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Original Article

# Residency-Affiliated Academic Neurosurgeons (RAAN): A Cross-Sectional Analysis of Neurosurgery Residency Program Rankings

Sheeny V Vo,[1] Olivia Duru,[1] Ciarán J. Powers.[2]

## Abstract

**Background:** Existing neurosurgery residency rankings do not assess programs based on graduate placement in academic faculty positions. We sought to develop a novel ranking system of neurosurgery programs to identify programs that produced academic faculty and evaluated these programs relative to established ranking systems. This novel ranking system, the Residency Affiliated Academic Neurosurgeons, was compared to the Doximity Residency Navigator, and Blue Ridge Institute for Medical Research. **Methods:** We evaluated neurosurgeons with positions in Accreditation Council for Graduate Medical Education neurosurgery programs. We looked at those programs websites and faculty under neurosurgery. Certain programs were excluded based on the data not being publicly available. We analyzed the relationship between Residency Affiliated Academic Neurosurgeons with Doximity Residency Navigator and Blue Ridge Institute for Medical Research. We analyzed the median rank of the ranking system per program and the percentage of legacy faculty. **Results:** We included 1623 faculty members in our analysis. This novel ranking system was evaluated against Doximity Residency Navigator and Blue Ridge Institute for Medical Research, revealing strong correlations ($r=0.73$, $p<0.0001$, $r=0.45$, $p<0.001$, respectively). Notably, the percentage of legacy faculty (defined as faculty who are appointed at the same location as residency training) had a significant association with Residency Affiliated Academic Neurosurgeons and Doximity Residency Navigator ($r=-0.33$, $p<0.05$ and $r=-0.38$, $p<0.001$, respectively). **Conclusion:** We developed a ranking of neurosurgery programs based on the placement of graduates in academic positions. RAAN rankings align with existing systems and provide an objective measure of residency program effectiveness in producing academic neurosurgeons.

## Introduction

Medical students weigh numerous factors—including program reputation, faculty expertise, research opportunities, clinical exposure, and geographic location—when creating their rank lists to find the optimal blend of excellence, opportunity, and personal fit. No prior studies have compared publicly available institutional rankings with rankings based on the academic placement of neurosurgery residency graduates.

Various publicly available ranking systems[1,2] have been established that can be applied to residency rank order lists by medical students, however, studies have specifically questioned the validity and reliability of the most prominent one, the Doximity Reputation Navigator (DRN) reputation rank. DRN rankings rely on peer evaluations, while RAAN objectively measures academic placement of graduates The major concern is that DRN is highly subjective since its methodology relies on peer evaluation.[3,6] Multiple studies have identified and reported errors in the Doximity profiles of residency programs and graduates.[7, 8] Additionally, whether DRN reputation data measures necessary "intangibles" or whether the data stems from academic productivity or popularity are important concerns.[5] Conversely, a purely objective ranking system is the Blue Ridge Institute for Medical Research (BRIMR), which only considers a subset of academic programs. It ranks institutions based on National Institutes of Health (NIH) funding, a measure of scientific merit.[9,15] However, NIH funding alone does not fully capture residency program quality, as it does not account for clinical training, faculty mentorship, or graduates' success in securing academic positions.

RAAN ranks neurosurgery residency programs based on the number of graduates securing academic faculty positions, providing an objective measure of program impact - a system that more appropriately assesses residency program effectiveness in graduates' placement in academic positions. We compared RAAN with the other systems (DRN and BRIMR) in predicting successful academic careers in neurosurgery. We sought to provide a more robust tool for assessing residency program quality and effectiveness.

## Methods

### Selection of Neurosurgery Residency Programs

We analyzed 116 Accreditation Council for Graduate Medical Education (ACGME)-accredited neurosurgery residency programs

[1] BS. The Ohio State University, Columbus, United States of America.

[2] MD, PhD. The Ohio State University, Columbus, United States of America.

**About the Author:** *: Sheeny V Vo is currently an alumnus from The Ohio State University. She is currently working in an Alzheimer's Disease lab under Hongjun (Harry) Fu where they investigate molecular vulnerabilities in early-stage Alzheimer's Disease.*

**Correspondence:**

Ciarán J. Powers.

Address: The Ohio State University College of Medicine, 370 W 9th Avenue, Columbus, OH 43210, United States

Email: mailto:ciaran.powers@osumc.edu

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using DRN Reputation Rank as of January 2024. We included BRIMR rankings of 50 neurological surgery departments. We excluded the U.S. News & World Report ranking system since it combines neurology and neurosurgery and not neurosurgery alone.[2] Programs without publicly available faculty training data were excluded. We adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines to ensure quality and transparency.

