Gender Trends in Radiology Authorship: A 35-Year Analysis

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OBJECTIVE. The purpose of this study was to describe trends over time in female authorship in the radiology literature and to investigate the tendency of female first authors to publish with female senior authors.

MATERIALS AND METHODS. Data on the gender of academic physician authors based in the United States for all major articles published in three general radiology journals—*Radiology*, *AJR*, and *Academic Radiology*—were collected and analyzed for the years 1978, 1988, 1998, 2008, and 2013. Multivariate logistic regression was used to identify significant trends over time, and a chi-square test of independence was performed to determine significant relations between the genders of first and senior authors.

RESULTS. The gender of 4182 of 4217 (99.17%) authors with MD degrees was determined. The proportion of original research articles published by women as first authors increased from 8.33% in 1978 to 32.35% in 2013 ($p < 0.001$). The proportion of original research articles with women as senior authors increased from 6.75% in 1978 to 21.90% in 2013 ($p < 0.001$). Female first and senior authorship increased significantly over time (first author, $p < 0.001$; senior author, $p < 0.001$). There was a statistically significant relation between the genders of first and senior authors of original research articles and guest editorials ($p < 0.001$).

CONCLUSION. Over 35 years, there was a statistically significant upward linear trend of female physician participation in authorship of academic radiology literature. Female first authors were more likely to publish with female senior authors.

Keywords: gender, medical literature, radiology, women physicians, workforce issues

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Despite a general upward trend of female participation in medicine since the 1970s, female physicians continue to be underrepresented in several specialties [1], including diagnostic radiology [2]. Women represented 19.2% of U.S. radiology residents in 1980 and 26.9% in 2013 [3]. Representation of women in diagnostic radiology residency has remained stagnant over 2 decades. In 1990, 25.5% of U.S. radiologists were women [3], and in 2013, 27.0% of all U.S. radiology residents were women [4, 5]. With regard to the general workforce, female radiologists constituted 11.5% of academic radiology faculty in 1978 and 28.1% of academic radiology faculty in 2013 [4]. Underrepresentation of women in academic medicine has been associated with decreased quality of patient care, teaching, and research [6, 7].

Although women are more likely than men to begin academic medical careers after training, they continue to lag behind their male counterparts in obtaining senior faculty positions [1]. Because academic advancement in science and medicine is largely driven by scholarly accomplishments, peer-reviewed original research and editorial publications serve as objective benchmarks for promotion [8, 9]. Results of previous studies in the specialties of internal medicine [10], orthopedic surgery [11], dermatology [12], family medicine [13], and radiation oncology [14] suggest that female physicians do not publish peer-reviewed manuscripts at the same rate as male physicians. Moreover, despite nearly equal representation of both genders during medical school, previous reports suggest that female physicians are less likely to be interested in research or to participate in major research programs [15]. This effect, however, can be altered by proper mentorship [16–18].

To help meaningfully modify indicators of gender disparity in academic radiology, our aim in this study was to assess trends over time in female authorship in the radiology literature and to investigate the tendency of female first authors to publish with female se-

nior authors. The results of our study may help the efforts of radiology societies and academic departments increase the representation of women in radiology by elucidating scientific article authorship and mentorship trends.

Materials and Methods

This study was exempt from Yale University human investigation committee review.

Data Sources

We focused our data collection and analysis on three major general radiology journals published in the United States: *Radiology*, *AJR*, and *Academic Radiology*. Journals were chosen on the basis of journal impact factor (6.3, 2.9, and 1.9, respectively, in the Journal Citation Reports of 2014), coverage of the entire discipline (coverage of all clinical radiology subspecialties), and expert opinion. We obtained data on female participation in academic medicine and diagnostic radiology residencies from the American Association of Medical Colleges (Fig. 1). Resident data were not available for all years of interest, so previously published data from similar years were used [3, 4, 19].

Data Collection

To examine gender variance and trends among authors of original research articles and invited editorials, we extracted data for the calendar years 1978, 1988, 1998, 2008, and 2013. As in previous studies, these years were chosen because of the breadth of sampling over a meaningful time, but we added the most recent year available at the time of data collection. Collected data variables included full author name, degree, institutional affiliation, and article type. We restricted our analysis to authors with affiliations at U.S. institutions. Only authors who were not editorial board members were included in the analysis of authorship of editorials.

