HHS Public Access
Author manuscript
Acad Med. Author manuscript; available in PMC 2017 August 01.

Published in final edited form as:
Acad Med. 2016 August ; 91(8): 1074–1079. doi:10.1097/ACM.0000000000001251.

Longitudinal Analysis of Gender Differences in Academic Productivity among Medical Faculty across 24 Medical Schools in the United States

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Abstract

Purpose—This study examines gender differences in academic productivity, as indicated by publications and federal grant funding acquisition, among a longitudinal cohort of medical faculty from 24 medical schools across the United States, 1995 to 2012.

Method—Data for this research was taken from the National Faculty Study involving a survey with medical faculty recruited from medical schools in 1995, and followed up in 2012. Data

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Other disclosures: None.

Ethical approval: This study was approved by the institutional review boards (IRBs) of Boston University School of Medicine (Protocol # 1.769575) on 04/24/2009 through 04/01/2015 and Tufts Health Sciences Campus (IRB # 10372) on 05/15/2012 through 5/14/2015; Tufts IRB reviewed on behalf of Massachusetts General Hospital through the Master Common Reciprocal Agreement approved on 10/01/2013.

Disclaimer: The opinions expressed in this article are those of the authors alone and do not reflect the views of the National Institutes of Health, the funders of this study.

Previous presentations: Poster presentation at the National Translational Science 2015 Meeting, Washington, DC, April 17, 2015.

included surveys and publication and grant funding databases. Outcomes were number of publications, *h*-index and principal investigator on a federal grant in the prior two years. Gender differences were assessed using negative binomial regression models for publication and *h*-index outcomes, and logistic regression for the grant funding outcome; analyses adjusted for race/ethnicity, rank, specialty area and years since first academic appointment.

Results—Data were available for 1,244 of the 1,275 (98%) subjects eligible for the follow up study. Men were significantly more likely than women to be married/partnered, have children, and hold the rank of professor ($P < .0001$). Adjusted regression models document that women have a lower rate of publication (relative number = .71; 95% CI = .63, .81; $P < .0001$) and *h*-index (relative number = .81; 95% CI = .73, .90; $P < .0001$) relative to men, though there was no gender difference in grant funding.

Conclusions—Women faculty acquire federal funding at similar rates as male faculty, yet lag behind in terms of publications and their impact. Medical academia must consider how to help address ongoing gender disparities in publication records.

Research from across diverse fields of medicine over the past two decades documents gender inequities in academic productivity among U.S. academic medical faculty. Specifically, studies have found that men relative to women produce on average more peer-reviewed publications and have a higher rate of citation of their work as calculated using the *h*-index, a measure of both the productivity and the citation impact of a research scholar.[1–7] Men are also more likely than women to hold prominent positions as first or senior author on the papers they publish.[5–8] Additionally, previous work has reported that male medical faculty and residents, relative to their female counterparts, apply for more grants, request higher levels of funding, and receive both more grants and higher funding from federal and non-federal sources.[1,9–11] These studies suggest that much of the observed disparity in productivity lies early in careers, and some research suggests that as women acquire greater seniority, more comparable productivity metrics by gender are seen.[1,8] One study found that as careers progress, women on average produce more publications than male faculty, after adjusting for rank and specialty.[2] However, other studies suggest that productivity early in a career is predictive of that later in career, impeding the likelihood of higher or even equitable productivity among women relative to men over time.[3] Greater clarity on the issue of gender inequities in the productivity of academic medical faculty from a longitudinal perspective is needed. This study examines gender differences in academic productivity, as indicated by publications and federal grant funding acquisition, among a longitudinal cohort of medical faculty from 24 medical schools across the U.S.

