

Faculty Rank, Biological Sex, and Geographical Distribution in U.S. Neurosurgery Residency Programs: A Cross-Sectional Program-Level Analysis

Maria Fioletova, BS

Nova Southeastern University

Mohammad Kasim Fatmi, MS

Nova Southeastern University

Pierina S. Barletti, MBS

Nova Southeastern University

Renee Reynolds, MD

Buffalo State University

Amanda Kwasnicki, MD

Joe DiMaggio Children's Hospital

Julieanne P. Sees, DO, MBA, DM

jseesdo@osteopathic.org

Saint Joseph's University

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Abstract

Objective

Neurosurgery is a rigorous surgical subspecialty. Despite increases in women entering surgery, significant biological sex disparities persist, especially at the faculty level, affecting mentorship, leadership, and visibility. Identifying these gaps is crucial to advancing equity. This study assesses the representation of women among faculty in U.S. neurosurgical residency programs.

Design

Cross-sectional observational study using publicly available data from U.S. Accreditation Council for Graduate Medical Education (ACGME)-accredited neurosurgical residency program websites and Fellowship and Residency Electronic Interactive Database (FREIDA). Faculty demographic variables, including biological sex, medical degree, and academic rank, were analyzed using descriptive statistics and chi-square analysis.

Setting

This study was conducted at Nova Southeastern University Kiran C. Patel College of Osteopathic Medicine, Fort Lauderdale, Florida.

Participants

Of 118 identified U.S. ACGME-accredited neurosurgical residency programs, 113 were included based on the availability of publicly accessible faculty data; 5 programs were excluded due to the absence of faculty information. A total of 1,889 neurosurgical faculty members entered the study.

Results

Out of a total of 1,889, only 238 (12.6%) were women, and 44 (2.33%) were osteopathic physicians; 8 (0.4%) were both. Among identified faculty, we found the academic rank of 1590 neurosurgical faculty. 46 women (7.6%) were full professors ($n = 606$), 56 (15.6%) were associate professors ($n = 360$), and 106 (17.0%) were assistant professors ($n = 624$). Significant biological sex disparities were found in each rank ($p < 0.05$).

Conclusion

Our findings confirm the persistent underrepresentation of women in neurosurgical faculty. Ongoing efforts are needed to advocate for and support women in prestigious academic leadership. Increased representation provides visible role models, inspiring more women students to pursue neurosurgery, and leading to a more diverse academic environment that positively impacts patient care.

Introduction

The competitive nature of neurosurgery academic programs is well known; however, the lack of diversity within this field is not explored deeply. According to the Association of American Medical Colleges (AAMC), less than 10% of neurosurgeons are women, and only 2% are osteopathic physicians [1, 2]. To find the reasons for this, it is important to understand the characteristics that comprise the current neurosurgery academic workforce. The diversity of faculty within a program plays a key role in potential candidates finding their fit [3]. The relationship between female faculty and female residents was found to have a significant positive correlation [4]. Female neurosurgery residents have increased from 7.3% in 1990 to 23.7% in 2023 [5], which is a relatively slow increase in female representation. Those low numbers could be explained by a potential biological sex bias during the interview selection process, as well as a high attrition rate among female residents. High attrition rate among female residents could be attributed to significant challenges female residents face, such as inconsistent family leave policies, lack of on-site childcare, and biological sex discrimination [5]. Furthermore, the numbers for women in neurosurgical faculty are even lower, where women comprise 11.0% of all academic neurosurgeons [6].

This study aims to analyze current trends in neurosurgical faculty across the United States (U.S.) residency programs. Data on neurosurgical faculty were collected via publicly available neurosurgical residency websites and further analyzed with statistical analysis. The goals of this study are to evaluate whether there are disparities in academic rank between men and women neurosurgeons, assess differences based on geographical areas and medical degree, and explore other factors that may contribute to these disparities. The significance of this study is to emphasize biological sex representation in the neurosurgical field and provide data on the geographical distribution of women and osteopathic neurosurgical faculty. We hypothesized that women and osteopathic (DO) faculty would be underrepresented within the academic ranks and that a higher proportion of female or DO program directors would be associated with a higher proportion of female or DO faculty at the program level, respectively. Understanding these disparities is critical for informing institutional policies, targeted mentorship programs, and leadership initiatives with a goal of promoting biological sex equity in academic neurosurgery.

Methods

This was a cross-sectional, program-level observational study of demographic and bibliometric data on neurosurgical faculty across accredited programs by the U.S. Accreditation Council for Graduate Medical Education. Data was evaluated from program websites and the Fellowship and Residency Electronic Interactive Database (FREIDA) between August 2025 and May 2026. No a priori sample-size calculation was performed; study size was instead determined by the total number of ACGME-accredited programs in existence at the time of data collection ($n = 118$), of which 113 met inclusion criteria. Data collection involved manually extracting faculty information from the official residency websites and FREIDA.

To ensure accuracy, data collection was performed in three phases. First, the authors divided programs for initial extraction. Then, a different author independently verified the information, allowing cross-checking between investigators and minimizing bias or error. In the final phase, individual program data

underwent a third round of verification. Collected variables included program location, U.S. region, and hospital category (university-based or community-based). Faculty were categorized based on degree type, sex, and rank (program director vs faculty).

Variable definitions

Biological sex was categorized as male or female. Medical degree was categorized as allopathic (MD) or osteopathic (DO). Academic rank was categorized as assistant professor, associate professor, or full professor; faculty without a rank listed publicly were excluded from the analysis. Program director status was cross-checked from FREID and the programs' websites. The institution's geographic region was assigned using the nine U.S. Census Bureau divisions (New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, Pacific). Hospital category was defined as university-based or community-based according to the program's self-description.