### Doximity Residency Navigator (DRN) Reputation Rank[16]

DRN helps inform medical student decisions regarding residency placements. Reputation data, derived from survey responses, is limited to Doximity's board-certified members in the specialty and weighted by alumni status. Each physician could nominate up to 5 residency programs that "offer the best clinical training." DRN classifies self-nominations as alumni or non-alumni and weighs those nominations by a static value less than non-alumni ones. More recent graduates' nominations are weighted more than less recent graduates. Lastly, DRN rationalizes adding more weight to those program directors' nominations due to their insight into residency training curricula.[1]

### BRIMR Rankings of NIH Funding[9]

Each year since 2006, BRIMR, an independent non-profit organization, has published rankings of institutions, departments, and investigators based on funding received by NIH. BRIMIR compiles and releases data obtained by the NIH, reflecting NIH funds awards during a given fiscal year ending on September 30. BRIMR rankings of NIH funding in 2023 ranked 50 neurosurgery school programs with the rank – 1 - the program with the most funding by the NIH. The BRIMR encompasses the factor of scientific vitality and has been used to examine trends in funding for academic specialties.[9]

### Selection of Neurological Surgeons faculty

To select trained neurological surgeons within each residency program in our study, we accessed the departmental faculty pages of each program to extract relevant information. In each accredited residency program, we selected faculty members who specified neurosurgery as their page's residency education/training section. Faculty selection data was validated through institutional websites and publicly available faculty directories. The following information was extracted and recorded: faculty name, residency program name, and fellowship name. We excluded faculty members if neurosurgery was not explicitly listed. We did not include residents and fellows in the analysis.

### Creation of Residency Affiliated Academic Neurosurgeons (RAAN) Ranking

We developed a ranking system of all ACGME neurosurgery residency programs based on program occurrences seen in academic neurosurgeons' residency training. Each residency program was ranked according to the number of its graduates who secured academic faculty positions. Each faculty member contributed equally to the ranking, with programs receiving higher ranks based on greater representation among the included academic neurosurgeons. Programs without representation among the selected academic neurosurgeons were excluded to ensure the ranking system's relevance. This methodology is illustrated in ***Figure 1.*** The resulting ranking system, presented in ***Table 1,*** reflects the residency program's ordinal contributions to the academic neurosurgeon pool in the United States.

***Table 1.*** Summary of Available and Collected Data for Each Information Source.

| Metric | Data Source | Total available | Total collected | % captured |
|---|---|---|---|---|
| **no. of trained residency programs** | Residency Affiliated Academic Neurosurgeons (RAAN) | 1585 | 1396 | 88.08 |
| | Doximity Residency Navigator (DRN) Reputation Rank | 1633 | 1442 | 88.30 |
| | Blue Ridge Institute for Medical Research (BRIMR) | 861 | 612 | 71.00 |
| **no. of programs ranked** | Residency Affiliated Academic Neurosurgeons (RAAN) | 108 | 101 | 93.52 |
| | Doximity Residency Navigator (DRN) Reputation Rank | 116 | 109 | 93.97 |
| | Blue Ridge Institute for Medical Research (BRIMR) | 50 | 49 | 98.00 |
| **no. of faculty** | Residency Affiliated Academic Neurosurgeons (RAAN) | 1546 | | |
| | Doximity Residency Navigator (DRN) Reputation Rank | 1623 | | |
| | Blue Ridge Institute for Medical Research (BRIMR) | 879 | | |

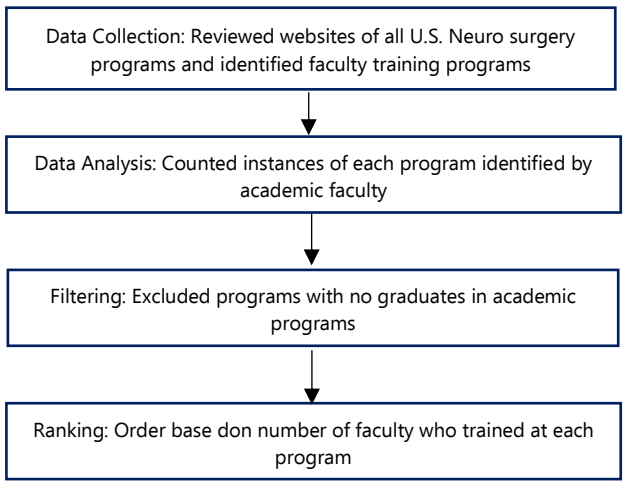
***Legend:*** The table includes the total number of faculty members identified, the number of residency programs ranked, and the coverage rates achieved by each source. Total available refers to the full dataset extracted from the ranking system website, while Total collected represents the publicly accessible data.