We determined gender by inspection of each author's first name. In cases in which we could not easily determine an author's gender by first name, we performed Google searches and made telephone calls to colleagues at each author's institution. For *AJR*, we also used Google searches to determine academic degrees, which were not available in the published articles. For purposes of this analysis, we assumed that last authors were the senior authors.

Statistical Analysis

We used Microsoft Excel (version 14.4.8) to tabulate and graph descriptive data for first and senior authors by gender and year. To approximate change over time, we used statistical software (SPSS Statistics for Mac, version 22.0, IBM-SPSS) to fit a logistic regression model treating author gender as the outcome and year as a numeric predictor. We also used the chi-square test of independence to find the relation between first and senior authors' genders to see whether women tended to publish as first authors with female senior authors. A value of $p < 0.05$ was considered statistically significant for all analyses.

Results

We abstracted data for a total of 4217 authors of original articles and editorials with MD degrees and affiliations with U.S. academic institutions. Of these, 2197 were first authors and 2020 were senior authors. We were able to determine gender for 99.17% (4182/4217) of the authors. Overall, 21.98% (483/2197) of publications had female first authors, and 13.81% (279/2020) had female senior authors.

Figure 2 shows the results of our descriptive analysis of the proportion of peer-reviewed radiology articles published by female physicians over the 35-year study period. The proportion of original research articles and invited editorials written by female physicians as first authors increased from 8.33% to 32.35% over the 35-year period. Likewise, the proportion of original research articles and editorials with female physicians as senior authors increased from 6.75% to 21.90% over the same time period. In contrast, the proportion of articles authored by female nonphysician (e.g., PhD) first-author investigators increased from 4.00% to 45.92%, and the proportion of articles authored by nonphysician female senior authors increased from 17.24% to 31.58% during the same 35-year period. In the determination of the genders of the authors of all 90 guest editorials published during the

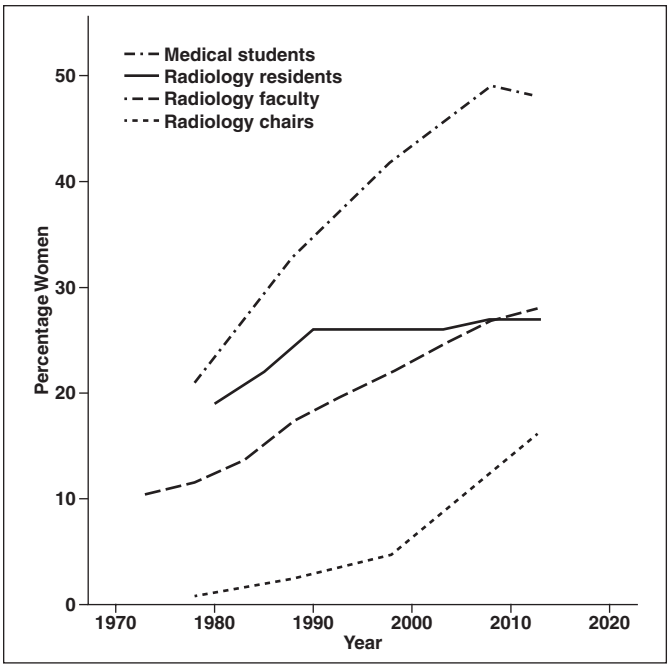

Fig. 1—Graph shows gender distribution of female diagnostic radiology faculty members and residents among medical school graduates over time. Data from [3, 4, 19].

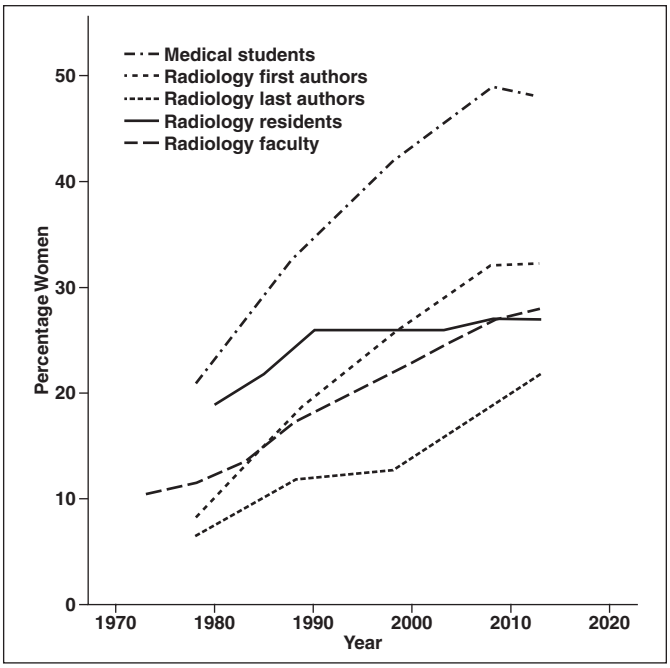

Fig. 2—Graph shows percentage of publications by female physicians in radiology journals compared with female medical school graduates and radiologists over time.

