CNS Podcasts Journal Club

"Home Field Advantage": The Presence of a "Home" Neurosurgical Residency Training Program is Associated With Improved Match Outcomes

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BACKGROUND AND OBJECTIVES: Competition for neurosurgical residency training positions remains fierce. The support provided by applicants' home neurosurgery residency training programs (NRTP) is suspected to play a key role in the National Resident Matching Program (NRMP) process. We sought to evaluate the impact of the presence of an Accreditation Council for Graduate Medical Education–accredited NRTP at medical students' home institutions has on NRMP match outcomes.

METHODS: Our cross-sectional observational study examined all US allopathic senior student Electronic Residency Application Service applications to a single NRTP from 2016 to 2022.

RESULTS: We analyzed a total of 1650 Electronic Residency Application Service applications to a single NRTP, of which 1432 (86.8%) were from schools with an Accreditation Council for Graduate Medical Education–accredited NRTP (NRTP+) and 218 (13.2%) were from schools without a residency (NRTP−). NRTP+ applicants matched a higher rate on both pooled analysis (80.8% vs 71.6%, $P = .002$) and paired analysis ($P = .02$) over the seven-cycle study period. This difference was present before (82.4% vs 73.9%, $P = .01$) and after (77.2% vs 65.6%, $P = .046$) the COVID-19 pandemic. Cohorts were overall similar; however, NRTP+ applicants had more publication experiences (19.6 ± 19.0 vs 13.1 ± 10.2, $P < .001$) and were more likely to complete a research gap year (RGY) (25.8% vs 17.0%, $P = .004$). Completing a RGY was associated with an increased likelihood of matching for NRTP+ applicants but not for NRTP− applicants: NRTP+: 84.9% vs 78.1% ($P = .0056$); NRTP−: 70.3% vs 70.9% ($P = .94$).

CONCLUSION: The presence of a NRTP at a medical student's home institution is associated with improved NRMP match outcomes. This held true both before and after the COVID-19 pandemic. Applicants from schools with a NRTP had more publication experiences and were more likely to complete a RGY. Completion of a RGY is associated with an increased likelihood of matching only for students with an affiliated NRTP.

KEY WORDS: Education, Neurosurgery residency match

ABBREVIATIONS: AOA, Alpha Omega Alpha; **ERAS,** Electronic Residency Application Service; **GHHS,** Gold Humanism Honor Society; **NRTP,** neurosurgery residency training program; **NRMP,** National Resident Matching Program; **RGY,** research gap year; **USMLE,** United States Medical Licensing Examination; **USNWR,** US News and World Report.

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Neurosurgery continues to be among the most competitive specialties for residency training. The past decade has borne witness to a disproportionate increase in the number of applicants relative to the number of residency positions available through the National Resident Matching Program (NRMP). From 2013 to 2022, the total number of Electronic Residency Application Service (ERAS) applications increased from 314 to 391 (24.5% increase), while available training positions only increased from 204 to 240 (17.6% increase).[1] This phenomenon has granted the luxury of increasing selectivity to neurosurgery residency training programs (NRTP) in selecting future trainees.

Historically, factors such as United States Medical Licensing Examination (USMLE) Step 1 scores, Alpha Omega Alpha (AOA) membership, research productivity, and medical school rankings have been associated with successful neurosurgery residency applications.[2-4] However, contemporary changes to medical education have seen a reduction in available objective metrics by which to evaluate candidates. These include the transition of USMLE Step 1 to pass/fail,[5] the phasing out of tiered grading systems citing benefits to student well-being,[6] and the suspension of many AOA chapters over concerns of bias in membership selection.[7,8] These changes will likely confer increased emphasis on remaining objective metrics such as USMLE Step 2 scores, medical school rankings, and research productivity when extending interview offers and generating rank lists.[9]

Since statistics were first published in 2009, there has been a well-documented increase in research output by successfully matched applicants. Wadhwa et al found that among successful applicants, gross research "products" (eg, all abstracts, posters, presentations, and peer-reviewed publications), as reported by NRMP Charting Outcomes in the Match, increased from 7.8 in 2009 to 18.3 in 2018.[10] Sheppard et al reported similar findings, with mean indexed (eg, peer-reviewed) publications increasing from 2.6 in 2011 to 6.5 in 2018.[11] Both groups found that applicants from medical schools ranking in the top 20 or top 40 of the *US News and World Report* (*USNWR*) "Best Research" category had significantly higher mean publication output.[10,11] Notably, all 40 of these programs have an affiliated NRTP.[12]

