

# Assessing the Gap in Female Authorship in Radiology: Trends Over the Past Two Decades

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## Abstract

**Purpose:** The aim of this study was to retrospectively identify trends in the representation of female authorship in prominent general radiology journals over the past 2 decades.

**Methods:** A comprehensive search was conducted for all articles published in 1993, 2003, and 2013 in *Radiology*, the *American Journal of Roentgenology (AJR)*, *European Radiology*, and *Investigative Radiology*. The genders of the first and last authors were collected. Chi-square tests were used for statistical analysis, and  $P$  values  $< .05$  were considered to indicate statistical significance.

**Results:** A total of 3,786 articles were reviewed. Overall, women constituted 20.0% authorship, 24.7% of first authors, and 15.2% of senior authors. The average overall female first and senior authorship grew from 19.7% to 32.1% and from 13.6% to 19.1%, respectively from 1993 to 2013. Female first authorship grew over the past 2 decades in the journals reviewed, with significant growth in *AJR* and *Radiology* ( $P < .0001$ ). Female first authorship in the individual journals grew from 16.4%-29.1% in 1993, to 29.1%-34.8% in 2013. Female senior authorship also demonstrated growth in the past 2 decades, growing from 4.3%-17.5% in 1993 to 15.5%-23.2% in 2013. There was significant growth in senior female authorship in *Radiology* (from 12.1% to 19.2%,  $P = .004$ ) and *European Radiology* (from 4.3% to 15.5%,  $P = .0433$ ). Female senior authorship remained significantly lower than first authorship over the past 2 decades ( $P = .002$ ,  $P < .001$ , and  $P < .0001$ ).

**Conclusions:** Although women's growth in first authorship in radiology literature is proportional to their growth in the specialty, they continue to remain a minority, especially in senior authorship, and demonstrate similar participation to other medical specialties.

**Key Words:** Academic promotion, gender, women, education

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## INTRODUCTION

Over the past 2 decades, there has been a significant focus on the disparity between women and men within academic medicine. Despite significant concerns and plans for improvement with the inclusion of more women in medicine, they continue to remain a minority in leadership positions in academia [1]. Data from the Association of American Medical Colleges from 2012 show that although women account for 50% of medical

school entrants and graduates, they represent only 37% of medical school faculty members (up from 29% in 2001) and only 13% of full professors [2-4]. Thus, despite the increasing number of female practitioners in the medical profession, there remains a distinct underrepresentation of women in academic medicine, in particular within the specialties [3,4]. In 2003, a study demonstrated that internal medicine, pediatrics, and family medicine were the most popular specialties among female resident physicians [5]. Unfortunately, not only is radiology not among the more popular specialties for female residents, it is one of the only major specialties that has not experienced an increase in the percentage of female residents (where parity has been surpassed by 2011 [6]). Women in radiology represented 28% of residents in 1995 [5], compared with 27% in 2012 [6]. In contrast, an analysis of female practicing radiologists in 1995 demonstrated that only 14% of all practicing

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radiologists in the United States were women [5]. Although the overall percentage of practicing female radiologists had grown to 27% in the United States by 2010 [7], it is concerning that the percentage of female residents has remained constant at 27% [6]. If this trend continues, the gender disparity in radiology will not improve in the near future.

Currently, there is considerable research investigating the representation of female authorship in specialties, including ophthalmology, otolaryngology, dermatology, emergency medicine, internal medicine, surgery, and obstetrics and gynecology [8-13]. Additionally, studies have examined the presence of female physicians in radiology societies and North American training programs [7,14] and of female authorship in academic medicine [8]. However, to date, no study has objectively reviewed the presence of female authorship in academic radiology. We therefore performed an analysis of 4 general radiology journals with the highest impact factors in 2013, with the following aims: (1) to evaluate the representation of female first and last authorship in 4 prominent general radiology journals over the past 2 decades and (2) to determine if significant growth has occurred in relation to the proportion of female radiologists and women in academic medicine.

## METHODS

In this retrospective study of gender trends in academic literature in radiology, the protocol was reviewed and the requirement for informed consent waived by the institutional review board.

