ORIGINAL CONTRIBUTION

# Does Sex Influence Publication Productivity Among Colorectal Surgeons Participating in Fellowship Training Programs?

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**BACKGROUND:** Underrepresentation of highly ranked women in academic surgery is recognized.

**OBJECTIVE:** Our objective was to examine whether sex differences exist in faculty representation, academic rank, and publication productivity among colorectal faculty in fellowship programs.

**DESIGN:** American Society of Colon and Rectal Surgeons fellowship program faculty were identified. Bibliometric data were obtained for each faculty member, including Hirsch index, the Hirsch index divided by research career duration, and number of publications. Linear mixed-effect regression models were constructed to determine the association between the Hirsch index and the Hirsch index divided by research career duration and sex, when controlling for institutional measures. A subset analysis of academic faculty examined the association between academic rank, sex, and Hirsch index and the Hirsch index divided by research career duration.

**SETTINGS:** Colorectal fellowship programs, defined as academic, satellite-academic, and nonacademic, were evaluated.

**RESULTS:** Three hundred fifty-eight faculty members were examined across 55 training programs; 22% (n = 77) were women and 78% (n = 281) were men. Sixty-one percent (n = 220) practiced in an academic setting, 23% (n = 84) in a satellite-academic setting, and 15% (n = 54) in a nonacademic setting. There was no difference in median number of publications between sexes (15 vs 10, $p = 0.33$); men, however, had longer careers (18 vs 11 years, $p < 0.001$). When controlling for confounders, there was no difference in the Hirsch index ($p = 0.42$) or the Hirsch index divided by research career duration ($p = 0.73$) between sexes. Academic rank was significantly associated with Hirsch index and the Hirsch index divided by research career duration ($p < 0.001$) after controlling for sex.

**LIMITATIONS:** Our assessment of association between publication productivity and academic rank was only possible in the subset of academic faculty. In addition, this study is limited by its retrospective nature.

**CONCLUSIONS:** We found no difference in median number of publications between men and women. When controlling for possible confounders, sex was not a significant predictor of a faculty member's publication productivity, as measured by the Hirsch index or the Hirsch index divided by research career duration; academic rank, however, was.

**KEY WORDS:** Colorectal surgery; Fellowship training programs; Publication productivity; Sex.

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The percentage of women practicing medicine has dramatically increased in the past decades, a phenomenon observed across almost all medical specialties.[1,2] Currently, over 47% of medical degrees are earned by women, compared with less than 10% in the early 1970s.[3] Today, in surgical residencies, 38% of trainees are women. First organized in 1934, colon and rectal surgery has one of the oldest established boarded surgical fellowships. Thirty-nine percent of trainees in colon and rectal surgery are women, slightly higher than that for general surgery.[4,5] The increased representation of women in surgical residencies and fellowships has not yet translated to equivalent representation in academic surgery faculty, particularly in the domain of senior academic rank. For example, only 22% of US surgical faculty are women, and their representation declines as rank increases. Women represent 43% of surgery instructors, 25% of assistant professors, 17% of associate professors, and only 9% of full professors.[2] Little is known regarding female faculty representation, academic rank, or publication productivity in the field of colorectal surgery.

Advancement in academic surgery is a multilayered process with publication productivity being one of the most critical and quantifiable factors. The Hirsch index (*h* index) is a measure of publication productivity and citation impact. The *m* index is the *h* index divided by research career duration, a modification that accounts for research career duration, because varying career lengths can affect the total number of publications.[6] These bibliometric measures take into account not only a faculty member's number of publications, but also factor in publication impact by including the number of citations of each publication. The *h* index and *m* index thereby assess both quality and quantity. These metrics have been shown to be discrepant between sexes and impact academic promotion in other fields of medicine.[7–9] Before this publication, it was unknown if *h* index or *m* index differed between sexes within colorectal surgery.

In this study, we aim to describe the current sex representation among faculty in colorectal surgery training programs, stratified by program type and geographic location. Our main objective was to describe female faculty representation in colorectal surgery fellowship training programs and to examine whether there is a difference in their publication productivity in comparison with male faculty, utilizing the *h* index and *m* index. In addition, we aimed to examine sex representation within different academic ranks and association with academic rank and publication productivity within the cohort of academic colorectal faculty.