Biological sex and medical degree were determined through review of publicly available online profiles, including program websites and LinkedIn. Geographical heat maps of faculty were generated in Microsoft Excel using the Filled Map tool. Chi-square tests (CHISQ.TEST, Excel Analysis ToolPak) were used to compare the distribution of biological sex across academic ranks. Pearson correlation coefficients (PEARSON, Excel Analysis ToolPak) assessed program-level associations between (1) percentage of female faculty and percentage of female residents, (2) female program director status and percentage of female faculty, (3) percentage of DO faculty and percentage of DO residents, and (4) DO program director status and percentage of DO faculty. This study did not require approval from the Nova Southeastern University Institutional Review Board, as it did not involve direct contact with human subjects or identifiable private information.

Results

Our team identified 118 neurosurgical programs nationwide, 113 of which had data available (Fig. 1). A total of 1889 neurosurgical faculty were observed, with only 238 (12.6%) being women: 230 (12.2%) allopathic physicians and 8 (0.4%) osteopathic physicians. Additionally, 1845 (97.7%) were allopathic physicians and 44 (2.3%) were osteopathic physicians. 36 (1.9%) osteopathic physicians were men, and 8 (0.4%) osteopathic physicians were women (Fig. 2).

Of the faculty rank identified ($n = 1590$), 606 were full professors (7.6% women), 360 were associate professors (15.6% women), and 624 were assistant professors (17.0% women). The breakdown of every academic rank out of the identified faculty was as follows: 603 (37.9%) of allopathic physicians and 3 (0.2%) of osteopathic physicians in the full professor rank. For associate professors, we found 355 (22.3%) allopathic physicians and 5 (0.3%) osteopathic physicians. For assistant professors, we found 606 (38.1%) allopathic physicians and 18 (1.1%) osteopathic physicians (Fig. 3). Consequently, statistically significant disproportions of biological sex in each rank ($p < 0.05$) were found. There was no

correlation found between female faculty percentage and female resident percentage ($R = -0.12$, $p = 0.24$). However, there is a possible positive correlation between females being program directors and having a high percentage of female faculty ($R = 0.27$, $p = 0.003$). When analyzing medical degrees, there was a strong positive correlation between faculty with a DO degree and residents holding a DO degree ($R = 0.60$, $p < 0.001$). There is also a strong positive correlation between programs' directors holding a DO degree and having a high percentage of DO faculty ($R = 0.57$, $p < 0.001$) (Table 1).

Further breakdown of academic ranks based on biological sex out of all faculty was conducted. Out of a total of 1,889 faculty members, 1,590 had data available for further analysis, and the percentages that follow are based on this sample of 1,590 (100%). 299 faculty were excluded due to a lack of publicly available academic rank information. For the full professor rank, there were 560 (35.2%) males and 46 (2.9%) females. For the associate professor rank, there were 304 (19.1%) males and 56 (3.5%) females. For the assistant professor rank, there were 518 (32.6%) males and 106 (6.7%) females (Fig. 4).

Correspondingly, we identified 118 total program directors of neurosurgical programs who were analyzed based on their degree and biological sex. There were a total of 107 (90.7%) male program directors, of whom 106 (89.8%) were allopathic physicians, and 1 (0.85%) was an osteopathic physician. There were a total of 11 female program directors (9.3%), all of whom were allopathic physicians (Fig. 5).

Further, neurosurgical faculty were analyzed based on the geographical region in the United States. A total of nine geographical regions were included in the study, and not all of them showed the percentage of osteopathic faculty. The highest percentage of osteopathic faculty in neurosurgery programs was found in the East North Central area (6.8%, $n = 9$), the second highest in the South Atlantic (4.3%, $n = 7$), and the third highest in the Middle Atlantic (2.2%, $n = 6$). The rest of the regions were distributed as follows: New England (1.8%, $n = 2$), West South Central (1.2%, $n = 2$), Pacific (0.2%, $n = 1$), and the rest of the regions were found to have 0 osteopathic faculty: Mountain, West North Central, and East South Central (Fig. 6).

Female neurosurgical faculty were further analyzed based on geographical region in the United States. The highest percentage of female faculty was found in the West South Central area (30.5%, $n = 25$), the second highest in the Mountain region (21.2%, $n = 18$), and the third highest in the New England area (20.1%, $n = 21$). The rest of the regions were distributed as follows: West North Central (18.7%, $n = 13$), East North Central (15.1%, $n = 24$), Pacific (14.2%, $n = 33$), East South Central (14.1%, $n = 11$), Middle Atlantic (14.0%, $n = 49$), and the lowest percentage was found in the South Atlantic (12.0%, $n = 32$) (Fig. 7).

Discussion

These findings raise concerns for possible entry barriers for women and DOs to academic neurosurgery programs, which result from diverse mentorship, representation, and recruitment of residency applicants. Limited faculty diversity, with only 5% of department chairs being women or members of underrepresented racial and ethnic minority groups, could prevent candidates from diverse backgrounds

from applying. According to a systematic review in 2022, women and racial/ethnic minority groups were less likely to hold high academic and leadership positions. A possible explanation could be a work–life balance issue, with 18.5% women attending finding less career fulfillment, and 20.4% of them would not pursue neurosurgery again because of a lack of protected personal time [7].

A strong positive correlation was found between faculty with a DO degree and residents holding a DO degree, which could emphasize the importance of having a DO mentor or a formerly known AOA program. In addition, a strong positive correlation was found between programs' directors holding a DO degree and having a high percentage of DO faculty. These results emphasize the importance of mentorship among DO faculty and the strong correlation to programs having a higher proportion of DO faculty with DO program directors. Furthermore, this study discusses differences in neurosurgical faculty based on faculty rank, biological sex, medical degree, and geographical location.

Faculty Rank Differences

Faculty rank differences among biological sexes are present in almost all academic fields, including the medical field. According to a systematic review conducted in 2021, men were 2.77 times more likely to hold the rank of full professor, with the biological sex gap being present in all specialties inside and outside of North America [8]. Similarly, a 2014 study found that only 14.7% of surgical faculty at U.S. medical schools were women [9].

