Attrition rates in neurosurgery residency: analysis of 1361 consecutive residents matched from 1990 to 1999

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OBJECT The objective of this study is to determine neurosurgery residency attrition rates by sex of matched applicant and by type and rank of medical school attended.

METHODS The study follows a cohort of 1361 individuals who matched into a neurosurgery residency program through the SF Match Fellowship and Residency Matching Service from 1990 to 1999. The main outcome measure was achievement of board certification as documented in the American Board of Neurological Surgery Directory of Diplomats. A secondary outcome measure was documentation of practicing medicine as verified by the American Medical Association DoctorFinder and National Provider Identifier websites. Overall, 10.7% (n = 146) of these individuals were women. Twenty percent (n = 266) graduated from a top 10 medical school (24% of women [35/146] and 19% of men [232/1215], p = 0.19). Forty-five percent (n = 618) were graduates of a public medical school, 50% (n = 680) of a private medical school, and 5% (n = 63) of an international medical school. At the end of the study, 0.2% of subjects (n = 3) were deceased and 0.3% (n = 4) were lost to follow-up.

RESULTS The total residency completion rate was 86.0% (n = 1171) overall, with 76.0% (n = 111/146) of women and 87.2% (n = 1059/1215) of men completing residency. Board certification was obtained by 79.4% (n = 1081) of all individuals matching into residency between 1990 and 1999. Overall, 63.0% (92/146) of women and 81.3% (989/1215) of men were board certified. Women were found to be significantly more at risk (p < 0.005) of not completing residency or becoming board certified than men. Public medical school alumni had significantly higher board certification rates than private and international alumni (82.2% for public [508/618]; 77.1% for private [524/680]; 77.8% for international [49/63]; p < 0.05). There was no significant difference in attrition for graduates of top 10–ranked institutions versus other institutions. There was no difference in number of years to achieve neurosurgical board certification for men versus women.

CONCLUSIONS Overall, neurosurgery training attrition rates are low. Women have had greater attrition than men during and after neurosurgery residency training. International and private medical school alumni had higher attrition than public medical school alumni.

<http://thejns.org/doi/abs/10.3171/2014.10.JNS132436>

KEY WORDS attrition; board certification; sex; neurosurgery residency

ABBREVIATIONS AAMC = American Association of Medical Colleges; AANS = American Association of Neurological Surgeons; ABNS = American Board of Neurological Surgery; NPI = National Provider Identifier.

SUBMITTED November 2, 2013. **ACCEPTED** October 9, 2014.

INCLUDE WHEN CITING Published online November 21, 2014; DOI: 10.3171/2014.10.JNS132436.

DISCLOSURE The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

IN 1991, 40% of medical school entrants were female; presently that number is 47%.⁴ Currently, however, only 236 of 4083 active board-certified neurosurgeons are female (5.8%); this percentage was 5.9% in 2004 and actually decreased to 5.1% in 2006 (data provided by the American Association of Neurological Surgeons [AANS] and the American Board of Neurological Surgery [ABNS]). The percentage of women who are board-certified neurosurgeons thus has not changed substantially in a decade; neurosurgical leadership has identified this as a problem requiring correction to optimize the potential of the neurosurgical workforce.²²

Board certification is a voluntary process. Upon completion of residency, a neurosurgeon becomes board eligible. After collecting independent surgical cases with more than 1 year of follow-up and several letters from board-certified neurosurgeons attesting to competency, a board-eligible neurosurgeon must pass an oral examination to become certified by the ABNS. Some neurosurgeons continue to practice without ABNS certification or seek certification from other credentialing organizations.

The objective of this study is to determine the attrition rates from neurosurgical training programs and years from match to board certification, broken down by sex, institution type, and rating. Comparisons will be made to other surgical training specialties in the *Discussion* to identify factors that may impact attrition. This objective is undertaken to determine whether attrition rates for particular subsets of matched applicants, particularly women, are lower than those for other subsets. It is hoped that if a problem is identified by this work, future studies will focus on means of fixing it.

Methods

Institutional review board approval for the study was obtained from the New York Harbor Healthcare System.

