongst those applicants, the publication number per applicant, and average USMLE Step 1 score per applicant.

Results

Through analysis of the 32 included studies and data extracted from ERAS from 2010–2020, we identified several factors in relation to current neurosurgery residency match rates.

Applying to Neurosurgery

Over the past decade, the number of neurosurgery residency applicants has risen from 427 to 487, an increase of 14.1% from 2010 to 2020. Notably, this increase occurred despite a decrease in international

medical graduate (IMG) applicants; U.S. medical school graduate (UMG) applicants increased from 286 to 361 (26.2%), while IMG applicants decreased from 141 to 126 (10.6%). Further, a retrospective review demonstrated an average match rate of 24% for IMGs, which is significantly lower than the 83% average match rate for UMGs [9].

Five studies reported on changes in trends of neurosurgery match over time. In the early 2000s, the number of applicants to neurosurgery residency began to decline, prompting concern about decreasing interest in the field [9]. Factors thought to be responsible for the decrease in applications included concerns for poor work-life balance, job security, and intellectual engagement with “bioscience” [10]. Three studies indicated that earlier exposure to the field by means of a neurosurgery student interest group is associated with more applicants from a respective school [9, 11]. Having a structured neurosurgery interest group correlates with an increased number of neurosurgery-related publications, attendance at neurosurgical conferences, and a higher match rate for applicants at these schools. Additionally, medical schools that have neurology, child neurology, and neurosurgery electives have higher match rates into neuro-medicine specialties as compared to schools without related electives [12].

Four studies discussed disparities in the neurosurgical match. Although over 50% of matriculants to medical school have been women, they comprise less than 20% of neurosurgery residents [10, 12–14]. While the percentage of female neurosurgery residents is increasing, there continues to be concern regarding gender inequities within the field, which may contribute to the relatively fewer female residents [14, 15].

Research

Six studies discussed the role of research in the neurosurgical match. Consistent with the upward trend in the numbers of publications, abstracts, and presentations indicated by the NRMP ChOM data, mean total publications per neurosurgery intern increased from 1.7 ± 0.3 in 2009 to 5.5 ± 0.6 in 2018 [16]. Among interns, those training at top 40 institutions exhibited a significantly higher mean number of publications than interns training at non-top 40 programs ($p < 0.001$), as did those with PhD degrees [16]. Interns at top 25 programs exhibited more publications overall and in the neurosciences compared to interns at lower ranked programs [17]. Statistically, intern publication H-index is a predictor of successfully matching into top research institutions, and positively correlates with number of original research publications ($p = 0.005$).

The Application Process

Four studies described the neurosurgery residency application process, of which two discussed the perspectives of faculty. Greater than 60% of program directors surveyed in one study indicated that they were “highly satisfied” with their match results in the current process [18]. However, the response rate was 46%, raising concern for selection bias. The majority of program directors also supported revamping the review process to become more objective. Nearly two-thirds of the responses supported a standard letter of evaluation [16], which ranks an applicant based on standard qualities deemed important in neurosurgery such as professionalism, medical knowledge, and work ethic. Although there are many

factors that programs consider in selecting residents, USMLE step 1 score, letters of recommendation, and interviews were of paramount importance across studies [16, 18–20]. Lubelski and colleagues studied a personality assessment for neurosurgery applicants and found an association between the number of publications and an “adjustment” score, which measures composure under pressure [21]. There was an inverse association between the number of publications and an applicant’s “excitable” and “skeptical” scores, which measure emotional lability and sensitivity to criticism, respectively.

Four studies focused on the experiences of applicants. Most applicants obtain their information about residency programs online and there was an association between the size of the program and the quality of the information provided on those websites [22]. Applicants indicate that contact from a program representative after an interview influences how they rank programs when composing their rank lists. Other important considerations include how applicants interact with current residents, overall program camaraderie, and the types of operative cases that a program performs [23].

