Adham M. Khalafallah, MD[‡*]
Adrian E. Jimenez, BS[‡*]
Samantha Camp[‡]
Melanie A. Horowitz[‡]
Ian Chiu[‡]
David Ryu[‡]
Natasha Charewycz[‡]
Lauren Vera[‡]
Myan Bhoopalam, MS[‡]
James Feghali, MD[‡]
Mayur Sharma, MD, MCh[§]
Daniel Lubelski, MD[‡]
Alan R. Cohen, MD[‡]
Rafael J. Tamargo, MD[‡]
Timothy Witham, MD[‡]
Judy Huang, MD[‡]
Henry Brem, MD[‡]
Debraj Mukherjee, MD, MPH[‡]

[‡]Department of Neurosurgery, Johns Hopkins University School of Medicine, Baltimore, Maryland, USA; [§]Department of Neurosurgery, University of Louisville, Louisville, Kentucky, USA

*Adham M. Khalafallah and Adrian E. Jimenez contributed equally to this work.

Correspondence:
Debraj Mukherjee, MD, MPH,
Department of Neurosurgery,
Johns Hopkins University School of Medicine,
1800 Orleans Street,
Baltimore, MD 21287, USA.
Email: dmukher1@jhmi.edu

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Predictors of Academic Neurosurgical Career Trajectory among International Medical Graduates Training Within the United States

BACKGROUND: Within the literature, there has been limited research tracking the career trajectories of international medical graduates (IMGs) following residency training.
OBJECTIVE: To compare the characteristics of IMG and US medical school graduate (USMG) neurosurgeons holding academic positions in the United States and also analyze factors that influence IMG career trajectories following US-based residency training.
METHODS: We collected data on 243 IMGs and 2506 USMGs who graduated from Accreditation Council for Graduate Medical Education (ACGME)-accredited neurosurgery residency programs. We assessed for significant differences between cohorts, and a logistic regression model was used for the outcome of academic career trajectory.
RESULTS: Among the 2749 neurosurgeons in our study, IMGs were more likely to pursue academic neurosurgery careers relative to USMGs (59.7% vs 51.1%; $P = .011$) and were also more likely to complete a research fellowship before beginning residency (odds ratio [OR] = 9.19; $P < .0001$). Among current US academic neurosurgeons, USMGs had significantly higher pre-residency h-indices relative to IMGs (1.23 vs 1.01; $P < .0001$) with no significant differences between cohorts when comparing h-indices during (USMG = 5.02, IMG = 4.80; $P = .67$) or after (USMG = 14.05, IMG = 13.90; $P = .72$) residency. Completion of a post-residency clinical fellowship was the only factor independently associated with an academic career trajectory among IMGs (OR = 1.73, $P = .046$).
CONCLUSION: Our study suggests that while IMGs begin their US residency training with different research backgrounds and achievements relative to USMG counterparts, they attain similar levels of academic productivity following residency. Furthermore, IMGs are more likely to pursue academic careers relative to USMGs. Our work may be useful for better understanding IMG career trajectories following US-based neurosurgery residency training.

KEY WORDS: Academic career, Global, International, Neurosurgery, Residency

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Within neurosurgery, there has been a significant interest in the experience of international medical graduates (IMGs) applying into US residency programs.[1-3] Compared to US medical graduates (USMGs), IMGs seeking to complete neurosurgical training within the US face unique challenges, such as securing a Visa, learning the many aspects and nuances of the US healthcare system, and assimilating into a new culture far from extended family support.[4-7] Furthermore, there remains limited research into factors influencing IMG career trajectories following US residency training.[8] Previous investigations have demonstrated that career trajectory varies widely even within neurosurgical subspecialties, emphasizing the need to analyze specific neurosurgical

ABBREVIATIONS: ACGME, Accreditation Council for Graduate Medical Education; **IMG,** international medical graduate; **MS,** Master of Science; **NRMP,** National Residency Matching Program; **PhD,** Doctor of Philosophy; **SUNY,** State University of New York; **USMG,** US medical school graduate; **VIF,** variance inflation factor

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populations independently to delineate factors affecting career trajectory.[9,10] Thus, the present study aimed to analyze the role of demographic and bibliometric factors in influencing academic neurosurgery career trajectory among IMGs who trained and currently practice in the United States.