TABLE 1: Representation of Female Physician Investigators

Authorship Status	1978	1988	1998	2008	2013	Slope	Time Trend		
							Odds Ratio[a]	*p*	95% CI
Medical school graduates	3085/14,391 (21.44)	5215/15,919 (32.76)	6650/15,958 (41.67)	7969/16,168 (49.29)	8721/18,157 (48.03)	0.793			
Overall authors									
First author	35/420 (8.33)	125/691 (18.09)	108/420 (25.71)	105/326 (32.21)	110/340 (32.35)	0.703	4.324 (1.043)	< 0.001	3.193–5.856
Last author	26/385 (6.75)	70/591 (11.84)	51/400 (12.75)	56/297 (18.86)	76/347 (21.90)	0.409	3.336 (1.035)	< 0.001	2.299–4.841
Journals total (%)	7.50	15.20	19.40	25.80	27.10				
Editorials									
First author	1/5 (20.00)	5/34 (14.71)	1/15 (6.67)	2/12 (16.67)	5/16 (31.25)	0.217	2.563 (1.027)	0.311	0.415–15.816
Radiology									
First author	21/219 (9.59)	81/460 (17.61)	48/202 (23.76)	41/139 (29.50)	28/113 (24.78)	0.493	3.122 (1.033)	< 0.001	1.981–4.919
Last author	11/202 (5.45)	44/375 (11.73)	21/183 (11.48)	17/124 (13.71)	24/120 (20.00)	0.333	2.824 (1.030)	< 0.001	1.592–5.009
Journal total (%)	7.60	14.97	17.92	22.05	22.32	0.413			
AJR									
First author	14/201 (6.97)	44/231 (19.05)	50/175 (28.57)	47/146 (32.19)	63/163 (38.65)	0.850	5.766 (1.051)	< 0.001	3.652–9.104
Last author	15/183 (8.20)	26/216 (12.04)	24/173 (13.87)	28/129 (21.71)	29/158 (18.35)	0.344	2.670 (1.028)	< 0.001	1.546–4.61
Journal total (%)	7.55	15.66	21.26	27.27	28.66	0.604			
Academic Radiology									
First author			10/43 (23.26)	17/41 (41.46)	19/64 (29.69)	0.335	2.309 (1.024)	0.409	0.319–16.848
Last author			6/44 (13.64)	11/44 (25.00)	23/69 (33.33)	0.687	14.815 (1.080)	0.023	1.459–150.401
Journal total (%)			18.39	32.94	31.58	0.513			

Note—Data are number of women per total number of authors. Except for odds ratio, values in parentheses are percentages. Time trends are over 35 years. Most editorials had only one author. There were too few total editorials in the dataset for a significant trend to be determined. Slope was calculated by linear regression. CI and *p* were calculated by logistic regression.

[a]Value in parentheses is time trend odds ratio for 1 year.

study period, we found that overall 17.07% of editorial first author physicians were women. In 1978, 20.00% (1/5) of editorials had women as first authors; in 2013, 31.25% (5/16) of editorial first authors were women.

Our time trend analyses showed that over time, first authors were more likely to be women. For physician authors the odds ratio [OR] was 1.043 ($p < 0.001$); for nonphysician authors, the OR was 1.075 ($p < 0.001$). The results also showed an increasing number of female senior authors over time. For physician authors the OR was 1.035 ($p < 0.001$); for nonphysician authors, the OR was 1.003 ($p = 0.742$). Across all groups, female authorship increased significantly over time ($p < 0.001$). Given the small number of guest editorials compared with original research articles, inclusion or exclusion of editorials from our analysis did not affect overall time trends in female authorship.

We found significant trends of increasing female senior authorship over time for all three journals ($p \leq 0.023$) and increasing female first authorship over time for *Radiology* and *AJR* (both $p < 0.001$) but not for *Academic Radiology* ($p = 0.409$) (Table 1). The proportions of first and senior authors who were women increased most sharply in *AJR* (slope of 0.604 from 1978 to 2013 for both first and senior authors combined) than for the other journals.