Consistent with these findings, our dataset shows a lower representation of women among full professors (7.6%, $n = 46$) compared with assistant professors (17.0%, $n = 106$) and associate professors (15.6%, $n = 56$) — approximately half the proportion seen at lower ranks. In total, women comprised 12.6% ($n = 238$) of all neurosurgery program faculty, slightly below the 14.7% reported in the 2014 study, highlighting the biological sex gap in academic neurosurgery. Another study analyzed female neurosurgery residency graduates over 50 years (1964–2013) and found that 26% ($n = 91$) have entered the academic field: 42 with the rank of assistant professor, 33 associate professor, and 16 reached full professor rank. This can be attributed to the overall younger age of females in the neurosurgery field, due to many being recent graduates. This could potentially change in the future as female neurosurgeons who currently comprise large proportions of assistant and associate professor ranks may take over a decade of academic work to reach a full professor rank. Another possible reason can be attributed to the glass-ceiling effect, where women are less likely to be promoted when compared to equally achieving male peers [10].

Furthermore, comparing other major surgical specialties such as otolaryngology (ENT), anesthesiology, orthopedic surgery, and general surgery, women remain underrepresented relative to men. Studies consistently show that while the proportion of women entering residency has increased, women are less likely to advance to full professor status, department chair, or other leadership positions. More specifically, orthopedic surgery demonstrates one of the lowest percentages of women residents (22.6%) as well as among faculty (13.1%). Whereas fields like ENT, 26.3% women in academic fields, and

anesthesiology, 36% women as program directors, demonstrated a better biological sex balance overall, but persistent attrition at higher ranks [11–13].

Biological Sex Differences

Across various specialties and program-level databases, prior studies have found that programs with higher numbers of female faculty tend to have higher numbers of female residents. Specifically, for each 1% increase in women faculty, there was a 1.45% increase in female trainees [14]. Similarly, a five-year longitudinal study of female physicians in orthopedic surgery residencies showed that there was an increase from 13.5% to 19.2% in female residents. This increase was correlated with residency programs that had higher percentages of female faculty [15]. An additional analysis done in 2024 also identified the significant positive correlation between female faculty and female resident percentages across 117 neurosurgical residency programs [4]. However, in our study, we did not observe a statistically significant association between female neurosurgical faculty representation and female resident percentages, suggesting that factors beyond faculty composition may influence these patterns. Given the strong association reported in prior studies, additional factors such as geographic practice distribution may contribute to the biological sex distribution patterns.

In an analysis of neurosurgeon migration patterns, female neurosurgeons were less likely to practice in the South. They also found that among female academic neurosurgeons specifically, there was a reduced probability of practicing in both the South and Northeast Regions [16]. Spatial analysis from another study identified the Middle Atlantic and Pacific divisions as hot spots for women neurosurgeons. These areas contained major metro cities like New York, Boston, Philadelphia, San Francisco, Portland, and Seattle. The same study identified that the cold spots were scattered across the East South Central and lower East North Central regions, with Memphis being the only major city in these cold spots [17].

Collectively, these findings suggest that female neurosurgeons are not evenly distributed within regions but rather are mainly concentrated in urban academic centers. Thus, regions with overall lower representation may still contain city-level hot spots, while regions with higher aggregate representation may have sparse presence in rural and smaller metro regions. Supporting this interpretation, another study showed that the number of female neurosurgeons was higher in urban states, but noticed rural states had an increase compared to five years ago [1]. A possible explanation for this distribution could be the more robust mentorship networks and higher visibility of women faculty within institutions in major metro areas. In contrast, rural and smaller metro regions may struggle in recruitment and retention due to limited academic infrastructure and professional isolation. All of these considerations highlight the need for targeted recruitment, mentorship, and institutional support to promote a more balanced neurosurgical workforce.

Osteopathic vs Allopathic Differences

Despite steady growth in the osteopathic medical profession, our data highlights the significant disparity between DO and MD faculty in neurosurgical academia. Only 2.3% (n = 44) of the total faculty were osteopathic physicians, with only 0.2% (n = 3) being full professors. This underrepresentation is significantly disproportionate to the increasing numbers of osteopathic medical students and residents entering the workforce. Historically, osteopathic medical schools have prioritized primary care and rural medicine, often lacking the robust research infrastructure and NIH funding found at large allopathic academic centers [18]. Generally, neurosurgical residency selection heavily weighs research productivity and academic pedigree [19]; osteopathic medical graduates likely face structural disadvantages early in their careers, among potentially several factors contributing to this gap in representation.

Furthermore, stigma and bias in residency selection processes likely persist [20]. Before the single accreditation system in graduate medical education, osteopathic candidates faced strong barriers to entering Accreditation Council for Graduate Medical Education (ACGME) neurosurgical residency programs, often relying on taking the USMLE in addition to COMLEX to prove competency [21]. While the 2020 merger aimed to standardize training, a certain “prestige” ranking associated with neurosurgical training remains. This is further evidenced by the historical scarcity of DO representation in residency leadership; data collected between 2018 and 2023 on program directors across multiple surgical subspecialties found a statistically significant correlation between the proportion of DO program directors and higher DO match rates [22]. At the time of our study, only 2 program directors in the USA were osteopathic physicians, furthering the cycle with a lack of advocacy and mentorship.

Geographic Location

The geographical distribution of neurosurgical faculty is attributed to many factors, but it appears closely linked to the historical training pipelines of osteopathic residents. Analysis of the 2023–2024 academic year reveals that DO neurosurgical residents tend to be clustered in legacy strongholds. Notably, residents were found to be significantly concentrated in New Jersey (27.5%) and Michigan (17.3%), with a statistically significant correlation with residents matching to these states [21]. On a broader regional scale, the West Pacific (8.3%), Middle Atlantic (7.8%), and West South Central (6.7%) also demonstrated higher proportions of osteopathic trainees [23]. These geographic concentrations likely serve as the primary feeders for future DO neurosurgical faculty. However, this pipeline faces potential constriction; the same dataset highlighted a sharp decrease in the absolute number of DO matches to neurosurgery, falling from 14 in 2016 to just 4 in 2024 [21]. This trend suggests that while current faculty may be clustered in established osteopathic hubs, the diminishing influx of new trainees could further restrict the geographic expansion of the workforce.