METHODS

Dataset Creation

The American Association of Neurological Surgeons (AANS) member database and residency program websites were used to obtain the names of neurosurgeons who graduated from an Accreditation Council for Graduate Medical Education (ACGME) neurosurgery residency program between 1968 and 2018. The accuracy of the names in our database was confirmed by contacting neurosurgery residency programs via email. A total of 48 out of 115 (41.7%) programs contacted responded. Data were obtained from residency websites, professional websites (ie, LinkedIn), and hospital websites where neurosurgeons were employed. Bibliometric data were obtained using Scopus.[11] Given that we used publicly available data, Institutional Review Board committee approval was not required for this study.

Variables Analyzed

For each neurosurgeon in our database, we collected the following information: sex, medical school name and graduation year, residency program name and graduation year, length of training, and months of protected research time during training. A graduate's h-index before, during, and after residency was also noted through Scopus. The time period "before residency" was defined as all years prior to beginning residency, including any years between medical school graduation and starting residency. The time period "during residency" was defined as all years during residency, and the time period "after residency" was defined as all years following a graduate's completion of their residency program. Protected research time was determined using information on residency program websites at the time of data collection. Information on the number of postresidency clinical fellowships completed by a neurosurgeon, as well as the locations of fellowships, was also collected from residency and professional websites. Additionally, we catalogued advanced degrees that have been associated with increased odds of academic career trajectory, namely a Master of Science (MS) or Doctor of Philosophy (PhD) degree.[12,13] Further, we noted graduates' current employment location and whether they were currently employed as an academic neurosurgeon. A position was considered "academic" if the individual was currently employed as an attending neurosurgeon at a hospital within the US affiliated with a neurosurgery residency program at the time of data analysis; all other positions were considered "nonacademic."[9,10,12,14] Retired neurosurgeons were excluded from our study cohort.

We also collected information on where graduates completed their medical education and neurosurgical training. For this study, "top" residency programs were identified through being listed at least once within the top 10 rankings of *U.S. News' Best Hospitals for Neurology and Neurosurgery* between 2007 and 2019. We also noted whether graduates completed their residency at a program affiliated with a medical school appearing at least once within the top 10 rankings of *U.S. News' Top Medical Schools for Research* (1993-2019).[9,14-16] All programs considered "top-ranked" for the purposes of our study are listed in **Supplementary Table 1**.

Statistical Analysis

Data were collected using Microsoft Excel (version 2016, Microsoft Corp.). Statistical tests were conducted using R Statistical Software (Version 3.3.2, r-project.org). Fisher's exact test was used for bivariate analysis of categorical variables and the Mann-Whitney *U* test was used for bivariate analysis of continuous variables. For our bivariate analysis, h-index during residency was analyzed as both a continuous variable and as a categorical variable dichotomized at a threshold of 4, which was the lowest value that led to a statistically significant difference between academic IMG and nonacademic IMG neurosurgeon cohorts. Multivariate analysis was conducted using a logistic regression model, with model covariates including all factors that approached statistical significance in bivariate analysis ($P < .10$). Variance inflation factors (VIFs) were calculated for all logistic regression model covariates to assess for collinearity.[17] Values of $P < .05$ were considered statistically significant and *P*-values were reported as 2-sided.

RESULTS

IMG Medical Schools and Residency Programs

A total of 2749 neurosurgeons were included in our cohort, including a total of 243 IMGs and 2506 USMGs. Table 1 lists the educational institutions from where more than one IMG in our cohort obtained their medical education, while **Supplementary Table 2** contains a list of the remaining schools that each graduated one IMG from our cohort. The top 3 international medical schools that graduated the most neurosurgeons in our cohort were the American University of Beirut (Lebanon), Ain Shams University (Egypt), and McGill University (Canada), which graduated 9, 8, and 8 neurosurgeons, respectively. The top 3 countries where the most IMGs within our cohort received their medical education were India (31), Canada (13), and Lebanon (14), with the remaining countries listed in **Supplementary Table 3**.