### Calculation of % legacy faculty

It is common in neurosurgery that faculty are recruited from their own trainee pool, so-called "legacy faculty". We analyzed the separate rank lists for the number of legacy faculty in each

ranking system (DRN, BRIMR, and RAAN). Here, we defined legacy faculty as individuals who have received training at the same neurosurgery residency program and are current faculty members. We conducted a straightforward calculation to determine the percentage of legacy faculty within these programs. First, we counted the number of faculty members meeting the criteria for legacy status. Next, we tallied the total number of faculty across each selected program. The percentage of legacy faculty was then computed by dividing the count of legacy faculty by the total number of faculty and multiplying the result by 100. This approach provided us with a clear metric to gauge the prevalence of legacy faculty within neurosurgery residency programs.

***Figure 1.*** Flow Diagram of Methodology Used to Develop RAAN.




### Statistical analysis

We performed program-to-program analyses to assess the correlation across ranking systems of the same residency program, utilizing the Pearson correlation test. Furthermore, we performed the same correlation test between the different types of ranking systems, median faculties' residency, types of ranking systems, and percent legacy faculty. We utilized Pearson correlation since the rankings in our dataset were normally distributed. We conducted all statistical analyses using GraphPad Prism (GraphPad Software). Significance was defined as $p<0.05$(*), $p<0.01$(**), $p<0.001$(***), or $p<0.0001$ (****).

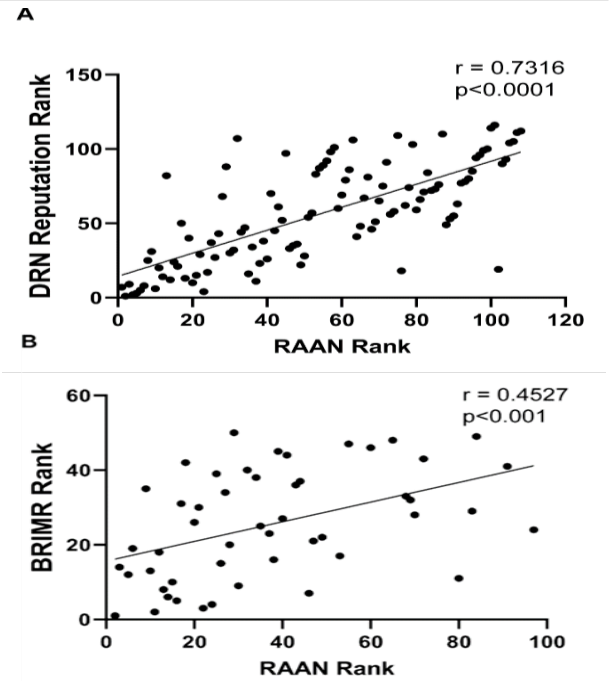
### IRB statement

The study focused on analyzing publicly available data and did not involve patient participation. Consequently, the Institutional Review Board approval and patient consent requirement were deemed unnecessary.

## Results

RAAN ranked 101 programs, covering 93.52% of all ACGME neurosurgery programs and 1,396 faculty members (88.08% of the total faculty). As shown in ***Table 2,*** the top five programs producing ACGME-accredited neurosurgery physicians are Massachusetts General Hospital, University of California-San Francisco (UCSF), University of Pittsburg Medical Center (UPMC), Barrow Neurological Institute, and Johns Hopkins University. *Specific residency programs consistently exhibit positive correlations in RAAN with DRN and BRIMR.* When comparing the RAAN and DRN rankings of 108 residency programs, RAAN rankings for 108 programs correlated strongly with DRN ($r=0.73$, $p<0.0001$, $n=108$), suggesting that programs highly ranked by RAAN are also highly ranked in DRN ***(Figure 2a).*** Similarly, the comparison between RAAN and BRIMR for 50 programs revealed a moderate positive correlation ($r=0.4527$, $p<0.001$, $n=50$), indicating alignment in program evaluations across these systems ***(Figure 2b).*** This demonstrates external validity of the RAAN ranking system.

***Figure 2.*** Correlations Between Residency Affiliated Academic Neurosurgeons (RAAN) rank and both Doximity Residency Navigator (DRN) Reputation rank and Blue Ridge Institute for Medical Research (BRIMR). (A) Correlation plot of Residency Affiliated Academic Neurosurgeons (RAAN) with Doximity Residency Navigator (DRN) reputation rank of matched programs (n=108). (B) Correlation plot of Residency Affiliated Academic Neurosurgeons (RAAN) programs matched with Blue Ridge Institute for Medical Research (BRIMR) (n=50).