A list of all individuals matching into neurosurgery residency from 1990 to 1999 inclusive, including the programs in which they matched and their prior medical schools, was obtained from the SF Match Fellowship and Residency Matching Service. Schools were divided into public versus private as classified by the American Association of Medical Colleges (AAMC) on its website (https://services.aamc.org/tsfreports/select.cfm?year_of_study=2006). Schools were deemed international if they were not located in the US and did not appear on the AAMC list. Schools were considered “top 10” as determined by *US News and World Report* ranking performed the year of acceptance into residency for any given medical student.

Individuals were classified as having completed residency if they were confirmed by the American Medical Association DoctorFinder and individual practice websites to be practicing neurosurgery. Outcome data for board certification were obtained through the Directory of Diplomats provided by the ABNS. Additional location information was obtained using the National Provider Identifier (NPI; <https://npes.cms.hhs.gov/NPESRegistry/NPIRegistryHome.do>), individual neurosurgical program websites, and the ancestry.com public information da-

tabase search engine. Data regarding sex were acquired through the NPI registry site. Three individuals were confirmed dead through the above search engines with independent confirmation by at least one neurosurgeon, and 4 individuals were noted to be nonpracticing physicians in the US and were lost to follow-up.

This cohort was monitored until November 2013 to assess whether board certification was obtained. The algorithm used to determine current status of the 1361 matched residents is depicted in Fig. 1.

A 2-sample t-test was performed for comparison of duration of time (years) from match to board certification and comparison among attrition rates in public versus private medical school attendees. Chi-square analysis with Yates' continuity correction was performed for comparison of binomial variables (practicing neurosurgery or not; board certified or not); $p < 0.05$ was considered significant.

Data analysis was performed using R Project version 3.0.1.

Results

Between 1990 and 1999, 1361 individuals matched into a neurosurgical residency program through the SF Match Fellowship and Residency Matching Service. Of these, 1081 (79.4%) achieved board certification (Figs. 1 and 2) and 90 (6.6%) were practicing neurosurgery without certification by the ABNS (Fig. 3). All of these individuals are presumed to have completed residency yielding a total residency completion rate of 86% overall.

Overall, 63.0% ($n = 92/146$) of women and 81.4% ($n = 989/1215$) of men were board certified. Women were found to be significantly more at risk for not becoming board certified than men with an RR of 1.29 (95% CI 1.14–1.47) and OR of 2.57 (95% CI 1.78–3.70) ($\chi^2 = 25.85$, $p = 3.693 \times 10^{-7}$). The majority of female attrition occurred during residency; 76.0% ($n = 111/146$) of women and 87.2% ($n = 1059/1215$) of men completed residency (RR for women = 1.15 [95% CI 1.05–1.26], OR 2.21 [95% CI 1.45–3.34], $\chi^2 = 13.50$, $p = 2.389 \times 10^{-4}$). The number of women starting residency in any given year who became board certified ranged from 7 to 12, with a mean of 9.2 (Table 1).

Public medical school alumni had significantly higher board certification rates than private and international alumni (82.2% for public [508/618], 77.1% for private [524/680], and 77.8% for international [49/63]; $p = 0.026$ for public vs private; public vs international and private vs international were not significant) (Fig. 4). Failure to achieve board certification was not dependent on graduating from a top 10 medical school for either men or women.

Thirteen of 35 females (37%) who graduated from a top 10 medical school, and 40 of 109 females (37%) not attending a top 10 medical school did not become board certified (not significant). For men the rates for failure to achieve board certification were 19% (45/231) and 18% (177/979) for those who had attended a top 10 medical school and those who had not, respectively (not significant). There was no significant difference in total attrition or board certification for graduates of top 10–ranked institutions versus other institutions.

The average number of years to achieve neurosurgical

FIG. 1. A search algorithm was used to ascertain the status of the 1361 individuals matched into neurosurgery between 1990 and 1999. Figure is available in color online only.

board certification for men was 12.3 years and for women it was 12.5 years ($p = 0.24$, 2-sample t-test).

Fates of individuals who matched between 1990 and 1999 and did not become board certified are summarized in Table 2. Board certification rates by individual medical school attended are listed in Table 3 and by individual residency program in which each applicant was matched in Table 4.