One of the factors is the association between formerly known AOA neurosurgical programs and osteopathic faculty distribution. There are a total of 5 programs: Riverside University Health System Program, Rutgers New Jersey Medical School Program, Ascension Providence/MSUCHM Program, Philadelphia College of Osteopathic Medicine Program, and Carilion Clinic-Virginia Tech Carilion School of Medicine Program [24]. The results from this study demonstrate a correlation between formerly AOA

programs and higher percentages of DO faculty. This study showed the highest number of DO faculty in East North Central (6.76%, n = 9), which included the Ascension Providence program, the second highest being South Atlantic (4.28%, n = 7), which included the Carilion Clinic-Virginia Tech Carilion program, third highest being Middle Atlantic (2.24%, n = 6), which included the Rutgers NJ program.

Furthermore, a study evaluated the relationship between medical students graduating from physician shortage area programs (PSAP) and practicing in rural areas as physicians. The results revealed that both women and men who graduated from PSAP were twice as likely to practice in rural areas as non-PSAP women and men. This indicates that medical school rural programs have the potential to help address the serious shortage of women physicians in rural areas, thereby increasing access to care for those living there [25].

The findings are gathered from U.S. ACGME-accredited neurosurgical residency programs with publicly available faculty information, 113 of 118 identified programs, at the time of data collection. Because our data source was limited to institutional websites and the FREIDA database, our findings may not generalize to faculty whose profiles are not publicly available on the databases. This cross-sectional analysis is limited to workforce trends over time; longitudinal data is needed to further evaluate these disparities.

Limitations

There are several limitations to our study. Our data were limited to the publicly available data from the faculty programs' websites and the FREIDA website, which may not fully capture the neurosurgical faculty's demographics. As a result, we are missing 5 programs with complete faculty data due to either a lack of publicly published faculty information or a lack of up-to-date faculty information entirely. The data extraction was conducted by the authors following standardized procedures, but inter-rater reliability was not assessed, which may lead to selection bias. The data provided on the websites may have limitations, such as an inability to capture ethnicity, race, years of experience or academic productivity, age, and many other characteristics that could affect the dataset. Due to the limited publicly available data, we have not conducted sensitivity analyses. Due to the limited publicly available data, no sensitivity analyses were conducted. Despite the limitations, the data are consistent with the publicly available information. Lastly, given that some of the statistical analyses had low R^2 values and high p-values, our observed patterns should be interpreted as a way to identify general trends rather than to predict outcomes.

Conclusion

Our study provides a comprehensive examination of biological sex, degree type, academic rank, and geographic distribution within U.S. neurosurgical faculty, with the findings highlighting the persistent underrepresentation of women in neurosurgical faculty. Despite gradual increases in women entering neurosurgical training, women remain underrepresented among faculty, particularly at senior academic

ranks and leadership positions. This disparity may partially reflect the time required for increasing numbers of women trainees to progress through residency, fellowship, and academic promotion, as well as potential differences in career pathways, including private practice. Nevertheless, structural and institutional factors may still contribute to disparities in advancement within academic neurosurgery.

While prior studies have demonstrated strong associations between female faculty representation and female resident recruitment, our findings did not identify a statistically significant correlation between these variables, indicating that faculty composition alone may not fully explain biological sex representation patterns. Instead, our results suggest that leadership representation, mentorship structures, and institutional context, such as geographic practice distribution, may play important roles in shaping these dynamics. The observed concentration of female neurosurgeons within urban academic centers further emphasizes the impact of regional resources, mentorship availability, and academic infrastructure on recruitment and retention.

Our findings suggest the need for ongoing efforts in advocating for and supporting women in prestigious leadership positions, such as academic neurosurgery. Increasing women's representation will inspire more women medical students to break down barriers and pursue the field of neurosurgery by providing visible role models and mentorship. A more diverse academic and work environment could positively impact patient care.

Declarations

Ethics approval and consent to participate:

Ethics approval and consent to participate were waived in this study.

AI Use Disclosure:

The authors did not use generative AI or AI-assisted tools in the preparation of this manuscript.

Competing interests:

The authors declare that they have no competing interests.

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Author Contribution

M.F., M.K.F., and P.B. were major contributors to project formulation, data analysis, and the manuscript. M.F., M.K.F., and P.B. were major contributors to the data analysis and manuscript. R.R., A.K., and J.S. were contributors to the revision of the manuscript. J.S. was the principal investigator on the project, providing guidance and support throughout the entire project, and was a contributor to the manuscript.

Data Availability

The datasets generated and analyzed during the current study consist of faculty demographic data manually extracted from publicly available neurosurgery residency program websites and the Fellowship and Residency Electronic Interactive Database (FREIDA). The compiled dataset is available from the corresponding author upon reasonable request. Underlying source data are publicly accessible via individual program websites and FREIDA (<https://freida.ama-assn.org/>).

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Table

Table 1 is available in the Supplementary Files section.