## MATERIALS AND METHODS

American Society of Colon and Rectal Surgeons US fellowship training program faculty were identified by using the American Society of Colon and Rectal Surgeons and participating program Web sites. A training program was defined as academic if it is affiliated with a residency and medical school, satellite-academic if a residency, but no medical school affiliation was present, and *nonacademic* if the program did not have a residency or medical school affiliation. Bibliometric data were collected from the commercially available Scopus database (Elsevier B.V.). Data collected included number of publications, year of first publication, and *h* index.[6] Consistent with literature examining *h* index in other fields, all data were collected over a defined 2-week period.[10] Publications were verified with PubMed (PubMed.gov, US National Library of Medicine National Institutes of Health). The *h* index is calculated by determining the total number of articles published by an author (n), having at least n citations. Research career duration was calculated by subtracting the number of years since an author's first publication from the year of data collection. The *m* index was calculated by dividing authors' *h* index by their career duration. Faculty member program regions were defined geographically into Northeast (Connecticut, Massachusetts, New Jersey, New York, Pennsylvania, Rhode Island), Midwest (Illinois, Indiana, Michigan, Minnesota, Missouri, Nebraska, Ohio), South (Distract of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Tennessee, Texas), and West (California, Oregon, Utah, Washington). Univariable analyses were performed to compare publication and career variables between men and women. A linear mixed-effects regression model with a random effect for fellowship program was constructed to identify factors associated with the *h* index. Variables included in the model were sex and institutional factors, including region of practice, type of practice (academic vs satellite-academic vs nonacademic), number of faculty members within the program, and research career duration. Similarly, a mixed-effects regression model with a random effect for fellowship program was also constructed to identify factors associated with *m* index. Variables included in the model were sex, region of practice, type of practice, and number of faculty within a program. Finally, a subset analysis was performed for those practicing in academic facilities. In this cohort, we examined faculty rank (assistant professor, associate professor, and professor) and association with *m* index and *h* index, with and without adjustment for sex, by using linear regression modeling. This study is a structured review of all publically available data and was exempt from institutional review board approval.

## RESULTS

A total of 358 colon and rectal surgery faculty were identified across 55 training programs. Sixty-one percent (n = 220) of faculty members practiced in academic pro-

**TABLE 1.** Univariable analysis

| | *Overall (N = 358)* | *Men (n = 281)* | *Women (n = 77)* | *p* |
|---|---|---|---|---|
| Program type, n (%) | | | | |
| Academic | 220 (61) | 171 (61) | 49 (64) | |
| Satellite-academic | 84 (23) | 65 (23) | 19 (25) | |
| Nonacademic | 54 (15) | 45 (16) | 9 (12) | 0.64 |
| Geographic region, n (%) | | | | |
| Northeast | 109 (30) | 88 (31) | 21 (27) | |
| Midwest | 129 (36) | 94 (33) | 35 (45) | |
| South | 84 (23) | 70 (25) | 14 (18) | |
| West | 36 (10) | 29 (10) | 7 (9) | 0.26 |
| No. of publications | 13.5 (4–36) | 15 (4–39) | 10 (4–30) | 0.33 |
| Career duration | 16 (9–24) | 18 (11–25) | 11 (6–18) | <0.001 |
| No. of publications per year | 0.88 (0.33–2.3) | 0.89 (0.30–2.34) | 0.87 (0.43–2.29) | 0.32 |
| *h* index | 6.5 (2–14) | 7 (2–16) | 4 (3–10) | 0.44 |
| *m* index | 0.44 (0.21–0.84) | 0.43 (0.17–0.84) | 0.50 (0.27–0.82) | 0.08 |

Values are displayed as n (%) or median (interquartile range).
*h* index = Hirsch index; *m* index = the *h* index divided by research career duration.