FIG. 2. The percentage of matched applicants from 1990 to 1999 who are practicing neurosurgery as indicated by the American Medical Association DoctorFinder and NPI is charted relative to year matched. Figure is available in color online only.

Discussion

Attrition impacts the neurosurgical workforce pipeline relatively more than board certification, as the latter is a voluntary process. Understanding factors impacting attrition enables addressing them.

FIG. 3. The percentage of matched applicants from 1990 to 1999 who are ABNS certified in neurosurgery as indicated by the ABNS directory is charted relative to year matched. Figure is available in color online only.

FIG. 4. The percentage of alumni achieving board certification by type of medical school attended is charted relative to year matched. Figure is available in color online only.

The residency completion rate for neurosurgery was 86.0% suggesting an attrition rate of 2% per year of training for a 7-year program. Direct comparison with other specialties is obfuscated by different methods of data collection. Surveys of ophthalmology program directors suggest an attrition rate of 1.1% per year.^{12,16} Similar surveys to obstetrics program directors suggested attrition of 3.74% per year.¹⁷ A 20-year audit of the Yale general surgery program from 1986 to 2006 demonstrated a 6.7% annual attrition rate, with 39% of women and 26% of men failing to finish the program. The statistics may appear inflated because some residents left for programs with greater specialty training, such as plastic surgery.¹⁴ Post-80-hour work-week attrition analysis demonstrates that 19.6% of general surgery residents leave training, with women twice as likely to leave as men.²³

The Impact of Medical School Ranking on Attrition

Our data demonstrate that medical school alumni graduating from schools rated in the top 10 by *US News and World Report* did not have significantly different attrition from alumni of non-top 10 schools. One limitation of this analysis is that only a single measure of medical school rank was used for this study.

TABLE 1. Breakdown of matched applicants by year, sex, and type of school attended

Variable	No. of Applicants										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
Men matched	117	120	126	126	125	126	114	118	126	117	1215
Men ABNS certified	105	95	92	99	107	108	95	96	102	90	989
Women matched	11	14	16	13	16	14	15	19	11	17	146
Women ABNS certified	9	9	9	7	10	9	10	12	8	9	92
Public grads matched	54	59	68	50	61	70	60	68	66	62	618
Public grads ABNS certified	46	51	50	36	53	61	49	58	55	49	508
Private grads matched	69	72	70	78	73	67	63	62	62	64	680
Private grads ABNS certified	63	50	49	62	58	55	50	46	48	43	524
Int'l grads matched	5	3	4	11	7	3	6	7	9	8	63
Int'l grads ABNS certified	5	3	2	8	6	1	6	4	7	7	49
Total matched	128	134	142	139	141	140	129	137	137	134	1361
Total ABNS certified	114	104	101	106	117	117	105	108	110	99	1081

Grad = medical school graduate; int'l = international medical school; private = private medical school; public = public medical school.

TABLE 2. Fates of matched applicants who were not board certified in neurosurgery

Career	No. of Applicants
Neurosurgery	90
Radiology	36
Anesthesiology	21
Emergency medicine	19
Neurology	11
Internal medicine	10
General surgery	8
Family medicine	7
Orthopedic surgery	7
Pain medicine	6
Dermatology	5
Ophthalmology	5
Pediatrics	4
Psychiatry	4
Radiation oncology/nuclear medicine	4
Pathology	3
Hematology/oncology	2
Otolaryngology	2
Urology	2
Other specialty*	9
Out of practice†	18
Lost to follow-up or deceased	7
Total	280

* Transplant, vascular, craniofacial/plastics, cardiology, physical medicine and rehabilitation, obstetrics and gynecology, occupational medicine, medical genetics.

† Entrepreneur or finance (n = 11), legal (n = 3), academic/research (n = 4).

