9-1-2022

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Trends in Matriculation from Neurological Surgery Training Programs into Academic Versus Private Practice

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■ OBJECTIVE: **A career in academic neurosurgery is an arduous endeavor. Specific factors influencing physician practice preferences remain unclear. This study analyzes data from the American Association of Neurological Surgeons membership identifying the impact of several demographic and educational characteristics influencing neurosurgical career choices centered on academia, private practice, or a combination in the United States.**

■ METHODS: **A list of all current neurosurgeons was obtained from the American Association of Neurological Surgeons membership, and information on physician characteristics was collected via internet searches and institutional databases. The practice type of all neurosurgeons considered in this study were categorized as follows: private practice, academic, or a combination of private practice and academic, termed privademic. These data were subsequently correlated to race, gender, current age, training at a top 40 National Institutes of Health–funded medical school or residency program, and current practice.**

■ RESULTS: **The median age of private practice and academic neurosurgeons was 58.18 and 53.61 years, respectively ($P < 0.001$). Age was significantly associated with practicing in an academic setting (odds ratio 0.96), with younger neurosurgeons pursuing careers in academia. Data indicated a positive and statistically significant contribution of female gender ($P < 0.001$) and training at a top-40 National Institutes of Health–funded institution to practicing in an academic setting ($P < 0.01$).**

■ CONCLUSIONS: **Neurosurgery as a field has grown significantly over the past century. The authors recommend that future efforts seek to diversify the neurosurgical workforce by considering practice setting, demographic characteristics, and educational background.**

INTRODUCTION

Neurosurgeons have a tremendous impact on patient outcomes, including overall survival and quality of life. Within the U.S. health care system, however, different incentives motivate neurosurgeons to pursue careers in one practice setting or another. An academic neurosurgical practice augments access to multidisciplinary care teams and collaboration for university-based research, often resulting in novel patient care methods. Academic practice enables one to foster innovation, generate informative data, and publish findings in the collective literature that can provide transformative insights into neurological disease. Meanwhile, in addition to providing vital care for their local communities and engaging in notable innovation,

Key words
- Academic medicine
- Demographics
- Neurosurgical training
- Private practice

Abbreviations and Acronyms
AANS: American Association of Neurological Surgeons
NIH: National Institutes of Health
OR: Odds ratio

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Citation: World Neurosurg. (2022) 165:e635-e642. https://doi.org/10.1016/j.wneu.2022.06.119

*Journal homepage: **www.journals.elsevier.com/world-neurosurgery***

*Available online: **www.sciencedirect.com***

neurosurgeons in the private practice setting spread new and innovative techniques and treatments, broadening access to new treatments and innovations to include vulnerable members of the U.S. patient population.[1]

Given the rich contributions to neurosurgery made in either practice setting, an individual's practice preference may be determined by individual, institutional, and societal factors that are worth investigating. Understanding demographic trends and potential predictive factors of practice setting is important, given that both academic and private practice are essential for the future development, growth, and spread of innovative neurosurgical treatment modalities.[2] As such, this study seeks to identify various factors associated with neurosurgical practice preference.

METHODS

Data Source

The American Association of Neurological Surgeons (AANS) maintains an up-to-date database of information on all neurosurgeons and neurosurgeons in training regardless of AANS membership status. A list containing all neurosurgeons currently practicing in the United States was obtained from the AANS membership information database, which included variables such as physician name, board certification status, gender, race, AANS membership status, city/state of practice, date of birth, degrees held, medical school attended, residency training program completed, and fellowship program completed. The dataset was filtered based on trainee status, location of neurosurgical practice, country of practice/board certification (United States), and neurosurgical board certification status. This list was then cross-checked with the American Board of Neurological Surgeons website.[3]

Data Collection

Additional neurosurgeon characteristics, including practice type (private vs. academic), were manually collected from the aforementioned list of physician names. Missing variables also were extracted during this process. Type of neurosurgical practice was determined based on Google search findings confirming the following criteria. Physicians were deemed to fit the academic category for having faculty status at an institution affiliated with a medical school or neurosurgery residency program. Physicians in the private category were members of a privately funded neurosurgical practice. Physicians were deemed to practice in both academic and private settings, namely privademic, if they met the criteria for academic practice and were also associated with a neurosurgical private practice.

