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Representation of Women as Authors of Rheumatology Research Articles

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ABSTRACT

Objective: In academic medicine, journal article authorship is central to career advancement and promotion. This study aimed to examine the contemporary representation of women as first and senior authors of rheumatology original research articles.

Methods: The gender of first and senior author, disease category, research design and funding source were extracted from rheumatology original research articles published in high impact rheumatology and general medical journals between 2015 and 2019.

Results: 7,651 original research articles were included in the analysis. In total, there were 51.5% [95% CI 50.4%, 52.6%] articles with women first authors and 35.3% [95% CI 34.2%, 36.4%] with women senior authors. Women were significantly less likely to be first and senior authors of articles reporting randomized controlled trials compared with other clinical research designs ($P<0.001$), and of articles reporting industry-funded/industry-initiated studies compared with studies not funded by industry ($P\leq0.01$). For articles reporting industry-funded/industry-initiated randomized controlled trials, women were first authors in 18.5% [95% CI 13.8%, 24.0%] and senior authors in 23.9% [95% CI 18.6%, 29.8%].

Conclusion: In rheumatology research articles, there is gender parity for first authorship, but women are under-represented in senior authorship positions. Under-representation of women in authorship is particularly apparent in articles reporting randomized controlled trials, and especially those that are initiated by industry.

Keywords: gender; authorship; disparities; rheumatology

INTRODUCTION

Globally, there have been some advances in gender equity within the medical workforce, with an increase in women physicians in recent decades [1, 2]. According to American College of Rheumatology (ACR) workforce surveys, 30% of rheumatologists in the US were women in 2005 [3], improving to 41% in 2015 [4]. By 2030, it is anticipated that women will make up 57% of the United States rheumatology workforce [4]. Women represented 47% of the rheumatology consultant workforce in the United Kingdom in 2018 [5], and approximately 50% of rheumatology specialists in Australia and New Zealand in 2019 [6]. In 2015, although 41% of US academic rheumatology faculty were women, women were less likely to be associate or full professors [7].

Publication of research articles is central to academic promotion [8-10]. Gender bias in authorship of scientific articles is well-described. Overall, men have a higher publication rate than women across multiple scientific disciplines [1, 11, 12], and women authors receive fewer citations [13, 14]. Women authors are also under-represented in first and senior authorship positions in articles published in medical journals, even in disciplines such as family medicine which are enriched for women practitioners [1, 12, 15]. Even in articles in which first and second authors of different gender contribute equally, men are more likely to be listed first [16].

In academic medicine, clinical trial leadership is important for career advancement, prominence in the field, and future funding opportunities. In oncology clinical trials, woman are under-represented as lead investigators in industry-funded studies [17]. Furthermore, in industry-funded collaborative cancer trials, women are under-represented as first and senior authors, compared with trials not funded by industry [18]. It is unknown whether funding source influences gender authorship for other specialties.

The aim of this study was to examine the contemporary representation of women as first and senior authors of rheumatology original research articles.

MATERIALS AND METHODS

Identification of journals and articles for inclusion

All original articles published in general rheumatology journals with 2016 Thomas Reuter's Impact Factors of > 3.0 (*Annals of the Rheumatic Diseases, Arthritis & Rheumatology, Rheumatology, Seminars in Arthritis & Rheumatism, Arthritis Research & Therapy, Joint*

Bone Spine, Arthritis Care & Research, Journal of Rheumatology) were considered for inclusion. All original research articles describing rheumatic diseases published in general medical journals with 2016 Thomas Reuter's Impact Factors > 15.0 (*New England Journal of Medicine, The Lancet, Journal of the American Medical Association, The British Medical Journal, JAMA Internal Medicine, Annals of Internal Medicine*) were also considered for inclusion.

All original research articles published over a 5-year period between January 2015 and December 2019 were included in the analysis. Included articles were full or concise reports and reported on clinical or basic research or systemic literature reviews and meta-analyses. Articles were excluded if they were narrative review articles, recommendations, guidelines, letters, or meeting proceedings.