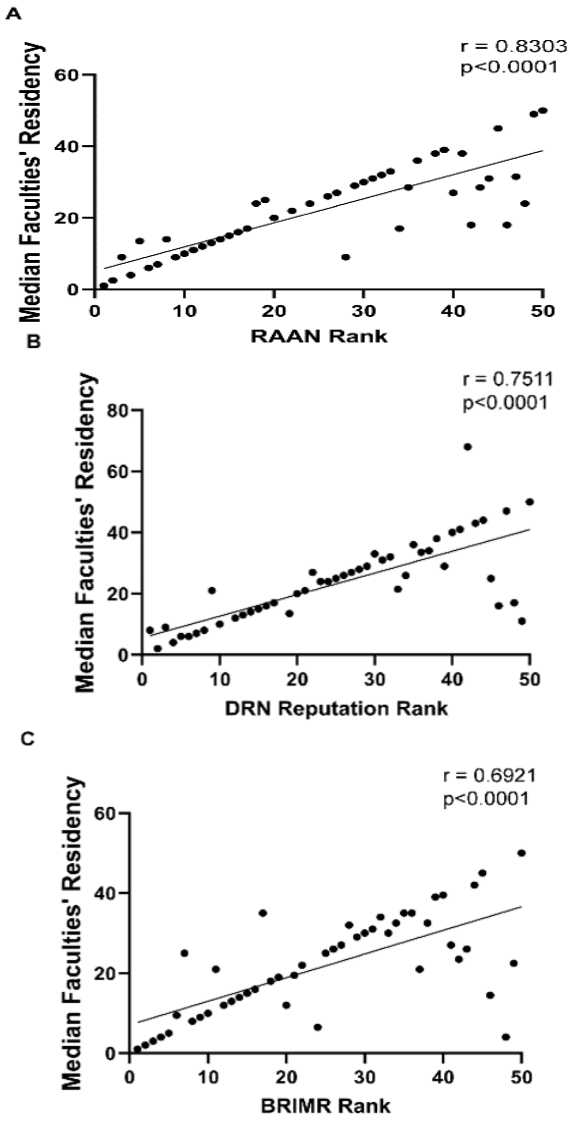

***Legend:*** Individual points represent the matched programs with their respective rank according to system. $p<0.0001$ (****), $p<0.001$ (***), Pearson correlation coefficient. This demonstrates external validity of the RAAN ranking system.

### Different ranking systems show that highly ranked programs are correlated with the median of faculties' residency rank.

We found robust positive correlations across all three ranking systems between the top 50 residency programs and the median faculty residency rank. We limited the analysis to only the top 50 programs in order to focus on programs likely to be of interest to

applicants. The top 50 residency programs in RAAN have a very strong positive correlation with median faculties' residency (r=0.8303, p<0.0001, n=46) ***(Figure 3a).*** In the DRN rank system, the top 50 programs have a very strong positive correlation with median faculties' residency (r=0.7511, p<0.0001, n=48) ***(Figure 3b).*** BRIMR rank system also has a very strong positive correlation with median faculties residency (r=0.6921, p<0.0001, n=48) ***(Figure 3c).*** This demonstrates a consistent trend where higher-ranking programs are associated with more successful faculty.

***Figure 3.*** Correlations between Ranking Systems and Median Faculties' Training Program. (A) The correlation plot of Residency Affiliated Academic Neurosurgeons (RAAN) with median faculties' residency (n=46). (B) The correlation plot of Doximity Residency Navigator (DRN) Reputation rank with median faculties' residency (n=48). (C) Correlation plot of Blue Ridge Institute for Medical Research (BRIMR) with median faculties' residency (n=48).