Primary end points were either found in the database or collected via Google search, and included gender, age, practice type, location of practice, confirmation of medical school and residency program attended, and degrees held. Medical schools and residency programs were further categorized by neurosurgery programs ranked in the top 40 National Institutes of Health (NIH)-funded institutions in the realm of neurosurgery, based on 2019 data from Blue Ridge Institute for Medical Research.[4] Data from the AANS membership database were specifically mined to identify the impact of several demographic and educational background characteristics among practicing neurosurgeons in the United States on academic or private practice preference.

Statistical Analysis

Baseline summaries were created of the major variables collected. Variables were compared based on practice type and academic involvement via χ^2 tests for categorical variables (gender, race, medical school, and residency NIH funding status), and t tests for the continuous variable of age. A logistic regression model was created to identify variables associated with neurosurgeon practice settings. States were compared based on the percentage of academic neurosurgeons. The data were further grouped into populations based on gender identity, with baseline characteristics among the 2 groups compared as before. States of residence were similarly compared based on the percentage of female neurosurgeons.

All statistical analyses were conducted using R 3.5.2 (R Foundation for Statistical Computing, Vienna, Austria) statistical software. A P value of <0.05 was used to define statistical significance throughout this study. In addition, because this study only used publicly available data found openly on the internet without any protected patient health information, ethics approval was not required from any institutional review board.

RESULTS

Comparisons of Neurosurgical Practice Type

A total of 4075 board-certified neurosurgeons were identified as currently practicing in the United States. Of these neurosurgeons, 2158 (52.96%) practice exclusively in private practice, 1272 (31.21%) practice exclusively in an academic setting, and 645 (15.83%) practice in some combination of private and academic practice types. **Table 1** outlines the association between neurosurgical practice type and demographic/educational background characteristics.

The median age of board-certified, actively practicing neurosurgeons in the United States was 55.22 years old (mean 56.03; minimum 35.71, interquartile range 15.03, maximum 90.73). There was a lower median age for academic neurosurgeons (53.61 years) versus nonacademic (only private practice) neurosurgeons (58.18 years) (**Figure 1**). Academic neurosurgeons were found to have a larger range in ages and were likely to be practicing at later ages, likely due to the longevity of an academic career.

Neurosurgical practice type was compared to training program level, showing a statistically significant difference between practice type and neurosurgeons coming from top 40 NIH-funded allopathic Doctor of Medicine (M.D.) programs ($P < 0.01$) and a top 40 NIH-funded residency training program ($P < 0.01$). Those neurosurgeons coming from top 40 NIH-funded institutions were more likely to practice in an academic setting, including top 40 funded medical school (odds ratio [OR] 1.44, $P = 0.002$) and top 40 funded residency training program rank (OR 1.37, $P = 0.007$) (see **Table 2**).

χ^2 tests examining the association between neurosurgical practice type and race showed a statistically significant association between distribution of racial self-identification and practice type ($P < 0.001$), suggesting an association between practice type and race. Individuals identifying as Asian ($n = 286$) and other races

Table 1. Comparison of Demographic Characteristics and Educational Background to Neurosurgical Career Practice Preference

Total Sample (n = 4075)	Private (n = 2158)	Academic (n = 1272)	Both Private and Academic (n = 645)	P Value
Race				0.0002028
Asian	0.47552448	0.37412587	0.15034965	
Black	0.65060241	0.26506024	0.08433735	
Hispanic	0.66666667	0.25000000	0.08333333	
Other	0.48333333	0.41666667	0.10000000	
White	0.57099081	0.26404494	0.16496425	
Native American	0.00000000	1.00000000	0.00000000	
M.D. program rank				0.002155
Not Top 40 NIH M.D.	0.5088790	0.3479467	0.1431743	
Top 40 NIH M.D.	0.4381503	0.3872832	0.1745665	
Residency program rank				1.846E-07
Not Top 40 NIH residency	0.5259580	0.3368356	0.1372064	
Top 40 NIH residency	0.4259132	0.4004135	0.1736733	

NIH, National Institutes of Health.