While alumni of *USNWR* top 40 schools are well-represented in neurosurgery, many individuals graduate from less-resourced institutions and some altogether without an affiliated NRTP. While it is unclear what effects, if any, the lack of a home NRTP has on the careers of successfully matched applicants, this circumstance likely impedes many qualified candidates from pursuing neurosurgical training, as has been witnessed in other competitive subspecialties.[13,14] Beyond availability of research infrastructure, the impact of access to a NRTP is likely pivotal in attracting and cultivating future neurosurgical talent through early exposure, mentorship, and networking.[15,16] In this light, we sought to examine the impact a "home" NRTP has on neurosurgical residency applicants.

METHODS

Study Design and Approval

A cross-sectional observational study was designed to evaluate the impact having an affiliated "home" NRTP has on residency match outcomes and conducted in accordance with Strengthening the Reporting of Observational Studies in Epidemiology guidelines.[17] This study was exempted by the Vanderbilt University Medical Center Institutional Review Board, and the requirement for written informed consent was waived (#202454).

Participants

All applications to a single NRTP submitted for the NRMP through ERAS over a seven-match cycle period were screened. This period began with the 2015–2016 match cycle and concluded with the 2021–2022 match cycle. Completed applications from US allopathic (MD) senior students were included for analysis, whereas applications from US osteopathic (DO) senior students, international medical graduates, and prior US graduates were excluded.

Data Collection

Applicant demographics and characteristics were extracted including application cycle; application type (US MD senior/US DO senior/international medical graduates/prior US graduate); self-reported gender (male/female); AOA member (yes/no); Gold Humanism Honor Society (GHHS) member (yes/no); PhD status (yes/no); research gap year (RGY) status (yes/no); number of research, work, volunteer, and publication experiences; USMLE Step 1 score; and Medical Student Performance Evaluation quartile. Also captured was the presence (NRTP+) or absence (NRTP−) of an accredited NRTP at the applicant's medical school (yes/no) during the year of application. This was determined by referencing the American Association of Neurological Surgeons program directory[18] and the annual NRMP Charting Outcomes in the Match.[1]

A match roster was compiled using "Current Residents" sections available on NRTP websites. To maximize fidelity, this roster was cross-referenced against publicly available institutional match lists and information published to the social media platforms Twitter (twitter.com), LinkedIn (www.linkedin.com), and Doximity (www.doximity.com). Data extraction was performed by 3 authors (SR, MF, NM) and occurred between 07/27/2022 and 12/18/2022. Data were stored in Research Electronic Data Capture.[19]

Statistical Analysis

χ^2 tests were used to assess for differences between categorical demographic characteristics of NRTP+ and NRTP− applicants, and Student *t*-tests were used to assess differences between continuous demographic characteristics. The significance level was adjusted using the Bonferroni correction to account for multiple testing. The Wilcoxon signed-rank test was used to examine the differences in the paired match rates of NRTP+ and NRTP− applicants over the course of 7 application cycles. χ^2 tests were used to assess for differences in the match rates of NRTP+ and NRTP− applicants before and after COVID-19 and to assess for differences in the match rates of applicants who completed RGYs and those who did not.

Multivariable logistic regression was used to investigate the association between demographic characteristics and match outcomes (matched/unmatched) of applicants. Our model included 11 independent variables: NRTP status, gender, AOA membership, GHHS membership, PhD status, RGY status, USMLE Step 1 score, and number of research, work, volunteer, and publication experiences. Statistical analyses were performed using MATLAB 2021a (MathWorks).