The Impact of Public Versus Private Versus International Medical School Training on Attrition

Despite the fact that there are a greater total number of medical students enrolled at public medical schools versus private medical schools, our data demonstrate

TABLE 3. Board certification rates by individual medical school attended

Medical School	Males Not Board Certified	Total No. of Males	% Males Not Board Certified	Females Not Board Certified	Total No. of Females	% Females Not Board Certified	Total Not Board Certified	Total	% Total Not Board Certified
University of Nebraska	0	9	0.0%	0	1	0.0%	0	10	0.0%
University of Alabama	0	15	0.0%	0	3	0.0%	0	18	0.0%
Brown University	0	9	0.0%	0	1	0.0%	0	10	0.0%
VCU Medical Center	1	18	5.6%	0	1	0.0%	1	19	5.3%
University of Cincinnati	1	15	6.7%	0	1	0.0%	1	16	6.3%
Washington University	1	14	7.1%	0	2	0.0%	1	16	6.3%
University of Maryland	1	12	8.3%	0	1	0.0%	1	13	7.7%
University of Florida	0	11	0.0%	1	1	100.0%	1	12	8.3%
UCSF	1	12	8.3%	0	0	NA	1	12	8.3%
Northwestern University	1	19	5.3%	1	4	25.0%	2	23	8.7%
Vanderbilt University	1	9	11.1%	0	1	0.0%	1	10	10.0%
University of Texas at Dallas	1	10	10.0%	0	0	NA	1	10	10.0%
USC	1	17	5.9%	1	1	100.0%	2	18	11.1%
University of Iowa	1	14	7.1%	1	2	50.0%	2	16	12.5%
Baylor COM	3	19	15.8%	0	2	0.0%	3	21	14.3%
Indiana University	3	22	13.6%	1	4	25.0%	4	26	15.4%
Loyola-Stritch SOM	3	15	20.0%	0	4	0.0%	3	19	15.8%
Cornell University	4	24	16.7%	0	1	0.0%	4	25	16.0%
SUNY-Syracuse	0	8	0.0%	2	4	50.0%	2	12	16.7%
University of Oklahoma	1	10	10.0%	1	2	50.0%	2	12	16.7%
St. Louis University	1	11	9.1%	1	1	100.0%	2	12	16.7%
University of Chicago	3	19	15.8%	1	4	25.0%	4	23	17.4%
New York University	5	26	19.2%	0	2	0.0%	5	28	17.9%
Rush Medical College	1	8	12.5%	1	3	33.3%	2	11	18.2%
Jefferson Medical College	2	10	20.0%	0	1	0.0%	2	11	18.2%
University of Texas at Galveston	2	11	18.1%	0	0	NA	2	11	18.2%
UCLA	3	19	15.8%	1	1	100.0%	4	20	20.0%
University of Colorado	2	9	22.2%	0	1	0.0%	2	10	20.0%
Columbia University	8	42	19.0%	2	7	28.6%	10	49	20.4%
Albany Medical College	3	16	18.8%	1	3	33.3%	4	19	21.1%
University of Texas at San Antonio	3	13	23.1%	0	1	0.0%	3	14	21.4%
University of Michigan	5	19	26.3%	0	4	0.0%	5	23	21.7%
University of Virginia	5	22	22.7%	0	1	0.0%	5	23	21.7%
Johns Hopkins University	8	42	19.0%	3	7	42.9%	11	49	22.4%
Harvard University	7	39	17.9%	3	5	60.0%	10	44	22.7%
Yale University	6	30	20.0%	2	4	50.0%	8	34	23.5%
Tulane University	4	16	25.0%	1	4	25.0%	5	20	25.0%
Temple University	3	17	17.6%	2	3	66.7%	5	20	25.0%
University of Pennsylvania	3	16	18.8%	2	4	50.0%	5	20	25.0%
Stanford University	3	11	27.3%	1	4	25.0%	4	15	26.7%
Wake Forest University SOM	4	13	30.8%	0	1	0.0%	4	14	28.6%
Case Western Reserve	2	9	22.2%	1	1	100.0%	3	10	30.0%
University of Texas-Houston	3	10	30.0%	0	0	NA	3	10	30.0%
Georgetown University	7	24	29.2%	1	2	50.0%	8	26	30.8%
Medical College of Georgia	3	13	23.1%	2	3	66.7%	5	16	31.3%
SUNY-Brooklyn	6	18	33.3%	0	1	0.0%	6	19	31.5%
Ohio State University	5	15	33.3%	0	0	NA	5	15	33.3%

(continued)