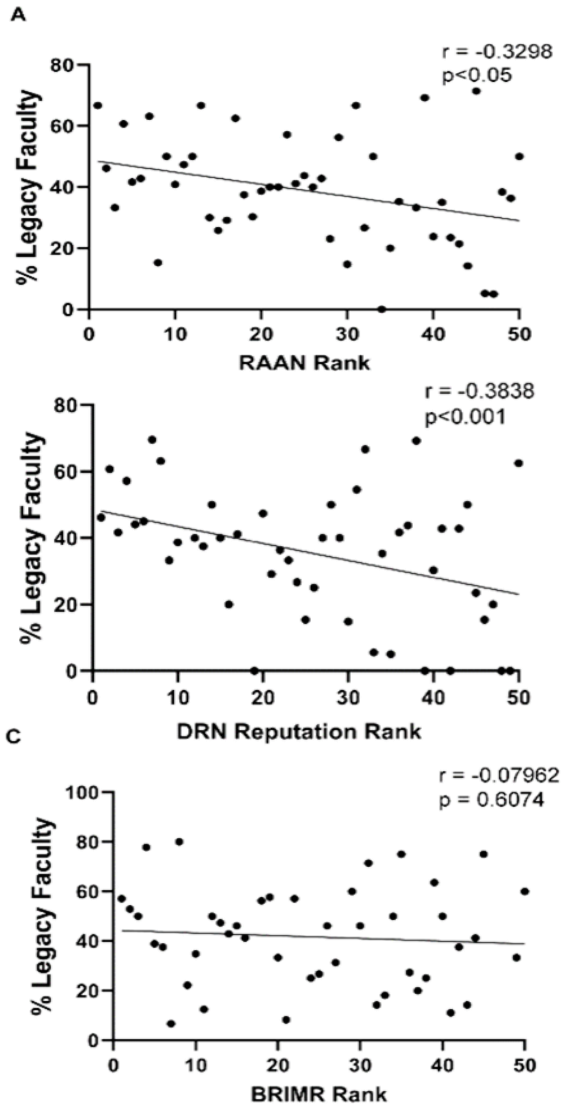



***Legend:*** Individual points represent median faculties' residency rank at a specific program. p<0.0001 (****), Pearson correlation coefficient. This demonstrates a consistent trend where higher-ranking programs are associated with more successful faculty.

**A Higher Percentage of legacy faculty correlates with highly ranked programs in RAAN and DRN.**

In RAAN, the top 50 programs show a correlation with the percentage of legacy faculty (r=-0.3298, p<0.05, n=49***)*** ***(Figure 4a).*** The DRN reputation rank has a more significant correlation (r=-0.3838, p<0.001, n=48) ***(Figure 4b).*** However, in the BRIMR system, the top 50 programs show no significance and are not correlated with the percent legacy faculty (r=-0.07962, p=0.6074, n=44) ***(Figure 4c).*** Regarding RAAN and DRN, better programs have a higher percentage of legacy faculty. This suggests that highly ranked programs keep their graduates as faculty.

***Figure 4.*** Correlations between Ranking Systems and Percent Legacy Faculty. (A) Correlation plot of Residency Affiliated Academic Neurosurgeons (RAAN) with % legacy faculty (n=49). (B) The correlation plot of Doximity Residency Navigator (DRN) Reputation rank with % legacy faculty (n=48). (C) Correlation plot of Blue Ridge Institute for Medical Research (BRIMR) with % legacy faculty (n=44).




***Legend:*** Individual points represent the percentage of legacy faculty at the specific program. p<0.05 (*), p<0.001 (**), Pearson correlation coefficient. This suggests that highly ranked programs keep their graduates as faculty.

***Table 2.*** Residency Affiliated Academic Neurosurgeons (RAAN) Ranking, Doximity Residency Navigator (DRN) Reputation rank, and Blue Ridge Institute for Medical Research (BRIMR) of ACGME Neurological Surgery Programs.

| RAAN | DRN | BRIMR | Program Name |
|---|---|---|---|
| 1 | 7 | N/A | Massachusetts General Hospital |
| 2 | 1 | 1 | University of California (San Francisco) |
| 3 | 9 | 14 | UPMC Medical Education |
| 4 | 2 | N/A | Barrow Neurological Institute at St. Joseph's Hospital and Medical Center |
| 5 | 3 | 12 | Johns Hopkins University |
| 6 | 5 | 19 | University of Washington |
| 7 | 8 | N/A | New York Presbyterian Hospital (Columbia Campus) |
| 8 | 25 | N/A | Brigham and Women's Hospital/Children's Hospital |
| 9 | 31 | 35 | University of Virginia Medical Center |
| 10 | 6 | 13 | Washington University/B-JH/SLCH Consortium |
| 11 | 20 | 2 | UCLA David Geffen School of Medicine/UCLA Medical Center |
| 12 | 14 | 18 | University of Michigan Health System |
| 13 | 82 | 8 | Yale-New Haven Medical Center |
| 14 | 12 | 6 | Baylor College of Medicine |
| 15 | 24 | 10 | University of Pennsylvania Health System |
| 16 | 21 | 5 | Duke University Hospital |
| 17 | 50 | 31 | University of Iowa Hospitals and Clinics |
| 18 | 13 | 42 | University of Southern California/LAC+USC Medical Center |
| 19 | 40 | N/A | Sidney Kimmel Medical College at Thomas Jefferson University/TJUH |
| 20 | 10 | 26 | NYU Grossman School of Medicine |
| 21 | 15 | 30 | University of Miami/Jackson Health System |
| 22 | 29 | 3 | Stanford Health Care–Sponsored Stanford University |
| 23 | 4 | N/A | Mayo Clinic College of Medicine and Science (Rochester) |
| 24 | 17 | 4 | University of Florida |
| 25 | 37 | 39 | New York Presbyterian Hospital (Cornell Campus) |
| 26 | 27 | 15 | Icahn School of Medicine at Mount Sinai |
| 27 | 43 | 34 | University of Wisconsin Hospitals and Clinics |
| 28 | 68 | 20 | University of Maryland |
| 29 | 88 | 50 | Virginia Commonwealth University Health System |
| 30 | 30 | 9 | McGaw Medical Center of Northwestern University |
| 31 | 32 | N/A | Cleveland Clinic Foundation |
| 32 | 107 | 40 | Montefiore Medical Center/Albert Einstein College of Medicine |
| 33 | 44 | N/A | Henry Ford Health/Henry Ford Hospital |
| 34 | 47 | 38 | University of Minnesota |
| 35 | 16 | 25 | University of Utah Health |
| 36 | 34 | N/A | Vanderbilt University Medical Center |
| 37 | 11 | 23 | Emory University School of Medicine |
| 38 | 23 | 16 | University of Texas Southwestern Medical Center |
| 39 | 38 | 45 | Case Western Reserve University/University Hospitals Cleveland Medical Center |
| 40 | 26 | 27 | University of Alabama Medical Center |
| 41 | 70 | 44 | University of Colorado |
| 42 | 45 | N/A | University of California (San Diego) Medical Center |
| 43 | 61 | 36 | Indiana University School of Medicine |
| 44 | 52 | 37 | SUNY Upstate Medical University |
| 45 | 97 | N/A | Albany Medical Center |
| 46 | 33 | 7 | Ohio State University Hospital |
| 47 | 35 | 21 | Penn State Milton S. Hershey Medical Center |
| 48 | 36 | N/A | Wake Forest University Baptist Medical Center |
| 49 | 22 | 22 | Rush University Medical Center |
| 50 | 28 | N/A | Tufts Medical Center |
| 51 | 54 | N/A | National Capital Consortium |
| 52 | 57 | N/A | Dartmouth-Hitchcock/Mary Hitchcock Memorial Hospital |
| 53 | 83 | 17 | University of Louisville School of Medicine |
| 54 | 87 | N/A | University of Illinois College of Medicine at Chicago |
| 55 | 89 | 47 | University of Texas Health Science Center San Antonio Joe and Teresa Lozano Long School of Medicine |
| 56 | 92 | N/A | Loyola University Medical Center |
| 57 | 98 | N/A | George Washington University |
| 58 | 101 | N/A | Temple University Hospital |
| 59 | 60 | N/A | University of North Carolina Hospitals |
| 60 | 69 | 46 | University of Cincinnati Medical Center/College of Medicine |
| 61 | 79 | N/A | Brown University |
| 62 | 86 | N/A | MedStar Health/Georgetown University Hospital |