RESULTS

A total of 2391 residency applications across 7 match cycles (2015-2016 to 2021-2022) were reviewed, of which 1650

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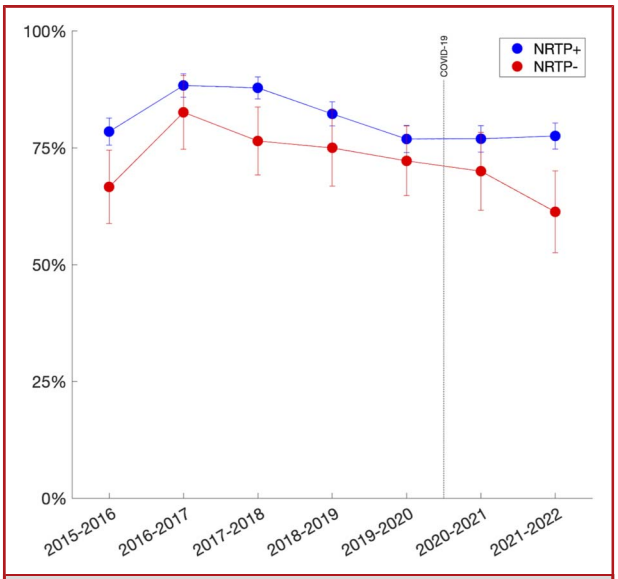

FIGURE. *Match rates of NRTP+ and NRTP− applicants plotted over the course of 7 cycles (2015-2016 to 2021-2022). Blue = NRTP+, Red = NRTP−, Dashed black line = start of COVID-19 pandemic. NRTP+ applicants were significantly more likely to match than NRTP− applicants on paired statistical analysis (P = .02; Wilcoxon signed-rank test). NRTP, neurosurgical residency training program.*

belonged to US MD seniors and were thus included for analysis. A total of 1432 applicants (86.8%) were NRTP+ and 218 (13.2%) were NRTP−. Using descriptive statistics, we found that NRTP+ applicants were significantly more likely to match than NRTP− applicants (80.8% vs 71.6%) in both pooled analysis (χ^2 test: χ^2 = 9.93, P = .002.) and paired analysis over the course of 7 cycles (Wilcoxon signed-rank test: N = 14, P = .02) (Figure). This difference was present both pre–COVID-19 (2015–2016 to 2019–2020): 82.4% vs 73.9% (χ^2 test: N = 893, χ^2 = 6.47, P = .01) and post–COVID-19 (2020–2021 to 2021–2022): 77.2% vs 65.6% (χ^2 test: N = 757, χ^2 = 3.98, P = .046). There was a significant decrease in the match rate of NRTP+ students post–COVID-19: 82.4% vs 77.2% (χ^2 test: N = 1432, χ^2 = 5.33, P = .02). The match rate of NRTP− students was also lower post–COVID-19 (73.9% vs 65.6%), but this did not reach statistical significance (χ^2 test: N = 218, χ^2 = 1.49, P = .22).

Overall, NRTP+ and NRTP− students had similar demographic characteristics (Tables 1 and 2). NRTP+ students did have significantly more publication experiences: NRTP+ mean = 19.6 ± 19.0 vs NRTP− mean = 13.1 ± 10.2 (t-test: P < .001). In addition, a significantly higher percentage of NRTP+ students completed RGYs: NRTP+ = 25.8% vs NRTP− = 17.0% (χ^2 test: N = 1650, χ^2 = 8.00, P = .0047). Completing at least 1 RGY, either nondegree seeking or culminating in a non-PhD degree (eg, Master of Public Health, Master of Clinical Investigation) during medical school was associated with an increased likelihood of matching only for NRTP+ applicants: NRTP+: 84.9% vs 78.1% (χ^2 test: N = 1323, χ^2 = 7.68, P = .0056) and NRTP−: 70.3% vs 70.9% (χ^2 test: N = 209, χ^2 = 0.01, P = .94). Applicants holding a PhD before matriculation or those extending medical school to complete a nonresearch focused degree (eg, Master of Business Administration or Juris Doctor) were grouped with traditional students.

TABLE 1. Applicant Demographic Characteristics

Characteristic	N (%) or μ ± σ NRTP+	N (%) or μ ± σ NRTP−	*P* value
Applicants			
Total applicants	1432 (87%)	218 (13%)	—
USMLE Step 1	244.9 ± 13.7	243.0 ± 14.1	.06
Male	1071 (75%)	165 (76%)	.78
Alpha Omega Alpha	413 (29%)	72 (33%)	.21
Gold humanism	141 (10%)	23 (11%)	.75
PhD (or MD/PhD)	128 (9%)	12 (6%)	.09
Research gap year	370 (26%)	37 (17%)	.0047[a]
ERAS experiences			
Research	5.1 ± 2.8	4.6 ± 2.6	.02
Work	3.1 ± 2.3	3.3 ± 2.2	.50
Volunteer	7.0 ± 4.3	7.2 ± 4.2	.54
Publication	19.6 ± 19.0	13.1 ± 10.2	<.001[a]
MSPE quartile			
Top 25%	440 (31%)	92 (43%)	—
25%–50%	212 (15%)	51 (23%)	
50%–75%	91 (6%)	23 (11%)	
Bottom 25%	40 (3%)	14 (6%)	
Not available	649 (45%)	38 (17%)	