TABLE 3. Board certification rates by individual medical school attended (*continued*)

Medical School	Males Not Board Certified	Total No. of Males	% Males Not Board Certified	Females Not Board Certified	Total No. of Females	% Females Not Board Certified	Total Not Board Certified	Total	% Total Not Board Certified
Duke University	5	14	35.7%	0	0	NA	5	14	35.7%
University of Kansas	4	11	36.4%	0	0	NA	4	11	36.4%
University of Louisville	4	11	36.4%	0	0	NA	4	11	36.4%
Albert Einstein COM	4	8	50.0%	1	2	50.0%	5	10	50.0%
George Washington University	6	14	42.9%	4	4	100.0%	10	18	55.6%

COM = College of Medicine; NA = not applicable; SOM = School of Medicine; SUNY = State University of New York; UCLA = University of California, Los Angeles; UCSF = University of California, San Francisco; USC = University of Southern California; VCU = Virginia Commonwealth University.

that more physicians matched into neurosurgery graduate from private schools ($n = 680$) than public schools ($n = 618$). Public medical school alumni have significantly lower attrition than private school alumni. Four potential hypotheses are among many that could contribute to this phenomenon: 1) Private school graduates may simply be more willing to change their career trajectory than those coming from public schools. 2) It may be more difficult for public school alumni to match into neurosurgery; those who do match may be thus less likely to leave. 3) Private school alumni may have greater socioeconomic resources than public school alumni and thus may be more willing to look at other career options after matching into neurosurgery. 4) Public schools may provide better preparation for residency.

The Number of Women Entering Neurosurgery Has Increased but Is Not Commensurate With the Pipeline

In 1986, 11,551 women applied to medical school (35% of the total number of applicants); 5520 enrolled (34%) and 4957 graduated (31% of total).⁴ Eleven women matched into neurosurgery residency in 1990 (8.6% of 128; Table 1), and 9 became board certified (7.9%).

Nearly 10 years later, in 1995, 19,776 women applied to medical school (43% of the total number of total applicants); 6941 enrolled (43%) and 6501 graduated (41% of total).⁴ Seventeen of those women matched into neurosurgery in 1999 (12.7% of total; Table 1), and 9 became board certified by November 2013 (9.1%). Thus the odds of a female medical school applicant becoming a board-certified neurosurgeon fell from 1:1283 in 1986 to 1:2197 in 1995.

Between 1990 and 1999, 21 of 92 neurosurgery residency programs matched no female applicants. More than one-third of neurosurgery residency programs (33 of 92) did not have a single female matched applicant who had become board certified by November 2013 (Table 4).

Since 2004, at least 47% of medical school graduates are women.⁴ As the percentage of women graduating from medical school approaches parity with men,⁴ there has been a commensurate increase in women in general surgery, with women making up 30% of the general surgery resident positions⁸ in 2007 and 37.4% in 2011.¹ Neurosurgery and orthopedic surgery have not kept pace with the pipeline increases in female medical school graduates.⁷ In 2011, 13.6% of orthopedic surgery residents were female.¹ As per the ABNS, during the 2011–2012 academic year, 15.5% of neurosurgery residents were female.¹⁵

Women Have Substantially Higher Attrition During and After Neurosurgery Residency Training

Our data demonstrate that nearly 4 in 10 women who began neurosurgical residency between 1990 and 1999 did not become board certified, and that women were twice as likely as men not to become board certified (Table 1, Fig. 1).

Few studies have evaluated the reasons for female attrition in neurosurgery;^{5,22} however, the subject has been investigated among general surgeons. Reasons for leaving general surgery residency have been evaluated in single studies on program attrition predating the 80-hour work week and found that women were more likely to leave for lifestyle reasons.^{6,10} A survey of 4402 general surgery residents demonstrated that married parents reported both greater satisfaction and work-life conflict and female residents looked forward to work less than male residents did.¹⁹ Female surgeons are noted to have greater work-home conflicts than male surgeons.¹¹

Surveys of collegiality and socialization between residents and attending physicians have demonstrated that residents who are male, parents, and older are more likely to socialize with attending physicians.¹⁸ Female residents are less likely to feel that they can approach faculty when having difficulty, and residents who were unable to approach faculty were 5-fold more dissatisfied with their training.¹⁸ The fear of impropriety may impede mentoring relationships and collegiality between female residents and predominantly male faculty and peers.