Additionally, we tracked where members of our IMG cohort received their neurosurgical residency training (Table 2). **Supplementary Table 4** displays the remaining residency programs that each graduated one IMG from our cohort. The 3 residency programs that graduated the most IMGs in our cohort were State University of New York (SUNY) Upstate Medical University (11), University of Minnesota (8), and University of Rochester (7).

Neurosurgeon Demographics and Overall Comparative Analysis Between IMGs and USMGs

The demographic and bibliometric characteristics of our 2749 neurosurgeon cohort are summarized in Table 3. Overall, most neurosurgeons were male (90.6%) and a slight majority (51.8%) were employed in academic positions. The mean h-indices of our cohort before, during, and after residency were 0.91, 3.88, and 9.59, respectively. The neurosurgeons in our cohort had a mean of 9.96 mo of protected research time during residency. Only a

TABLE 1. Foreign Medical Schools Graduating 2 or More International Medical Graduates in Our Cohort (n = 128)

Medical school name	Country	Number of graduates
American University of Beirut	Lebanon	9
Ain Shams University	Egypt	8
McGill University	Canada	8
St. George's University	Grenada	5
Aga Khan University	Pakistan	4
Damascus University	Syria	4
Universidad Nacional Autonoma de Mexico	Mexico	4
University of Vienna	Austria	4
All India Institute of Medical Science	India	3
King Edward Medical College	Pakistan	3
Ludwig Maximilian University	Germany	3
Saint Joseph University	Lebanon	3
Tehran University of Medical Sciences	Iran	3
University of Oxford	United Kingdom	3
Universidad Autonoma de Guadalajara	Mexico	3
Universidad Peruana Cayetano Heredia	Peru	3
Ankara University	Turkey	2
Catholic University of Louvain	Belgium	2
Catholic University of the Sacred Heart	Italy	2
Christian Medical College	India	2
Istanbul University	Turkey	2
Jawaharlal Nehru University	India	2
Karolinska Medical Institute	Sweden	2
Kasturba Medical College	India	2
Lebanese University	Lebanon	2
Madras University	India	2
National University of Cuyo	Argentina	2
Osmania Medical College	India	2
Pontificia Universidad Javeriana	Bolivia	2
Ross University	Barbados	2
Semmelweis University	Hungary	2
Shiraz University	Iran	2
Tel Aviv University	Israel	2
Universidad Autonoma de San Luis Potosi	Mexico	2
University of Athens	Greece	2
University of Auckland	New Zealand	2
University of Buenos Aires	Argentina	2
University of Geneva	Switzerland	2
University of Heidelberg	Germany	2
University of Lausanne	Switzerland	2
University of Leiden	Netherlands	2
University of London	United Kingdom	2
University of Puerto Rico	Puerto Rico	2
University of the Philippines	Philippines	2
University of Valencia	Spain	2

minority of neurosurgeons attended a "top-ranked" *U.S. News* residency program (28.7%) or a residency program affiliated with a "top-ranked" *U.S. News* research medical school (26.6%). A total of 284 (10.3%) and 75 (2.7%) neurosurgeons held PhD and MS degrees, respectively, and a majority (59.8%) of neurosurgeons completed at least one clinical fellowship after residency. Furthermore, significantly more IMGs completed vascular fellowships relative to USMGs ($P = .0033$).