Residency Recruitment During the COVID-19 Pandemic

Widespread concerns for the health and safety of patients and residents recently pushed neurosurgery programs to rapidly integrate online communications into their current efforts to recruit prospective residents and maintain quality of curriculum [24, 25]. A notable common adaptation across medical schools has been the mandated shift from in-person to virtual interviews. This seismic change has reduced applicant financial costs but has limited opportunities for the applicant to connect with program faculty and current residents [26]. A review of average financial costs per surgical residency applicant for in-person interviews from 2008–2017, as compared to current costs for virtual interviews, found that costs were significantly reduced with the shift to virtual interviews (average cost reduction during the 2020 cycle was approximately $6000) [26]. However, the lack of in-person interactions still prompts applicant concern regarding the quality of connections made and information conveyed between surgical specialty programs and their prospective residents [26]. Additionally, we can compare this to the traditional pre-COVID-19 interview process, where applicants to 2019 and 2020 residency programs reported that live interactions with current residents were the most important factor influencing their perception of a program, followed by their overall impression following exploration of the city and faculty interviews [27]. The latter study surveyed 80% of applicants to a urology residency program in 2019 and 2020, reporting a sufficient relative sample size (n = 156) for generalizability of responses.

Among applicants pursuing surgical specialties, there is also increased concern with suspended away rotations due to the pandemic (as per recommendation by the Association of American Medical Colleges as of March 17, 2020) [28]. A traditional applicant completing two away rotations was correlated with their increased likelihood of successfully matching into a surgical program, followed by a > 50% probability of matching at either a home program or a program at which they completed an away rotation [29]. A retrospective study by Aiyer and colleagues regarding the current orthopedic surgery program application process emphasized that the studied link between completing an away rotation and increased prospects of matching into a surgical program was due in part to how away rotations have been reliable sources for letters of recommendation, surgical experience, and mentorship, all of which

have been commonly cited across studies on the residency match process as essential components of a successful traditional application [27, 29].

Discussion

The arrival of COVID-19 in the U.S. heightened concerns for public health, resulting in medical institutions limiting in-person curricular activities. Notably, residency program outreach and application processes are now much more dependent on online communications. For neurosurgery program applicants, there has been increasing concern regarding virtual interviews, limited research opportunities, and indefinite suspensions of external internships and sub-internship rotations, all of which have traditionally contributed to a prospective applicant's thorough exploration of neurosurgery programs and consequently a successful match [25, 27, 30]. For virtual interviews, specifically, residency applicants are concerned with the relative lack of tangible components, hampered capacity to present themselves accurately, and reduced ability to accurately gauge their compatibility with residency programs [26, 30].

Nonetheless, with the increase in public health efforts to decrease the transmission of COVID-19, it is expected that neurosurgery programs will integrate more intensive utilization of virtual conferencing into curriculum and recruitment over time [25, 31]. A pioneer virtual event that was implemented to address applicant concerns with COVID-19 limitations on rotations and in-person interactions was the 2020 National Virtual Medical Student Symposium, held by the Congress of Neurological Surgeons (CNS). Post-attendance survey data indicated a unanimous approval to establish the symposium as an annual event and overall satisfaction with an improved understanding of neurosurgery residency and the increased opportunities presented by the virtual format of the symposium to connect with more programs and the broader neurosurgical community [32]. It is also significant that over the past decade, neurosurgery program rankings by applicants have consistently taken into consideration educational aspects, such as the academic reputation of the program and established faculty, but are also increasingly prioritizing the resources that the programs offer to address applicant concerns and support resident wellbeing [33]. Additional studies focusing on the current development of virtual communications by individual neurosurgery programs to increase resident recruitment and promote community may provide essential insight for how neurosurgery residency programs can continue to address concerns with the loss of traditional in-person opportunities and adapt their residency recruitment efforts moving forward.

In addition to novel challenges presented by the COVID-19 pandemic to a successful neurosurgery match in current times, certain difficulties associated with the match process are inherent to the established factors of a successful match. We detail in the following sub-sections the longstanding challenges of the neurosurgery match process and relevant focuses for facilitating a more equitable and successful process in current times.

Medical Student Recruitment and Interest Groups

Recently, more studies have focused on potential areas of improvement for neurosurgery resident recruitment and retention. One significant factor that contributes to current recruitment of residents is the presentation and accessibility of relevant information on neurosurgery departmental websites. Larger and higher ranked neurosurgery programs were found to have an overall larger online presence and more easily accessible information on their websites [22]. Other factors for applicant rank list consideration include surgical caseload, team collaboration, current residents, the interview day, and information regarding their particular rank by the program [23]. AANS Medical Student Chapters have spearheaded current efforts to facilitate the neurosurgery residency match process for medical students. Studies have investigated the influence of these groups on future neurosurgery residency match outcomes, research output, and overall medical student neurosurgical learning [11].