Figures

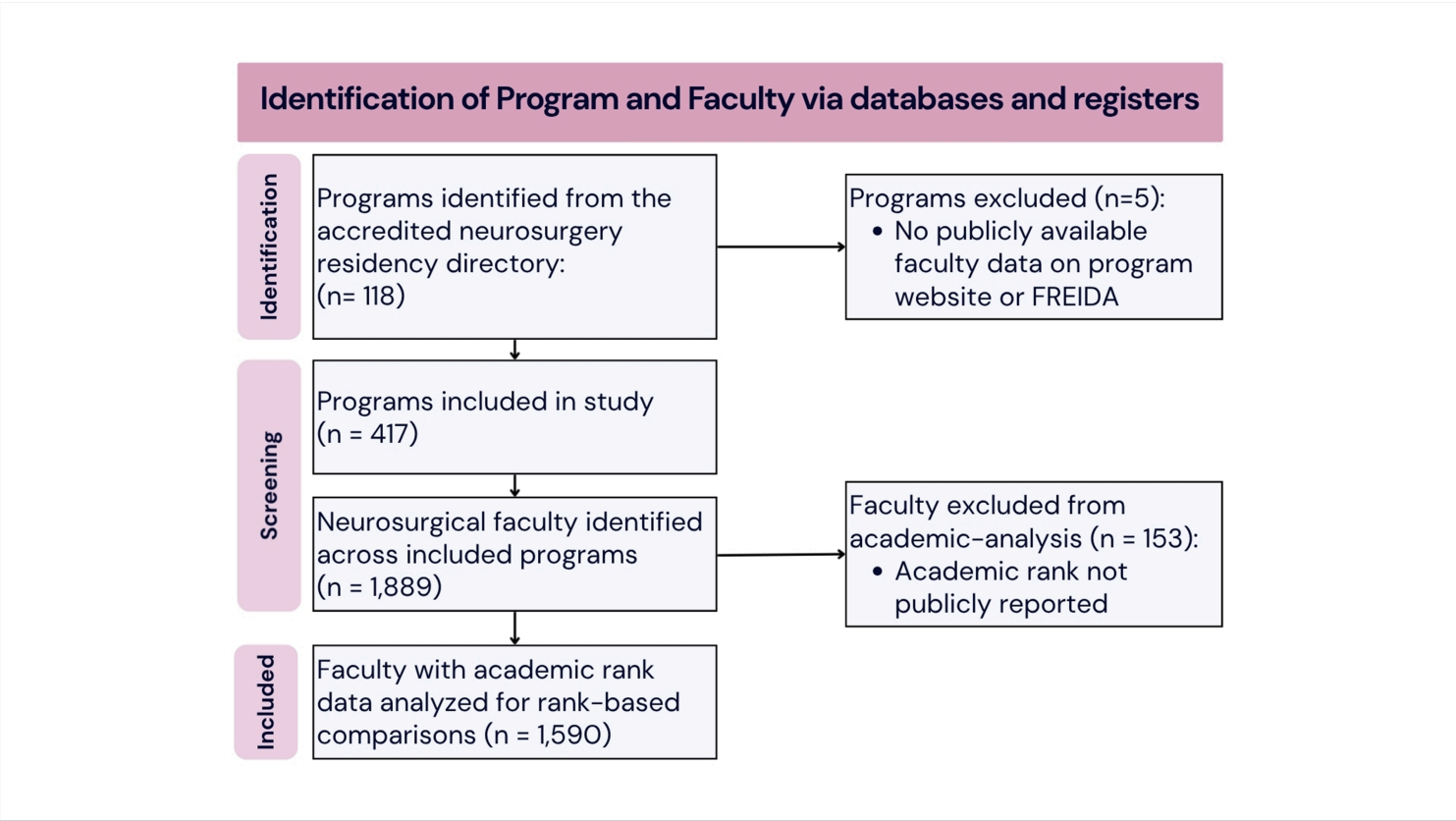


Figure 1

Program and faculty PRISMA flow diagram, illustrating inclusion and exclusion criteria amongst U.S. neurosurgery residency programs and faculty.