Method

We conducted this research as a longitudinal follow-up to the National Faculty Study,[12] a study initiated with medical faculty from 24 medical schools in 1995 to examine gender and racial/ethnic disparities in productivity, advancement, and promotion among academic medical faculty; this longitudinal follow-up study was designed to assess differences over time on these same outcomes, measured by survey with the same faculty in 2012. Medical schools included in the original study were selected from the pool of medical schools in the continental United States with at least 200 faculty, 50 women, and 10 minority faculty, and

24 schools were randomly selected with balance for geographic region and private/public status. Within each selected medical school, six full time faculty members were randomly sampled within each of 24 cells: four areas of medical specialization (generalist, medical specialty, surgical specialty, and basic sciences), three graduation cohorts (before 1970, 1970–1980, after 1980) and gender. In order to oversample for underrepresented faculty and senior women, all underrepresented minority faculty and all women who graduated before 1970 were sampled. The initial survey response rate was 60% with 1,790 full time faculty responding. A subset of 1,335 subjects in the 1995 survey indicated willingness to be contacted for future or follow-up studies, and these comprised our sample pool for the longitudinal study. No significant differences in gender at initial participation or willingness to be followed for study were seen.

Using name, academic specialty and background, and prior institution of the faculty members in 1995, we conducted a web-based search to obtain the current location, and contact information of subjects. Where valid email addresses were identified, we provided an email invitation to the survey and four follow up reminder emails. When no email address was available, we attempted contact by telephone or mailing address. We invited subjects to participate in this study and to complete a follow up survey, either online, or by mail. In order to ensure matches between the original and follow up surveys, the follow up survey asked for gender, year of birth and race/ethnicity. We provided subjects with a modest remuneration for their time in completing the survey. For those who did and did not respond to the follow-up survey, we developed a methodology to access publically available databases in order to assess our metrics of productivity. Using the name, departmental affiliation, year of birth and academic institution in 1995 as personal identifiers, we searched for evidence of the subject’s current academic affiliation or professional activities outside of academic medicine and included data where a match occurred. We searched the National Institutes of Health (NIH) Research Portfolio Online Reporting Tools (RePORT) website[13] for federal funding in the prior two years, the bibliographic database Scopus[14] for the total number of peer-reviewed publications through 2012, and also utilized Scopus to calculate the *h*-index, a measure of a scholar’s publication impact.[15] We conducted a validity assessment of this methodology by reviewing the Scopus publication number for all participants who returned the on-line survey and determined excellent consistency between self-reported outcomes and data available from these databases, with no gender differences in consistency.

Institutional review board approval for the study was received from Boston University, Tufts Medical Center, and for Massachusetts General Hospital through a reliance agreement with Tufts Medical Center.

Measures

We chose four outcome measures: federal grants, total number of peer-reviewed publications, change in number of peer reviewed publications since 1995, and *h*-index as of 2012. We assessed number of federal grants for the prior two years and dichotomized this variable into those with and without grant funding. We used the past two years of funding timeframe to provide information on current or very recent federal funding; we dichotomized this variable due to skewed distribution. We calculated number of peer-reviewed publications in total and since 1995, and analyzed these data as a count variable. The *h*-index is a calculated measure of impact of one's publication record, and utilizes number of publications and number of citations per publication, and was calculated in Scopus and analyzed as a count variable.[15]

The primary independent variable for this study was gender. Covariates included race/ethnicity (dichotomized as white versus other), marital status (dichotomized as married or partnered versus all others), parental status (having children or not), specialty (generalist, basic sciences, surgical, other specialist), percent effort spent on different work tasks (administrative, research, clinical, teaching), academic setting (versus industry or other private institution setting), and number of years since first academic appointment. All items were taken from 1995 data except for current academic rank and setting which were taken from the 2012 follow-up survey.

Analysis plan

Descriptive statistics were calculated for subject characteristics. Unadjusted and adjusted negative binomial regression models were developed to assess associations of gender with number of refereed articles and *h*-index. Unadjusted and adjusted logistic regression analyses were used to assess the association between gender and current grant funding. Gender and race/ethnicity were forced into all models. Backward elimination was used to select the remaining covariates (marital status, parental status, specialty, setting, and years since first appointment) for the model. Variables significant at $P < 0.10$ in bivariate analyses were candidates for the model, and were retained if the association reached the $P < 0.05$ level in the multivariable model. All data analyses were performed with SAS version 9.3.