Data extraction

All data was extracted into a Microsoft Access database. For each article, the journal, year, issue, gender of the first and last (senior) authors, research design (randomised controlled trial, other clinical, systematic review/meta-analysis, basic), funding source, industry initiation, and region of affiliation of the first author (categorised as 'North America', 'Europe', or 'Other') was recorded. In addition, the disease category (ankylosing spondylitis and other spondyloarthropathies, crystal arthritis, osteoarthritis, miscellaneous rheumatic disease, paediatric rheumatology, pain syndromes, psoriatic arthritis, rheumatoid arthritis, systemic lupus erythematosus, systemic sclerosis/scleroderma, other connective tissue disorders, vasculitis, not disease-specific) was also extracted using a previously established set of rules to ensure standardisation in categorising [19].

When the author's gender was uncertain by initial inspection of their first name, or in cases where only an initial of their first name was provided, an internet search using the authors name and institutional affiliation was used to identify individual web pages or online profiles that included a photograph of the individual. If the gender remained unclear, the author's first name was entered into genderize.io (https://api.genderize.io/?name=) which returns the gender and probability of certainty. Probabilities < 0.5 were labelled as 'unknown'.

The source of funding for each study was categorised as industry-funded, or not industry-funded based on funding declaration statements appearing in the article (i.e. under 'funding' or 'acknowledgements' sections). Articles that did not declare industry funding were assumed

to be not industry-funded. Industry-funded studies were further separated into investigator-initiated or industry-initiated studies, based on declarations in the manuscript. For the purpose of analysis, articles were categorised as 'industry-funded/industry-initiated', 'industry-funded/investigator-initiated' and 'not industry-funded'.

Prior to data extraction, two researchers (EB, SS) independently extracted data from five randomly selected issues to ensure standardization. A total of 65 articles were reviewed, with kappa scores of 1.00 for first author gender, last author gender, geographical region and funding source, and 0.98 [95% confidence interval [CI] 92.7%, 99.9%] for disease category. (98.5% agreement). All data was then extracted by one of the two researchers (EB, SS).

Data analysis

Descriptive statistics were used to report the proportion of articles with women and men first and last authors, as well as the proportion of articles authored by women according to geographical region, disease category, research design, and funding source for each gender. The percentage and 95% confidence intervals for the proportion of articles with first and senior authors who were women was calculated using openepi.com [20]. As there were relatively few (18.2%) articles from regions outside Europe and North America, three geographical region categories were analysed (Europe, North America and other). Data were plotted against a hypothetical gender parity (50%) and the percentage of women in the 2015 United States academic rheumatology workforce (41%) [7].

To compare differences between groups, odds ratios (ORs) and their 95% confidence intervals [95% CIs] were computed. Linear-by-linear association tests (Cochran-Armitage trend tests) were used to analyse trends in authorship gender between 2015 and 2019 using SPSS (Version 26.0. IBM Corp, Armonk, NY). All tests were two tailed. $P< 0.05$ was considered significant and no adjustments for multiplicity was made.

RESULTS

Articles

Data were extracted from a total of 7,699 articles, including 7,602 articles from general rheumatology journals. From the general medical journals, there were 4,588 original research articles published between 2015 and 2019, of which 97 articles reporting rheumatology research were included. The gender of the first author could not be determined in 14 (0.2%) papers, the senior author gender in 31 (0.4%) papers, and both first and senior authors in 3

(0.04%) papers; these articles were excluded from further analysis. In total, 7,651 articles were analysed. The characteristics of these articles are shown in **Table 1**.

There were 51.5% [95% CI 50.4%, 52.6%] articles with women first authors and 35.3% [95% CI 34.2%, 36.4%] with women senior authors (**Table 2**). Articles from geographical regions other than Europe and North America had a lower proportion of first authors who were women (42.7% [95% CI 40.1%, 45.3%]) (**Table 2**). The proportion of women senior authors was below 40% for articles for all geographical regions.