Interaction with colleagues and cooperative working relationships have been found to be statistically significantly associated with job satisfaction in a survey of practicing academic physicians.¹³ Structured mentoring also improves faculty retention.²¹

Surveys of women in academic medicine have found that minority women are most likely to leave,² and the three most commonly associated reasons are inequity in professional advancement, lower salary than peers, and problems with departmental chairs and leadership.⁹ Women in academic medicine, and minority women in particular, start with lower pay and fewer research resources.^{2,24} Female general surgeons are promoted less rapidly and face both overt and covert discrimination.²⁴

There are very few women in leadership roles in neurosurgery. A review of 2010 data maintained by the AANS suggested that there were 5 female tenured full professors in the US of 213 full neurosurgery professors (2.3%), ex-

TABLE 4. Board certification rates by individual residency program at which applicant matched

Program Name	Total Attrition Rate	Male Residents			Female Residents			Total Residents		
		No.	No. Board Certified	% Board Certified	No.	No. Board Certified	% Board Certified	No.	No. Board Certified	% Board Certified
Columbia University	0%	20	20	100%	1	1	100%	21	21	100%
University of South Florida	0%	6	6	100%	1	1	100%	7	7	100%
UMDNJ, Newark	0%	7	7	100%	1	1	100%	8	8	100%
UC, Irvine	0%	6	6	100%	0	0	NA	6	6	100%
University of Kentucky	0%	14	14	100%	0	0	NA	14	14	100%
Baylor COM	3%	27	26	96%	2	2	100%	29	28	97%
Johns Hopkins University	4%	24	23	95%	1	1	100%	25	24	96%
Barrow Neurological Institute, Phoenix	5%	21	20	95%	1	1	100%	22	21	95%
Vanderbilt University	5%	19	18	95%	1	1	100%	20	19	95%
University of Illinois	6%	13	12	92%	3	3	100%	16	15	94%
University of Virginia	10%	21	19	90%	0	0	NA	21	19	90%
University of Colorado	10%	6	6	100%	4	3	75%	10	9	90%
LSU, New Orleans	10%	10	9	90%	0	0	NA	10	9	90%
Stanford University	10%	8	7	88%	2	2	100%	10	9	90%
Tulane University, New Orleans	10%	6	5	83%	4	4	100%	10	9	90%
University of Iowa	11%	17	16	94%	2	1	50%	19	17	89%
Washington University St. Louis	11%	16	15	94%	2	1	50%	18	16	89%
University of Arkansas	11%	9	8	89%	0	0	NA	9	8	89%
University of Pittsburgh	12%	24	22	92%	2	1	50%	26	23	88%
Indiana University	13%	13	11	85%	3	3	100%	16	14	88%
St. Louis University	13%	7	6	86%	1	1	100%	8	7	88%
University of Connecticut	13%	8	7	88%	0	0	NA	8	7	88%
Mount Sinai, New York	14%	19	17	89%	2	1	50%	21	18	86%
UCSF	14%	16	15	94%	5	3	60%	21	18	86%
Allegheny General Hospital, Pittsburgh	14%	7	6	86%	0	0	NA	7	6	86%
University of Nebraska	14%	6	5	83%	1	1	100%	7	6	86%
University of Minnesota	14%	21	18	86%	0	0	NA	21	18	86%
Loyola University	15%	13	11	85%	0	0	NA	13	11	85%
New York University	15%	18	16	89%	2	1	50%	20	17	85%
Mayo Clinic	16%	18	16	89%	1	0	0%	19	16	84%
Northwestern University	16%	16	13	81%	3	3	100%	19	16	84%
University of Cincinnati	16%	19	16	84%	0	0	NA	19	16	84%
University of Pennsylvania	16%	17	14	82%	2	2	100%	19	16	84%
University of Tennessee at Memphis	20%	22	18	82%	3	3	100%	25	21	84%
VCU Medical Center	17%	16	14	88%	2	1	50%	18	15	83%
University of Oklahoma	17%	12	10	83%	0	0	NA	12	10	83%
Oregon Health & Science University	18%	10	9	90%	1	0	0%	11	9	82%
University of Washington	18%	20	17	85%	2	1	50%	22	18	82%
University of Texas at Dallas/Southwest	18%	35	28	80%	3	3	100%	38	31	82%
USC/Los Angeles City Hospital	19%	20	17	85%	1	0	0%	21	17	81%
Brown University	20%	8	7	88%	2	1	50%	10	8	80%
Georgetown University	20%	8	7	88%	2	1	50%	10	8	80%
New York Medical College	20%	8	7	88%	2	1	50%	10	8	80%
Ohio State University	20%	16	14	88%	4	2	50%	20	16	80%
Hahnemann Medical College, Philadelphia	20%	5	4	80%	0	0	NA	5	4	80%
Medical University of South Carolina	20%	10	8	80%	0	0	NA	10	8	80%
Rush/Presbyterian/St. Luke's	20%	8	6	75%	2	2	100%	10	8	80%

