Original Investigation

Sex Differences in Academic Rank in US Medical Schools in 2014

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IMPORTANCE The proportion of women at the rank of full professor in US medical schools has not increased since 1980 and remains below that of men. Whether differences in age, experience, specialty, and research productivity between sexes explain persistent disparities in faculty rank has not been studied.

OBJECTIVE To analyze sex differences in faculty rank among US academic physicians.

DESIGN, SETTING, AND PARTICIPANTS We analyzed sex differences in faculty rank using a cross-sectional comprehensive database of US physicians with medical school faculty appointments in 2014 (91 073 physicians; 9.1% of all US physicians), linked to information on physician sex, age, years since residency, specialty, authored publications, National Institutes of Health (NIH) funding, and clinical trial investigation. We estimated sex differences in full professorship, as well as a combined outcome of associate or full professorship, adjusting for these factors in a multilevel (hierarchical) model. We also analyzed how sex differences varied with specialty and whether differences were more prevalent at schools ranked highly in research.

EXPOSURES Physician sex.

MAIN OUTCOMES AND MEASURES Academic faculty rank.

RESULTS In all, there were 30 464 women who were medical faculty vs 60 609 men. Of those, 3623 women (11.9%) vs 17 354 men (28.6%) had full-professor appointments, for an absolute difference of −16.7% (95% CI, −17.3% to −16.2%). Women faculty were younger and disproportionately represented in internal medicine and pediatrics. The mean total number of publications for women was 11.6 vs 24.8 for men, for a difference of −13.2 (95% CI, −13.6 to −12.7); the mean first- or last-author publications for women was 5.9 vs 13.7 for men, for a difference of −7.8 (95% CI, −8.1 to −7.5). Among 9.1% of medical faculty with an NIH grant, 6.8% (2059 of 30 464) were women and 10.3% (6237 of 60 609) were men, for a difference of −3.5% (95% CI, −3.9% to −3.1%). In all, 6.4% of women vs 8.8% of men had a trial registered on ClinicalTrials.gov, for a difference of −2.4% (95% CI, −2.8% to −2.0%). After multivariable adjustment, women were less likely than men to have achieved full-professor status (absolute adjusted difference in proportion, −3.8%; 95% CI, −4.4% to −3.3%). Sex-differences in full professorship were present across all specialties and did not vary according to whether a physician's medical school was ranked highly in terms of research funding.

CONCLUSIONS AND RELEVANCE Among physicians with faculty appointments at US medical schools, there were sex differences in academic faculty rank, with women substantially less likely than men to be full professors, after accounting for age, experience, specialty, and measures of research productivity.

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The total number of women entering US medical schools has increased since 1970. Women now make up half of all US graduates.[1] However, sex disparities in senior faculty rank persist in academic medicine.[2] Although the percentage of female first or senior authors of papers published in leading medical journals has increased over 4 decades,[3] female physicians now constitute 38% of full-time medical school faculty; however, in 2013 only 21% of full professors, 15% of department chairs, and 16% of deans were women.[4] Moreover, male physician researchers earn more than female researchers even after adjustment for differences in academic productivity.[5]

Previous studies of sex differences in academic rank have several limitations, including analyses of single institutions or specialties, limited survey sizes, use of publications as the sole marker of productivity, and noncontemporary data.[6-13] Data from the Association of American Medical Colleges (AAMC) have provided the most comprehensive evidence of sex differences in faculty rank.[14] However, to our knowledge, no published work has linked these data to information on physician training, specialty, experience, research funding, clinical trial participation, and scientific authorship, all of which influence faculty rank and may vary by sex.[9]

We analyzed sex differences in faculty rank using a comprehensive cross-sectional database of 91 073 physicians in the United States in 2014, which included detailed information on sex, age, years since residency completion, specialty, scientific authorship, National Institutes of Health (NIH) research funding, and clinical trial participation. We hypothesized that sex differences in faculty rank may still exist after adjustment for these factors.

Methods

Data Sources

We analyzed data from Doximity, a company that provides online networking services for US physicians. The company has assembled a comprehensive cross-sectional database of US physicians, which included 1 005 419 physicians as of November 10, 2014 (the date we were provided the data). The database draws on several sources of information to identify physicians, including the National Plan and Provider Enumeration System (NPPES) National Provider Identifier (NPI) Registry, self-registered members without active NPIs (ie, physicians with medical degrees who have not practiced), and physicians without NPIs who are employed by collaborating institutions that provide information to the company (eg, researchers or administrators who have not practiced, and therefore do not have an NPI, but work at an institution that provides information on its employees of alumni of the company, or both). Physicians can register with the company and use its services for free. As of November 10, 2014, 23.8% of US physicians (239 136 of 1 005 419) were registered members.

For each physician, data were assembled by the company on (1) any faculty appointment at a US medical school and faculty rank (assistant, associate, or full professor), obtained by matching name and institution to the AAMC faculty roster database, (2) physician age, sex, year of residency completion, and specialty, obtained through data partnerships, including the American Board of Medical Specialties, state licensing boards, and collaborating hospitals and medical schools, and by methods described below, (3) number of authored scientific publications indexed in PubMed (first author, last author, and total publications), (4) number of NIH grants for which the physician was a principal investigator, obtained from the NIH RePORT database, and (5) number of registered clinical trials for which the physician was a principal or subinvestigator, obtained from ClinicalTrials.gov.