| | | | |
|---|---|---|---|
| 63 | 106 | N/A | University of Vermont Medical Center |
| 64 | 41 | N/A | University of Rochester |
| 65 | 48 | 48 | University at Buffalo |
| 66 | 67 | N/A | University of South Florida Morsani |
| 67 | 81 | N/A | University of Chicago |
| 68 | 46 | 33 | Oregon Health & Science University |
| 69 | 51 | 32 | Medical College of Wisconsin Affiliated Hospitals |
| 70 | 65 | 28 | Rutgers Health/New Jersey Medical School |
| 71 | 75 | N/A | Allegheny Health Network Medical Education Consortium (AGH) |
| 72 | 91 | 43 | Loma Linda University Health Education Consortium |
| 73 | 56 | N/A | University of Kansas School of Medicine |
| 74 | 58 | N/A | West Virginia University |
| 75 | 109 | N/A | Louisiana State University School of Medicine |
| 76 | 18 | N/A | University of Tennessee |
| 77 | 62 | N/A | Westchester Medical Center |
| 78 | 74 | N/A | University of Missouri–Columbia |
| 79 | 103 | N/A | University of Mississippi Medical Center |
| 80 | 59 | 11 | University of Texas Health Science Center at Houston |
| 81 | 66 | N/A | University of Oklahoma Health Sciences Center |
| 82 | 71 | N/A | University of Kentucky College of Medicine |
| 83 | 84 | 29 | Medical College of Georgia |
| 84 | 72 | 49 | University of Texas Medical Branch Hospitals |
| 85 | 73 | N/A | Cedars-Sinai Medical Center |
| 86 | 76 | N/A | Clinical Center at the National Institutes of Health |
| 87 | 110 | N/A | Spectrum Health/Michigan State University |
| 88 | 49 | N/A | Zucker School of Medicine at Hofstra/Northwell |
| 89 | 53 | N/A | Carolinas Medical Center |
| 90 | 55 | N/A | Medical University of South Carolina |
| 91 | 63 | 41 | Tulane University/Ochsner Clinic Foundation |
| 92 | 77 | N/A | Carilion Clinic–Virginia Tech Carilion School of Medicine |
| 93 | 78 | N/A | University of Nebraska Medical Center College of Medicine |
| 94 | 80 | N/A | Methodist Hospital (Houston) |
| 95 | 85 | N/A | University of California (Irvine) |
| 96 | 94 | N/A | University of Arizona College of Medicine–Tucson |
| 97 | 96 | 24 | University of California Davis Health |
| 98 | 99 | N/A | University of Illinois College of Medicine at Peoria |
| 99 | 100 | N/A | Louisiana State University (Shreveport) |
| 100 | 114 | N/A | Ascension Providence/MSUCHM |
| 101 | 116 | N/A | University of Connecticut School of Medicine |
| 102 | 19 | N/A | Mayo Clinic College of Medicine and Science (Jacksonville) |
| 103 | 90 | N/A | Beth Israel Deaconess Medical Center |
| 104 | 93 | N/A | University of Arkansas for Medical Sciences (UAMS) College of Medicine |
| 105 | 104 | N/A | St. Louis University School of Medicine |
| 106 | 105 | N/A | Riverside University Health System |
| 107 | 111 | N/A | Cooper Medical School of Rowan University/Cooper University Hospital |
| 108 | 112 | N/A | Southern Illinois University School of Medicine |