Finally, we found that 22.67% (124/547) of female first authors published with female senior authors compared with 13.67% (246/1799) of male first authors publishing with female senior authors (Table 2). Female first authors were more likely to publish with female senior authors than with male first au-

TABLE 2: Cross-Tabulation of First Author Gender by Senior Author Gender

Senior Author	First Author		
	Male	Female	Total
Male			
No.	1553	423	1976
Percentage	66.2	18.0	84.2
Female			
No.	246	124	370
Percentage	10.5	5.3	15.8
Total			
No.	1799	547	2346
Percentage	76.7	23.3	100.0

Note—A statistically significant association was found between first author gender and senior author gender ($p < 0.001$; $\chi^2 = 25.55$).

thors (OR, 1.85; $p < 0.001$). This statistically significant association between first author gender and senior author gender suggests a tendency for men to publish with men and women to publish with women.

Discussion

Our study yielded information about the gender gap in radiology authorship over a 35-year period. We found a statistically significant increase over time in the proportion of articles by female physicians as both first and senior authors published in the major general radiology journals. However, the number of female senior authors continued to be disproportionately low relative to the overall proportion of women in academic radiology. We also found a significant tendency for female physicians to publish with female senior physicians and for male physicians to publish with male senior physicians.

Our findings support those of previous studies [10, 20] showing that women in diverse medical specialties are not as academically productive as their male counterparts, including having lower rates of authorship of peer-reviewed publications than men do. Our findings also inform results of other studies suggesting that male investigators have a greater tendency to conduct research and an increased likelihood of receiving federal grant dollars for research [21] and that women have fewer opportunities for promotion and leadership, which are driven by academic productivity [22, 23].

Our analysis of the relation between first authors and senior authors as a proxy for gender-specific mentorship may have important implications regarding interventions for decreasing the gender gap in both the publication of radiology research and academic promotion of female radiologists. It may be that female academic radiologists receive more publication opportunities with female senior authors and mentors or that junior female investigators and senior female investigators seek out one another in academic pursuits. The exact reasoning behind this statistically significant gender association between first and senior authors will require further investigation.

Documenting specific gender discrepancies in the field of radiology is an important step in determining root causes of inequality [24] and catalyzing program reform. Previous research findings [25] suggest that department chairpersons considered the core reasons for the lack of female leaders in academic medicine stereotyped gender roles, sexism at work, and a lack of female mentors. Nevertheless, research conducted by gender-diverse teams has been found to be of better quality [6, 22], and research into women's health issues may be underrepresented if women remain underrepresented in specific specialties [26]. In this regard, mentorship is thought to be one of the most crucial activities enabling academic career advancement, especially for women [25, 27–29]. Our finding that a gender association exists between first and senior authors suggests a critical mentorship step for female academic radiologists. Results of previous studies [30, 31] suggest that individuals tend to view the work of people similar to themselves more favorably. Encouraging senior female investigators to work with female junior investigators may be one step in addressing the problem that men in the sciences remain better mentored than women [32].

Our study had several limitations. First, gender could not be established for a small proportion (0.8%) of authors. Second, we assumed gender based on traditional genders of given names, and that may have led to misassignment of gender. We believe, however, that this would be the case for only an insignificant number of authors. For the purposes of our analysis, we also considered the last author the senior author and a proxy for main mentor. It is also possible that nonradiologists publish in radiology journals and that this possibility affected our generalization that these authors are representative of the authors in the specialty. We also analyzed our data by article and not by individual author; therefore, it is possible that particularly prolific authors weighted their gender categories. We focused our analysis on three major general radiology journals and did not include subspecialty journals or stratify by subspecialty. We collected data only at intervals throughout the 35-year study period, not for every year. Our analysis was not intended to be predictive of future time series. We also did not examine the type of original research article (e.g., basic science versus clinical research) by author gender; this relation could be examined in future research efforts.

Conclusion

Our findings show that female first authorship in general radiology publications increased over the 35-year study period to be consistent with the proportion of women in the field. Representation of female senior authors of original research in the field of radiology, however, continued to lag, and women tended to work with other women. The cause of the gender disparity is not clear, but our findings support the notion that senior female investigator mentorship may be critical for increasing involvement of women in radiology research. Future studies should track the newer cohort of women who are publishing in radiology as first authors to see whether they become productive senior authors and mentors of other female academic radiologists.

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