(n = 60) were more likely to practice neurosurgery in an academic setting. Of all races, those identifying as White (n = 1958) were most likely to have a hybrid neurosurgical practice including both academic and private practice components (16.49%).

Logistic Regression for Neurosurgical Practice Type

Table 2 outlines logistic regression results for academic practice with associated ORs for the measured variables. Male gender (more likely to be private, $P < 0.05$), Hispanic ethnicity (more likely to be private, $P < 0.01$), graduation from top 40 NIH-funded medical school (more likely to be academic, $P < 0.01$), completion of top 40 NIH-funded residency training program (more likely to be academic, $P < 0.01$), and age (more likely to be private, $P < 0.001$) were all statistically significantly associated with neurosurgical practice type.

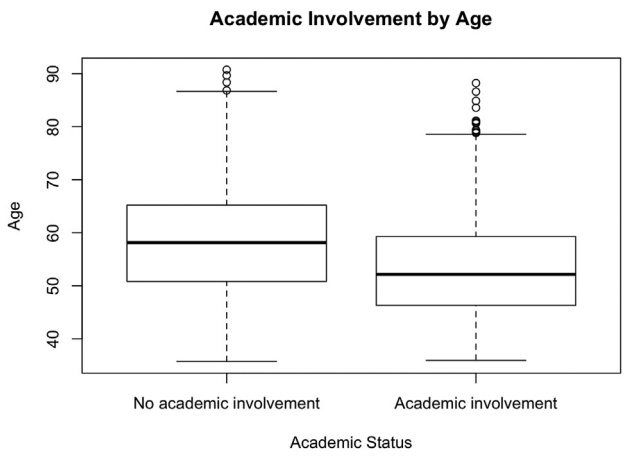

Figure 1. Box-and-whisker plot displaying academic involvement by neurosurgeon age. The *thick black center line* denotes the median age (50th percentile) whereas the ends of the box contain the 25th to 75th percentiles of the dataset. The *black whiskers* mark the 5th and 95th percentiles, and values beyond these upper and lower bounds are outliers, marked as *open circles*. The mean age for private practice, nonacademic neurosurgeons (no academic involvement) was 58.18 years, whereas the mean age for academically involved neurosurgeons was 53.61 years.

In the study cohort, 245 (6.01%) neurosurgeons identified as "female," 3829 (93.96%) identified as "male," and 1 (0.02%) identified as "other" gender. Female neurosurgeons were found to be practicing in an academic setting more often than their male counterparts (OR 0.63 male/female, an equivalent of 1.59 female neurosurgeons entering academic neurosurgery for every 1 male neurosurgeon). As shown in Table 3, no statistically significant difference was found when comparing male and female gender to respective distributions amongst top 40 NIH-funded MD ($P = 0.7241$) and residency training ($P = 0.7201$) programs, suggesting that male and female neurosurgeons have similar training experiences in neurosurgery. Despite no significant differences in training, female neurosurgeons were found to practice in any academic setting more often than male neurosurgeons (62.86% female neurosurgeons having academic involvement vs. 46.02% of male neurosurgeons, $P < 0.001$).

In terms of race, Asians and White neurosurgeons were more likely to enter academic neurosurgery than Black and Hispanic neurosurgeons (OR 0.54 and OR 0.43, respectively). Attending a top 40 NIH-funded medical school (OR 1.44), or residency training program (OR 1.37) resulted in increased odds of practicing neurosurgery in an academic setting. Female neurosurgeons tend to be younger than male neurosurgeons, with a median age of 49.86 versus 56.42, respectively. Age was significantly associated with odds of practicing neurosurgery in an academic setting (OR 0.96), with each additional year of age making a neurosurgeon less likely to practice in academia.