Physician data on publications, grants, and clinical trials have been iteratively populated in the database as follows. For all physicians, a matching algorithm was first used based on first and last name (including maiden name), geographic location, specialty, and institutional affiliation to search through PubMed, NIH RePORT, and ClinicalTrials.gov. For registered members, that information can be edited in profiles, and information in our database for these members was based on that self-verified information. For some nonregistered physicians, additional information supplied by institutions has been used to improve findings of the matching algorithm. For example, nonregistered physicians may be employed by institutions with collaborative sharing agreements with the company. These institutions provide resumes from which information is extracted to refine the database. For other nonregistered physicians, database refinements are further made based on the company's review of institutional websites that contain information on physicians. Finally, for nonregistered physicians for which no further information exists, data were based only on the initial matching algorithm used.

Study Population

The study population included physician faculty in the 2014 AAMC faculty roster. A list of these physicians was obtained and matched with information available for each of these physicians in our database. Data were approved for study and participant consent was waived by the human subjects review committee at Harvard Medical School.

Data Validity

We assessed data validity in 2 ways. First, we analyzed the subgroup of faculty who were registered members, assuming that their data were more likely to be accurate. We compared this subgroup to the subgroup of nonmember physicians. Second, for a random sample of 200 faculty, we manually confirmed faculty rank (through review of institutional websites); publications in PubMed (using, where possible, direct links to PubMed from the physician's institutional website, review of online resumes, and assessment of whether ambiguous articles were in the author's clinical discipline or from prior institutions with which the author was affiliated); clinical trial participation through manual review of ClinicalTrials.gov; and NIH funding through manual review of NIH RePORT database.

Statistical Analysis

Differences between men and women in age, experience, specialty, medical school research ranking, and academic productivity may confound sex differences in faculty rank. We therefore created a multilevel (hierarchical) multivariable logistic model to estimate the probability of full professorship as a function of sex, age, years since residency completion, specialty, number of publications (first author, last author, and total), NIH grants (binary variable indicating whether or not a physician was ever a principal investigator on an NIH grant), clinical trial participation (binary), and employment at a medical school ranked among the top 20 US medical schools for research by *US News & World Report* in 2013 (binary). Our model included school-level random effects parameters to allow for correlated outcomes among faculty nested within each school. In prespecified subgroup analyses, we analyzed whether sex differences in full professorship varied according to specialty and medical school research ranking (top-20 vs not). We reported the absolute adjusted difference between men and women in the proportion that had full-professor status. The 95% confidence interval around reported estimates reflects 0.025 in each tail or $P \leq .05$.

The primary analysis was of sex differences in full professorship among faculty of all ranks. We also analyzed sex differences in associate or full professorship (combined outcome) compared with assistant professorship, as well as sex differences in full professorship compared to associate professorship (with sample including associate and full professors).

We assessed the importance of missing data by first comparing the characteristics of physicians for whom data were missing vs nonmissing. We then conducted our primary multivariable analysis excluding physicians for whom data were missing. In addition, we created 10 independent data sets in which missing data for a given physician were imputed on the basis of all other nonmissing covariates from our multivariable model (eg, physician age, sex, specialty, publications, etc).[15] We used standard methods to combine analysis results of sex differences in full professorship across the imputed data sets.[16]

Sensitivity Analyses

We conducted several sensitivity analyses. First, to evaluate data inaccuracies, we estimated our primary hierarchical multivariable model of faculty rank among registered physician members as well as among nonmembers. Second, because we lacked information on career track (clinical vs research) and full- or part-time status, both of which could confound sex differences in faculty rank,[17] we investigated sex differences in faculty rank among faculty with NIH funding, who presumably were more likely on full-time research tracks.

Stata statistical software, version 13 (StataCorp) was used for analyses.

Results

Characteristics of Study Population

The study population consisted of 91 073 physician faculty members (9.1% of 1 005 419 physicians in the overall database), of whom 38.1% (34 745 of 91 073) were registered members and 66.5% (60 609) were men. Women were less likely than men to be full professors (11.9% [3623 of 30 464] vs 28.6% [17 354 of 60 609]; absolute difference, −16.7%, 95% CI, −17.3% to −16.2%; **Table 1**). On average, women were younger, completed residency more recently, and were concentrated in internal medicine, obstetrics and gynecology, and pediatrics. Women were similarly represented at schools ranked highly in research vs less highly ranked (29.2% [8893 of 30 464] vs 28.3% [17 173 of 60 609]; difference, 0.9%; 95% CI, 0.7% to 1.1%). Women had fewer total and first- or last-author publications (mean total, 11.6 vs 24.8, difference, −13.2; 95% CI, −13.6 to −12.7; mean first- or last-author publication; 5.9 vs 13.7; difference, −7.8; 95% CI, −8.1 to -7.5), were less likely to have NIH funding (6.8% vs 10.3%, difference, −3.5%; 95% CI, −3.9% to −3.1%), and were less likely to have conducted clinical trials (6.4% vs 8.8%; difference, −2.4%, 95% CI, −2.8% to −2.0%).