(continued)

TABLE 4. Board certification rates by individual residency program at which applicant matched (*continued*)

Program Name	Total Attrition Rate	Male Residents			Female Residents			Total Residents		
		No.	No. Board Certified	% Board Certified	No.	No. Board Certified	% Board Certified	No.	No. Board Certified	% Board Certified
Tufts University	20%	8	6	75%	2	2	100%	10	8	80%
UCSD	20%	10	8	80%	0	0	NA	10	8	80%
UCLA	20%	19	15	79%	1	1	100%	20	16	80%
University of Maryland	20%	13	10	77%	2	2	100%	15	12	80%
University of Mississippi	20%	10	8	80%	0	0	NA	10	8	80%
Emory University	21%	17	14	82%	2	1	50%	19	15	79%
George Washington University	21%	17	14	82%	2	1	50%	19	15	79%
University of Michigan	21%	16	13	81%	3	2	67%	19	15	79%
Harvard University	22%	35	28	80%	2	1	50%	37	29	78%
Medical College of Wisconsin	22%	7	6	86%	2	1	50%	9	7	78%
University of Louisville	22%	9	7	78%	0	0	NA	9	7	78%
University of Missouri, Columbia	22%	8	7	88%	1	0	0%	9	7	78%
Bowman Gray, North Carolina	22%	9	7	78%	0	0	NA	9	7	78%
University of Florida, Gainesville	23%	21	17	81%	1	0	0%	22	17	77%
Cleveland Clinic	24%	19	15	79%	2	1	50%	21	16	76%
University of New Mexico	25%	3	3	100%	1	0	0%	4	3	75%
University of Rochester	27%	11	8	73%	0	0	NA	11	8	73%
Cornell/New York Hospital	29%	13	9	69%	1	1	100%	14	10	71%
Loma Linda University	29%	7	5	71%	0	0	NA	7	5	71%
University of Alabama at Birmingham	29%	12	8	67%	2	2	100%	14	10	71%
University of Utah	29%	19	13	68%	2	2	100%	21	15	71%
Albany Medical College	30%	9	7	78%	1	0	0%	10	7	70%
Medical College of Georgia	30%	7	6	86%	3	1	33%	10	7	70%
UC, Davis	30%	6	5	83%	4	2	50%	10	7	70%
University of Vermont	30%	9	6	67%	1	1	100%	10	7	70%
Case Western Reserve	30%	17	13	76%	6	3	50%	23	16	70%
Albert Einstein COM	31%	15	11	73%	1	0	0%	16	11	69%
University of Miami	32%	17	12	71%	2	1	50%	19	13	68%
Henry Ford Hospital	33%	18	12	67%	3	2	67%	21	14	67%
Temple University, Philadelphia	33%	7	5	71%	2	1	50%	9	6	67%
Eastern Virginia Medical School	33%	2	1	50%	1	1	100%	3	2	67%
University of Chicago	33%	9	6	67%	0	0	NA	9	6	67%
University of Wisconsin	33%	8	5	63%	1	1	100%	9	6	67%
Wayne State University	33%	8	5	63%	1	1	100%	9	6	67%
Duke University	35%	18	12	67%	2	1	50%	20	13	65%
Dartmouth-Hitchcock	36%	10	7	70%	1	0	0%	11	7	64%
SUNY	38%	32	21	66%	7	3	42%	39	24	62%
University of Puerto Rico	40%	9	6	67%	1	0	0%	10	6	60%
University of North Carolina, Chapel Hill	40%	9	6	67%	1	0	0%	10	6	60%
Yale University	40%	7	5	71%	3	1	33%	10	6	60%
Jefferson University, Philadelphia	40%	14	8	57%	1	1	100%	15	9	60%
University of Kansas	40%	10	6	60%	0	0	NA	10	6	60%
West Virginia University	50%	8	4	50%	2	1	50%	10	5	50%
Pennsylvania State University	60%	4	2	50%	1	0	0%	5	2	40%
University of Massachusetts	80%	4	0	0%	1	1	100%	5	1	20%

