

Improving medical student recruitment to neurosurgery

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OBJECTIVE Neurosurgery seeks to attract the best and brightest medical students; however, there is often a lack of early exposure to the field, among other possible barriers. The authors sought to identify successful practices that can be implemented to improve medical student recruitment to neurosurgery.

METHODS United States neurosurgery residency program directors were surveyed to determine the number of medical student rotators and medical students matching into a neurosurgery residency from their programs between 2010 and 2016. Program directors were asked about the ways their respective institutions integrated medical students into departmental clinical and research activities.

RESULTS Complete responses were received from 30/110 institutions. Fifty-two percent of the institutions had neurosurgery didactic lectures for 1st- and 2nd-year medical students (MS1/2), and 87% had didactics for MS3/4. Seventy-seven percent of departments had a neurosurgery interest group, which was the most common method used to integrate medical students into the department. Other forms of outreach included formal mentorship programs (53%), lecture series (57%), and neurosurgery anatomy labs (40%). Seventy-three percent of programs provided research opportunities to medical students, and 57% indicated that the schools had a formal research requirement. On average, 3 medical students did a rotation in each neurosurgery department and 1 matched into neurosurgery each year. However, there was substantial variability among programs. Over the 2010–2016 period, the responding institutions matched as many as 4% of the graduating class into neurosurgery per year, whereas others matched 0%–1%. Departments that matched a greater ($\geq 1\%$ per year) number of medical students into neurosurgery were significantly more likely to have a neurosurgery interest group and formal research requirements. A greater percentage of high-matching programs had neurosurgery mentorship programs, lecture series, and cadaver training opportunities compared to the other institutions.

CONCLUSIONS In recent decades, the number of applicants to neurosurgery has decreased. A major deterrent may be the delayed exposure of medical students to neurosurgery. Institutions with early preclinical exposure, active neurosurgery interest groups, research opportunities, and strong mentorship recruit and match more students into neurosurgery. Implementing such initiatives on a national level may increase the number of highly qualified medical students pursuing neurosurgery.

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KEYWORDS recruitment; medical students; neurosurgery; interest group; NSIG; exposure

IN recent decades, there has been a decline in the number of neurosurgery residency applicants in the United States.^{1,13} Numerous factors likely contribute to this decline including lifestyle, duration of training, lack of mentors, and lack of early exposure.^{1,12,28}

Neuroscience is among the most common undergraduate majors among premedical students, reflecting a strong interest in neurological disease.^{21,31,32} While the intellec-

tual challenge of neurosurgery may be a draw, students appear to gravitate toward other specialties early during medical school. This change likely occurs because of students' late and/or insufficient exposure to clinical neurosurgery. In a survey of US medical school deans, 59% believed that neurosurgery should not be a required rotation, and only 33% offered neurosurgery rotations prior to students' 4th year.¹⁴ Furthermore, even if institutions of-

ABBREVIATIONS AANS = American Association of Neurological Surgeons; NSIG = neurosurgery interest group.

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TABLE 1. Summary of program characteristics

Variable	Value
No. of responding programs	30
Medical student body size/yr	155 [120, 181]
Formal neurosurgical education	
Preclinical yrs (1–2)	13/25 (52%)
Clinical yrs (3–4)	26/30 (87%)
Mandatory didactic hrs	
<1	5/27 (19%)
1–3	8/27 (30%)
4–6	6/27 (22%)
7–10	3/27 (11%)
>10	5/27 (19%)
Neurosurgeon involvement	28/30 (93%)
Mandatory clinical neurosurgery rotation	11/30 (37%)
Mandatory clinical neurosurgery wks	2 [2, 3]
Mandatory clinical neuroscience wks	4 [2, 4]
Neurosurgery outreach	
Mentorship program	16/30 (53%)
Lecture series	17/30 (57%)
Anatomy labs	12/30 (40%)
Standardized curriculum	3/30 (10%)
Student Interest Group in Neurology	4/30 (13%)
NSIG	23/30 (77%)
Summer shadowing/research opportunities	29/30 (97%)
Research opportunities	
Available research opportunities	22/30 (73%)
Departmental recruiting of medical students	23/30 (77%)
Formal research expectations	16/28 (57%)
Web-based research opportunities	8/25 (32%)
Regular research meetings	19/30 (63%)
Students completing elective or subinternship rotation/yr	3.1 [1.9, 5.3]
Students matched into neurosurgery residency/yr	1.3 [0.5, 2.3]

Values are presented as number/total number (%) or median [interquartile range].