Table 2. Logistic Regression Results for Demographic and Educational Characteristics Correlation to Academic Practice Type

Estimate	Beta	z	Value	Pr (>|z|)	Odds Ratio
Constant	2.613493	7.243	4.40E-13	*	
Gender (male)	−0.455515	−2.086	0.03701	†	0.63
Race (Asian)					
Black	−0.620006	−1.832	0.06701		0.54
Hispanic	−0.851621	−2.641	0.00827	‡	0.43
Other	−0.083709	−0.236	0.81373		0.91
White	−0.179655	−1.077	0.28148		0.84
Native American	12.063456	0.037	0.97037		173,417
Top 40 NIH MD	0.371170	3.063	0.00219	‡	1.44
Top 40 NIH Residency	0.312812	2.699	0.00695	‡	1.37
Age	−0.049549	−14.18		*	0.96

NIH, National Institutes of Health.
*$P < 0.001$.
†$P < 0.05$.
‡$P < 0.01$.

Figure 2 displays the percentage of academic neurosurgeons by U.S. state. Finally, Figure 3 highlights the geographic distribution of female neurosurgeons by U.S. state. Of note, many U.S. states do not have even a single board-certified, actively practicing female neurosurgeon.

DISCUSSION

Neurosurgeons in both the academic and private practice setting provide meaningful contributions to patient care. The authors of the present study dissected various sociodemographic, geographic, and educational factors associated with practice choice, including, but not limited to, age, gender, race and educational background and training (medical school or residency), with an aim to discuss trends in academic and private practice neurosurgery.

Table 3. Comparison of Educational Background and Practice Type to Neurosurgery Gender

	Female ($n = 245$)	Male ($n = 3829$)	*P* Value
MD program rank			0.7241
Not Top 40 NIH M.D.	0.6651163	0.6768666	
Top 40 NIH M.D.	0.3348837	0.3231334	
Residency program rank			0.7201
Not Top 40 NIH residency	0.5163934	0.5283286	
Top 40 NIH residency	0.4836066	0.4716714	
Academic practice type			2.2E-16
Private	0.37142857	0.53982763	
Academic	0.55918367	0.29642204	
Both Private and Academic	0.06938776	0.16375033	

NIH, National Institutes of Health.

More neurosurgeons chose private practice over academia, although 15.82% of all neurosurgeons practice in both settings (Table 1). χ^2 analysis revealed a statistically significant tendency for those who completed medical school or residency training at a top 40 NIH-funded institution to pursue an academic career in neurosurgery, while neurosurgeons in private practice were older and identified as White, Hispanic, or Black ($P < 0.001$). Notably, those who self-identified as White were significantly more likely to practice in a privademic setting. A logistic regression of these data indicated a statistically significant positive contribution of female gender and training (medical school or residency) at a top 40 NIH-funded institution to entry into academic neurosurgical practice (Table 2). When analyzed by gender, these data indicate that female neurosurgeons are significantly younger than their male counterparts, and unfortunately only make up approximately 6.01% of the total neurosurgical workforce (Figure 4).

For several decades, there has been a push to increase the number of physicians entering the academic workforce.[5] A recent survey suggests that a disproportionately large fraction of medical school graduates intend to pursue careers in private practice.[6] There are several factors associated with this decision, including concerns regarding the financial viability of academia and the burden of academia on family life and work–life balance.[7-9] In the ensuing text, several factors that potentially affect an individual's likelihood of attaining a neurosurgical career are discussed, and the impact of these factors on the setting of neurosurgical academic medicine, private practice, or a hybrid of both is explored.

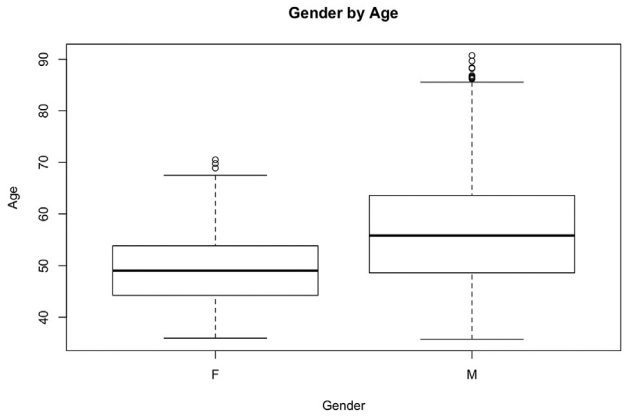

Figure 2. Box-and-whisker plot displaying neurosurgeon gender by age. The *thick black center line* denotes the median age (50th percentile), whereas the ends of the box contain the 25th to 75th percentiles of the dataset. The *black whiskers* mark the 5th and 95th percentiles, and values beyond these upper and lower bounds are outliers, marked as *open circles*. The mean age for female neurosurgeons was 49.86 years, whereas the mean age for male neurosurgeons was 56.42 years.