Among the neurosurgeons in our study, IMGs were significantly more likely to pursue academic neurosurgery careers relative to USMGs (odds ratio [OR] = 1.42, $P = .011$). Additionally, IMGs were significantly more likely to have completed a research fellowship after medical school and prior to beginning residency training compared to USMGs (OR = 9.19, $P < .0001$). Of the 39 IMGs who completed research fellowships, 10 (25.6%) stayed at the same institution to complete

TABLE 2. Residency Program List for International Medical Graduates (n = 218)

Residency program name	Number of graduates
State University of New York (SUNY) Upstate Medical University	11
University of Illinois	8
University of Minnesota	7
University of Rochester	7
Johns Hopkins University	6
University of Cincinnati	6
University of Miami	6
George Washington University	5
Northwestern University	5
Thomas Jefferson University	5
University of Chicago	5
University of Pittsburgh	5
University of Texas, Galveston	5
Albert Einstein College of Medicine	4
Baylor College of Medicine	4
Dartmouth-Hitchcock	4
Duke University	4
Emory University	4
Henry Ford Hospital	4
Icahn School of Medicine at Mount Sinai	4
Tufts University	4
University of Alabama	4
Virginia Commonwealth University	4
Wayne State University	4
Yale University	4
Brigham and Women's Hospital	3
Case Western University	3
Cedars-Sinai Medical Center	3
Cleveland Clinic	3
Drexel University	3
New York University Medical Center	3
Oregon Health and Science University	3
University at Buffalo	3
University of California, Davis	3
University of Louisville	3
University of South Florida	3
University of Vermont	3
University of Virginia	3
University of Washington	3
West Virginia University	3
Albany Medical Center	2
Barrow Neurological Institute	2
Brown University	2
Cornell University	2
Geisinger Health System	2
Louisiana State University	2
Mayo Clinic, Rochester	2
Medical College of Wisconsin	2
Ohio State University	2
Pennsylvania State University	2
Rutgers University	2
Stanford University	2
University of Arizona	2
University of California, Los Angeles	2
University of Colorado	2
University of Iowa	2
University of Kansas	2
University of Mississippi	2
University of Texas, Houston	2
University of Texas, San Antonio	2
University of Texas, Southwestern	2
Washington University in St. Louis	2

their residency training. While USMGs had significantly higher h-indices prior to residency (mean = 0.93) when compared to IMGs (mean = 0.69; $P < .0001$), there was no significant difference between these groups regarding h-indices during residency ($P = .18$), despite the finding that USMGs were significantly more likely to have attended a top-ranked *U.S. News* residency program (OR = 2.17, $P < .0001$) or a residency program affiliated with a top-ranked *U.S. News* research medical school (OR = 1.99, $P < .0001$) compared to IMGs. There were no other significant differences between IMGs and USMGs regarding the remaining characteristics analyzed in our study.

Comparative Analysis Between IMGs and USMGs in Academia

Table 4 lists demographic and bibliometric characteristics for IMG and USMG neurosurgeons currently holding academic faculty positions. Compared to IMGs, USMGs in academia were significantly more likely to have a higher h-index prior to residency (IMG mean = 1.00, USMG mean = 1.23; $P < .001$). However, there were no significant difference between these 2 cohorts with regard to h-indices during (IMG mean = 4.80, USMG mean = 5.02; $P = .67$) or after (IMG mean = 13.90, USMG mean = 14.05; $P = .72$) residency. Compared to IMGs in academia, USMGs in academia were significantly more likely to have trained at a top-ranked *U.S. News* residency program (OR = 2.76, $P < .0001$) or at a residency program affiliated with a top-ranked *U.S. News* research medical school (OR = 2.33, $P < .0001$). Finally, IMG faculty were significantly more likely to have completed a research fellowship after medical school but prior to residency training (OR = 14.55, $P < .0001$) when compared to USMG faculty.