Similar patterns of authorship gender were observed for articles related to different rheumatic diseases (**Table 2**). Paediatric rheumatology articles had the highest proportion of women first and senior authors, and vasculitis articles had the lowest proportion of women first and senior authors.

There was no significant change in gender patterns for first authors between 2015 and 2019 (P for trend = 0.30). However, there was a small increase in women senior authors over this period (P for trend = 0.019, **Figure 1** and **Supplementary Table 1**).

Analysis of the gender of first author and senior author pairs demonstrated that women had higher odds of being a first author on an article with a woman senior author (OR 1.91 [95% CI 1.73, 2.10]), P <0.001 (**Table 3**).

Research design

Similar proportions of women first authors were observed for articles reporting basic science (51.5% [95% CI 49.2%, 47.0%]), systematic literature reviews/meta-analyses (50.6% [95% CI 45.9%, 55.2%]), and other clinical research (53.7% [95% CI 52.4%, 55.2%]), but only 33.3% [95% CI 29.7%, 37.2%] of articles that reported randomized controlled trials had women first authors (**Table 2**). Women had significantly lower odds of being first authors of articles reporting randomised controlled trials compared with articles reporting basic science research (OR 0.47 [95% CI 0.39, 0.57], P <0.001), systematic literature reviews/meta-analyses (OR 0.49 [95% CI 0.38, 0.63], P <0.001), and other clinical research (OR 0.43 [95% CI 0.36, 0.51], P <0.001).

The highest proportion of women senior authors was for articles reporting systematic literature reviews/meta-analyses and other clinical research (39.6% [95% CI 35.2%, 44.2%]

and 37.9% [36.6%, 39.3%], respectively). The lowest proportion of women senior authors were observed for articles reporting basic science (30.1% [95% CI 28.0%, 32.2%]) and randomized controlled trials (26.4% [95% CI 23.0%, 30.0%]) (**Table 2**). Women had significantly lower odds of being senior authors on articles reporting randomised controlled trials compared with articles reporting other clinical research (OR 0.59 [95% CI 0.48, 0.71], P <0.001) and systematic literature reviews/meta-analyses (OR 0.55 [95% CI 0.42, 0.71], P<0.001).

Funding sources

For articles reporting industry-funded/industry-initiated studies, women were first authors of 39.2% [95% CI 35.7%, 42.8%] articles and senior authors of 30.9% [95% CI 27.7%, 34.3%]) articles. Women were less likely to be first authors of articles reporting industry-funded/industry-initiated research than of articles reporting industry-funded/investigator-initiated studies (OR 0.64 [95% CI 0.52-0.79], P <0.001) or of research not funded by industry (OR 0.57 [95% CI 0.49-0.67], P<0.001) (**Table 2**).

Similarly, women were less likely to be senior authors on articles reporting industry-funded/industry-initiated research compared with articles reporting research not funded by industry (OR 0.81 [95% CI 0.68-0.95], P = 0.010), with a similar trend for comparison with articles reporting industry-funded/investigator-initiated research (OR 0.81 [95% CI 0.65-1.01], P =0.067). For articles reporting industry-funded/industry-initiated randomized controlled trials, only 18.5% [13.8%, 24.0%] had women first authors and 23.9% [18.6%, 29.8%] had women senior authors (**Figure 2 and Supplementary Table 2**).

DISCUSSION

This study has demonstrated that women are under-represented in senior authorship positions of rheumatology research articles, compared with both hypothetical gender parity (50%) and the percentage of women in the 2015 United States academic rheumatology workforce (41%). There is under-representation of women in both first and senior authorship positions in articles reporting rheumatology randomized controlled trials, especially those that are initiated by industry.