Academic Training

Neurosurgeons graduating from top 40 NIH-funded M.D. and residency training programs appear more likely to practice in an academic setting. Similar trends are reflected in the literature, with individuals of high academic standing or advanced training choosing academia over private practice.[7,10,11] There are several factors that may feed into this trend. It may reflect enhanced emphasis on academic careers throughout training at top 40 NIH-funded institutions, leading to a preference for academia.[1] These institutions may also offer more resources and opportunities for trainees, allowing them to quickly build connections conducive to entering academic positions.[12-14] These trends are also partly self-selected, as medical students interested in academia often attend these institutions and thus are more likely to have the resources and support throughout residency to obtain an academic position afterwards. Recently, a trend of increased basic science and clinical research has been observed among neurosurgery residency applicants.[15] Importantly, this analysis represents the first direct comparison of neurosurgery practice choice based on medical school NIH-funding rank.[2]

Gender

The present study demonstrates a statistically significant preference among female neurosurgeons to enter academia over private practice. This is corroborated by studies in other medical specialties, although there are no similar analyses in neurosurgery.[7,11] In addition, academic medicine as a whole continues to be predominantly male, with minimal female involvement and even fewer women in leadership roles.[16,17] This is emphasized by the fact that only 12% of all practicing U.S. and Canadian neurosurgeons are female.[18] Unfortunately, this perception may not yet be realized in the neurosurgical sphere, as an overwhelming body of literature presents significant disparities in the training, academic ranks,

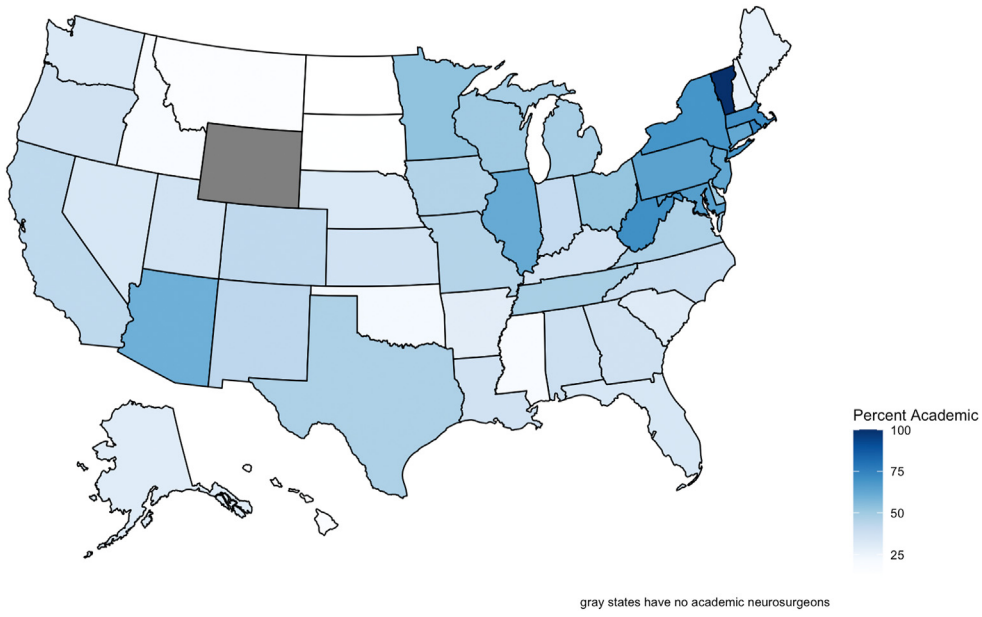

Figure 3. Map of the United States displaying the percentage of academic neurosurgeons ($n = 1917$) in each U.S. state. Wyoming has no academic neurosurgeons with an active clinical practice. *Lighter-shaded* states have fewer academic neurosurgeons, whereas *darker-shaded* states have more academic neurosurgeons.