Academic Career Trajectory Among IMGs

Table 5 displays the results of our bivariate analysis of IMG academic career trajectory. A higher h-index (analyzed as a continuous variable) during residency ($P = .037$) was significantly associated with an academic career trajectory among IMGs. When h-index during residency was analyzed as a categorical

TABLE 3. Neurosurgeon Demographics

Characteristic	IMGs (n = 243)	USMGs (n = 2506)	*P* value
Male sex (%)	93.8	90.3	.083
Academic position (%)	59.7	51.1	.011[a]
H-index before residency	0.69 ± 2.62	0.93 ± 2.42	< .0001[a]
H-index during residency	4.33 ± 5.22	3.84 ± 4.99	.18
H-index after residency	11.08 ± 14.85	9.45 ± 13.78	.11
Mean months of protected research time during residency (mo)	10.84 ± 8.39	9.87 ± 8.46	.12
Top 10 *U.S. News* residency program (2007-2019) (%)	16.5	29.9	< .0001[a]
Residency program affiliated with top 10 research medical school (1993-2019) (%)	16.0	27.6	< .0001[a]
PhD (%)	9.9	10.4	.91
MS (%)	2.9	2.7	.84
Research fellowship after medical school and before residency (%)	16.0	2.0	< .0001*
Completion of a clinical fellowship (%)	61.7	59.6	.54
Spine (%)	14.8	19.8	.062
Vascular (%)	16.9	10.3	.0033*
Neuro-oncology (%)	8.2	5.1	.050
Pediatrics (%)	7.8	8.9	.64
Skull base (%)	9.9	6.8	.088
Other (%)	12.3	9.7	.18

IMG, international medical graduate; USMG, US medical school graduate; MS, Master of Science; PhD, Doctor of Philosophy.
[a]Statistical significance (P < .05).
Means are presented as ± standard deviation. Categorical variables were analyzed using Fisher's exact test. Continuous variables were analyzed using the Mann-Whitney *U* test.

TABLE 4. Academic Neurosurgeon Demographics

Characteristic	IMGs (n = 145)	USMGs (n = 1280)	*P* value
Male sex (%)	92.4	89.0	.26
Mean h-index before residency	1.01 ± 3.30	1.23 ± 2.77	< .001[a]
Mean h-index during residency	4.80 ± 5.26	5.02 ± 5.62	.67
Mean h-index after residency	13.90 ± 15.58	14.05 ± 16.07	.72
Mean months of protected research time during residency (mo)	11.81 ± 8.51	11.38 ± 8.68	.78
Top 10 *U.S. News* residency program (2007-2019) (%)	17.9	37.7	< .0001[a]
Residency program affiliated with top 10 research medical school (1993-2019) (%)	19.3	35.9	< .0001[a]
PhD (%)	11.0	13.4	.52
MS (%)	3.4	3.7	1.00
Research fellowship after medical school and before residency (%)	17.2	1.4	< .0001[a]
Completion of a clinical fellowship (%)	67.6	68.9	.78
Spine (%)	15.2	18.8	.37
Vascular (%)	16.6	12.7	.19
Neuro-oncology (%)	8.3	6.7	.49
Pediatrics (%)	9.0	12.3	.28
Skull base (%)	11.7	7.9	.11
Other (%)	15.2	10.6	.12

IMG, international medical graduate; USMG, US medical school graduate; MS, Master of Science; PhD, Doctor of Philosophy.
[a]Statistical significance (P < .05).
Means are presented as ± standard deviation. Categorical variables were analyzed using Fisher's exact test. Continuous variables were analyzed using the Mann-Whitney *U* test.

variable, we identified 74 (51.0%) academic IMGs with an h-index ≥4 and 36 (36.7%) nonacademic IMGs with an h-index ≥4. Our analysis demonstrated that IMGs with an h-index of ≥4 were significantly more likely to pursue academic careers compared to IMGs with h-indices less than 4 (OR = 1.79, $P = .035$). A greater amount of protected research time during research time trended toward but did not attain statistical significance ($P = .051$). Furthermore, IMGs who completed a postresidency clinical fellowship were significantly more likely to pursue academic careers relative to those who did not (OR = 1.84,

TABLE 5. Bivariate Analysis of Academic Career Choice Among International Medical Graduates