For the entire dataset, the proportion of women first authors was consistent with hypothetical gender parity and higher than the academic rheumatology workforce proportion. The pattern of more women first authors compared with senior authors is consistent with studies in other

fields including gastroenterology [21], oncology research [21], pharmacy [22], and paediatrics [23]. The proportion of women in the rheumatology workforce has grown rapidly over the past decade, and it is predicted that women will be the majority of the rheumatology workforce in the next ten years [4]. As first authors of most studies tend to be those who are more junior in experience [24], the higher proportion of women first authors is consistent with the changing gender distribution of the rheumatology workforce. The gender differences between first and senior author may also signify challenges to career progression for women entering academic rheumatology [25]. The genders of the first and last authors were associated, with women more likely to be first authors of rheumatology articles with women senior authors. This authorship pattern is also described in other disciplines [26, 27] and may be due to the tendency for women in senior positions to select and mentor women; prior research has shown that men senior authors are less likely to mentor junior women in medical academia [28]. Early in their career, women may also seek women mentors due to shared social identity [29].

In contrast to first author position, we observed fewer women senior authors, below both hypothetical gender parity and United States academic rheumatology workforce levels. The most striking gender disparities were observed for randomized controlled trials, with low proportions of both women first authors and women senior authors. This is consistent with a recent analysis of biomedical and internal medicine journals in which women were less likely to author articles reporting clinical trials than men (7% vs. 13%, respectively) [30]. Our findings may be due to the low number of women in rheumatology academic leadership positions, with women less likely to be full or associate professors compared to men [7, 31]. Given that randomized controlled trials are widely regarded as the highest quality of research and have a large impact on clinical practice [32], these findings highlight a potential barrier in career advancement for female rheumatologists.

Consistent with findings in oncology [18], women were less likely to be first and senior authors of rheumatology articles that were funded and initiated by industry. Women physicians and academics receive significantly fewer industry-sponsored research grants compared to men [33, 34]. Gender differences in financial relationships are also apparent for speaker and consulting relationships with industry [33, 35]. Our analysis does not allow interrogation of the causes for these gender differences, but our results may reflect industry selection of men with higher perceived ‘authority’ status [13]. Women may also have less willingness or interest to work with industry.

A potential limitation of this analysis was that individual author names were not analysed, and it is possible that multiple articles were authored by the same person. Given the relatively low number of women in academic rheumatology leadership positions [7, 31], our method of analysis may have over-represented the number of women authors of rheumatology publications, particularly in senior positions. A further limitation is that our analysis of industry funding was dependent on author disclosures which may have been incomplete [36].

In conclusion, this analysis of rheumatology publications has identified some gender disparities in authorship of original research articles. Women are under-represented as senior authors, and as authors of clinical trials, particularly those funded and initiated by industry. These findings highlight the importance of institutional and industry leaders to take steps to ensure that women are represented equally as the future gender gap in the rheumatology workforce narrows.

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FIGURE LEGENDS

Figure 1. Percentage of articles with women first and senior authors over the study period. Dashed line indicates gender parity (50%), dotted line shows the percentage of women in the 2015 United States academic rheumatology workforce. Data are shown as % [95% CI].

Figure 2. Percentage of articles reporting randomized controlled trials with women first and senior authors according to funding source. Dashed line indicates gender parity (50%), dotted line shows the percentage of women in the 2015 United States academic rheumatology workforce. Data are shown as % [95% CI].

Table 1. Characteristics of included articles.

	N (%)
Total	7651
General rheumatology journals	7554 (98.7%)
General medical journals	97 (1.3%)
First author gender	
Woman	3939 (51.5%)
Man	3712 (48.5%)
Senior author gender	
Woman	2699 (35.3%)
Man	4952 (64.7%)
Geographical region	
Europe	3852 (50.3%)
North America	2410 (31.5%)
Other	1389 (18.2%)
Disease category	
Ankylosing spondylitis	558 (7.3%)
Crystal arthritis	347 (4.5%)
Miscellaneous	294 (3.8%)
Not disease-specific	491 (6.4%)
Osteoarthritis	857 (11.2%)
Other connective tissue diseases	370 (4.8%)
Pain syndromes	154 (2.0%)