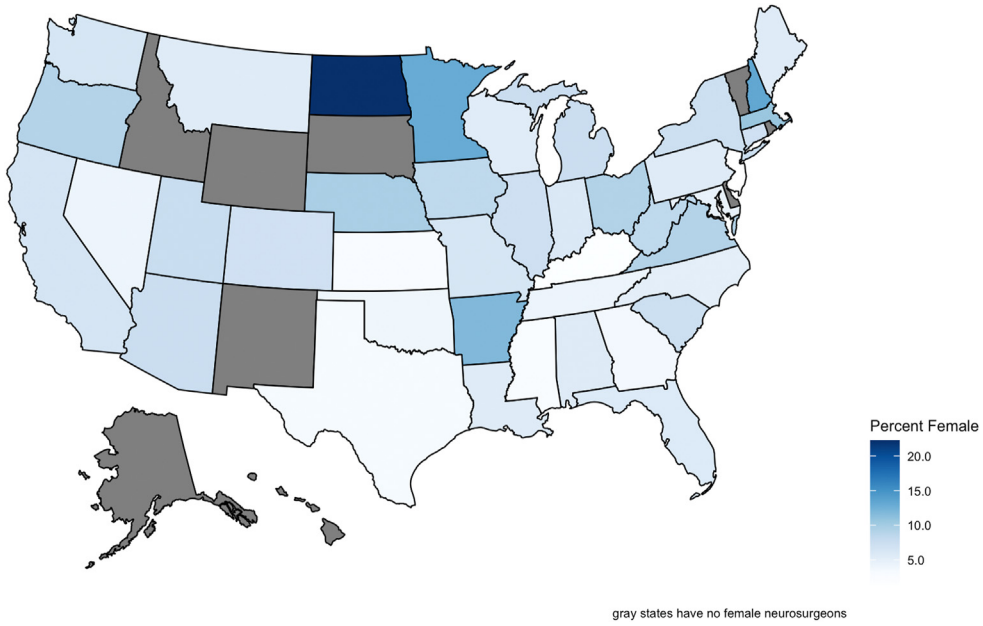

Figure 4. Map of the United States displaying the percentage of female neurosurgeons ($n = 245$) in each U.S. state. Several states have no female neurosurgeons with an active clinical practice. *Lighter-shaded* states have fewer female neurosurgeons, whereas *darker-shaded states* have more female neurosurgeons.

publication records, and leadership positions of female neurosurgeons.[18-22] To exemplify, in their study on neurosurgical residency attrition, Agarwal et al.[23] found that neurological surgery women trainees had a greater attrition rate (18.50%) than their men (10.35%) counterpart. In light of these findings, it is encouraging to see systematic changes that have been previously proposed to strengthen the recruitment and retention of women in neurosurgery. As per Benzil et al.,[21] to ensure gender equality in the field of neurosurgery, it is important to, "1) Characterize the barriers. 2) Identify and eliminate discriminatory practices in the recruitment of medical students, in the training of residents, and in the hiring and advancement of neurosurgeons. 3) Promote women into leadership positions within organized neurosurgery. 4) Foster the development of female neurosurgeon role models by the training and promotion of competent, enthusiastic, female trainees and surgeons."[21]

Importantly, however, there is hope for future growth and development of female neurosurgeons. A recently published article in the *Journal of the American College of Surgeons* demonstrated that more NIH funding and a greater number of first-time NIH grants were awarded to female surgeons when compared with their male counterparts.[17] For this to be extended to female neurosurgeons, neurosurgery departments and divisions must set dedicated goals to support female trainees and young faculty from their earliest stages of training.[24]

Race

Through the aforementioned analysis, we have identified several differences in postresidency neurosurgical practice decisions based on race. The overall preference of individuals who self-identified as White for private practice and the significant ratio of White individuals who practiced in both the academic and private settings echoes trends in several other specialties.[14] Although efforts have been made in recent years to diversify the neurosurgical workforce, they have not yet led to substantial change, as evidenced by previous studies.[25-27] To that end, numerous studies have outlined concrete steps to increase interest in the field for aspiring neurosurgeons from diverse backgrounds, with a collective aim to foster rich diversity within neurosurgery.[14,19,20,22,27]