Characteristic	Academic (n = 145)	Nonacademic (n = 98)	*P* value
Male sex (%)	92.4	95.9	.42
H-index before residency	1.01 ± 3.30	0.22 ± 0.79	.25
H-index during residency	4.80 ± 5.26	3.63 ± 5.11	.037[a]
Mean months of protected research time during residency (mo)	11.81 ± 8.51	9.41 ± 8.03	.051
Top 10 *U.S. News* residency program (2007-2019) (%)	17.9	14.3	.49
Residency program affiliated with top 10 research medical school (1993-2019) (%)	19.3	11.2	.11
PhD (%)	11.0	8.2	.52
MS (%)	3.4	2.0	.70
Research fellowship after medical school and before residency (%)	17.2	14.3	.60
Completion of a clinical fellowship (%)	67.6	53.1	.031[a]
Spine (%)	15.2	14.3	1.00
Vascular (%)	16.6	17.3	.86
Neuro-oncology (%)	8.3	8.2	1.00
Pediatrics (%)	9.0	6.1	.47
Skull base (%)	11.7	7.1	.28
Other (%)	15.2	8.2	.12

MS, Master of Science; PhD, Doctor of Philosophy.
[a]Statistical significance (P < .05).
Means are presented as ± standard deviation. Categorical variables were analyzed using Fisher's exact test. Continuous variables were analyzed using the Mann-Whitney ^{U} test.

TABLE 6. Multivariate Analysis of Academic Career Choice Among International Medical Graduates (n = 243)

Characteristic	Odds ratio	95% CI	*P* value	VIF
Greater h-index during residency	1.03	0.98-1.09	.25	1.04
Greater protected research time during residency	1.03	1.00-1.06	.082	1.04
Completion of a clinical fellowship	1.73	1.01-2.96	**.046**[a]	1.01

CI, confidence interval; VIF, variance inflation factor.
[a]Statistical significance (P < .05).

$P = .031$). In multivariate analysis, only completion of a clinical fellowship was significantly and independently associated with academic career trajectory among IMGs (OR = 1.73, $P = .046$), as shown in Table 6. All model covariate VIFs were below 2, suggesting a lack of collinearity.[17] Similarly, the 1494 (59.6%) USMGs who completed a clinical fellowship were also significantly more likely to pursue academic careers in bivariate analysis (OR = 2.22, $P < .0001$). Among USMGs, a significant association between clinical fellowship completion and academic career trajectory was also observed in multivariate analysis (OR = 1.93, $P < .0001$) when controlling for h-index (OR = 1.10, $P < .0001$) and protected research time (OR = 1.03, $P < .0001$) during residency.

DISCUSSION

Recent research has detailed a changing landscape for IMGs applying into US neurosurgery residency training programs, with National Residency Matching Program (NRMP) data collected from 2009 to 2017 demonstrating a significant increase in IMG applicants without a significant increase in submitted applications per applicant or matched IMGs over this time period.[2] However, there has been limited research specifically investigating IMGs' academic career trajectories following residency training.[1-3] Neurosurgery career trajectories are complex and multifactorial, especially so for IMGs who must effectively navigate additional logistical challenges, such as Visa sponsorship, compared to their USMG counterparts.[4,5,12,14] Further, many IMGs face the additional tasks of taking their board examinations often in a non-native language, attempting to obtain clinical and research opportunities from abroad, and learning about the complex US healthcare system while also assimilating into a foreign culture.[6,7] The present study is the first to specifically characterize a cohort of IMGs currently employed within US academic neurosurgery and to analyze factors associated with career trajectory specifically among IMGs.