for 3rd- or 4th-year clinical neurosurgical rotations, most medical students decide on their specialty choice prior to these clinical years.^{9,14}

While women now have equal representation in medical school, they still represent a small fraction of neurosurgery residents.³³ The leadership of Women in Neurosurgery (WINS) published a white paper on the recruitment and retention of women in neurosurgery,³ highlighting some of the obstacles facing the specialty. They emphasized the lack of mentorship over lifestyle concerns as a barrier to recruitment, particularly early during medical school. This applies to women in neurosurgery, but it also applies to the specialty as a whole. Other surgical subspecialties such as cardiac surgery,^{16,18} plastic surgery,^{10,22} and orthopedic surgery²⁰ have also investigated methods to improve medical student recruitment.

In the present study, we surveyed neurosurgery residen-

cy programs on their curriculum and activities offered to medical students and sought to correlate such offerings to the number of students who applied and matched into neurosurgery. We hypothesized that mentorship and research programs early in medical school would correlate with a greater number of students applying for and matching into neurosurgery.

Methods

Study Sample

Using a REDCap database (Research Electronic Data Capture), we created an online survey to identify medical school neurosurgical curriculum and neurosurgical department practices in recruiting and integrating medical students (Supplementary Fig. 1). Collected data included the number of medical students and whether there was exposure to neurosurgery in the 1st- and 2nd-year didactic curriculum or during the 3rd- and 4th-year curriculum. We asked whether there was a mandatory neuroscience rotation and whether neurosurgeons in the department were involved. We also sought to identify how the department engaged medical students, including research opportunities, neurosurgery interest groups (NSIGs), anatomy labs, and mentorship programs. Finally, program directors were asked to report the number of students who did electives or subinternships in neurosurgery and how many students matched into a neurosurgery residency over the period of 2010–2016. The number of matched students was further confirmed using American Association of Neurological Surgeons (AANS) membership data (personal communication, 2019) as well as individual medical school online published match lists. The number of matched students was normalized for medical school size and presented as the average number of matching students per class per year.

Data Collection and Analysis

The survey was sent electronically to all program directors of neurosurgery programs in the US (<http://redcap.ccf.org/redcap/surveys/?s=nFF6T4bJEQ>). This process was repeated three times over the course of 2 years in order to maximize the number of responses, with the final responses collected in January 2018. Collected data were analyzed using the JMP Pro 13 statistical software package (SAS Institute Inc.). Continuous data were expressed as medians with interquartile ranges and were compared using nonparametric Wilcoxon rank-sum tests. Qualitative statistics are represented as counts with percentages and were compared using Fisher's exact tests. All values of $p < 0.05$ were considered statistically significant.

Results

A total of 30/110 neurosurgery programs responded to the survey (Table 1). Among the medical schools represented by these programs, the median student body size per year was 155 students (IQR 120–181). Approximately half of the responders with known curriculum details confirmed formal preclinical neurosurgical education during the 1st and 2nd years of medical school (13/25 [52%]); dur-

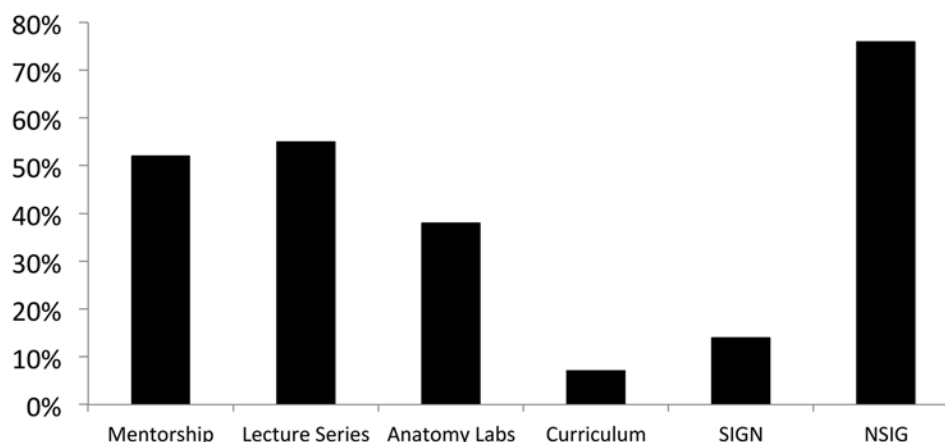


FIG. 1. Bar graph showing the percentage of neurosurgery residency programs with various medical student outreach methods: mentorship programs, lecture series by neurosurgeons, anatomy laboratories, specific neurosurgery curriculum for medical students, Student Interest Group in Neurology (SIGN), and NSIG.