Results

Of the 1,335 subjects who expressed willingness to participate in future research, 60 were identified as deceased, leaving 1,275 potential subjects. For this analysis, we excluded 29 participants with no outcome data and two participants who did not report their gender, leaving us with a final analytic sample of 1,244. Participants were predominantly white (78.1% of men, 82.1% of women), in academia (72.1% of men, 69.2% of women), and held the rank of professor (71.6% of men, 59.7% of women). (See Table 1). The majority were married or partnered (87.7% of men, 73.3% of women) and had children (83.5% of men, 68.7% of women). Men on average had been in academia slightly longer and were more likely to hold the rank of professor compared with women. Men were also more likely than women to be married/partnered and have children. Women reported a greater percent effort toward teaching.

The mean number of lifetime publications in refereed journals was 49.3 for women and 69.2 for men, for an unadjusted relative number of publications comparing women to men of 0.71 (95% CI = .63, .81; $P < .0001$). (See Table 2). After controlling for race/ethnicity, specialty, setting, and years since first appointment, women continued to have a lower rate of publication (relative number to men = .71; 95% CI = .63, .81; $P < .0001$). Gender differences in number of publications from 1995 to 2012 yielded similar findings; compared to men, women had .74 times the number of referred journal articles from 1995 to 2012, with women having an average of 25.1 papers compared to men's average of 34.1 papers. Again, adjusted analyses did not meaningfully alter these findings. A post hoc analysis was then conducted using the same models with the subsample of participants who were at the Assistant Professor level in 1995, to determine if findings were attributable to a cohort effect. These subgroup findings were similar to those seen in the overall analysis, with women having 0.72 (95% CI = 0.58, 0.9; $P < 0.0033$) the relative publication rate of men in this sub-cohort.

With regard to impact of publications, the unadjusted relative *h*-index for women was .83 times that of men (95% CI = .75, .92; $P = .0005$), with women having an average *h*-index of 16.6 compared to men's average *h*-index of 20.0. (See Table 2). Adjusting for race/ethnicity, specialty, setting, and years since first appointment, the relative *h*-index for women compared with men remained similar at .81 (95% CI = .73, .90; $P < .0001$). We conducted a sensitivity analysis utilizing the *h*-index without self-citations. Nearly identical results were seen, with an adjusted relative *h*-index for women of .81 (95% CI =.73, .90; $P < .0001$) to that of men, indicating that findings were not attributable to self-citation.

Analysis of the grant funding outcome documents that 27.6% of men and 29.0% of women were principal investigators on federal grants in the past two years; neither simple nor adjusted regression analyses indicated a significant association between gender and grant funding.

Discussion

Findings from this national longitudinal and multi-institution, multi-specialty research study document that women in academic medicine are as likely as their male counterparts to have federal grant funding as a principal investigator, but have significantly fewer refereed publications and a lower *h*-index, the latter as a measure of scholarly impact from publications generated over her career. These findings provide new insights over prior research on gender disparity in publication records that were based on cross-sectional, single site and single discipline studies.[1–5]

Our longitudinal data run counter to prior findings on gender disparities in receipt of grant funding,[1,7–11] but similar to our prior findings from the 1995 cohort, which also showed no difference by gender for this outcome.[12] Lack of findings related to gender disparities in acquisition of grant funding may be attributable to reduction in this disparity over the course of careers. Our findings may in part be attributable to the specific timeframe of the survey. Assessment of funding was conducted in 2011–12, during a period of recovery from national economic crisis and the timeframe of the American Recovery and Reinvestment Act of 2009 (ARRA) funding to the National Institutes of Health (NIH) of over 12,000 awards as part of the national stimulus package.[16] Hence, we may have evaluated this outcome during a time period of short term increases in the number of principal investigators of federal grants, and these increases may not have equally affected groups by gender. With recalibration of federal dollars for research funding, it will be important to continue to assess gender disparities in funding and, if these are identified, consider how they may be better addressed, particularly in a context of lower pay lines by the NIH. Another possible explanation of our findings may be that men who have now attained more senior leadership positions are less likely to have grant funding, reducing the rates of grant funding for men in the study sample.