grams, 23% in satellite-academic programs (n = 84), and 15% in nonacademic training programs (n = 54). Twenty-two percent (n = 77) of the faculty members were women. The proportion of female faculty was similar across the various program types, when compared with the male faculty (61% academic (n = 171), 23% satellite-academic (n = 65), and 16% nonacademic (n = 45) among men, and 64% academic (n = 49), 25% satellite-academic (n = 19), and 12% nonacademic (n = 9) among women; $p = 0.64$). The proportion of female faculty was also similar across geographic regions in comparison with male faculty (31% Northeast (n = 88), 33% Midwest (n = 94), 25% South (n = 70), 10% West (n = 29) among men, and, 27% Northeast (n = 21), 45% Midwest (n = 35), 18% South (n = 14), and 9% West (n = 7) among women; $p = 0.26$). There was no significant difference in median number of publications (15 for men vs 10 for women, $p = 0.33$), publications per year (0.89 for men vs 0.87 for women, $p = 0.32$), *h* index (7.0 for men vs 4.0 for women, $p = 0.44$), or *m* index (0.43 for men vs 0.50 for women, $p = 0.08$) between men and women. Men had significantly longer career durations than women, with a median of 18 years vs 11 years for women ($p < 0.001$) (Table 1). In a linear mixed-effects model, longer career duration was the only significant covariate associated with *h* index, with each additional year or career duration corresponding to an increase of 0.49 (95% CI, 0.38–0.60; $p < 0.001$) in the *h* index. Sex, program type, number of faculty at a program, and region were not significant covariates of *h* index (Table 2). In a linear mixed-effect model of *m* index, type of program was the only significant covariate associated with *m* index ($p = 0.04$) (Table 2).

Within the cohort of academic colorectal faculty (N = 148), there was no significant difference in sex distribution across the 3 academic ranks. Forty-seven percent (n = 52) of men and 63% (n = 24) of women were assistant professors, 25% of men (n = 28) and 18% (n = 7) of women were associate professors, and 27% (n = 30) of men and 18% (n = 7) of women were professors ($p = 0.24$). Median *h* index and *m* index were significantly different across academic ranks. Median *h* index was 4, 11, and 25 ($p < 0.001$) and median *m* index was 0.36, 0.64, and 1.06 ($p < 0.001$) for associate, assistant, and full professors (Table 3). There were no significant differences in median *h* index and *m* index by sex within each rank (Fig. 1). In a lin-

**TABLE 2.** Linear mixed-effects model for *h* index and *m* index

| | *h index* | | *m index* | |
|---|---|---|---|---|
| | *Coefficient (95% CI)* | *p* | *Coefficient (95% CI)* | *p* |
| Female sex | –1.12 (–3.81 to 1.58) | 0.42 | –0.03 (–0.19 to 0.13) | 0.73 |
| Region (reference: Midwest) | | 0.38 | | 0.14 |
| Northeast | –3.02 (–7.83 to 1.79) | | –0.26 (–0.53 to 0.001) | |
| South | –4.52 (–9.71 to 0.68) | | –0.29 (–0.58 to –0.005) | |
| West | –3.17 (–9.87 to 3.53) | | –0.30 (–0.67 to 0.07) | |
| Type (reference: academic) | | 0.08 | | 0.04 |
| Satellite-academic | 2.88 (–1.52 to 7.27) | | 0.16 (–0.09 to 0.40) | |
| Nonacademic | –4.04 (–9.32 to 1.24) | | –0.27 (–0.56 to 0.02) | |
| No. of faculty in training program | 0.36 (–0.17 to 0.90) | 0.18 | 0.007 (–0.02 to 0.04) | 0.65 |
| Career duration | 0.49 (0.38 to 0.60) | <0.001 | | |

*h* index = Hirsch index; *m* index = the *h* index divided by research career duration.

**TABLE 3.** Univariable analysis of academic rank

| | *Assistant professor (n = 76)* | *Associate professor (n = 35)* | *Professor (n = 37)* | *p* |
|---|---|---|---|---|
| Sex, n (%) | | | | 0.24 |
| Male | 52 (47) | 28 (25) | 30 (27) | |
| Female | 24 (63) | 7 (18) | 7 (18) | |
| *h* index | 4 (3–8) | 11 (8–16) | 25 (14–36) | <0.001 |
| *m* index | 0.36 (0.23–0.58) | 0.64 (0.50–1.14) | 1.06 (0.61–1.67) | <0.001 |

Values are displayed as n (%) or median (interquartile range).
*h* index = Hirsch index; *m* index = the *h* index divided by research career duration.

ear regression model, after adjusting for sex, academic rank was still significantly associated with *h* index and *m* index ($p < 0.001$). Associate professors had an increase of 6.71 in *h* index (95% CI, 3.15–10.26), and professors had an increase of 21.03 (95% CI, 17.53–24.52) in comparison with assistant professors after adjusting for sex. Associate professors had an increase of 0.36 (95% CI, 0.11–0.62) and professors had an increase of 0.76 (0.51–1.01) in *m* index, compared with assistant professors, after adjusting for sex (Table 4).