***Legend:*** The top five programs producing ACGME-accredited neurosurgery physicians (RAAN) are Massachusetts General Hospital, University of California-San Francisco (UCSF), University of Pittsburg Medical Center (UPMC), Barrow Neurological Institute, and Johns Hopkins University.

## Discussion

Our study introduces RAAN, a novel ranking system that effectively correlates the number of academic neurosurgeons with their alma mater's program rank. This correlation underscores RAAN's potential to influence future methodologies for evaluating residency programs, particularly its role in highlighting programs that produce and retain academic neurosurgeons. This may indicate that faculty at the highly ranked DRN programs may have stayed at their residencies location and contributed towards the DRN reputation rank. The significant alignment between RAAN and traditional ranking systems like DRN and BRIMR suggests that our RAAN methodology could complement existing measures by providing a more nuanced perspective on program effectiveness. Since DRN is widely used by medical students but lacks objectivity, RAAN provides an alternative based on objective metrics.[17,18] The significant positive correlation of RAAN with DRN suggests that the matched programs producing the high numbers of academic neurosurgeons (RAAN) are also ranked reputationally well (DRN). This also suggests that DRN may capture meaningful academic reputation signals. This coincides with the size of the neurosurgery residency program correlating with the Doximity reputation – as identified by Feinstein et al., expanding the size of a residency program by one resident correlated with a rise in Doximity rank ranging from 0.80 to 6.32 ranks, varying by specialty rank.[19] On a program-to-program basis, the DRN ranking system, at least for the top 10 reputation-ranked institutions, remains stable yearly and is not impacted by subjective data.3 The correlation between RAAN and BRIMR may suggest that research output does not associate with faculty

placement. Notably, the positive correlation between programs producing a high number of academic neurosurgeons with high amounts of NIH funding suggests that the number of academic neurosurgeons in residency programs trained may be associated with NIH funding. These highly funded programs may attract more academic neurosurgeons who prioritize discovery and scientific merit. This may be important in the decision to award funding for individual researchers depending on their location. The correlation between ranking systems of matched programs indicates an underlying factor across academic neurosurgery faculty.

The positive correlation between the median rank of faculties' residency and RAAN indicates that the programs producing high numbers of academic neurosurgeons have faculty trained from highly ranked programs. Notably, this suggests that programs like Massachusetts General Hospital, UCSF, UPMC, Barrow Neurological Institute, and Johns Hopkins University – programs that produce higher numbers of academic neurosurgeons – essentially employ more faculty trained from those programs. This indicates a strong association between academic neurosurgeons employed at institutions and those producing the most academic neurosurgeons. Reputationally, the data shows that higher ranked programs typically have faculty trained from higher ranked programs. One possible explanation for these findings is that larger programs correlated with reputation rank may have more residents and alums responding to the Doximity survey.19 In the context of NIH funding, the results follow the same trend where programs with the most NIH funding mainly hire faculty trained at well NIH-funded programs.[20] Furthermore, NIH funding likely influences faculty recruitment by fostering strong scientific mentorship.[12] This warrants further investigation of each program on a faculty basis.

We analyzed each program's directory and gathered that the most prolific programs are hiring faculty trained at their own institutions. In the case of RAAN, those programs producing more academic neurosurgeons may also be hiring many of their own trained physicians. Additionally, this may suggest that larger programs intrinsically retain more faculty. There may be an association in which programs producing high numbers of academic neurosurgeons also hire more faculty that trained at the program. Finding an association of legacy faculty across RAAN and DRN suggests that program rank may be associated with how much of their faculty they are hiring. This finding is consistent with the fact that graduates from the top 25 medical schools were more likely to enter a high-ranking neurosurgical residency program.[21] This emphasizes the hiring tendencies of programs from the upper echelons of academia to "inbreed."