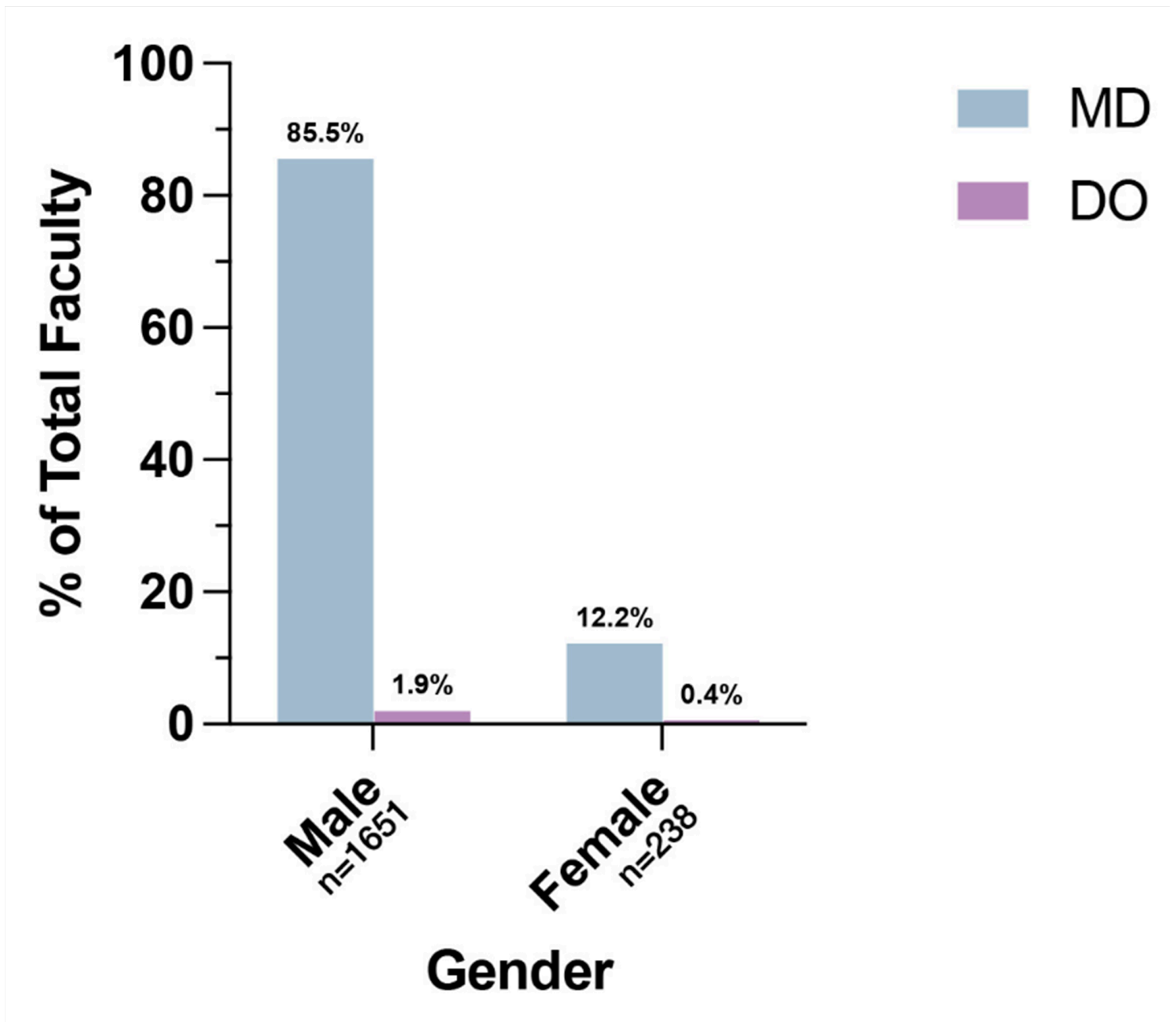


Figure 2

Percentage of Allopathic and Osteopathic Female vs Male Faculty in Neurosurgery programs. Blue = MD, Pink = DO.

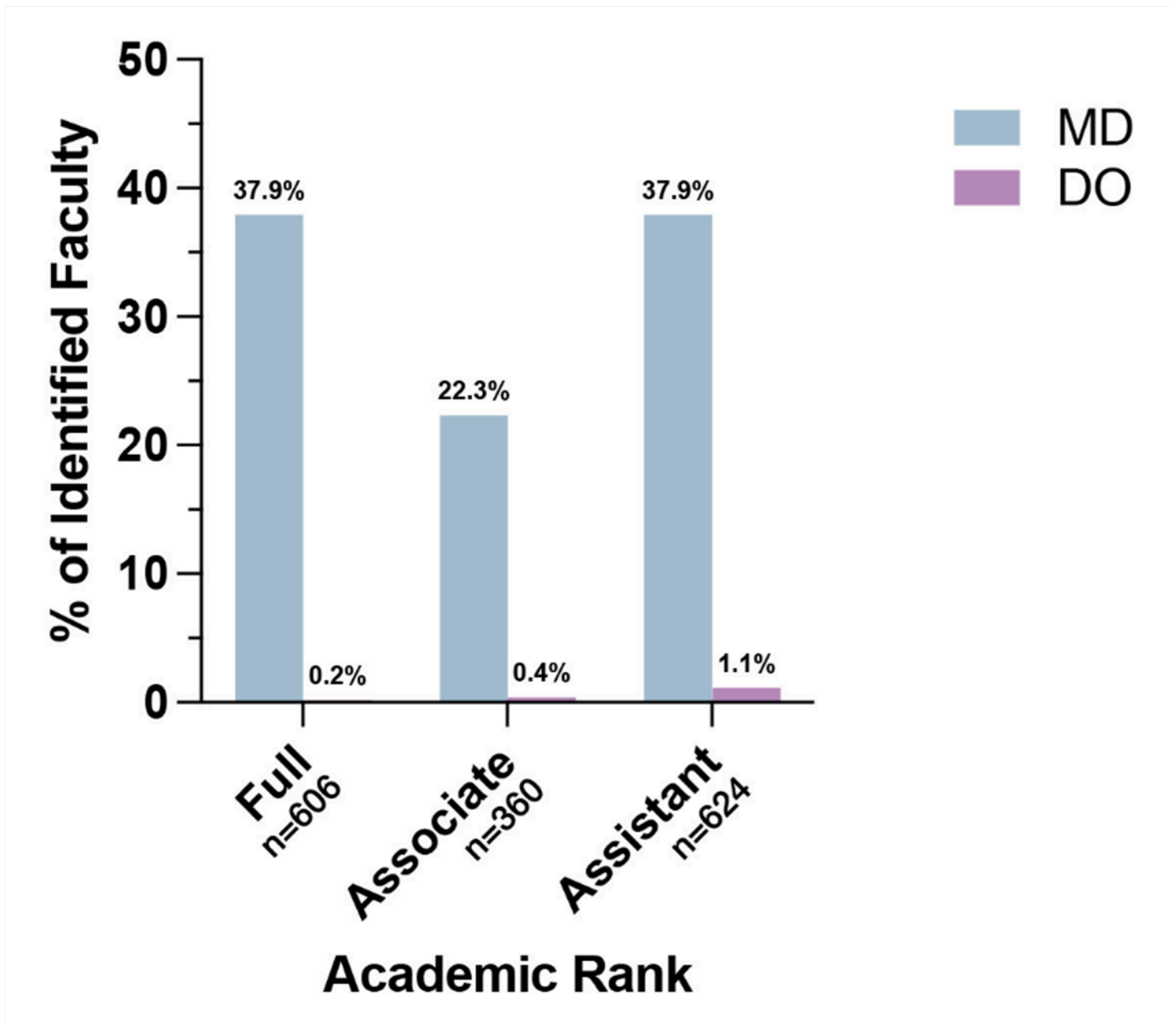


Figure 3

Percentage of Allopathic and Osteopathic Faculty by academic rank in neurosurgery programs, by degree type. Blue = MD, Pink = DO.