ERAS, electronic residency application service; MSPE, medical student performance evaluation; NRTP, neurosurgical residency training program; USMLE, United States Medical Licensing Examination.

[a]P < .005.

Demographic characteristics of NRTP+ and NRTP− applicants. Last column indicates P value for t-test (continuous variables) or χ^2 test (categorical variables). Significance level was adjusted to 0.005 using the Bonferroni correction to account for multiple testing.

We used multivariable logistic regression to investigate the association between applicants' demographic characteristics and match outcomes (overall model χ^2 = 282, P < .001). Four demographic characteristics were significantly associated with match success: AOA membership (OR = 1.92 [95% CI 1.33-2.80], P < .001), USMLE Step 1 score (OR = 1.06 [95% CI 1.05-1.07], P < .001), number of publication experiences (OR = 1.05 [95% CI 1.03-1.06], P < .001), and number of volunteer experiences (OR = 1.04 [95% CI 1.00-1.08], P = .035). While not reaching statistical significance, 3 additional variables were associated with a trend toward match success: RGY status (OR 1.42 [95% CI 0.99-2.02], P = .051), PhD status

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TABLE 2. Annual Applicant Counts by Residency Training Program Status from 2015–2016 to 2021–2022

	2015–2016	2016–2017	2017–2018	2018–2019	2019–2020	2020–2021	2021–2022
NRTP+ total	200	163	189	220	212	221	227
Matched	157	144	166	181	163	170	176
Unmatched	43	19	23	39	49	51	51
NRTP− total	36	23	34	28	36	30	31
Matched	24	19	26	21	26	21	19
Unmatched	12	4	8	7	10	9	12

NRTP, neurosurgical residency training program.
Counts of NRTP+ and NRTP− applicants over the course of 7 cycles (2015-2016 to 2021-2022) stratified by NRTP home institution status and match status.

(OR 1.72 [95% CI 0.94-3.13], $P = .078$), and NRTP status (OR = 1.35 [95% CI 0.84-1.93], $P = .099$) (Table 3).

DISCUSSION

Our data suggest that for US MD senior students, attending a medical school with an affiliated Accreditation Council for Graduate Medical Education–accredited NRTP is associated with a significantly higher likelihood of matching into neurosurgery residency (80.8% vs 71.6%, $P = .002$). This held true in both pre–COVID-19 and post–COVID-19 eras. Demographically, there were no significant differences between the NRTP+ and NRTP− cohorts in USMLE Step 1 scores, gender, AOA membership, GHHS membership, or numbers of research, work, or volunteer experiences. The NRTP+ cohort had a significantly higher mean number of publication experiences and was significantly more likely to complete a dedicated RGY. Interestingly, taking a RGY was associated with a higher likelihood of matching only in the NRTP+ cohort, with overall match rates for NRTP− students being slightly lower than those of traditional, 4-year NRTP− students. Using a multivariable logistic regression model, 4 variables were identified as being significantly associated with match success: AOA membership, USMLE Step 1 score, number of publication experiences, and

TABLE 3. Multivariable Logistic Regression Model Parameters and Odds Ratios

	Coefficient	Odds ratio	CI lower	CI upper	*P* values
NRTP+	0.3015	1.3519	0.9443	1.9353	.099[b]
Gender	−0.20591	0.8139	0.5980	1.1079	.190
USMLE step 1	0.059929	1.0618	1.0502	1.0734	<.001[a]
Research	−0.030482	0.9700	0.9222	1.0202	.236
Work	−0.034979	0.9656	0.9100	1.0247	.248
Volunteer	0.037325	1.0380	1.0026	1.0747	.035[a]
Publication	0.047145	1.0483	1.0333	1.0634	<.001[a]
AOA	0.65516	1.9255	1.3265	2.7948	<.001[a]
GHHS	0.13781	1.1478	0.7074	1.8622	.576
PhD	0.53981	1.7157	0.9406	3.1295	.078[b]
RGY	0.35171	1.4215	0.9986	2.0234	.051[b]