Pediatric rheumatology	442 (5.8%)
Psoriatic arthritis	287 (3.8%)
Rheumatoid arthritis	2159 (28.2%)
Systemic lupus erythematosus	762 (10.0%)
Systemic sclerosis	538 (7.0%)
Vasculitis	392 (5.1%)
Research design	
Basic science	1801 (23.5%)
Randomised controlled trials	603 (7.9%)
Systematic literature reviews/meta-analyses	449 (5.9%)
Other clinical	4798 (62.7%)
Funding source	
Industry-funded/industry-initiated	724 (9.5%)
Industry-funded/investigator-initiated	734 (9.6%)
Not industry-funded	6193 (80.9%)

Table 2. Proportion of articles according to author gender.

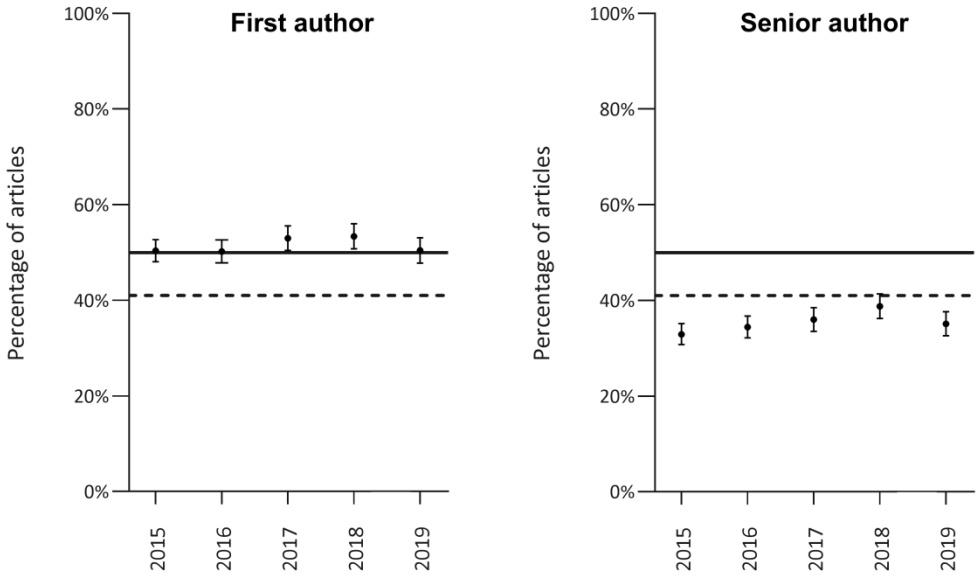
		First author gender, women		Senior author gender, women	
	Number of articles	**n**	**% [95% CI]**	**n**	**% [95% CI]**
All	7651	3939	51.5% [50.4%, 52.6%]	2699	35.3% [34.2%, 36.4%]
Geographical region					
Europe	3852	2092	54.3% [52.7%, 55.9%]	1350	35.0% [33.6%, 36.6%]
North America	2410	1254	52.0% [50.0%, 54.0%]	899	37.3% [35.4%, 39.3%]
Other	1389	593	42.7% [40.1%, 45.3%]	450	32.4% [30.0%, 34.9%]
Disease category					
Ankylosing spondylitis	558	294	48.54% [48.5%, 56.8%]	206	36.9% [33.0%, 41.0%]
Crystal arthritis	347	188	54.2% [48.9%, 59.4%]	115	33.1% [28.3%, 38.2%]
Miscellaneous	294	135	45.9% [40.3%, 51.6%]	94	32.0% [26.8%, 37.5%]
Not disease-specific	491	267	54.4% [50.0%, 58.8%]	165	33.6% [29.5%, 37.9%]