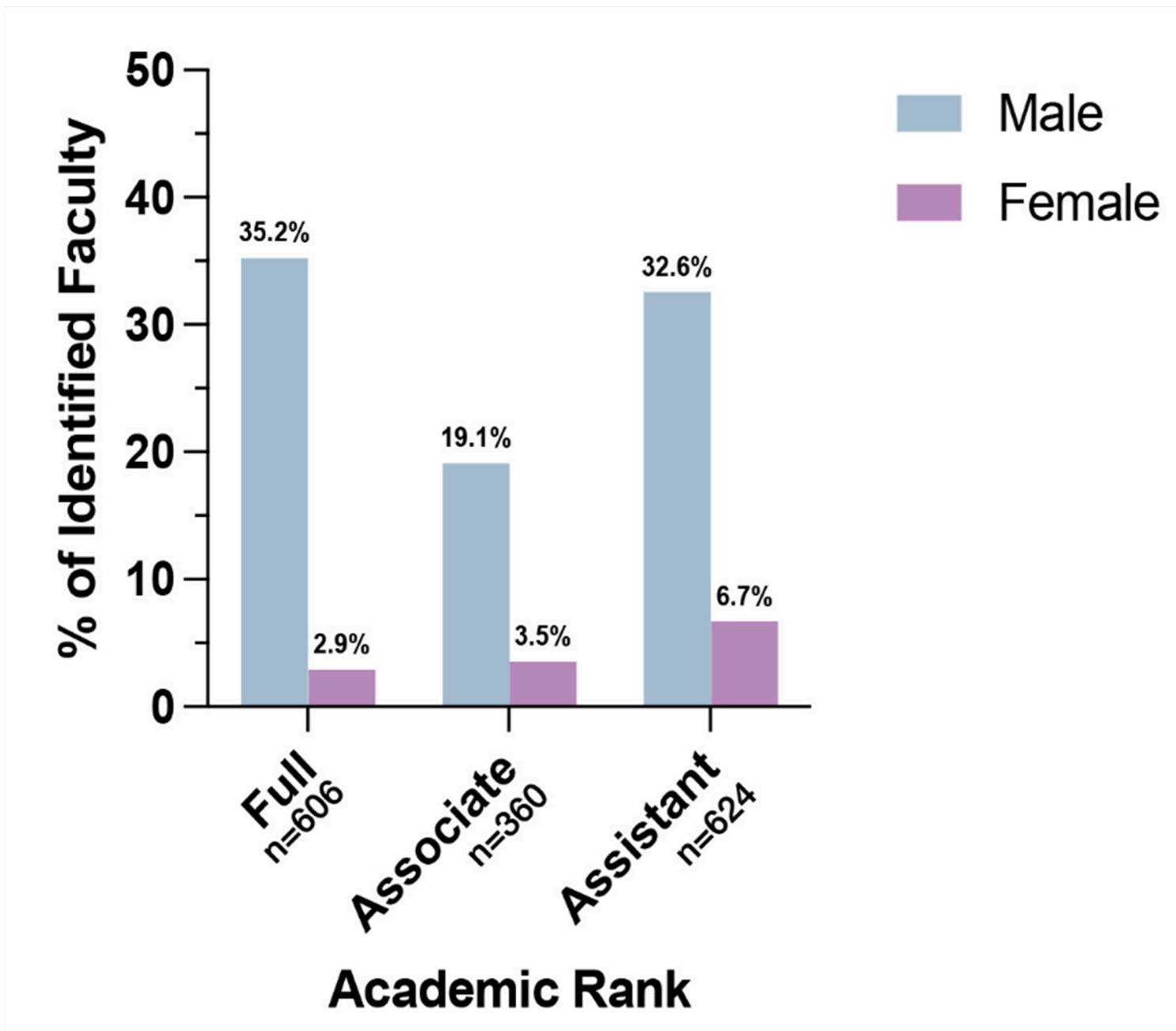


Figure 4

Percentage of Male and Female Faculty by academic rank in neurosurgery programs, by biological sex. Blue = Male, Pink = Female.