Among 3 residency cohorts (1980, 1990, and 2000), women were less likely to be full professor, or associate or full professor (combined outcome), by 2014 (**Table 2**). For example, among 230 women who completed residency in 1980 and were on faculty in 2014, 46.6% were full professors compared with 60.5% among the 1089 men who finished residency in 1980 ($P < .001$). In addition, among faculty who were either associate or full professor in 2014, the proportion of women who were full professor was lower than it was for men for all cohorts. For example, among 398 female and 945 male associate or full professors in the 1990 cohort, 171 women (42.3%) were full professor in 2014 compared with 540 men (57.1%), $P < .001$.

Multivariable Analysis

After adjustment for age, years since residency, scientific authorship, NIH funding, and clinical trial participation, women were less likely than men to be full professors (absolute adjusted difference in proportion, −3.8%; 95% CI, −4.4% to −3.3%; **Table 3**). Full professorship was positively associated with years since residency, total and first- or last-author publications, NIH funding, and clinical trial leadership. Full professorship was not significantly different between highly ranked research institutions and other schools.

Sex differences in the proportions of faculty who were associate or full professor compared with assistant professor also persisted after adjustment. Women were less likely to be associate or full professors (adjusted difference, −2.8%; 95% CI, −3.4% to −2.2%; $P < .001$). In a subgroup that included associate and full professors, women were less likely than men to be full professor (adjusted difference, −6.2%; 95% CI, −7.2% to −5.1%; $P < .001$).

Sex Differences in Full Professorship by Specialty

Sex differences in full professorship were present across specialties (**Table 4**). In internal medicine and pediatrics, specialties with the largest percentages of women, the absolute adjusted sex differences in full professorship were −3.9% (95% CI, −5.3% to −2.5%) and −4.0% (95% CI, −5.2% to −2.9%), respectively. The only specialties without statistically signifi-

Table 1. Characteristics of the Study Population

	Faculty, No. (%)			
	All (n = 91 073)	Men (n = 60 609)	Women (n = 30 464)	*P* Value for Comparison by Sex[a]
Faculty rank				
Assistant professor	50 019 (54.9)	29 256 (48.3)	20 763 (68.2)	<.001
Associate professor	20 077 (22.0)	13 999 (23.1)	6078 (20.0)	<.001
Full professor	20 977 (23.0)	17 354 (28.6)	3623 (11.9)	<.001
Age, mean (SD), y	50.5 (11.4)	52.3 (11.7)	46.8 (9.9)	<.001
Age, y				
<40	17 535 (19.3)	9347 (15.4)	8188 (26.9)	
40-44	14 218 (15.6)	8583 (14.2)	5635 (18.5)	
45-49	12 369 (13.6)	7939 (13.1)	4430 (14.5)	
50-54	11 912 (13.1)	8055 (13.3)	3857 (12.7)	<.001
55-59	11 401 (12.5)	8091 (13.3)	3310 (10.9)	
60-64	9140 (10.0)	6936 (11.4)	2204 (7.2)	
>65	14 498 (15.9)	11 658 (19.2)	2840 (9.3)	
Years since residency, mean (SD)	18.9 (11.8)	20.8 (12.3)	15.1 (9.7)	<.001
Specialty				
Anesthesiology	5657 (6.2)	3914 (6.5)	1743 (5.7)	<.001
Cardiology	3996 (4.4)	3337 (5.5)	659 (2.2)	<.001
Emergency medicine	3508 (3.9)	2507 (4.1)	1001 (3.3)	<.001
Family medicine	3795 (4.2)	2208 (3.6)	1587 (5.2)	<.001
Gastroenterology	1987 (2.2)	1570 (2.6)	417 (1.4)	<.001
Hematology/oncology	3148 (3.5)	2199 (3.6)	949 (3.1)	<.001
Infectious disease	1976 (2.2)	1247 (2.1)	729 (2.4)	.001
Internal medicine[b]	8902 (9.8)	5255 (8.7)	3647 (12.0)	<.001
Neurology	3880 (4.3)	2652 (4.4)	1228 (4.0)	.02
Obstetrics and gynecology	3822 (4.2)	1864 (3.1)	1958 (6.4)	<.001
Orthopedic surgery	2477 (2.7)	2244 (3.7)	233 (0.8)	<.001
Other	11 674 (12.8)	7770 (12.8)	3904 (12.8)	.98
Pathology	3479 (3.8)	2112 (3.5)	1367 (4.5)	<.001
Pediatrics	12 396 (13.6)	6252 (10.3)	6144 (20.2)	<.001
Psychiatry	4789 (5.3)	3003 (5.0)	1786 (5.9)	<.001
Radiology	5003 (5.5)	3573 (5.9)	1430 (4.7)	<.001
Surgery, general	4455 (4.9)	3561 (5.9)	894 (2.9)	<.001
Surgery, subspecialty	6129 (6.7)	5341 (8.8)	788 (2.6)	<.001
Publications, mean (SD), No.				
Total	20.4 (31.2)	24.8 (35.9)	11.6 (23.4)	<.001
First or last author	11.1 (23.2)	13.7 (26.3)	5.9 (14.0)	<.001
NIH grants				
≥1 grant	8296 (9.1)	6237 (10.3)	2059 (6.8)	<.001
Median No. for those with >1 grant	4 (2-8)	4 (2-9)	3 (1-6)	<.001
Clinical trial investigator				
≥1 Trial	7310 (8.0)	5362 (8.8)	1948 (6.4)	<.001
>1 Trial, median (range)	1 (1-2)	1 (1-2)	1 (1-2)	.81
Faculty at top-20 school[c]	26 066 (28.6)	17 173 (28.3)	8893 (29.2)	.007