Osteoarthritis	857	419	48.9% [45.6%, 52.2%]	326	38.0% [34.8%, 41.3%]
Other connective tissue disorders	370	176	47.6% [42.5%, 52.7%]	119	32.2% [27.6%, 37.1%]
Pain syndromes	154	86	55.8% [47.9%, 63.5%]	62	40.3% [32.7%, 48.2%]
Pediatric rheumatology	442	258	58.4% [53.7%, 62.9%]	187	42.3% [37.8%, 47.0%]
Psoriatic arthritis	287	147	51.2% [45.4%, 57.0%]	112	39.0% [33.5%, 44.8%]
Rheumatoid arthritis	2159	1098	50.9% [48.8%, 53.0%]	770	35.7% [33.7%, 37.7%]
Systemic lupus erythematosus	762	417	54.7% [51.2%, 58.2%]	274	36.0% [32.6%, 39.4%]
Systemic sclerosis	538	283	52.6% [48.4%, 56.8%]	173	32.2% [28.3%, 36.2%]
Vasculitis	392	171	43.6% [38.8%, 48.6%]	96	24.5% [20.4%, 28.9%]
Research design					
Basic science	1801	931	51.5% [49.4%, 54.0%]	542	30.1% [28.0%, 32.2%]
Randomised controlled trial	603	201	33.3% [29.7%, 37.2%]	159	26.4% [23.0%, 30.0%]
Systematic literature review/meta-analysis	449	227	50.6% [45.9%, 55.2%]	178	39.6% [35.2%, 44.2%]

Other clinical	4798	2580	53.7% [52.4%, 55.2%]	1820	37.9% [36.6%, 39.3%]
Funding source					
Industry-funded/industry-initiated	724	284	39.2% [35.7%, 42.8%]	224	30.9% [27.7%, 34.3%]
Industry-funded/investigator-initiated	734	369	50.3% [46.7%, 53.9%]	261	35.6% [32.2%, 39.1%]
Not industry-funded	6193	3286	53.1% [51.8%, 54.3%]	2214	35.8% [34.6%, 37.0%]

Table 3. Gender of first and senior author pairs. Data are shown as n (%) [95% confidence interval].

	Senior author gender	
	Woman	**Man**
First author gender, woman	1667 (21.8%) [21%, 23%]	2272 (29.7%) [29%, 31%]
First author gender, man	1032 (13.5%) [13%,14%]	2680 (35.0%) [34%, 36%]



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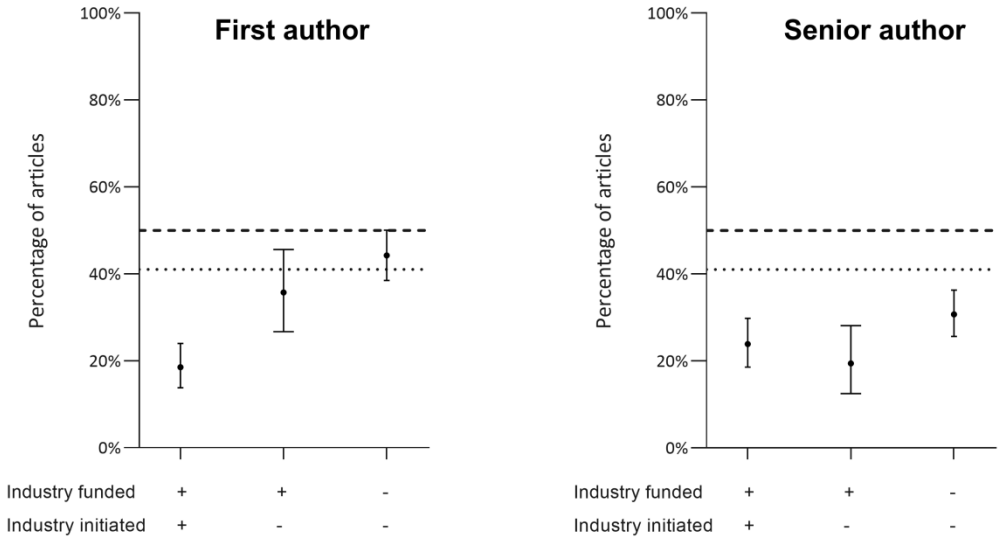

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