These studies provide further evidence that presence of neurosurgical mentorship during the preclinical and clinical years of medical school, accessible information regarding residency programs and applications, access to a home neurosurgery residency program, a “bioscientific orientation”, along with ample research and publication opportunities can increase neurosurgical interest and improve the prospects of a successful match [9, 10, 12, 14, 15, 34–37].

Academic Performance and Academic Prestige

Multiple studies have indicated that academic performance, as measured through the United States Medical Licensing Exam (USMLE) Step 1 score or clinical clerkship grades and academic prestige, may influence match success [5]. A study by Durham and colleagues investigated pre-residency factors influencing match success. The authors observed that from 1990–2007, students scoring > 245 had a 21-fold increase in matching into neurosurgery compared to students scoring < 215, with a mean USMLE Step 1 match score of 233 ± 18.5 As USMLE Step 1 scores continue to trend upwards, even higher scores are likely required to be a competitive applicant. Moreover, they observed that students from top-40 medical schools matched at a significantly higher rate (2-fold increase) than students at non-top-40 medical schools [5]. A more recent analysis on factors influencing match success for the years 2009, 2011, 2014, and 2016, similarly demonstrated that USMLE Step 1, Step 2, graduating from a top-40 medical school, and AOA status were significantly correlated with matching into a neurosurgery residency program [19].

The recent decision to change score reporting of USMLE Step 1 from a three-digit numeric score to a pass/fail outcome is believed to significantly impact the neurosurgery residency selection process [38, 39]. Specifically, this change poses a challenge to program directors, who previously used Step 1 as a key objective criterion in distinguishing highly competitive applicants. Without this metric, the focus may be shifted to Step 2CK scores. Though this does offer an objective numerical data point, Udawatta and colleagues found that Step 2CK performance is not a reliable predictor of neurosurgical board performance [40]. Ultimately, the forthcoming change in Step 1 score reporting presents a novel challenge for the resident recruitment process moving forward.

Publications and Grants

Most notably, the relationship of publications, including neurosurgery specific, basic, translational, and clinical science topics, to an applicant's neurosurgery match success has been extensively researched [16, 17, 19, 37]. Neurosurgery-matched applicants have significantly greater overall research productivity compared to other specialties [41]. However, evidence regarding the association between number of publications and match success is conflicting [19, 41]. Although one study found no association [19], Kashkoush and colleagues demonstrated that h-index was the only factor associated with the residency tier of the matched program [37]. Moreover, h-index was significantly influenced by years since first publishing original research articles [37].

Wadhwa and colleagues found that publication volume of post-graduate year 1 (PGY-1) neurosurgery residents increased from 2009 to 2018 [16]. Moreover, in 2018, PGY-1s at top-40 programs had a significantly higher volume of neurosurgery, first/senior author, basic science, and clinical research publications compared to PGY-1s at non-top-40 programs. A separate study observed that PGY-1s at top-25 programs had a significantly higher volume of overall publications, neuroscience-specific publications, and average citation quantity per publication than PGY-1s at non-top-25 programs [17]. Overall, both studies demonstrate that publication volume is increasing overtime for prospective neurosurgery applicants. On the other hand, the increased quantity of research may be attributed in part to nonindexed works and/or the growing increase in publication misrepresentation amongst neurosurgery applicants [16]. Misrepresentation is common, particularly among medical students applying into neurosurgery from unranked medical schools [42]. Future studies are warranted to both investigate the specific factors within research experience that distinguish applicants to program directors, and to characterize the influence of publication record on matching into neurosurgery.

In addition to publications, medical student grants have also been implicated as a potential factor influencing an applicant's prospects of matching into neurosurgery. Awad and colleagues determined that 51% of grant awardees between 2007–2016 successfully matched into neurosurgery residencies [13]. The majority of grant awardee medical students were from University of Toronto, Harvard University, University of Rochester, and Columbia University, which may be due to the propensity of these universities to accommodate their students' research interests. Grant awardees may have a slight advantage for matching successfully into neurosurgery, potentially through increased contact with neurosurgical mentors and research opportunities. However, further studies should assess the impact of these grant awards, as well as the impact of institutional T32 awards, MSTP status, and F30/F31 awards on the match success rate for neurosurgery applicants.