Abbreviation: NIH, National Institutes of Health.

[a] *P* values reflect 2-sided *t* tests and χ^2 comparisons where appropriate. *P* value for age reflects comparison of age distributions.

[b] Internal medicine excludes internal medicine based sub-specialties listed in the table (eg, cardiology, gastroenterology, etc).

[c] Top-20 school refers to whether a physician was on faculty at a medical school ranked among the top-20 US medical schools for research by *US News & World Report* in 2013.

cant sex differences in full professorship were hematology/oncology and radiology. Compared with hematology/oncology, sex differences in full professorship were largest in gastroenterology (adjusted difference, −6.1%; 95% CI, −10.8% to −1.4%; *P* = .06) and infectious disease (adjusted difference, −6.9%; 95% CI, −10.4% to −3.4%; *P* < .001).

Sex Differences in Full Professorship by School Research Ranking

Full professorship was more common overall at medical schools ranked highly in research than at other schools (Table 4). Sex differences in full professorship did not vary according to research ranking (adjusted difference, −4.5%; 95%

Table 2. Medical School Faculty Rank in 2014 by Sex and Year of Residency Completion[a]

Year of Residency Completion	No. of Professors	Faculty Rank in 2014, No. (%) of Professors		
		Assistant	Associate	Full
1980				
Men	1089	218 (20.0)	212 (19.5)	659 (60.5)
Women	230	70 (30.4)	53 (23.0)	107 (46.6)
P value		.001	.22	<.001
1990				
Men	1320	375 (28.4)	405 (30.6)	540 (41.0)
Women	606	208 (34.3)	227 (37.5)	171 (28.2)
P value		.009	.003	<.001
2000				
Men	1550	823 (53.1)	623 (40.2)	104 (6.7)
Women	969	635 (65.5)	306 (31.6)	28 (2.9)
P value		<.001	<.001	<.001

[a] Table shows faculty rank in 2014 of men and women who completed residency in 1 of 3 cohorts and were on faculty in 2014. *P* values reflect 2-sided comparison between men and women at a given faculty rank (eg, full professor).

CI, −5.5% to −3.4% for the top 20; adjusted difference, −3.8%; 95% CI, −4.5% to −3.2% for those not in the top 20).

Sensitivity Analyses

Data for years since residency were missing for 6669 of 91 073 physicians (7.0%). Because data on publications, NIH funding, and clinical trials were from either validated physician profiles or a matching algorithm, data were not classifiable as missing in the traditional sense although it is possible that errors in self-report or attribution could have occurred, as addressed below. Data were not missing for other physician characteristics, including age, sex, and specialty. In multivariable analysis, physicians with missing data on years since residency were excluded because their characteristics were comparable with physicians for whom data were not missing (eTable 1 in the Supplement). Absolute adjusted sex difference in full professorship between men and women were unchanged when using imputation methods to address missing data.

In a random sample of 200 physicians (81 members and 119 nonmembers; 124 men and 76 women), faculty rank was validated in all cases; the percentage of physicians with a number of PubMed publications within 5 of that reported in the database was 85%; the percentage with prior clinical trial participation matching that reported was 97%; and the percentage with prior NIH funding matching that reported was 93%. In all categories, errors did not systematically differ by sex.

Adjusted sex differences in full professorship were noted among physicians for whom information was self-validated, ie, registered members (adjusted difference in proportion who were full professor between women and men, −3.5%; 95% CI, −4.4% to −2.6%), as well nonmembers (adjusted difference, −4.0%; 95% CI, −4.7% to −3.4%; eTables 2 and 3 in the Supplement). Finally, among the 13 225 faculty members with NIH funding, adjusted sex differences in full professorship were noted among these physicians as well (adjusted difference in proportion full professor between women and men, −2.8%; 95% CI, −4.3% to −1.4%; eTable 4 in Supplement).