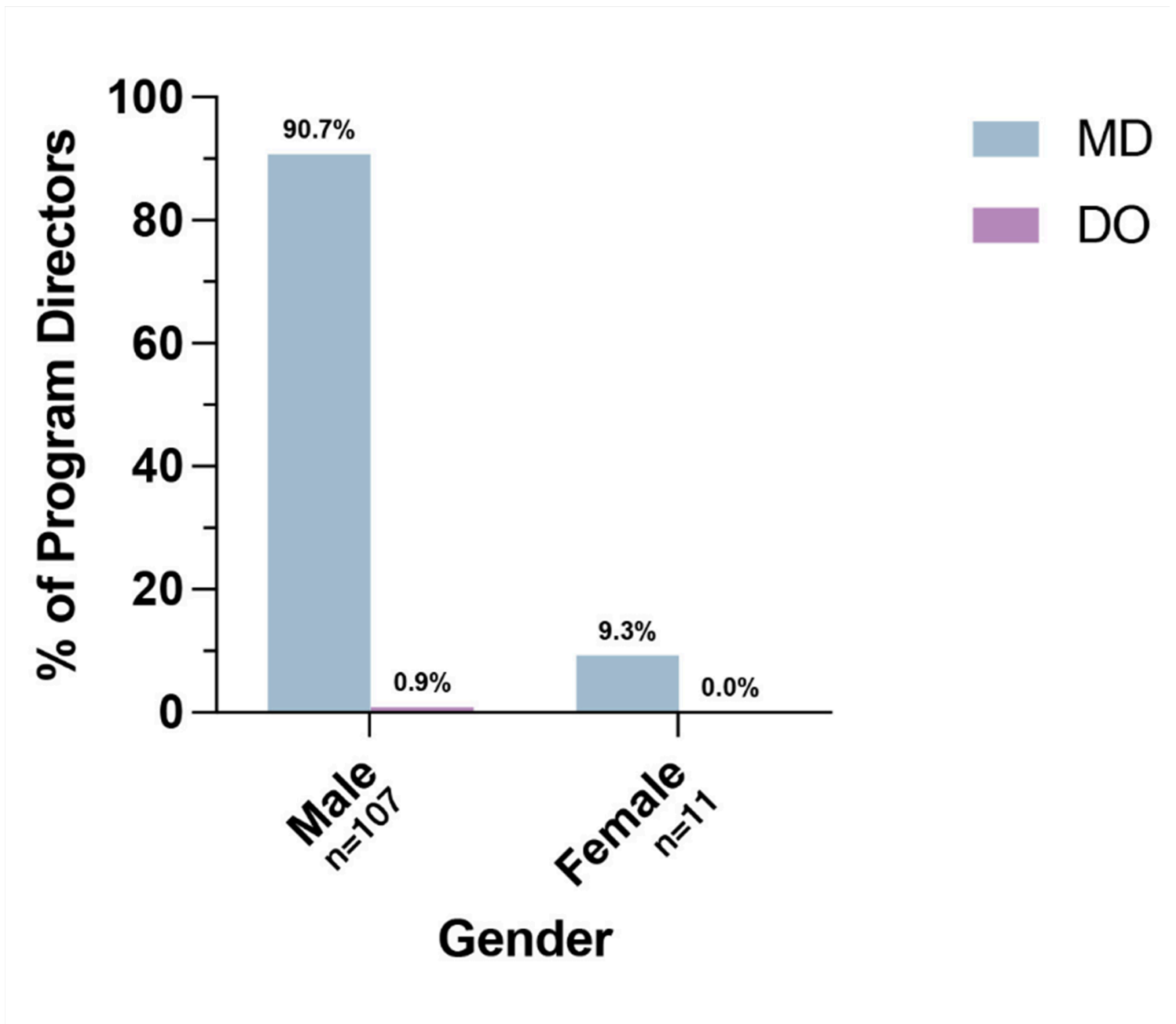


Figure 5

Percentage of Female vs Male Program Directors in Neurosurgery programs. Blue = MD, Pink = DO.

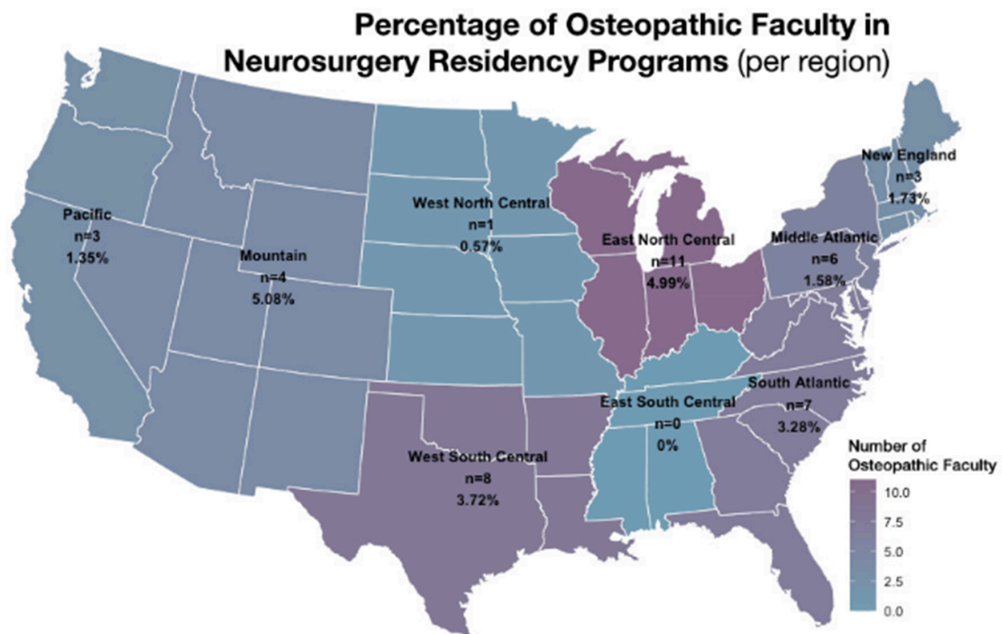


Figure 6

Percentage of DO Faculty in Neurosurgery per region (n, %).

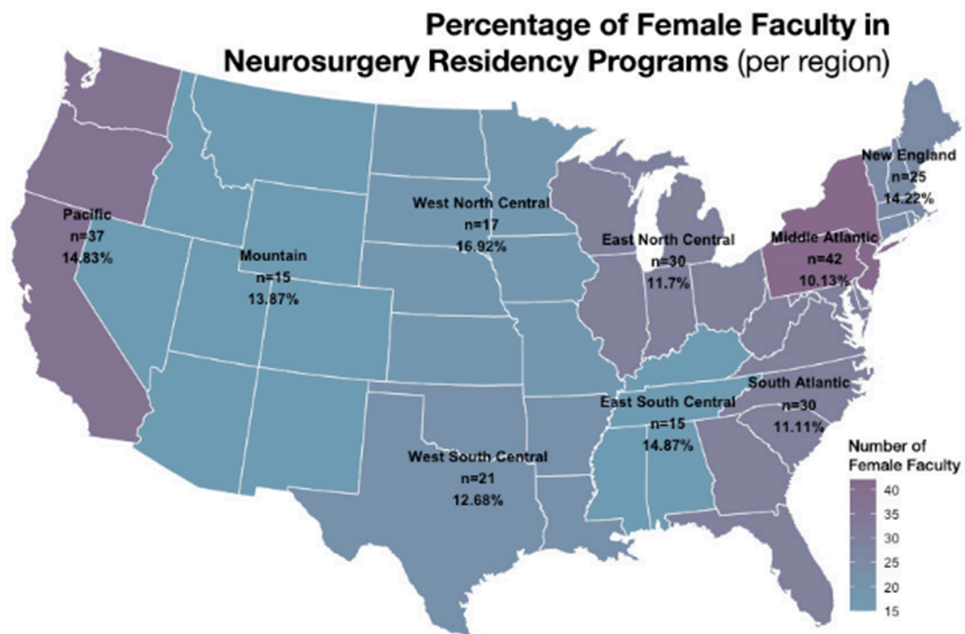


Figure 7

Percentage of Female faculty in Neurosurgery based on region (n, %).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table1.tiff](#)