LSU = Louisiana State University; UC = University of California; UCSD = University of California, San Diego; UMDNJ = University of Medicine and Dentistry of New Jersey.

cluding 39 service chiefs and 65 department chairs with unknown academic rank (AAMC data, obtained through institutional connection). There is currently one female department chair in neurosurgery. Although neurosurgery has a higher percentage of female practitioners (approximately 6%) than orthopedic surgery (4.8%), the number of female faculty members and full professors is lower. In 2012, 15% of orthopedic surgery faculty were women, with 7% serving as full professors.³

One might speculate that the relative parity of women in college and medical school and availability of female faculty mentors in other fields creates a particularly jarring experience for women who are entering neurosurgery and are abruptly facing a relative paucity of female peers, mentors, and role models. Such a phenomenon is exacerbated the higher a woman rises in the field as more and more women drop out, and she is left with no female colleagues or mentors.

General Limitations of the Data and Their Applicability

The data collected represent only those individuals who entered neurosurgery through the match and thus exclude physicians who acquired positions postmatch or obtained them through attrition of other physicians or program openings and expansions.

We assume that individuals who have practiced neurosurgery after residency as confirmed by the American Medical Association DoctorFinder and NPI have completed residency and are still practicing neurosurgery. The search algorithm in Fig. 1 suggests that once an individual is either found to be practicing neurosurgery or has completed residency, he or she is still practicing. This is not necessarily a valid assumption. Thus, it is possible that our study overestimates the number of neurosurgeons who have completed residency and/or are still practicing neurosurgery.

The accuracy of our study is limited to its recordable outcome measures. Board certification does not mean that someone is practicing neurosurgery, nor does lack of it mean that they are not. This is a limitation of the methodology that could be overcome by contacting individual programs and residents for a more rigorous study.

Due to the length of neurosurgical training, which we found to be longer than 12 years from match to board certification, the findings of this study are not necessarily applicable to individuals presently matching in neurosurgery. Residents who entered neurosurgical residency during the first 7 years of the study period completed their residencies prior to the introduction of the 80-hour work week. Those who entered residency during the last 3 years of the study period were senior enough in their training that they were not necessarily impacted by the 80-hour work week. Current neurosurgical residents have work-hour limitations that substantially alter workload, the nature of training, lifestyle, and other issues that impact attrition. Data regarding attrition linked to particular medical schools and residency training programs are particularly likely to have changed since most programs have changed leadership and faculty.

This study demonstrates that 19% of men and 37% of women who matched into neurosurgery over one decade

did not become board-certified neurosurgeons, but it does not assess causality for attrition. Data regarding the specifics as to why these individuals did not become board certified and at what point in their training they came off track would enable better understanding of the discrepant attrition described in this study.

Conclusions

Private medical school alumni and women were less likely to become board certified than public medical school alumni and men. The percentage of women in neurosurgery has remained relatively constant for a decade due in part to a higher attrition rate for female surgeons.

Acknowledgments

We thank SF Match, the American Board of Neurological Surgery, the American Association of Neurological Surgeons, and the Ruth Jackson Orthopedic Society for access to their databases.

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Supplemental Information

Previous Presentation

Preliminary data were presented at the 82nd AANS Annual Scientific Meeting held in San Francisco, CA, on April 8, 2014.

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