Discussion

We examined sex differences in full professorship status among physician faculty at US medical schools using one of the most comprehensive databases of physicians to date. Even after adjustment for age, years since residency, specialty, and measures of research productivity, men were substantially more likely than women to be full professors. Sex differences in full professorship were present across nearly all specialties and were consistent across medical schools with highly and less highly ranked research programs. These findings are consistent with a seminal 1995 study of US medical school faculty that found that after adjustment for research productivity, women were less likely than men to be full professors.[9]

One might expect sex differences in full professorship to be greater at institutions highly ranked in research. Female physician-researchers earn less than males, particularly at top-ranked, research-intensive institutions.[5] Furthermore, teaching hospitals have fewer female chief executive officers than community hospitals and women comprise a small minority of deans and department chairs at top academic medical centers.[18,19] However, we found that women were equally likely to be full professors at medical schools with highly and less highly ranked research apparatuses.

Although we primarily focused on sex differences in full professorship among faculty overall, we also found that women were less likely than men to hold the rank of associate or full professor (a combined outcome) than to hold the rank of assistant professor and that women were less likely to hold the rank of full professor than hold the rank of associate professor. These findings do not necessarily imply sex differences in promotion at the assistant- or associate-professor level because the prevalence of a given faculty rank at any point in time reflects both promotion to that rank and exit (eg, as individuals retire after full professorship). However, if sex differences in promotion do exist, disparities at different levels of the academic hierarchy may

Table 3. Multivariable Analysis of Factors Associated With Medical School Faculty Rank in 2014

	Full Professor[a]			Associate or Full Professor[b]			Full Professor[c]		
	No./Total (%) of Professors	Absolute Difference In Proportion		No./Total (%) of Professors	Absolute Difference In Proportion		No./Total (%) of Professors	Absolute Difference In Proportion	
		Unadjusted,%	Adjusted (95% CI)[d]		Unadjusted,%	Adjusted (95% CI)[d]		Unadjusted,%	Adjusted (95% CI)[d]
Sample, No.	91 073 (All faculty)			91 073 (All faculty)			41 054 (Associate or full faculty)		
Sex									
Men	17 354/60 609 (28.6)	1 [Reference]		31 353/60 609 (51.7)	1 [Reference]		17354/31 353 (55.4)	1 [Reference]	
Women	3623/30 464 (11.9)	−16.7	−3.8 (−4.4 to −3.3)	9701/30 464 (31.8)	−19.9	−2.8 (−3.4 to −2.2)	3623/9701 (37.3)	−18.1	−6.2 (−7.2 to −5.1)
Age, y									
<40	142/17 535 (0.8)	1 [Reference]		611/17 535 (3.5)	1 [Reference]		142/611 (23.2)	1 [Reference]	
40-44	207/14 218 (1.5)	0.7	−1.4 (−2.6 to −0.2)	2850/14 218 (20.0)	16.5	18.1 (16.8 to 19.4)	207/2850 (7.3)	−15.9	−35.5 (−40.4 to −30.5)
45-49	1180/12 369 (9.5)	8.7	9.1 (7.8 to 10.4)	5428/12 369 (43.9)	40.4	31.4 (29.9 to 32.9)	1180/5428 (21.7)	−1.5	−18.8 (−23.4 to −14.1)
50-54	3042/11 912 (25.5)	24.7	18.1 (16.7 to 19.6)	7231/11 912 (60.7)	57.2	35.6 (33.9 to 37.2)	3042/7231 (42.1)	18.9	−4.9 (−9.6 to −0.2)
55-59	4383/11 401 (38.4)	37.6	19.9 (18.4 to 21.5)	7795/11 401 (68.4)	64.9	33.3 (31.5 to 35.1)	4383/7795 (56.2)	33	-1.6 (−6.4 to 3.2)
60-64	4496/9140 (49.2)	48.4	19.7 (18 21.3)	6753/9140 (73.9)	70.4	29.2 (27.2 to 31.1)	4496/6753 (66.6)	43.4	−0.3 (−5.3 to 4.7)
>65	7527/14 498 (51.9)	51.1	15.2 (13.6 to 16.9)	10 386/14 498 (71.6)	68.1	22.6 (20.7 to 24.5)	7527/10 386 (72.5)	49.3	−5.4 (−10.6 to −0.2)
Years since residency (per 1 y)		1.1 (1 to 1.1)			1.4 (1.4 to 1.5)			1.6 (1.5 to 1.7)	
Specialty									
Anesthesiology	874/5657 (15.4)	1 [Reference]		2067/5657 (36.5)	1 [Reference]		874/2067 (42.3)	1 [Reference]	
Cardiology	1159/3996 (29.0)	13.6	−0.2 (−1.5 to 1.1)	2062/3996 (51.6)	15.1	−1.9 (−3.4 to −0.3)	1159/2062 (56.2)	13.9	−1.1 (−3.8 to 1.5)
Emergency medicine	386/3508 (11.0)	−4.4	−0.1 (−1.7 to 1.6)	1042/3508 (29.7)	−6.8	0.6 (−1.1 to 2.2)	386/1042 (37.0)	−5.3	1.5 (−1.8 to 4.9)
Family medicine	535/3795 (14.1)	−1.3	−1.2 (−2.7 to 0.2)	1294/3795 (34.1)	−2.4	−2.5 (−4 to −0.9)	535/1294 (41.3)	−1.0	0.0 (−3 to 3.1)
Gastroenterology	563/1987 (28.3)	12.9	1.0 (−0.7 to 2.7)	1000/1987 (50.3)	13.8	0.4 (−1.6 to 2.4)	563/1000 (56.3)	14	0.8 (−2.6 to 4.1)
Hematology/ oncology	1007/3148 (32.0)	16.6	0.5 (−0.9 to 2)	1730/3148 (55.0)	18.5	−2.0 (−3.8 to −0.3)	1007/1730 (58.2)	15.9	−0.3 (−3.2 to 2.5)
Infectious disease	619/1976 (31.3)	15.9	3.0 (1.3 to 4.7)	1125/1976 (56.9)	20.4	4.4 (2.4 to 6.3)	619/1125 (55.0)	12.7	0.9 (−2.2 to 4.1)
Internal medicine	1434/8902 (16.1)	0.7	−0.5 (−1.7 to 0.7)	3239/8902 (36.4)	−0.1	−0.2 (−1.5 to 1.1)	1434/3239 (44.3)	2	−0.4 (−2.8 to 2)
Neurology	1107/3880 (28.5)	13.1	3.3 (1.9 to 4.7)	1956/3880 (50.4)	13.9	2.7 (1.1 to 4.3)	1107/1956 (56.6)	14.3	2.6 (−0.1 to 5.3)
OB/GYN	767/3822 (20.1)	4.7	1.4 (0 to 2.8)	1634/3822 (42.8)	6.3	1.8 (0.3 to 3.3)	767/1634 (46.9)	4.6	0.9 (−1.9 to 3.7)