AOA, Alpha Omega Alpha; GHHS, Gold Humanism Honor Society; NRTP, neurosurgical residency training program; RGY, research gap year; USMLE, United States Medical Licensing Examination.
[a]$P < .05$
[b]$P < .10$
Relationship between match outcomes and demographic characteristics using multivariable logistic regression. Regression coefficients, *P* values, and odds ratios with corresponding upper and lower levels of 95% CIs are shown. Characteristics with significant *P* values (<.05) are marked with an asterisk.

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number of volunteer experiences. An additional 3 variables were associated with a trend toward match success: RGY status, PhD status, and NRTP status.

Delayed exposure to neurosurgery has been implicated as a factor hampering recruitment, as most medical students choose a specialty before the clinical (MS3/MS4) years.[20,21] Lubelski et al[15] postulate that for students electing to pursue neurosurgery, delayed exposure also makes it more difficult to identify mentors, become involved in productive research endeavors, and successfully navigate the application process. We suspect that the "double-negative" impact of delayed exposure, both in reduced initial interest and increased difficulty constructing a competitive application, may be exacerbated in an NRTP− environment.

The COVID-19 pandemic was a catalyst for change to the residency application process. Most notably, travel restrictions prevented students from participating in away rotations, an integral part of the application process.[22] Away rotations serve as a source of valuable letters of recommendation from prominent neurosurgical faculty members, ideally allowing for unbiased appraisal of an applicant's potential.[3,23-25] Although provisions were established for NRTP− applicants to rotate at a geographically nearby NRTP, this may still have resulted in disadvantage.[22] Under normal circumstances, applicants may not have selected the nearest NRTP over concerns of "fit," such as perceived incompatibility with training goals (eg, research vs clinically focused) and career aspirations (eg, academic vs private practice). Furthermore, written endorsements derived from a single month's exposure could potentially be weaker relative to those of peers with whom letter writers had greater familiarity. In addition to away rotation changes, interviews were transitioned to a virtual format. Without the self-imposed constraints of travel time and cost, concerns were raised that the most competitive applicants would attend larger numbers of interviews, thus reducing availability for others. In a survey of neurosurgery program directors, 60.5% indicated that applicants from less prestigious schools would likely suffer from virtual interviews.[26] Although we did observe a drop in match rates for NRTP− students after the pandemic (73.9% vs 65.6%), this did not reach statistical significance (P = .22), potentially due to the small sample size of the postpandemic NRTP− pool (n = 61).

Our multivariate logistic regression model identified AOA membership, USMLE Step 1 score, number of publication experiences, and number of volunteer experiences as significant independent predictors of match success along with trends toward significance in RGY status, PhD status, and NRTP status. These findings are overall consistent with prior studies[2-4,10]; however, modeling will almost certainly shift in the near term with the transition of USMLE Step 1 to pass/fail and the ongoing suspension of many AOA chapters. The positive trend but lack of significance for NRTP status (P = .099) was somewhat surprising given that descriptive statistics demonstrated a significantly lower match rate for NRTP− students (80.8% vs 71.6%, P = .002). One possibility is that given the relatively small proportion of NRTP− applicants (13.2%), the sample size was not sufficient to definitively capture the effect of NRTP status. Another possibility is that attending an NRTP− school does not in and of itself decrease an applicant's likelihood of matching, but rather this effect is mediated by another variable such as publication output. In other words, multiple variables within the model may be interdependent. Our data confirm a significant difference in publication output (19.6 ± 19.0 vs 13.1 ± 10.2, P < .001), congruent with prior studies suggesting that increases in publication output are primarily clustered in *USNWR* top 20/top 40 programs, all of which are noted to be NRTP+.[10,11]