### Study Setting and Selection of Articles

We reviewed the gender of the first and last authors of radiology articles using publicly available Internet databases, including PubMed, Google, and the Web of Science. We examined 4 commonly cited general radiology journals on the basis of their significant impact factors in 2013 among the top 30 radiology journals: *Radiology* (impact factor, 6.339), *Investigative Radiology* (impact factor, 5.46), *European Radiology* (impact factor, 3.548) and the *American Journal of Roentgenology (AJR)* (impact factor, 2.897). A search for all articles published in 1993, 2003, and 2013 was conducted in all 4 journals. Research studies, case reports, review articles, and pictorial essays were included. Articles such as letters, correspondence essays, book reviews, and media reviews were excluded. Special editions or supplementary issues were also excluded from the analysis.

## Study Protocol

The gender of the first and last authors was designated by each reviewer on the basis of names listed within each article. If the article was published by a single author, that author was considered the first author. Author gender was categorized as male or female on the basis of authors' names using the knowledge that many names are associated with one gender or another (ie, Elizabeth for women and Phillip for men). If the gender of the author could not be ascertained from inspection, a computer search for the author's website with images or for articles recognizing the author's gender was performed to determine the gender. If the gender was still uncertain after an exhaustive Internet search (ie, no profile pages or images were found within the first 30 search listings), the author was excluded. Authors were not contacted personally by telephone or e-mail.

## Statistical Analysis

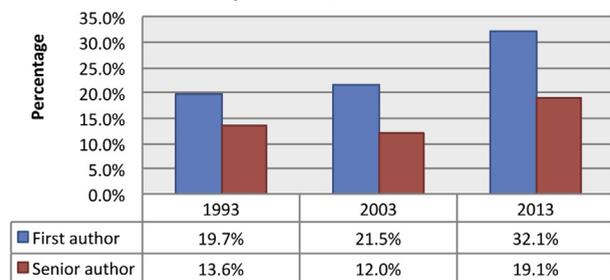
Statistical tests were performed with a commercially available medical statistical package (PASW version 20; SPSS, Inc, Chicago, Illinois). Trends in female authorship comparing the proportions of female authors throughout the years were analyzed using simple descriptive statistics, such as  $\chi^2$  tests and confidence intervals. A difference with a *P* value < .05 was considered statistically significant.

## RESULTS

From these 4 radiology journals, we identified 3,786 articles fulfilling the inclusion criteria during the sampled years (3,207 original articles, 276 review articles, 115 pictorial essays, and 188 case reports). This represented 7,512 total authors reviewed, of whom 3,786 were first authors (of whom 60 were first solo authors) and 3,726 last authors. Overall, we were able to determine the gender of 87.1% of first authors (3,297 of 3,786) and 87.9% of senior authors (3,275 of 3,726). However, the percentage of authors whose gender was unknown was as high as 48.4% (44 of 91), as demonstrated in *European Radiology* in 1993.

Overall, women constituted 20.0% of all known authors (1,314 of 6,572); further analysis demonstrated that 24.7% of known first authors (816 of 3,297) and 15.2% of known senior authors (498 of 3,275) were women. Women constituted 19.7% (215 of 1,094), 21.5% (217 of 1,007), and 32.1% (384 of 1,196) of first authors and 13.6% (139 of 1,023), 12.0% (121 of 1,009), and 19.1% (238 of 1,243) of senior authors in 1993, 2003, and 2013, respectively (Figure 1).

**Percentage of Overall Female Authorship in 1993, 2003 and 2013**



**Fig 1.** Overall representation of female radiologists in first and senior authorship by year in the *AJR*, *Radiology*, *European Radiology*, and *Investigative Radiology*.

The data for percentage of first and last female authorship by publication year and radiology journal are tabulated in [Tables 1 and 2](#). From 1993 to 2013, the percentage of female first authors increased overall ([Figure 1](#)). Authorship grew significantly, from 20.7% to 34.8% and from 16.4% to 30.4%, as reflected in *AJR* and *Radiology* respectively ( $P < .0001$  and  $P < .0001$ ;

[Figure 2](#)). Although a similar trend was demonstrated in *European Radiology* and *Investigative Radiology*, with growth in the percentages of female first authors from 29.1% to 31.6%, and from 21.2% to 29.1%, respectively, significant growth was not observed ( $P = .7237$  and  $P = .1739$ ; [Figure 2](#)).

During these same two decades, the percentage of senior female authorship also increased ([Figure 1](#)). There was significant growth in senior authorship in *Radiology* (from 12.1% to 19.2%,  $P = .004$ ) and *European Radiology* (from 4.3% to 15.5%,  $P = .0433$ ) ([Figure 3](#)). Growth, although not significant, was also noticed in the percentage of senior female authorship in *AJR* and *Investigative Radiology*, from 17.5% to 23.2% and from 11.7% to 15.6%, respectively ( $P = .051$  and  $P = .4369$ ; [Figure 3](#)). When comparing female representation in different authorship positions, female senior authorship consistently remained significantly lower than first authorship over the past 2 decades ( $P = .002$ ,  $P < .001$ , and  $P < .0001$ ).