(continued)

Table 3. Multivariable Analysis of Factors Associated With Medical School Faculty Rank in 2014 (continued)

	Full Professor[a]			Associate or Full Professor[b]			Full Professor[c]		
	No./Total (%) of Professors	Absolute Difference In Proportion		No./Total (%) of Professors	Absolute Difference In Proportion		No./Total (%) of Professors	Absolute Difference In Proportion	
		Unadjusted,%	Adjusted (95% CI)[d]		Unadjusted,%	Adjusted (95% CI)[d]		Unadjusted,%	Adjusted (95% CI)[d]
Orthopedic surgery	597/2477 (24.1)	8.7	0.8 (−0.8 to 2.4)	1221/2477 (49.3)	12.8	1.6 (−0.2 to 3.4)	597/1221 (48.9)	6.6	−0.2 (−3.2 to 2.9)
Other	3283/11 674 (28.1)	12.7	2.2 (1.1 to 3.3)	5913/11 674 (50.7)	14.2	2.3 (1 to 3.5)	3283/5913 (55.5)	13.2	1.8 (−0.3 to 4)
Pathology	1088/3479 (31.3)	15.9	6.7 (5.2 to 8.2)	1974/3479 (56.7)	20.2	7.9 (6.3 to 9.4)	1088/1974 (55.1)	12.8	7.4 (4.7 to 10)
Pediatrics	2395/12 396 (19.3)	3.9	1.4 (0.3 to 2.5)	5086/12 396 (41.0)	4.5	1.7 (0.5 to 2.9)	2395/5086 (47.1)	4.8	−0.2 (−2.4 to 2)
Psychiatry	1018/4789 (21.3)	5.9	−1.6 (−2.9 to −0.4)	1983/4789 (41.4)	4.9	−2.2 (−3.7 to −0.8)	1018/1983 (51.3)	9	−2.6 (−5.2 to 0.1)
Radiology	1148/5003 (22.9)	7.5	2.5 (1.1 to 3.8)	2155/5003 (43.1)	6.6	0.2 (−1.3 to 1.7)	1148/2155 (53.3)	11	4.4 (1.8 to 7)
Surgery, general	1232/4455 (27.7)	12.3	5.4 (4 to 6.8)	2294/4455 (51.5)	15	4.3 (2.8 to 5.8)	1232/2294 (53.7)	11.4	6.6 (4 to 9.2)
Surgery, subspecialty	1765/6129 (28.8)	13.4	3.5 (2.2 to 4.7)	3279/6129 (53.5)	17	3.2 (1.8 to 4.6)	1765/3279 (53.8)	11.5	3.7 (1.3 to 6.1)
Publications (per 1 publication)[e]									
Total		0.2 (0.2 to 0.2)			0.4 (0.3 to 0.4)			0.2 (0.2 to 0.2)	
First or last author		0.1 (0.1 to 0.2)			0.2 (0.2 to 0.3)			0.2 (0.2 to 0.3)	
NIH grant[f]									
No	16 142/82 777 (19.5)	1 [Reference]		34 157/82 777 (41.3)	1 [Reference]		16 142/34 157 (47.3)	1 [Reference]	
Yes	4835/8296 (58.3)	38.8	3.9 (3.0 to 4.7)	6897/8296 (83.1)	41.8	3.7 (2.5 to 4.8)	4835/6897 (70.1)	22.8	4.7 (3.3 to 6.1)
Clinical trial investigator									
No	17 586/83 763 (21.0)	1 [Reference]		35 621/83 763 (42.5)	1 [Reference]		17 586/35 621 (49.4)	1 [Reference]	
Yes	3391/7310 (46.4)	25.4	5.9 (5.1 to 6.8)	5433/7310 (74.3)	31.8	8.4 (7.4 to 9.5)	3391/5433 (62.4)	13	6.4 (5 to 7.8)
Top-20 medical school	13 879/65 007								
No	7098/26 066 (21.4)	1 [Reference]		27 855/65 007 (42.8)	1 [Reference]		13 879/27 855 (49.8)	1 [Reference]	
Yes	17 586/83 763 (27.2)	5.8	1.5 (−1.5 to 4.5)	13 199/26 066 (50.6)	7.8	−0.1 (−4.3 to 4.2)	7098/13 199 (53.8)	4	1.4 (−2.4 to 5.2)