RGYs are often considered as a mechanism to strengthen residency candidacy through research experience and establishing connections.[27-29] In our regression model, the association of RGY completion and match success approached significance (P = .051). The likely explanation is that our model was trained on the entirety of our data set, while RGY completion was associated with an increased likelihood of matching solely for NRTP+ applicants: NRTP+: 84.9% vs 78.1% (χ^2 test: N = 1323, χ^2 = 7.68, P = .0056) and NRTP−: 70.3% vs 70.9% (χ^2 test: N = 209, χ^2 = 0.01, P = .94). It is possible that NRTP− students are completing RGYs at smaller, underresourced centers; however, this assertion is beyond the scope of our study. This could also be a function of insufficient access to high-quality advising and that some NRTP− students with an already low likelihood of matching, such as those with poor Step scores or remediated coursework, may still pursue RGYs in hopes of bolstering their applications.

Possible barrier reduction methods for NRTP− students center on increased exposure. Critically, NRTP− medical schools and/or individual students should attempt to foster relationships with geographically related NRTP+ institutions. These relationships may influence more highly qualified candidates to pursue neurosurgery as well as facilitate access to mentorship and research opportunities. Vanderbilt University Medical School (NRTP+) developed an elective program for nearby Meharry Medical College (NRTP−) which includes preclinical lectures and clerkship opportunities during the MS3 year. Although no data are available regarding match outcomes, this resulted in improved perceptions of the neurosurgical field.[30] On a larger scale, leadership in organized neurosurgery could consider developing a robust, centralized hub to promote available research and mentoring opportunities for interested medical students. Our data suggest that RGY completion is not associated with increased likelihood of matching for NRTP− students. However, future analysis may prove that this option is beneficial for students with access to high-quality advising and/or those who are able to secure a position at well-resourced centers.

Limitations

Our study is not without limitation. Data analysis is restricted to US MD senior students, and thus, the results are not generalizable to other types of applicants such as US DO senior students, IMGs, or prior US graduates. Furthermore, our sample only includes ERAS applications submitted to a single NRTP and, while robust, is not representative of the entire applicant cohort as certain applicants may have preferentially applied to other

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institutions. Compared with published NRMP totals, we were able to capture 91.6% of US MD senior applications (1650 of 1801) and 93.7% of successfully matched US MD seniors (1313 of 1402).[1] Complete match lists are not available and by necessity were derived from sources including current resident rosters, institutional match lists, and popular social media platforms. Accuracy may suffer due to outdated information and other confounding factors such as resident attrition, program transfers, and name changes, all likely worsened with time.

CONCLUSION

A confluence of increasing numbers of applications, falling match rates, elimination of objective metrics, and the ongoing research productivity "arms race" may disproportionately affect medical students at less-resourced institutions, particularly those without home training programs. As a specialty, we must continue to design programs to provide this cohort with enhanced exposure to neurosurgery, greater access to research opportunities, and to facilitate networking. By striving for inclusivity, we can continue to welcome the best possible candidates to our field, regardless of educational background.

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COMMENTS

This is an excellent analysis of differences in applicant success in matching into a neurosurgical training program between students at medical schools with (NRTP+) and without a home neurosurgical training program (NRTP−). Perhaps not surprisingly, NRTP+ applicants had a higher success rate in the match, although the difference is smaller (perhaps much smaller) than one would suspect given the potential disadvantages of NRTP− applicants—later and less opportunity for longitudinal exposure to clinical neurosurgery, fewer prospects for neurosurgical research, and fewer opportunities for neurosurgical mentorship. The overall success of these applicants is a testament to the tenacity of NRTP− applicants as well as the commitment of programs to find the best applicants for each training program.

It is difficult to disentangle the factors that may contribute to decreased match rates amongst NRTP− applicants. A key objective difference between the groups is the number of "publication experiences." When taken with the fact that number of "publication experiences" correlates with successful match, one may jump to conclude that NRTP− applicants need to publish more to succeed in the match. We should be careful to not use these results to further the publications "arm race." Notwithstanding the fact that quality should be more important than quantity of publications, we should also be cognizant though that we cannot quantify and therefore assess the impact of neurosurgical exposure, experience, and mentorship, which we all recognize as critical to success in every aspect of our careers. Solutions for early exposure and mentorship for NRTP− students should be a high priority for our field and for medical schools. This should serve as a call-to-action for all of our training programs as well as medical schools without a training program to give and create these opportunities across institutions in order to help deserving future neurosurgeons succeed.

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