Age

At every level of analysis, the age of private practice neurosurgeons (58.18 years) emerged as a differentiating factor in practice preference. The fact that private practice neurosurgeons tend to be older than academic neurosurgeons may also indicate that private practice neurosurgeons retire later than academicians, or, more likely, that increased numbers of recent neurosurgical residency graduates are gravitating toward academic medicine. This finding could also indicate that those who choose neurosurgical private practice tend to be older than those who choose academia. Furthermore, this analysis might suggest that neurosurgeons might start off in academia and then shift to private practice at a later stage in their career. Given the conflicting trends in the literature with regards to recent reviews in similarly competitive medical specialties (e.g., otolaryngology and anesthesiology),[7,11] future studies are needed to further explore the reported age trends.

Limitations

One limitation of this work is its dependence on the availability of public information for all AANS neurosurgeons. In completing this study, our analysis only includes U.S. neurosurgeons who are registered and have up-to-date information in the AANS database. In addition, physician age was compared between subgroups rather than years of practice, mainly due to the lack of availability of granular data for all physicians. Further, little information is provided in this study regarding non-top 40 NIH-funded medical schools. Importantly, information on age based on practicing physicians having graduated residency, which would serve to help stratify based on physician years of practice, could not be obtained. For analyses, only board-certified neurosurgeons were included. Therefore, an additional limitation of the present study includes that the dataset did not consider non—board-certified neurosurgeons, a group with potentially different practice pattern trends. Thus, the demographic trends and potential predictive factors of neurosurgeon career identified in this study may not necessarily generalize to the non—board-certified neurosurgeon population. Further research may look into the impact of sociodemographic factors, income, and work environment on the type of career a neurosurgeon pursues. Lastly, data were lacking for neurosurgeons who attend ed medical schools without top 40 NIH funding. Future research should explore practice patterns in neurosurgeons without board certification, and those who attended medical schools that do not fall in the category of top 40 with NIH funding to achieve a heightened understanding of the neurosurgical workforce.

CONCLUSIONS

This study aimed to elucidate demographic trends and potential predictors of neurosurgery practice patterns, reflecting opportunities to foster more academic and private practice patterns among providers. Neurosurgery is an evolving field with a particular emphasis on research, innovation, and a responsibility to care for marginalized communities. Future research should further explore predictive factors of practice preference to explain why trainees pursue academic or private practice neurosurgical careers. Such work may encourage practice entry type based on national demand, ensuring optimal care is provided in an equitable manner.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Neha Siddiqui: Conceptualization, Methodology, Formal analysis, Data curation, Writing — original draft, Writing — review & editing. **Vamsi P. Reddy:** Conceptualization, Methodology, Formal analysis, Data curation, Writing — original draft, Writing — review & editing. **James L. Rogers:** Formal analysis, Data curation, Writing — original draft, Writing — review & editing, Visualization. **Donald K.E. Detchou:** Formal analysis, Data curation, Writing — original draft, Writing — review & editing. **Imaima Casubhoy:** Formal analysis, Data curation, Writing — original draft, Writing — review & editing. **Rhea Gopali:** Formal analysis, Data curation, Writing — original draft, Writing — review & editing. **Subhang Bhalla:** Formal analysis, Data curation, Writing — original draft, Writing — review & editing. **Mika Janbahan:** Formal analysis, Data curation, Writing — original draft, Writing — review & editing. **Emily Morris:** Formal analysis, Data curation, Writing — original draft, Writing — review & editing. **Meghna Priyanka Peesapati:** Formal analysis, Data curation, Writing — original draft, Writing — review & editing. **Nitin Agarwal:** Conceptualization, Methodology, Writing — original draft, Writing — review & editing, Supervision.

ACKNOWLEDGMENTS

The authors thank the American Association of Neurological Surgeons (AANS) for supplying demographic data on U.S. neurosurgeons.

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Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 13 November 2021; accepted 22 June 2022

Citation: World Neurosurg. (2022) 165:e635-e642. https://doi.org/10.1016/j.wneu.2022.06.119

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