The implications of our findings extend beyond individual program rankings, potentially influencing broader educational policies and accreditation standards. This investigation within residency institutions and their faculty shows that various factors may interplay on the journey of becoming an academic neurosurgeon. Applicants interested in pursuing neurosurgery and staying in academia may benefit from prioritizing programs with higher RAAN scores, as these programs have a track record of placing graduates into faculty positions. Our findings support those of Khalafallah et al., namely that the training environment strongly impacts the career path of academic neurosurgeons.[22] DRN enormously impacts medical students when creating their rank lists. It is crucial to be aware of the limitations of the existing ranking systems. By offering an additional ranking system based on objective criteria,[23] our proposal of RAAN should aid in addressing limitations and provide a more robust evaluation of neurosurgery residency programs. These findings underscore the importance of ranking systems derived from multiple facets to ensure they capture a representative snapshot of program quality. The application of this process for ranking of other academic medical specialties is unclear, although we would expect similar findings regardless of the specialty.

### Limitations

We did not account for programs that did not list faculty and their educational background which may skew rankings by underrepresenting their academic contributions. While we accounted for residency retrieved from faculty, during the downstream analysis, some programs have several locations, and the faculty did not specify. Another limitation could arise from larger residency programs which may inflate rankings for larger programs in the RAAN ranking system. Additionally, as the analysis relied on publicly available data not every academic neurosurgeon was definitely identified. Also, we did not verify faculty with board certifications since there may be academic neurosurgeons who are early in their careers as neurosurgeons and are still board-eligible. Lastly, RAAN does not account for long-term career success only faculty placement. Future studies should assess whether RAAN-ranked programs produce neurosurgeons who achieve leadership positions, research impact, and other markers of academic success.

### Conclusion

The introduction of RAAN adds a valuable dimension to the evaluation of neurosurgery residency programs by quantifying the contribution of these programs to the field of academic neurosurgery. Our findings highlight the pivotal role of residency training not just in fostering individual careers and sustaining the academic vitality of the neurosurgery field at large. RAAN provides an objective ranking system based on graduate academic placement, offering a valuable tool for applicants and program directors. This approach will aid medical students in making informed choices and guide program directors in refining their curricular offerings to better prepare the next generation of academic neurosurgeons. Future ranking systems could include information on academic productivity in addition to academic position for greater robustness. Ultimately, our study underscores the necessity of a multi-faceted evaluation system in maintaining the rigor and relevance of medical training in neurosurgery.

## Summary – Accelerating Translation

A Novel Ranking System for Neurosurgery Residency Programs: Residency-Affiliated Academic Neurosurgeons (RAAN)

There currently remains no ranking system where academic placement is taken into consideration. Many medical students embarking on the

journey towards a career in neurological surgery consider many factors when creating their residency rank list. Using established ranking systems such as Doximity Residency Navigator (DRN), underscores the complexity of this decision-making process. Despite the multifaceted nature of residency program evaluations, the alignment of these rankings with the pursuit of an academic career remains unclear. In this study, we aimed to elucidate the influence of residency institution rankings on the pursuit of academic careers in neurological surgery. Our objective was to establish whether there exists a significant association between the rankings of residency institutions and the placement of graduates in academic positions.

Utilizing the Doximity Residency Navigator (DRN), we compiled a comprehensive list of Accreditation Council for Graduate Medical Education (ACGME)-accredited neurological surgery residency programs. From each program, we extracted and compiled data on trained neurological surgery physicians' residency information. This dataset facilitated the development of a novel ranking system based on the programs' production of neurosurgery academic teaching faculty – referred to as Residency-Affiliated Academic Neurosurgeons (RAAN). We explored the relationship between residency institution rankings, as determined by our proposed RAAN ranking system, and the placement of graduates in academic careers. Our methodology allowed for a comprehensive examination of the factors influencing career trajectories in neurological surgery

Our analysis reveals strong positive correlations between RAAN and DRN ($r=0.7316$; $p<0.0001$), as well as between RAAN and BRIMR ($r = 0.4527$; $p < 0.001$), suggesting consistency across different systems. Additionally, top-ranked residency programs in all three systems demonstrate strong positive correlations with median faculty residency ranks.

By establishing a novel ranking system based on the production of academic teaching faculty, we provide valuable insights into the factors guiding medical students' residency program selection. These findings provides medical students with a new tool that allows them to create a rank list based on their academic career goals. Our findings contribute to a deeper understanding of the dynamics shaping academic career pathways in neurological surgery and offer valuable guidance for aspiring neurosurgeons navigating the residency selection process..

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**Author Contributions**

Conceptualization: SV, OD. Data Curation: SV. Formal Analysis: SV. Investigation: SV, CJP. Methodology: SV. Software: SV. Supervision: CJP. Validation: SV. Visualization: SV. Writing - Original Draft: SV, OD, CJP. Writing - Review Editing: SV, CJP.

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