## DISCUSSION

To our knowledge, this is the first study that has examined female representation in colorectal surgery fellowship training programs, and assessed whether publication productivity differs between sexes. In our cohort, men had a longer career duration than women with men practicing a median of 7 years longer; there was, however, no statistical difference in median number of publications or publications per year between sexes. When controlling for geographic location, program type, number of cofaculty, and career duration, sex was not a significant predictor of a faculty member's publication productivity, as measured by the *h* or *m* index. Academic rank, however, was significantly associated with publication productivity, irrespective of sex. Although, overall, women are underrepresented among colorectal surgery faculty, there is no significant difference in representation of female teaching staff stratified by program type or geographic location.

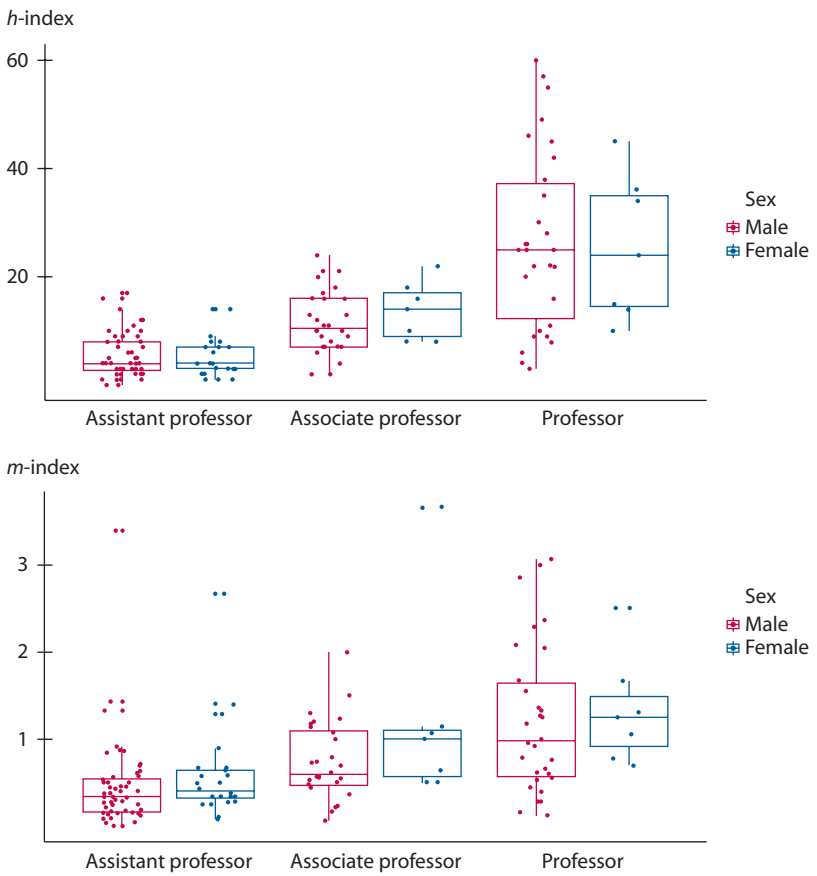


**FIGURE 1.** Box plots of *h* index and *m* index by academic rank and sex. *h* index = Hirsch index; *m* index = the *h* index divided by research career duration.

**TABLE 4.** Linear regression model for *h* index and *m* index

| | *h index* | | *m index* | |
|---|---|---|---|---|
| | *Coefficient (95% CI)* | *p* | *Coefficient (95% CI)* | *p* |
| Female sex | 0.01 (–3.28 to 3.30) | 0.99 | 0.20 (–0.04 to 0.43) | 0.11 |
| Rank (reference: assistant professor) | | <0.001 | | <0.001 |
| Associate professor | 6.71 (3.15 to 10.26) | | 0.36 (0.11 to 0.62) | |
| Professor | 21.03 (17.53 to 24.52) | | 0.76 (0.51 to 1.01) | |

Values are displayed as median (interquartile range).
*h* index = Hirsch index; *m* index = the *h* index divided by research career duration.