Comparative Analysis of IMG and USMG Academic Faculty

Our results demonstrating that IMG academic faculty had significantly lower h-indices compared to USMG faculty prior to residency training appears to disagree with previous results by Chandra et al, who noted in their study that USMG residency applicants had significantly lower h-indices prior to residency when compared to IMG residency applicants ($P < .001$).[2] It is important to note that our cohort, including 2749 neurosurgeons, is larger in size and different in character relative to the cohort in the Chandra et al[2] study, which focused on 1857 neurosurgery residents in training. Further research into the association between IMG/USMG status and pre-residency h-index will be necessary to more fully describe the relationship between these 2 variables. Our observation that IMGs have significantly lower h-indices compared to USMGs may partly reflect less research opportunities for IMGs abroad relative to the United States. For example, USMGs may be more able to conduct research during their undergraduate and medical school education compared to IMGs. The lack of significant difference between IMG and USMG faculty h-indices during and after residency may reflect more opportunities to engage in research for IMGs upon beginning residency training. We also noted that IMGs were significantly more likely than USMGs to complete a research fellowship after medical school and prior to residency. As described in other studies, such research experiences allow IMG applicants to raise their publication count and h-index in order to improve their chances of matching to a US residency program; such opportunities also allow IMGs to establish professional networks that may lead to letters of recommendations and other formative mentor-mentee relationships.[1,2]

Our finding that IMGs are significantly less likely to match into top-ranked *U.S. News* residency programs or residency programs affiliated with top-ranked *U.S. News* research medical schools has been previously reported.[2] Importantly, prior research has demonstrated that IMGs who have more publications (F ratio = 3.81, $P < .001$), take a gap year (F ratio = 3.14, $P < .001$), or have a higher h-index (F ratio = 2.77, $P = .008$) are more likely to match into top residency programs.[2]

IMGs' Academic Career Trajectory

Our finding that completion of a clinical fellowship is independently associated with an academic career trajectory among IMGs emphasizes the importance of subspecialty training in influencing career trajectory. Previous research by Lawton et al[18] has noted that completion of a subspecialty fellowship was significantly associated with an academic career trajectory. Given that clinical fellowships expose trainees to specialized clinical niches within neurosurgery, such experiences may better allow trainees to develop a specific research focus that can be further pursued by means of an academic career. Therefore, an interest in subspecialty training may be a reliable metric for identifying IMGs who are inclined toward academia. Interestingly, while both h-index and protected during residency were significantly associated with academic career trajectory among IMGs in the present study's bivariate analysis, these associations were no longer significant in multivariate analysis. Therefore, among IMGs, the decision to pursue dedicated subspecialty training more strongly influences academic career trajectory compared to research productivity during residency training.

Limitations

There are a number of limitations to our study. First, it is important to note that our database is restricted to neurosurgeons currently practicing within the United States. Second, this was a retrospective study utilizing data from specific online sources within a limited time frame, and therefore it is possible that a degree of selection bias was introduced into our study. Specifically, any programs that have changed the number of months offered to residents for protected research time before or after our initial data collection may introduce error into our results. Third, our definition of "academic" positions was based on specific criteria, and studies that define these variables on criteria other than those utilized in the present study may yield different results. Fourth, we acknowledge that *U.S. News* rankings are not valid measures for academic productivity of residency programs. Nevertheless, we included these rankings in our study because previous research has demonstrated them to be significantly associated with career trajectory in various medical specialties, including neurosurgery.[14-16]

CONCLUSION

The present study conducted the first comparative analysis between IMG and USMG academic faculty practicing within the United States. Importantly, we found that although there is a significant difference in pre-residency h-indices for IMGs and USMG, there is no significant difference across h-indices of both groups during and after residency. Further, IMGs were significantly more likely to pursue academic careers compared to USMGs. Our study suggests that IMGs may begin their US residency training with different research backgrounds and achievements relative to USMG counterparts, but attain similar levels of academic productivity following residency. Our work may serve to clarify factors influencing career trajectory following residency training among IMGs.

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Supplementary Table 1. List of top neurosurgery residency programs (in alphabetical order).

Supplementary Table 2. International medical schools that each graduated 1 IMG in our cohort (n = 115) [in alphabetical order].

Supplementary Table 3. Remaining countries where IMGs in our study cohort received their medical education.

Supplementary Table 4. Residency programs that each graduated one IMG in our study cohort (n = 25) [in alphabetical order].