Observed gender inequities in publication record likely are affected by multiple factors. Baseline analyses on this issue from this same cohort identified that among faculty with children, women had fewer publications than men, but this difference did not hold true for those without children.[12] Such findings highlight the role that children or family responsibilities may have on publication participation. However, having children had no effect on publications for the cohort at this stage in their career; effects of young children earlier in career may be the issue, as women in academic medicine are more likely than their male counterparts to take leave for family reasons and carry a disproportionate burden of family responsibility, and these may compromise academic productivity in the early years of child rearing.[17–18] One study found that among married faculty with children, women reported on average 8.5 additional hours per week in domestic responsibilities than men, and women were more than three times more likely to interrupt their work activities for childcare disruptions.[19] Such distribution of domestic labor on gender lines compromises academic productivity for women, but it may also compromise opportunity for positive engagement in family life among men. Both are issues that should be addressed to better support junior faculty, particularly as development of family responsibilities often occurs simultaneous with the vulnerable period of early career development.

Institutional support requires a climate respectful of family life and fostering of faculty during times of family development. However, academic medicine climate assessments document that women remain less likely than men to view their institution as family friendly, and women are more likely than men to describe their institutional climate as isolating, non-supportive, and discriminatory.[20–21] Greater likelihood of marriage and children for male relative to female faculty in this study suggests that women with less family responsibility may be more likely to be retained in academia. Institutions may need to consider how to provide more family friendly environments for both women and men, such as child care support at a reasonable cost and flexible hours/schedules. Recent research findings documents that senior faculty in leadership, including those in the Group on Women in Medicine and Science (i.e., gender focused leadership) positions, are commonly unaware of their institutions' family leave policies,[17] such lack of awareness from the designated advocates for women faculty suggest that family friendly policies and supports may not be at the forefront on institutional considerations.

Lack of mentoring, in particular, has been identified by women as a key concern in academic medicine,[21] and lack of mentoring is also negatively associated with achieving first author papers.[4] In the absence of supportive mentors, women may feel less able to position themselves for authorship, and in particular first or senior authorship on publications, and this may be supporting observed disparities in productivity. Further research on this issue is needed, with more comprehensive variables related to institutional research support which may differ by gender, such as designated mentors, intramural research funding and early in career engagement in research, to help consider how institutions may be better able to help eliminate gender differences in publication records. Reasons for ongoing gender differences in distribution of time for research, clinical practice and teaching should also be considered by institutions, as this too may be contributing to observed disparity in publication productivity.[7,20–22]

Journal review climate as a contribution to inequities in academic success may also be an issue to consider, though it has received less focus, in part due to use of anonymous reviews by most academic journals. However, a recent media story on gender bias in the academic manuscript review process highlights that there can be both subtle and blatant discrimination against women as authors.[23] The scope of such discrimination is unknown, but it, too, may affect gender differences in publication records, as a disproportionate number of negative reviews can be a deterrent to continued efforts in publishing work. This issue of gender bias in publication records is seen across disciplines of sciences and across geographic settings, globally.[24] It may be a combination of inadequate mentoring, support and engagement of women in publication development in conjunction with larger institutional biases in medicine and by journals that maintain this concern. If so, a multi-pronged solution will be necessary, including potentially publication audits by labs, academic departments, and the journals themselves to see if they are moving in the right direction to end these biases.

While current findings offer important insight into gender differences in academic productivity among medical faculty, they must be considered in light of certain study limitations. First, research productivity metrics were based on publication or being principal investigator on a federally funded grant. There are other domains that may be important, such as level of grant funding, positioning as first or senior author on paper, or invited presentations in national or international professional forums, and other measures of impact of one's academic contributions. While use of federal funding as a means of determining grant productivity offers a reliable metric that can be assessed consistently across areas of medical research, fields more reliant on foundation or industry funding may be less represented. There do appear to be gender differences in industry funding, with men more likely than women to receive it.[25] An additional limitation is that the grant funding data available from this study was limited to past two year federal funding; gender differences in historic and non-federal funds should also be explored in future research, but this timeframe allows for indications of active funding. A potential concern is the difficulty ensuring all publications and grant awards were captured for those faculty who did not complete the survey, and for whom public databases were utilized. Misattribution may have occurred for those with more common names, and women are more likely to have name changes that impede recognition of prior works. Scopus, however, is able to identify name changes involving hyphenations more readily than changes of the surname. Our use of available curriculum vitae to provide a validity check for our Scopus findings offers support regarding the validity of this approach.