Abbreviation: NIH, National Institutes of Health; OB/GYN, obstetrics and gynecology.

[a] Factors associated with full professorship among faculty of all ranks.

[b] Factors associated with associate or full professorship among faculty of all ranks.

[c] Factors associated with full professorship among faculty at the associate or full professor rank.

[d] Each model estimated the association between faculty rank and physician sex, adjusted for age, years since residency, specialty, publications (total, as well as first and last author), whether a physician was ever principal investigator on an NIH grant, whether a physician had conducted a clinical trial, and whether a physician was faculty at a top-20 US medical school in terms of *US News & World Report* 2013 medical school research ranking.

[e] Number of authored scientific publications was based on publications indexed in the US National Library of Medicine's PubMed database (not excluded to first- or last-author publications). The reported association between faculty rank and publication count (or years since residency) reflects the marginal effect of an additional publication (or year after residency) on the probability of a given faculty rank.

[f] NIH grant information was obtained from the NIH RePORT grants database. Clinical trial information was obtained from ClinicalTrials.gov database.

Table 4. Professorship Status by Specialty and Medical School Research Ranking

	Full Professorship[a]			
	No. of Full Professors/Total (%)		Absolute Difference in Proportion	
	Men	Women	Unadjusted, %	Adjusted, % (95% CI)
Specialty[b]				
Anesthesiology	723/3914 (18.5)	151/1743 (8.7)	−9.8	−3.4 (−5.2 to −1.5)
Cardiology	1044/3337 (31.3)	115/659 (17.5)	−13.8	−4.6 (−8.1 to −1.2)
Emergency medicine	330/2507 (13.2)	56/1001 (5.6)	−7.6	−2.5 (−4.6 to −0.4)
Family medicine	416/2208 (18.8)	119/1587 (7.5)	−11.3	−4.4 (−6.6 to −2.1)
Gastroenterology	519/1570 (33.1)	44/417 (10.6)	−22.5	−6.1 (−10.8 to −1.4)
Hematology/oncology	831/2199 (37.8)	176/949 (18.5)	−19.3	0.2 (−2.0 to 3.2)
Infectious disease	501/1247 (40.2)	118/729 (16.2)	−24.0	−6.9 (−10.4 to −3.4)
Internal medicine	1131/5255 (21.5)	303/3647 (8.3)	−13.2	−3.9 (−5.3 to −2.5)
Neurology	946/2652 (35.7)	161/1228 (13.1)	−22.6	−5.1 (−7.7 to −2.5)
Obstetrics and gynecology	572/1864 (30.7)	195/1958 (10.0)	−20.7	−5.1 (−7.6 to −2.7)
Orthopedic surgery	571/2244 (25.4)	26/233 (11.2)	−14.2	−2.5 (−8.0 to −3.7)
Other	2700/7770 (34.7)	583/3904 (14.9)	−19.8	−3.2 (−4.7 to −1.6)
Pathology	826/2112 (39.1)	262/1367 (19.2)	−19.9	−6.3 (−9.0 to −3.7)
Pediatrics	1709/6252 (27.3)	686/6144 (11.2)	−16.1	−4.0 (−5.2 to −2.9)
Psychiatry	835/3003 (27.8)	183/1786 (10.2)	−17.6	−5.2 (−7.3 to −3.0)
Radiology	918/3573 (25.7)	230/1430 (16.1)	−9.6	−2.0 (−4.0 to 0.4)
Surgery, general	1117/3561 (31.4)	115/894 (12.9)	−18.5	−4.6 (−7.6 to −1.6)
Surgery, subspecialty	1665/5341 (31.2)	100/788 (12.7)	−18.5	−3.6 (−7.0 to −0.2)
Research ranking of medical school[c]				
Ranked in top 20 in US	5761/17 173 (33.5)	1337/8893 (15.0)	−18.5	−4.5 (−5.5 to −3.4)
Not ranked in top 20	11 593/43 436 (26.7)	2286/21 571 (10.6)	−16.1	−3.8 (−4.5 to −3.2)

[a] Sample includes faculty of all ranks.