Remarkable findings with subanalysis per year and per journal, included the lower female senior authorship percentage (4.3%) in the 1993 volume of *European*

**Table 1.** Summary of first authors' gender distribution in journals reviewed in 1993, 2003, and 2013

Variable	1993	2003	2013	P Value, 1993 vs 2013	P Value, 2003 vs 2013
<i>AJR</i>					
Male authors	287	251	260	<.0001	.0104
Female authors	75	88	139		
Unknown-gender authors	47	89	87		
Total included authors	362	339	399		
% Female authors	20.7%	25.9%	34.8%		
<i>Radiology</i>					
Male authors	421	236	229	<.0001	.0930
Female authors	83	76	100		
Unknown-gender authors	49	50	39		
Total included authors	504	312	329		
% Female authors	16.4%	24.4%	30.4%		
<i>European Radiology</i>					
Male authors	78	222	245	.7237	<.0001
Female authors	32	42	113		
Unknown-gender authors	26	47	39		
Total included authors	110	264	358		
% Female authors	29.1%	15.9%	31.6%		
<i>Investigative Radiology</i>					
Male authors	93	81	78	.1739	.0033
Female authors	25	11	32		
Unknown-gender authors	8	8	0		
Total included authors	118	92	110		
% Female authors	21.2%	12.0%	29.1%		

Note: Data are shown in counts of authorship unless specified as percentages. *P* values are for comparison of percentage of female authorship in 2013 versus 1993 and 2003. *AJR* = *American Journal of Roentgenology*.

**Table 2.** Summary of senior authors' gender distribution in journals reviewed in 1993, 2003, and 2013

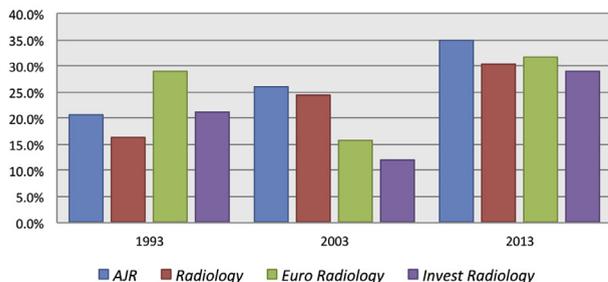
Variable	1993	2003	2013	P Value, 1993 vs 2013	P Value, 2003 vs 2013
<i>AJR</i>					
Male authors	298	293	322	.0510	.0016
Female authors	63	48	97		
Unknown-gender authors	48	87	52		
Total included authors	361	341	419		
% Female authors	17.5%	14.1%	23.2%		
<i>Radiology</i>					
Male authors	443	271	286	.0040	.4887
Female authors	61	56	68		
Unknown-gender authors	49	35	14		
Total included authors	504	327	354		
% Female authors	12.1%	17.1%	19.2%		
<i>European Radiology</i>					
Male authors	45	233	305	.0433	.0001
Female authors	2	14	56		
Unknown-gender authors	44	64	36		
Total included authors	47	247	361		
% Female authors	4.3%	5.7%	15.5%		
<i>Investigative Radiology</i>					
Male authors	98	91	92	.4369	.0037
Female authors	13	3	17		
Unknown-gender authors	15	6	1		
Total included authors	111	94	109		
% Female authors	11.7%	3.2%	15.6%		

Note: Data are shown in counts of authorship unless specified as percentages. P values are for comparison of percentage of female authorship in 2013 versus 1993 and 2003. *AJR* = *American Journal of Roentgenology*.