ing the 3rd and 4th years, this number increased to 87% (26/30) of schools offering formal neurosurgical education. Total mandatory didactic time providing neurosurgical education varied from < 1 hour (5/27 [19%]), 1–3 hours (8/27 [30%]), 4–6 hours (6/27 [22%]), 7–10 hours (3/27 [11%]) to > 10 hours (5/27 [19%]). Neurosurgeons were involved with formal neurosurgery education in 93% (28/30) of the schools. Clinical neurosurgery rotations were required for 37% (11/30) of schools and required a median of 2 weeks (IQR 2–3). Median mandatory length of clinical neuroscience rotations was 4 weeks (IQR 2–4). Neurosurgery outreach methods (Fig. 1) included mentorship programs (53%), lecture series (57%), anatomy labs (40%), standardized curriculum (10%), Student Interest Group in Neurology (13%), and NSIG (77%). Ninety-seven percent of the institutions indicated that students could shadow neurosurgeons. Offered research programming (Fig. 2) included research opportunities (73%), departmental recruiting of medical students (77%), formal

research expectations (57%), Web-based research opportunities (32%), and regular research meetings (63%). The median number of home students completing an elective or subinternship rotation in neurosurgery per year was 3.1 (IQR 1.9–5.3). The median number of home students matching into neurosurgery residency per year was 1.3 (IQR 0.5–2.3).

We performed a subset analysis by dividing our sample into a high-matching group (programs that had a match rate into neurosurgery $\geq 1\%$ of the graduating class per year over the 2010–2016 period) versus a low-matching group (programs with < 1%; Table 2). The match rate ranged from 0.1% to 4% per year. We found that the high-matching departments/schools were more likely to have neurosurgery outreach programs. High-matching programs were significantly more likely to have an NSIG (100% vs 65%, $p = 0.02$) as well as formal research requirements (77% vs 24%, $p = 0.01$). Sixty-nine percent of the high-matching schools had neurosurgery mentorship

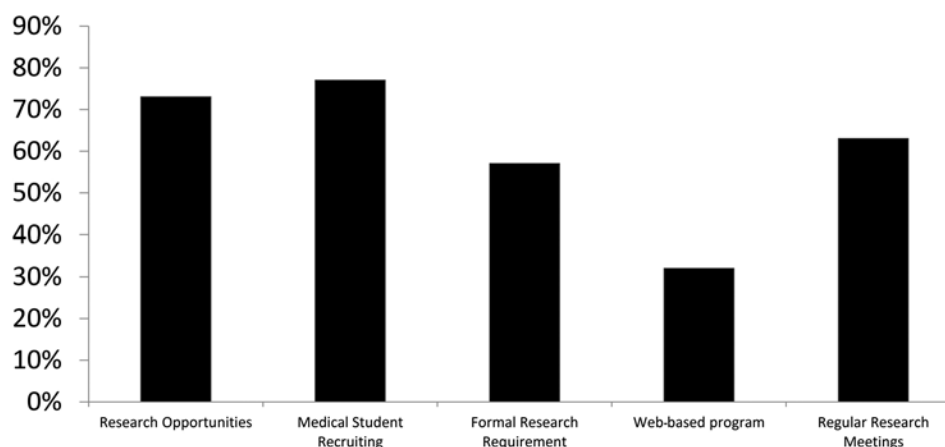


FIG. 2. Bar graph showing the percentage of neurosurgery residency programs with the specific research opportunities. These include having any neurosurgery research opportunities for medical students, active recruiting of medical students, a formal research requirement as part of the medical student curriculum, Web-based/online opportunities to pair medical students with research mentors/projects, and summer research or shadowing opportunities.

TABLE 2. Differences between high-matching ($\geq 1\%$ per year) and low-matching ($< 1\%$ per year) programs