Some have hypothesized that women are less productive academically than men because of demands from familial responsibilities that may be especially accented during the critical earlier phases of any professional career.[11] We have shown, however, that this supposition is not accurate within our cohort. Despite the fact that men had longer career durations, there was no difference in median number of publications, publications per year, *h* index, or *m* index between men and women. These findings indicate that, even though women have shorter research careers, they may actually be slightly more productive than their male colleagues. Others have demonstrated that women are more likely than their male counterparts to delay or forgo childbearing to further their careers, which could explain a contributing factor to the increased productivity we see with women early in their research careers.[12] We have also demonstrated that longer career duration correlates with a higher *h* index and higher academic rank. Thus, as career durations of women faculty in colorectal fellowship training programs increase, their publication productivity and *h* indices will also likely continue to increase. Although we did not examine clinical practice factors in our study, others have shown that, within colon and rectal surgery, women and men work a similar number of hours and take a similar number of clinical call responsibilities.[13] This supports equality within the field and the expectation that, as more women progress in number of years of practice, their overall productivity will demonstrate an increase equal to their male colleagues.

Many studies that report publications and *h* indices in other fields report mean values that can be skewed by a few high performers. When considering those who report median values as we have, the number of publications are slightly lower in our colorectal cohort, but the *h* indices are comparable.[7,10,14,15] This suggests high quality, despite slightly lower quantity of work. Furthermore, most studies examining publication productivity only include academic faculty. We, however, have examined satellite and nonacademic teaching faculty as well, which could also explain the lower total publication number compared with other fields.

We have demonstrated that female sex is not an independent predictor of *h* index among colon and rectal surgery faculty members. This observation stands in contrast to other fields of medicine. Multiple other studies have demonstrated differences in *h* indices in men, when compared with their female colleagues.[7,8,16] In studies of academic orthopedic surgeons and hand surgeons, men had significantly higher *h* indices than their female colleagues.[8,16] In a recent study examining differences in academic productivity among male and female gastroenterology faculty, it was similarly found that men had more publications and higher *h* indices.[10] Similarly, in a study of academic surgeons across all specialties among 3 medical centers, men had a higher number of publications than women at all academic levels.[17] Bibliometric measures, such as the *h* index and number of publications, have been shown to directly correlate with academic rank, departmental funding, and even individual salary.[8,16–22] In our subset analysis, we have similarly shown that *h* index and *m* index are associated with academic rank, but did not demonstrate statistical difference in female representation within the academic ranks. The reasons that women excel academically in colorectal surgery more so than in other fields are unknown, but suggest a supportive working environment for women within the field.

Currently, female faculty representation in colon and rectal surgery is half that of female trainees.[4] This discrepancy possibly reveals a deficiency in same-sex role models and mentorship for female trainees. Trainees often desire same-sex mentorship.[13] A recent study by Jagsi et al[23] did not find an association between exposure of a female medical student to a female chairman and choice of pursuing that specialty, but did find that women were more likely to choose to attend a residency with a higher percentage of women in the prior class, suggesting residents may look for mentorship in those closer to their level of training. Increased female trainee representation in recent years is encouraging, and would lead one to expect that we will see an equally increased representation of women in high academic rank as their careers mature.[23,24] It is also promising that, although women are underrepresented overall, their proportion within each academic rank on subset analysis is similar to that of men, again affirming that, in the field of colon and rectal surgery, women are able to academically excel as well as their male colleagues who have similar publication productivity.

Our study has several limitations that need to be discussed. Research and clinical career duration are difficult to determine. We used the year of first publication as a surrogate for career duration, because we were unable to determine first year of faculty appointment. Because many faculty members started to publish literature while still in training, this calculation could potentially over- or underestimate career duration. Second, the total number of publications may not have been captured if a faculty member changed his or her name during the course of their publication career. In addition, SCOPUS database catalogues the individual's number of publications without specifying authorship status. We were also unable to determine or control for percentage of a faculty member's practice that may have been divided between different institutional types. Despite these limitations, this article is the first to assess, using a standardized and objective measure, whether sex differences exist within colon and rectal surgery faculty publication productivity and academic rank.

With this study, we have demonstrated that, despite having significantly shorter research career durations, women do not differ from men in their median number of publications or bibliometrics, such as *h* index or *m* index. This suggests that overall, within colorectal training faculty, women possess equal publication productivity compared with men. This implies a supportive working environment for female faculty within the field and suggests that publication productivity should not be a barrier to academic career advancement for female colorectal surgeons.

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