*Radiology* in comparison with the weighted average of all 4 journals that year (13.6%). Another finding included a drop in overall senior authorship to 12.0% in 2003 from 13.6% in 1993, although the percentage rebounded to 19.2% in 2013. On the other hand, despite the continuous overall growth in female first authorship (19.7%,

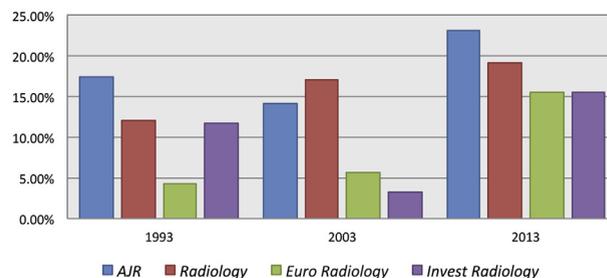
21.5%, and 32.1% in 1993, 2003, and 2013), both *European Radiology* and *Investigative Radiology* showed decreases in 2003, which then rebounded in 2013 to the average (from 29.1% to 15.9% to 31.6% for *European Radiology* and from 21.2% to 12.0% to 29.1% for *Investigative Radiology*).

**First Author Gender Distribution in Journals in 1993, 2003, 2013**



**Fig 2.** Female radiologists' first authorship percentage by year in the *American Journal of Roentgenology* (*AJR*), *Radiology*, *European Radiology* (*Euro Radiology*), and *Investigative Radiology* (*Invest Radiol*).

**Last Author Gender Distribution in Journals in 1993, 2003 and 2013**



**Fig 3.** Female radiologists' senior authorship percentage by year in the *American Journal of Roentgenology* (*AJR*), *Radiology*, *European Radiology* (*Euro Radiology*), and *Investigative Radiology* (*Invest Radiol*).

## DISCUSSION

### Academic Radiology and Women in Authorship in Radiology

We have retrospectively reviewed 3,786 articles to review the gender distribution of first and senior authorship in 4 major journals in general radiology over the past 2 decades. We observed that overall, women constituted 20.0% of the authorship, 24.7% of first authors, and 15.2% of senior authors. This percentage parallels the percentages of practicing female radiologists (14% in 1995 and up to 27% in 2010) [5,7].

We examined the gender of first and last authors for several reasons. The lead author of an article is generally the person performing and directing the study; therefore, the gender of the first author may be an indicator of active involvement of women in research. The last author of an article is often the person responsible for the study, and this status may be an indicator of the progression of women into more senior positions in radiology. Interestingly, the percentage of female first authors is consistently greater than the overall percentage of practicing female radiologists, from 19.7% in 1993 to 32.1% in 2013, compared with 14% to 27% of practicing female radiologists from 1995 to 2010 in the United States [5,7], whereas the percentage of senior authors is consistently lower, from 13.6% in 1993 to 19.2% in 2013. Thus, we conclude that there seems to be maintained growth of female academic radiologists, paralleling their presence in the field, in both the participation in and supervision of research. Despite this growth, the percentage of research supervision, as evidenced by the consistently lower senior authorship, continues to lag behind that of research participation.

In terms of the subanalysis by year and by journal, the 1993 and 2003 volumes of *European Radiology* had considerably lower percentages of female senior authorship (4.3% and 5.7%, respectively) which might be explained by the poor data representation, due to an elevated number of authors whose gender was undetermined (48.4% and 20.5%, respectively), as many given names were presented only as initials. The unusual drop in overall female senior authorship representation in 2003, in addition to the slower growth in female first authorship, is likely due to normal year-to-year variation, as the overall growth is maintained and proportional to the overall growth of female radiologists in the United States [5,7].

### Academic Radiology and Academic Medicine

For better appreciation of this observed gender gap in senior authorship in academic radiology, it is relevant to

compare it to trends in academic medicine. In 2013, women constituted 20.3% of full professors, 33.1% of associate professors, and 43.5% of assistant professors. Similarly, in academic radiology, women represented 18.2% of full professors, 24.7% of associate professors, and 31.6% of assistant professors, with a total representation in academic radiology of 26.9%. This closely mirrors the 27% female practicing radiologists in 2010 [15]. A noteworthy observation from these Association of American Medical Colleges statistics in relation to our data is that in academic radiology, there is good representation of female radiologists (26.9%) relative to their representation in the field (27%); therefore, there do not seem to be significant barriers to female radiologists carrying out academic activity.

In comparison with similar studies in other aspects of medicine, there have been comparable significant increases and representation of female authorship in otolaryngology (growth in first authorship from 12.9% to 21.3% from 1998 to 2008, with the proportion of practicing female otolaryngologists growing from 6% to 11.2% from 1998 to 2007) [11,16,17]. In dermatology, the percentages of recent growth in first and senior authorship, from 1976 to 2006, were 12% to 48% and 6.2% to 31%, respectively, and the recent 2007 representation parallels the 38.2% female practicing dermatologists [10,18]. In ophthalmology, growth from 21.0% to 24.2% and from 18.5% to 20.5% in first and senior authorship respectively, was documented from 2000 to 2009. The 2009 female authorship representation is similar to the 16% practicing female ophthalmologists in the American Academy of Ophthalmology in 2008 [13,19]. Therefore, similarly to other specialties, women's growth in radiology literature authorship is proportional to their growth in the specialty, but they continue to remain a minority, in particular in senior authorship positions.