Letters of Evaluation

Another aspect of potential neurosurgery match success is the value and impact of letters of recommendation (LOR). In a 16-question survey with a 7-point Likert scale sent to all US neurosurgery program directors, LOR was ranked as the highest factor for selecting applicants to interview [20]. Although the response rate was less than 50%, more than half of the program directors that responded found the LOR essential in their residency applicant selection process. A related finding from this study was that the majority of responses indicated support for a shift towards more objective LORs, provided

the potential of a standardized LOR and inclusion of statements focused on an applicant's professionalism, collaborative abilities, communication, and work ethic.

Rotations and In-Person Interviews

Although rotations and in-person interviews are an important aspect of the match process, significant financial costs are often incurred. All neurosurgery applicants tend to have at least one away rotation, and roughly one-third match at one of the institutions at which they performed their away rotation(s) [43]. The away rotation can often be an essential component of the successful match, but the opportunity to participate in at least one of these programs is not equally available to all applicants: across all specialties surveyed, financial cost was the main determining factor for not performing an away rotation, meaning that applicants who cannot afford to attend away rotations may be placed at a significant disadvantage. On average, applicants spend $10,255 on the neurosurgery residency match process, with nearly 70% of that cost being comprised of interview fees and commuting expenses. Interestingly, students who match at their home institution encounter the same cost burden as others.

Potential solutions to high costs include coordination of cost-sharing efforts, such as pooling hotel or transportation or staying with a current local medical student or resident [44]. Another potential solution is virtual interviews [45], which has been found to not significantly affect applicant ranking when compared to in-person interviews and has grown in importance during the COVID-19 pandemic [46]. However, one caveat concerning virtual interviews is the difficulty in deciphering key personality characteristics known to correlate with standard residency selection without in-person cues [21].

International Medical Student Graduates

IMGs are facing increasing competition for U.S. neurosurgery residency spots with no changes in IMG match success over the last decade [3, 47]. Most IMGs have come from the Middle East, specifically Lebanon, and most match into programs in New York, Texas, and Kentucky [48]. A recent study comparing USGs to IMGs demonstrated that the match rates were lower for IMGs despite greater age, percent taking a research gap year, volume of publications, and h-index. Moreover, IMGs are less likely to match into National Institutes of Health top-40 or Doximity top-20 programs, except when previously affiliated with a US neurosurgical department [47].

Conclusion

The process of selecting a career within and matching into neurosurgery is multifaceted and more competitive than ever before. Factors that may influence medical student decisions to pursue a career in neurosurgery include proper neurosurgery-focused mentorship and research, an inquisitive mindset, and resilience. Additionally, factors that have historically influenced successfully matching into neurosurgery include USMLE Step 1 score, scholarly productivity, AOA status, grants, LOR, away rotations, and in-person interviews. However, this data is based on a residency selection system which may never be the same again. With the shift in score reporting for the USMLE Step 1 examination from a three-digit numerical score to a pass/fail system, uncertainty remains as to how residency programs will screen

applicants and which factor(s) will become most important when programs determine who they will interview. As has been observed during the COVID-19 pandemic, these factors are dynamic and future studies are needed to characterize the effects of recent changes - including the USMLE Step 1 scoring change - on the residency selection process.

Another paradigm shift that has occurred during the pandemic is the transition from in-person to virtual residency interviews. While there are obvious disadvantages associated with virtual interviews - including the absence of in-person interactions and the lack of opportunities for applicants to experience the location and culture of a program in person - it remains to be seen whether these disadvantages are actually outweighed by the advantages of virtual interviews: including the fact that a greater number of deserving candidates can be interviewed online and the idea that the virtual approach has leveled the playing field for candidates who might previously have been unable to travel to interviews due to financial limitations.

It also remains to be seen whether the pandemic will have any lasting effect on away rotations, which were suspended during the 2020–2021 cycle and have been limited to one per applicant during the 2021–2022 cycle. Away rotations had previously provided many applicants with up to 3 unique opportunities to impress programs of choice by joining their neurosurgery service for weeks at a time. This was of particular importance for specific programs that seemed to require applicants to rotate with them in order to be considered. Now that away rotations are occurring on a limited basis, it remains to be seen whether these programs will continue to regard attendance at their away rotation as a requisite to match. If they continue to do so, then candidacy would likely be limited to those students choosing to attend an away rotation in order to signal that said program is their top choice (and this would also remove candidates who do not attend from consideration, regardless of their merits). As with other off-stream effects of the COVID-19 pandemic, only time will tell what factors correlate most closely with a successful match into neurosurgery residency in the post-pandemic era.

Declarations

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Declaration of Interest Statement

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