Despite gender equity advancements in academic medicine over the past two decades, including increases in number of women faculty and proportions of those at the level of professor,[26] our longitudinal analysis of medical faculty across 24 U.S. medical schools documents that women continue to lag behind men in publication record and impact of publications. Addressing this issue likely requires consideration of how to mentor and support women faculty to pursue publications more, especially early in their career.

However, institutions both within medicine and within journal groups need to take more responsibility to consider their roles in improving equity in publication. Audits of publications within departments and journals, and recognition of where improvements are and are not being made, would be a first step in that goal. Given the importance of publications in the promotion process, the alternative is to impede further gains from being made in the equitable advancement of women in medicine.

Acknowledgments

The authors would like to thank Carolyn Luk, BA, Tufts Medical Center, for administrative work on the project, Subash Pathak, MS, Fred Hutchinson Cancer Research Center, for assistance with analyses, and Sharon Tennstedt, PhD, Heather Cochran, Julie Barenholtz, and Olga Dain, New England Research Institutes (NERI), for survey data collection.

Funding/Support: The project described was supported by Award Number R01GM088470 from the National Institute of General Medical Sciences and Office of Research in Women's Health, National Institutes of Health.

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Table 1

Characteristics of academic medicine faculty, total sample and by gender, Follow up to the National Faculty Study 1995 – 2012. (N=1244)

Characteristics	n for variable[a]		Men n=623 n (%)	Women n=621 n (%)	p-value
Race	1242	White	486 (78)	509 (82)	0.08
Rank	1059	Professor	390 (72)	307 (60)	<0.0001
Department	1193	Basic sciences	142 (24)	133 (22)	0.2
		Generalists	152 (26)	174 (29)	
		Medical specialty	186 (31)	195 (33)	
		Surgical specialty	117 (20)	94 (16)	
Mean number of years since initial academic appointment (SD)[b]	1220		29.4 (9)	28.2 (9)	0.02
Currently in academic setting	1186		430 (72)	408 (69)	0.3
Marital status	1232	Married or partnered	541 (88)	451 (73)	<0.0001
Parental status	1236	Parent to one or more children	517 (84)	424 (69)	<0.0001
Mean Effort distribution in 1995 (SD)[b]	1236	% time for administrative work	18.7 (18)	18.7 (18)	0.9
	1237	% time for research	30.5 (30)	28.8 (29)	0.3
	1241	% time for clinical work	31.9 (29)	31.5 (29)	0.8
	1239	% time for teaching	18.9 (13)	21.0 (15)	0.009

[a]Reported samples sizes by variable differ due to missing data

[b]SD: Standard Deviation

Data Sources: Longitudinal survey of faculty from 24 randomly selected medical schools in 1995, with follow-up data in 2012–3 from survey and from public access data sources. Variables were constructed using data from 1995 except for current academic rank and setting, which were taken from the 2012 follow-up survey.

Table 2

Associations of gender with mean number of refereed articles, H-value, and receipt of federal grant funding, Follow up to the National Faculty Study 1995 – 2012. (n=1137)

Outcome	Men Mean (SD)	Women Mean (SD)	Unadjusted Relative Number (95% CI)	p value	Adjusted[a] Relative Number (95% CI)	p value
Total Publications	69 (71.6)	49 (55.1)	.71 (.63, .81)	p<.0001	.71 (.63, .81)	p<.0001
Publications 1995–2012	34 (48.1)	25 (32.6)	.74 (.63, .87)	p=.0002	.72 (.62, .85)	p<.0001
h-Index (with self-citations)	20 (15.5)	17 (14.6)	.83 (.75, .92)	p=.0005	.81 (.73, .90)	p<.0001
Outcome	**Men (%)**	**Women (%)**	**Unadjusted OR (95% CI)**		**Adjusted[1] OR (95% CI)**	
Grant Funding in Prior 2 Yrs	27.6%	29.0%	.93 (.73, 1.19)	p=.6	.96 (.73, 1.26)	p=.8

[a]SD: Standard Deviation

[b]Adjusted relative numbers and odds ratio included the following covariates: race/ethnicity, specialty, setting (for the Grant funding and Publications 1995–2012 models), and years since first appointment (for the Total publications and h-Index models). Although both marital and parental status were considered for the models, neither were retained in the backward selection process.