### Radiology and Residency

Even with the proportional growth of female academic radiologists paralleling their presence in the field, it is important to recognize that there has been stagnant growth of female radiology residents in the past two decades [5]. In fact, radiology is one of the only major medical specialties to have such a large gap [6,20]. To prevent the future growth of an increased gender gap among practicing academic radiologists, some potential barriers, including the lack of female mentors, decreased patient contact in comparison with other specialties, the myth of lifelong radiation exposure, and the competitive

chances of obtaining a residency position, need to be addressed [5,21]. Solutions include having a greater presence of successful female mentors who can foster and help develop passion for the field, increased positive radiology exposure early in the medical curriculum to demonstrate the opportunities for significant patient contact (particularly in areas of interventional radiology), dismissal of myths about significant radiation exposure, and encouragement of applicants regardless of the competition for residency placement [22]. Additionally, as recently studied by Baerlocher and Walker [23], it is important to reassure and encourage applicants to recognize when applying that there is no discrimination against female applicants in residency acceptance. Finally, in recent years, there seems to be markedly decreased interest in radiology among both genders. In the most recent 2014 National Resident Matching Program data, “the proportion of Diagnostic Radiology positions...filled by U.S. seniors was among the lowest in the past 15 years” [24]. The lack of undergraduate medical exposure to radiology is currently taking a toll on the specialty as a whole, and is affecting women even more so [6,25].

### Limitations

Our study had several limitations. First, gender designation was based on name recognition; therefore, we cannot be absolutely certain of the gender of authors.

Second, we had a high percentage of authors of indeterminate gender, as high as 48.4% in the 1993 volume of *European Radiology*. Indeterminate names were often names of Asian origin that were not consistent with common Western gender associations or represented authors whose first names were presented only as initials, more commonly observed in older issues (1993) and in *European Radiology*. Therefore, this can potentially lead to less reliable data in older issues of some of the journals analyzed. We performed a thorough Internet search of authors' names, but if still unsure, we excluded them. We elected not to e-mail individual authors, although this was done in a similar study [26]. The majority of similar studies in other specialties have also excluded authors when their gender remained unclear after a thorough Internet search [8-13].

Third, we did not further analyze whether the authors were clinicians or basic scientists, and thus, the numbers may not entirely reflect the proportion of female academic radiologists; nor did we divide authors into residents, fellows, and practicing radiologists, as the sought designations were not available in the older editions of the journals reviewed.

Fourth, we aimed to obtain a representative sample by selecting the general radiology journals with the highest impact factors among the top 30 radiology journals in 2013, but female representation might be different in various radiology subspecialty journals, which was not accounted for in this study.

Fifth, although we selected journals with the highest impact factors, all 4 are based in either North America or Europe. Although beyond the scope of this study, it may be worthwhile to include other internationally published journals in the future for potentially more global representation. In the future, it may be worthwhile to determine whether other radiology subspecialties, such as body imaging, women's imaging, and pediatric radiology, have greater female participation.

### CONCLUSIONS

We have demonstrated in our study analyzing female authorship in the 4 general radiology journals with the highest impact factors, that although there has been growth in female representation in general radiology literature over the past two decades, female authors continue to remain the minority. Despite proportional representation of female radiologists in academia relative to the number of practicing female radiologists, female senior authorship representation in particular continues to remain low, and is similar across other areas of academic medicine. Measures to encourage women's increased participation in radiology and academic radiology should be considered. These could include increased and early exposure to radiology during medical education and emphasizing its impact on patient care, improving mentorship during residency and fellowship, and redefining senior academic positions in radiology, so that our specialty can become a leader in narrowing the gender gap in academic medicine.

### TAKE-HOME POINTS

- Women's growth in overall authorship in radiology literature is proportional to their growth in the specialty over the past two decades.
- Women continue to remain a minority, in particular in senior authorship positions, similar to other medical specialties.
- Assessment of female authorship representation in radiology subspecialties should be encouraged.
- Measures to encourage increased female participation in radiology and academic radiology should be considered.

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