[b] Presents estimates of the association between faculty rank and physician sex in each specialty, adjusting for age, years since residency, publications (total, as well as first and last author), number of NIH grants, whether a physician had conducted a clinical trial, and whether a physician was faculty at a top-20 US medical school in terms of US News and World Report 2013 medical school research ranking.

[c] Subgroup analysis conducted among physician faculty and top-20 and non-top-20 schools in terms of medical school research ranking. For each group (top-20 vs not), we estimated the association between faculty rank and physician sex, adjusting for age, specialty, years since residency, publications (total, as well as first and last author), number of NIH grants, and whether a physician had conducted a clinical trial.

have different origins and drivers and distinct interventions may be necessary to mitigate them. For example, lower rates of promotion to associate professorship among women, if present, may stem from differences in choice of career track. Women may more often enter clinical tracks, which promote more slowly than research tracks. Potential interventions to address these barriers to promotion include greater investment in early research career development for women and modifying the promotions process in nonresearch career tracks. Alleviating sex differences in promotion from associate to full professor may require a distinct set of strategies.

A number of explanations have been advanced to explain sex differences in faculty rank,[7-9,20-24] including explanations for why women faculty have lower average research productivity than men,[24] which may impede promotion, and explanations for why, even after accounting for research productivity, women are less likely than men to be full professors.[9] Differential household responsibilities,[22,25,26] childrearing, and different preferences on work-life balance[27,28] may contribute to sex differences in full professorship primarily by reducing research productivity but should have little independent effect on faculty rank once measures of productivity are accounted for. In contrast, women may face difficulties finding effective mentors and receiving recognition from senior colleagues,[7,20,21,29] workplace discrimination, and inequitable allocation of institutional resources.[5,30-33] These challenges may adversely affect research productivity and may also explain why even after adjusting for research productivity, women are still less likely than men to be full professors.[9]

Our study had several limitations. First, the database did not include information on faculty track, which could confound sex differences in full professorship if women are more likely to enter nonresearch tracks in which full professorship is less common. Having information on job track would be helpful not only for interpreting our estimates but also for informing the design of policies to reduce sex differences in faculty rank. For example, if men and women are equally productive in research and funding, but higher proportions of women choose to pursue clinician educator activities, sex disparities in faculty rank could be partially alleviated by changing how promotion committees weigh the work of clinician educators. We partially addressed this issue by demonstrating that

even among faculty with NIH funding, who are presumably more likely to be on research tracks, sex differences in full professorship exist. A similar limitation would arise if women were more likely to choose part-time work and therefore choose not to pursue academic advancement. Although lack of information on part-time status is an important unmeasured confounder, it is unlikely that the subgroup of NIH-funded principal investigators consists of men or women in part-time academic positions.

Second, our study was cross-sectional and could not identify sex differences in promotion. Our study identified sex differences in the prevalence of specific faculty rank at a given point in time, which reflects both promotion to and exit from that rank. Longitudinal data are needed for studying promotion trends.

Third, we relied on externally developed algorithms to match physicians to databases containing information on publications, NIH funding, and clinical trial investigation, a process that may entail errors. For example, in our own audit, publication information in our database was only about 85% accurate compared with a manual review of PubMed. If measurement errors are correlated with physician sex, these inaccuracies could bias estimated sex differences in full professorship. For example, women who change their surname after marriage may not have appropriate research attributed to them. In this specific example, estimated sex differences in full professorship would understate the disparity, since the estimates would not fully capture the research productivity of these women. However, the matching algorithm also incorporated information on maiden name reported by physicians to the NPPES. Moreover, we conducted sensitivity analyses designed to directly address this concern and found sex differences in full professorship among registered members who presumably verified their profile information. In addition, in an analysis of 200 physicians, error rates in attributed publications, NIH funding, and clinical trial participation did not vary by sex, which suggests that our findings should not be biased by measurement error.

Fourth, our measures of research productivity are not exhaustive of other unmeasured considerations important to faculty rank, such as teaching, awards, committee service, and presentations. Unmeasured sex differences in these achievements could confound our estimates. For example, in our subgroup analysis of NIH investigators, sex differences in full professorship moved closer to the null, which raises the possibility that unmeasured residual confounding (in this case, absence of information on job track) could explain observed sex differences. More generally, residual confounding may be possible because of several significant differences between men and women (eg, age differences) that may not be entirely overcome with statistical adjustment.

Finally, our analysis focused on sex differences in academic rank, and did not account for other leadership roles, including residency or fellowship directorship, or other administrative positions.

Conclusions

Among physicians with faculty appointments at US medical schools, there were sex differences in academic faculty rank, with women substantially less likely than men to be full professors, after accounting for age, experience, specialty, and measures of research productivity.

ARTICLE INFORMATION

Author Contributions: Dr Jena had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Jena, Khullar, Blumenthal.
Acquisition, analysis, or interpretation of data: All the authors.
Drafting of the manuscript: Jena, Khullar, Ho, Blumenthal.
Critical revision of the manuscript for important intellectual content: Jena, Khullar, Olenski, Blumenthal.
Statistical analysis: Jena, Ho, Olenski.
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