Characteristic	Low Match/Yr	High Match/Yr	p Value
No. of medical schools	17	13	
Formal neurosurgical education			
Preclinical yrs (1–2)	35%	54%	0.5
Clinical yrs (3–4)	76%	85%	0.7
Mandatory didactic hrs			0.04*
<1	8%	25%	
1–3	54%	17%	
4–6	0%	42%	
7–10	15%	8%	
>10	23%	8%	
Neurosurgeon involvement	100%	85%	0.2
Mandatory neurosurgery rotation wks	1 \pm 1.4	0.5 \pm 1.0	0.3
Mandatory clinical neuroscience wks	3 \pm 1.3	2.7 \pm 1.6	0.6
Neurosurgery outreach			
Mentorship program	30%	69%	0.06
Lecture series	47%	69%	0.3
Anatomy labs	24%	54%	0.1
Standardized curriculum	12%	0%	0.5
Student Interest Group in Neurology	0%	23%	0.07
NSIG	65%	100%	0.02*
Summer shadowing/research	93%	100%	1.0
Research opportunities			
Available research opportunities	74%	73%	1.0
Departmental recruiting	71%	69%	0.4
Formal research expectations	24%	77%	0.01*
Web-based research opportunities	29%	25%	0.1
Regular research meetings	56%	69%	0.4

Continuous data are presented as mean \pm standard deviation and categorical data are presented as percentage.

* Statistically significant at $p < 0.05$.

programs compared to 30% among the low-matching schools ($p = 0.06$). Neurosurgery lecture series given by faculty or residents were more common among the high-matching programs (69% vs 47%, $p = 0.3$). And while 54% of high-matching programs had neurosurgery cadaver lab opportunities for medical students, such opportunities were seen in only 24% of the low-matching programs ($p = 0.1$).

Discussion

Compared to previous decades, a decreasing number of applicants are selecting neurosurgery as their first choice.¹³ Some authors have suggested that lifestyle is a major deterrent,³⁰ but others have postulated that the very limited exposure that students receive early in medical school leads to fewer numbers pursuing the specialty.¹ This effect is seen despite the substantial interest in neuroscience noted among undergraduate students.^{21,31,32}

Limited exposure to neurosurgery early in medical

school translates into students forming impressions of the specialty based on minimal and late exposure. For those who may become interested following a rotation, delayed exposure makes it more difficult to identify mentors, become involved in productive research, or complete subinternships prior to the application deadline early during the final year of medical school.

Exposure to role models early in medical school is integral to students developing favorable perceptions toward a surgical career.¹⁵ Pilitsis et al.³⁰ surveyed senior medical students and attendings at six institutions. Among the student respondents, 6% were considering a neurosurgical career. Seventy-two percent of students cited medical school exposure to a particular specialty as the main reason they chose it, and 47% indicated their specialty choice was because of clinical mentors. Thirty-six percent of students indicated they did not consider a neurosurgical specialty because of a lack of exposure and lack of familiarity; 53% cited quality of life concerns.

Recognizing these concerns, some institutions have implemented programs to expose 1st- and 2nd-year medical students to surgical specialties and particularly neurosurgery. At the University of Toronto,¹⁵ Dr. James Rutka and colleagues developed the Surgical Exploration and Discovery (SEAD) program. They ran a 2-week program including observerships, simulated workshops, and career discussions for 20 1st-year medical students and found that after the 2 weeks all indicated greater interest in a surgical career. At Johns Hopkins, Brem and Amundson⁶ reported on the “aggressive” exposure to neurosurgery that medical students receive as early as their 1st year. First-year students can shadow neurosurgeons in the clinic and the operating room. Faculty provide clinical-correlation lectures on neuroanatomy and neuropathology, and medical students are encouraged to attend any departmental conference. Additionally, neurosurgery residents assist in neuroanatomy laboratories. Between the 1st and 2nd year, medical students are funded to do summer research, many of whom choose to join one of many neurosurgery laboratories. Additionally, 3rd-year medical students can do a neurosurgery clerkship rotation. Brem and Amundson argued that these interventions led to the relatively large number of medical students pursuing neurosurgery each year at Johns Hopkins. In more recent years, the Departments of Neurosurgery at University of Medicine and Dentistry of New Jersey (UMDNJ),¹ University of Pittsburgh,²¹ and Vanderbilt University³⁵ have published their own institutional strategies to provide preclinical exposure to medical students. The authors reported corresponding annual increases in the number of students pursuing neurosurgery as well as changed preconceptions regarding neurosurgeon personalities and neurosurgery attendings’ quality of life.³⁵

Early exposure to neurosurgery and early identification of mentors enable students to recognize that concerns regarding quality of life and career satisfaction in neurosurgery may be fewer than what they had perceived. Klimo et al.²³ published a survey of 81 AANS members and found that 73% were “very satisfied” with their choice of career and that 88% would choose a career in neurosurgery again. In a follow-up survey of 783 AANS members, McAbee

et al.²⁷ reported that 80% of respondents were “very” or “somewhat” happy with their career and that 70% would choose the career again. Furthermore, burnout was lowest among academic neurosurgeons. Accordingly, early exposure of medical students (most of whom are at academic institutions) to neurosurgeons leads to greater interest and leads to the correction of negative misperceptions about neurosurgeon personalities and quality of life.

The impact of early exposure has also been demonstrated in other surgical specialties. In a systematic review, Peel et al.²⁹ identified 120 articles looking at barriers to, as well as techniques to increase, the recruitment of medical students to surgical residency. Similar to our findings herein regarding neurosurgery, Peel and colleagues found that some of the most successful methods involved pre-clerkship and clerkship exposure to the surgical fields. Preclinical exposure, and strong mentorship in particular, allowed students to recognize the work-life balance and the ability to provide meaningful impact on patients.^{2,7,11} Within the clerkship experience, hands-on and simulation training^{16,22,24} led to improved student experience and improved student interest.

The present study was developed in an effort to identify the most effective interventions that can be performed to attract medical students to neurosurgery. There has been a recent drive by the AANS leadership to focus efforts on attracting students to neurosurgery, and this has led to the development of AANS Medical Student Chapters. We sought to survey program directors in an effort to inform such chapters of the successful strategies seen nationally. In the present study, we found that there was substantial variability between institutions in the total number of medical students matching in neurosurgery. Most matched between 0 and 1 student per year, but there was a group of high-matching programs that matched an average of 2 or more students per year. Of the responding programs, after adjusting for graduating class size, the programs matching the highest percentage of their students to neurosurgery per year were Cleveland Clinic, Johns Hopkins, University of Pittsburgh, University of Tennessee, and Rutgers New Jersey Medical School. Supplementary Fig. 2 depicts the total number of students matched into neurosurgery between 2010 and 2016 among US medical schools. When comparing the high- versus low-matching programs, we found that institutions with greater numbers matching in neurosurgery had active mentorship programs, faculty and resident lectures, cadaver laboratories, research opportunities, and NSIGs. As previously described, mentorship programs were uniquely important in that they were seen in 69% of high-matching schools, as compared to only 30% of low-matching schools. Moreover, NSIGs are seen much more commonly in high-matching programs (100% vs 65% in low-matching schools).

The strong influence that mentorship has on career selection is well described.^{3–5,8,19,25,26,33} Our data reflect the importance of fostering interest in neurosurgery early in a medical student’s education particularly in the form of mentorship and NSIGs. Interest groups are critical in recruiting students to neurosurgery by facilitating educational conferences, anatomy and skills laboratories, research networking, and mentorship opportunities. Previous

papers have shown the benefit of interest groups on recruiting students to surgery and neurosurgery,^{1,17,21,34} and our data reflect this effect on a national level as well. For these reasons, organized neurosurgery has created national initiatives such as the AANS Mentoring Program and the AANS Medical Student Chapters. These chapters provide a forum for students to organize research and educational activities, offer early involvement in AANS Young Neurosurgeons Committee (YNC) leadership opportunities, and promote mentorship. The chapters have increased student membership in organized neurosurgery from 41 upon inception to more than 2000. While some institutions may have limited research opportunities or exposure to neurosurgeons, these types of national programs can pair students with neurosurgery mentors based on interest and help to foster early interest in the specialty.

There are limitations within our study that must be considered when interpreting the data. This was a survey study with a limited sample size, and only 27% of program directors responded to the survey. While this response rate is not uncommon for survey studies, the relatively small sample size likely introduced selection bias into the results. Statistical analyses were likely underpowered, and given a greater sample size, we may have been able to identify more statistically significant differences between those schools that matched greater numbers of students to neurosurgery and those with fewer. These data demonstrate the effect of past interventions, and ongoing and newly implemented programs are not reflected herein. With the newly founded and increasing number of national AANS Medical Student Chapters, future studies can assess their impact on medical student recruitment.

Conclusions

Medical student exposure to neurosurgery is variable across institutions. Early exposure, research opportunities, mentorship, and NSIGs are more commonly seen at institutions that have a greater number of students pursuing neurosurgical careers. In an effort to attract the best medical students, promote innovation, recruit and retain women, and ensure a sufficient workforce, organized neurosurgery must continue to promote such programs both within individual institutions and on a national level. The creation of AANS Medical Student Chapters and national mentorship programs will, we hope, help to achieve this goal.

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Supplemental Information

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Supplemental material is available with the online version of the
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Supplementary Figures 1 and 2. <https://thejns.org/doi/suppl/10.3171/2019.5.JNS1987>.

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